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Common Law Division
Supreme Court
New South Wales

Case Name:	Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 22)
Medium Neutral Citation:	[2019] NSWSC 1657
Hearing Date(s):	4 – 15 December 2017; 12 – 14 February 2018 (view), 19 – 28 February 2018; 1 – 22 March 2018, 26 – 29 March 2018; 4 – 5 April 2018, 9 – 12 April 2018;16 – 30 April 2018; 1 – 31 May 2018; 4 – 8 June 2018, 12 – 20 June 2018, 25 – 29 June 2018; 4 July 2018, 24 – 31 July 2018; 1 August 2018, 6 – 10 August 2018, 15 – 16 August 2018, 31 August 2018; 14 September 2018, 11 October 2018, 27 – 30 November 2018; 3 – 12 December 2018, 22 February 2019; 11 March 2019, 18 to 20 March 2019. Final written submission – 10 May 2019.
Date of Orders:	29 November 2019
Date of Decision:	29 November 2019
Jurisdiction:	Common Law
Before:	Beech-Jones J
Decision:	Answers to common questions pronounced in accordance with Chapter 15. (1) The proceedings stand over to 9.30am on 21 February 2020 for directions; and (2) By no later than 7 February 2020 the parties are to confer as to the further progress of the proceedings.
Catchwords:	REPRESENTATIVE ACTIONS – property damage arising out of widespread urban flooding from Brisbane River escaping its banks in January 2011 – group defined by reference to ownership or interest in property affected by flooding and whether group members or their insurer signed litigation funding agreement – lead plaintiff owned store affected by flooding – determination of all issues of fact and law

affecting lead plaintiff – determination of all issues other than quantum affecting a sample of group members – determination of all issues affecting the respective obligations of the defendants to each other – determination of common questions identified relevant to plaintiff and all or many group members

FLOOD MITIGATION – dams located above major metropolitan area – dual function of water supply and flood mitigation – first defendant owner of dam and employer of two flood engineers on duty during flood event – second defendant contractor to first defendant and employer of senior flood operations engineer – third defendant employer of flood engineer – whether first defendant had statutory function of flood mitigation – statutory regulation of interference with watercourses – permissions granted to undertake flood mitigation – approval under statute of manual of flood operations – significance of manual to flood engineers controlling dams before, during and after flood events – manual does not have force of law but governs content of any duty of care and exempts dam owner from any liability if complied with – whether manual required use of rainfall forecasts in conduct of flood operations – whether manual required use of actual or predicted reservoir levels – role of experts in interpretation and application of manual – whether flood operations during previous flood events supported posited interpretation of the manual – relevance of events surrounding drafting of manual to its interpretation and application – whether flood engineers had reasonable belief as to construction and application of manual – whether peer professional practice at other dams permitted releases below full supply level

ADMINISTRATIVE LAW – whether regulatory regime permitted flood releases from below full supply level of each dam – validity of approval granted to dam owner to make releases for flood mitigation from below full supply level – role of discretionary bases for refusing relief in determining a collateral challenge to executive action

NEGLIGENCE – DUTY OF CARE – dams located above major metropolitan area – dams controlled approximately half of downstream river flows – ultimate control of outflows from dam during flood event retained by dam owner but shared with flood engineers operating under Manual - risk posed to property owners from Brisbane river breaking its banks depending on their proximity to river and elevation – downstream property owners and those with interest in property vulnerable to negligent exercise of control over dams – size of affected class does not render class indeterminate – relevance of fact that rate of flow released is less than peak flow rate if dam not present - alleged inconsistency between posited duty and statute – whether duty imposes inconsistent obligations in favour of persons at different downstream locations – whether duty imposed on flood engineers inconsistent with duties to their employers – scope of duty provided by contractor proving engineering services – held duty owed by dam owner and flood engineers – duty owed by contractor but only in respect of provision of flood management services under contract

NEGLIGENCE – DUTY OF CARE – whether duty owned by dam owner or contractor a non-delegable duty – nature of activity conducted on dam owner's land – conduct of flood operations for ostensible benefit of downstream residents and property holders – not taking advantage of property to engage in dangerous activity – statutory provisions granting permission to dam owner to conduct flood mitigation not exhibiting strict non-delegability – held dam owner did not owe non-delegable duty – held contractor did not owe non-delegable duty

VICARIOUS LIABILITY – flood engineers – whether employee "pro hac vice" of second defendant – necessity for high degree of control over performance of duties – not established – whether flood engineers performed independent legal duty such that third defendant not vicariously liable for conduct of flood engineer it employed – whether point properly pleaded – independent legal duty only denies vicarious liability if employee performing duty imposed by statute or by common law – common law imposes duties on those holding office – flood engineers neither performing duties imposed by statute or by common law – held each defendant vicariously liable for flood engineer they employed

NEGLIGENCE – STANDARD OF CARE – flood engineers – Civil Liability Act 2003 (Qld); s 36(1) – whether proceeding based on an alleged wrongful exercise of or failure to exercise a function of a public or other authority – whether such exercise was so unreasonable that no such authority could properly consider the act or omission to be a reasonable exercise of its functions – whether section confined to actions for breach of statutory duty – held section not so limited but not engaged in respect of any vicarious liability that the public authority incurs for breach by an employee of a duty of care owed by the employee – whether proceedings “based on” exercise of a “function of a public authority” – requirement for function conferred by governmental authority – held defendants not exercising any such function – Civil Liability Act 2003 (Qld); s 22(1) – no breach of duty by professional if established that “acted in a way that...was widely accepted by peer professional opinion by a significant number of respected practitioners in the field as a competent professional practice” – whether necessary to identify existing practice that was conformed with – practice of flood engineers and flood operations in Australia and overseas – all such practices conditioned by necessity to comply with water control manual – held in the absence of compliance flood engineers did not act in conformity with any practice – held relevant standard was that of the reasonably competent flood engineer

NEGLIGENCE – BREACH – allegations of breach governed by ss 9 and 10 of Civil Liability Act 2003 (Qld) – content of flood engineer’s duty involved compliance with the manual – whether allegations of breach tied to necessity for flood engineers to make releases in conformity with counterfactual flood operations proposed by plaintiff’s expert – not possible to comply throughout period of flood event as divergence between reservoir levels and counterfactual increased over time –counterfactuals and their reasoning inform allegations of breach – systemic failure of flood engineers to comply with manual over course of flood event – failure to select strategies and make releases by reference to rainfall forecasts – failure to conduct flood operations in accordance with priorities specified by manual – prioritisation of avoiding inundation of low lying bridges at expense of avoiding risk of urban inundation – breach established

NUISANCE – whether release of water from dam inundating plaintiff’s store was an unreasonable interference with its use and enjoyment – relevance of fact that rate of water flow released less than peak river flow rate if dam not present – scope of defence of statutory authorisation and necessity – held unreasonable interference not established – defences would have failed

TRESPASS – whether release of water from dam inundating plaintiff's store was a trespass – necessity for intrusion to be immediate or direct result of defendant's actions – held trespass not established

NEGLIGENCE – CAUSATION – Civil Liability Act 2003 (Qld); s11 – necessity to identify "particular harm" – counterfactual flood operations – plaintiff's expert accepted – counterfactual simulation identified – use of hydraulic modelling to ascertain depth of flooding at relevant locations using simulated outflows from dam – reliability of modelling – approach to findings at particular locations – necessity to consider all the evidence relevant to each location as model not determinative – future assessments to be conducted by reference to all such evidence but consistent with findings to date and forensic choices made by the parties

NEGLIGENCE – CAUSATION – successive tortfeasors causing combined state of affairs that caused harm – s11(1)(a) – material contribution – Strong v Woolworths – "jointly sufficient to account for the occurrence of the harm" – set of conditions necessary to the occurrence of harm – each tortfeasor's breach may not be sufficient to satisfy but combined effect of breaches of the tortfeasors are sufficient – held s 11(1)(a) established – scope of harm – s 11(1)(b) – whether individual tortfeasor responsible for harm caused by the combination of all such breaches – held attribution of liability for all harm caused appropriate

QUANTUM – loss of profits of business – out of date stock – treatment of charitable and similar payments that but for the flooding would not have been paid – grants made Rural and Regional Adjustment Act 1994 – statutory scheme for reimbursement of direct costs associated with flooding – held plaintiff and group members not entitled to recover costs the subject of grant payment - whether commercial cost of volunteers who cleaned plaintiff's premises and stock recoverable – measure of damage – whether provision of services intended to operate in the interests of the defendant and diminish damages otherwise payable – held costs recoverable at commercial rate – whether plaintiff can recover amount representing commercial cost of free storage provided for damaged stock – not an expense or a true consequential loss – held not recoverable

CIVIL PROCEDURE – cross-claims – Civil Liability Act 2003 (Qld); ss 28(1), 31(1), 32A – plaintiff's claim in negligence is proportionate claim – no claims in contribution maintainable – cross-claim by dam owner against contractor – seeking contractual indemnity for liability to plaintiff and group members as well as costs – contractual exclusion for "indirect and consequential loss" – held exclusion applies – cross-claim fails

LIMITATION PERIODS – Limitation of Actions Act 1974 (Qld) – whether institution of representative proceedings in Supreme Court of New South Wales meant that "action...[was] brought" by group members within relevant period – held action brought

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Category:	Principal judgment
Parties:	Rodriguez & Sons Pty Limited (Plaintiff) Queensland Bulk Water Supply Authority t/as Seqwater (First Defendant) SunWater Limited (Second Defendant) State of Queensland (Third Defendant)
Representation:	Counsel: J Sexton SC; N Owens SC; R Yezerski; J Taylor (Plaintiff)

	B O'Donnell QC; A Pomerenke QC; D Piggott; D Klineberg (First Defendant) D Williams SC; HJA Neal; N Simpson; A Barnett (Second Defendant) GA Thompson QC; JM Horton QC; E Morzone (Third Defendant) Solicitors: Maurice Blackburn Pty Ltd (Plaintiff) King & Wood Mallesons (First Defendant) Norton Rose Fulbright (Second Defendant) Crown Solicitor for the State of Queensland (Third Defendant)
File Number(s):	2014/200854
Publication Restriction:	

JUDGMENT

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CHAPTER 1: SUMMARY

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CHAPTER 1: SUMMARY

1 These representative proceedings arise out of the large-scale flooding that occurred in the greater Brisbane and Ipswich area from on or around 11 January 2011. Before I summarise the nature of the proceedings and the findings made in the balance of this judgment, three matters should be noted.

2 First, the obvious question that arises is why these proceedings were heard in the Supreme Court of New South Wales when every relevant fact, matter and circumstance occurred in Queensland? Although it is surmise on my part, the answer appears to be that, at the time these proceedings were commenced, there were no legislative provisions in force governing representative actions in the Supreme Court of Queensland. Such provisions are now operative.[1] Thus, the hearing of this case in this State appears to be an accident of time. For the sake of completeness, I note that this Court's jurisdiction to hear the matter derives (at least in part) from s 4(1) of the *Jurisdiction of Courts (Cross Vesting) Act 1987* (Qld).

3 Second, on the afternoon and evening of 10 January 2011, severe flash flooding occurred in Toowoomba and the Lockyer valley including the towns of Helidon and Grantham. Tragically, a number of people lost their lives. That flooding is not the subject matter of this case. There is no relevant connection between the conduct of any of the defendants and the occurrence of that flooding. Instead, the large increase in flows in Lockyer Creek that occurred on that day is simply part of the factual background to the "over the floor" flooding that was occasioned at other places in the Brisbane River catchment on 11 and 12 January 2011 (and beyond).

4 Third, during 2011 and 2012 a Commission of Inquiry constituted under the *Commissions of Inquiry Act 1950* (Qld) was conducted into various matters concerning the flooding the subject of these proceedings (the "QFCI"). Parts of the evidence before that inquiry were tendered in these proceedings as

[1] See Part 13A of the *Civil Proceedings Act 2011* (Qld).

were some of its recommendations.[2] However, the bulk of the evidence before the QFCI and its report were not tendered and therefore could not be considered by this Court. I have not read the QFCI report.

Background

5 Like the situation at present, from 2001 to 2008 severe drought was experienced in eastern Australia, including South East Queensland. By 2009 the drought had broken. Towards the end of calendar year 2010 significant rainfall was expected and fell in South East Queensland as the effect of a "La Niña" climate phase took hold. The rainfall caused the declaration of a number of so-called "flood events" and the conduct of flood operations at Wivenhoe Dam and Somerset Dam in the last three months of 2010.

6 By early January 2011, the catchment area of the Brisbane River[3] was saturated. Despite significant flood releases having been made during December 2010, as at early January 2011, each dam was above its so-called "Full Supply Level" ("FSL").[4]

7 Although the period from 2 January 2011 was referred to as the "January 2011 Flood Event", releases for flood mitigation from Wivenhoe Dam and Somerset Dam ceased on that day. They would not resume again until the afternoon of 7 January 2011. From 3 January 2011, various weather forecasts began to predict significant rainfall over the Brisbane River basin, including the catchments above the dams. These forecasts steadily increased and became ominous over the following days. Significant amounts of rain fell in the Brisbane River basin, including in the catchments above the dams, on 5 January 2011. It continued for the next two days, although it eased on Saturday 8 January 2011.

8 On Sunday 9 January 2011, the heavens opened. Over that day and the following two days rainfall totals approximating 350mm to 400mm in depth

[2] See for example Chapter 7 at [480].
[3] This being the "Brisbane River basin": see Chapter 2, Figure 2-1.
[4] A list of various technical phrases used in the judgment is set out in Appendix A.

were experienced in the catchment areas above the dams.[5] The rainfall on 11 January 2011 in the area of Wivenhoe Dam was of biblical proportions.[6] Extreme rainfall was also experienced during this period in the catchments downstream of the dams, especially in the Lockyer Valley which caused a significant increase in the flow of water in Lockyer Creek. Lockyer Creek flows into the Brisbane River just downstream of Wivenhoe Dam.[7] Extreme rain also fell in the catchment area for the Bremer River. The Bremer River flows through Ipswich and into the Brisbane River at a point 16 hours flow time downstream of Wivenhoe Dam and just above Moggill, a suburb of Brisbane.[8] The central business district of Brisbane is a further 10 hours flow time downstream of Moggill.[9]

9 During 11 January 2011, the rate of inflow of water into Wivenhoe Dam increased rapidly, so much so that by 10.00am the rate was over 10,000m^3/s. The level of Wivenhoe Dam rose well above Elevation Level ("EL") 74.0m Australian Height Datum ("AHD"). That level is recognised by the "Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam" (the "Manual")[10] as a point at which a consideration of Wivenhoe Dam's safety predominates.[11] From around 8.00am on 11 January 2011, the flood engineers responsible for flood operations at both dams directed that there be further openings of the radial gates at Wivenhoe Dam in an attempt to address the rising reservoir levels.[12] This continued until 7.00pm that evening, by which time the reservoir level had stabilised at a height of EL 74.97 AHD. Thereafter it began to slowly drop. The peak rate of outflows from the dam was 7464m^3/s.[13]

10 The Manual designated a flow rate of 4000m^3/s in the Brisbane River at Moggill as the threshold point at which homes and businesses downstream of

[5] See Chapter 6; Table 6-1.
[6] See Chapter 7 at [374]; Table 7-3.
[7] Chapter 2; Figure 2-6.
[8] Id.
[9] Id.
[10] QLD.001.001.0146; see Chapter 3.
[11] See Chapter 3 at [61] and section 3.3.11.
[12] Chapter 7 at [378]; Table 7-4.
[13] Id.

the dams would commence to be flooded.[14] The flows in the Brisbane River at Moggill comprise the outflows from Wivenhoe Dam as well as outflows from Lockyer Creek and the Bremer River into the Brisbane River. Unfortunately, to a significant extent the large increase in outflows from Wivenhoe Dam coincided with large outflows from Lockyer Creek and the Bremer River. The peak flow rate experienced at Moggill was at around 1.00pm to 2.00pm on 12 January 2011. It was between 10,420m^3/s and 10,700m^3/s, of which between 4200m^3/s and 5300m^3/s was attributable to releases from Wivenhoe Dam.[15]

11 The flooding of homes and businesses in areas proximate to the Brisbane River, the lower Bremer River and the lower part of Lockyer Creek commenced on 11 January 2011 and continued through at least the following day. The distress, dislocation and heartache that was occasioned by the flooding was taken as a given in the proceedings.

The Parties

12 The plaintiff, Rodriguez and Sons Pty Ltd, was one of the many affected by the flooding. As at January 2011, it conducted a retail sporting goods and clothing store under the name “Sports Power Fairfield” from within the Fairfield Gardens shopping centre in Fairfield. Fairfield is approximately five kilometres south east of the central business district of Brisbane.

13 Vincente Rodriguez was the sole director of the plaintiff. At around midday on 11 January 2011 he was contacted by his wife, Maria, and told that the management of the shopping centre had advised that all the retail outlets had to be closed by 12.00pm due to the risk of flooding.[16] He rushed to the store and assisted his wife to stack expensive items of stock on elevated tables.[17] They then left to secure their home before returning the next morning at 6.00am with other members of the family to remove and store stock.[18] They

[14] The “upper limit of non-damaging floods”: Chapter 3 at [56].
[15] Chapter 7 at [404].
[16] LAY.ROD.001.0001 at [77].
[17] Ibid at [79].
[18] Ibid at [88].

were forced to leave at around 11.30am as flood waters were approaching the entrance to the shopping centre.

14 Mr Rodriguez and his family were not able to return to the store until 16 January 2011. When they did so they discovered the flooding had, in Mr Rodriguez's words, "devastated the shop".[19] The extent of the inundation and the nature of the damage they suffered are addressed later in this judgment.[20] As fate would have it, the Rodriguez family home in Graceville was also devastated by flooding. Whether any of the defendants are legally responsible for the damage occasioned there was not litigated during this phase of the proceedings.

15 In these proceedings, the plaintiff seeks to recover for the loss and damage occasioned by the inundation of its store. This includes the loss of stock, clean-up costs and lost profits for the period in which it could not trade and for a period thereafter.

16 As noted, these are representative proceedings under Part 10 of the *Civil Procedure Act 2005* (NSW). The plaintiff brings the proceedings on its own behalf and on behalf of a group of persons who satisfy the group definition and have not opted out of the proceedings.[21]

17 The group definition has two limbs, both of which must be satisfied. To satisfy the first limb, the group member must have suffered one or both of two subcategories of damage. The first subcategory concerns persons that held an interest in land and either suffered loss or damage from the inundation of that land by flood water from the Brisbane River or Bremer River or their tributaries in the period from 9 January 2011 to 24 January 2011 or had their use or enjoyment of that land interfered with by reason of that inundation such that they suffered loss and damage.[22] The other subcategory is persons who owned personal property in that period which was damaged or destroyed by

[19] Ibid at [93].
[20] Chapter 13 and Chapter 14.
[21] *Civil Procedure Act 2005* (NSW); s 162.
[22] Fifth Further Amended Statement of Claim ("5ASOC"), PLE.010.001.0001 at .0009, [6(a)(i) and (ii)].

the inundation of land on which it was located by flood water from the Brisbane River or Bremer River or their tributaries during the same period.[23] The second limb of the group definition is that either the group member or an insurer who has indemnified them for loss arising out of the subject matter of the proceeding must have entered into a litigation funding agreement with IMF Bentham Limited.[24]

18 There are approximately 6870 persons or entities who are group members. They are named in the schedule to a statement of claim filed in a parallel set of proceedings commenced by one of the group members, Ms Lynette Lynch (the "Lynch proceedings").[25] Those proceedings were commenced to address a potential issue that arose concerning the application of the *Limitation of Actions Act 1974* (Qld) to representative proceedings filed in this Court. The Lynch proceedings were stayed pending the outcome of these proceedings on terms that the parties to those proceedings would be bound by the findings in these proceedings.

19 There are three defendants to these proceedings namely, Queensland Bulk Water Supply Authority trading as Seqwater ("Seqwater"), SunWater Limited ("SunWater") and the State of Queensland (the "State").

20 Seqwater was established by section 6 of the *South East Queensland Water (Restructuring) Act 2007* (Qld). Seqwater was vested by statute with ownership of Wivenhoe and Somerset Dams and the land on which they are located. Seqwater received statutory permissions enabling it to interfere with the flow of water in the Brisbane River for the purpose of operating the dams for flood mitigation and water supply. There was a dispute about whether it was conferred with a statutory function of flood mitigation.[26] Seqwater was the employer of two of the four flood engineers who were either on duty or

[23] Ibid at [6(b)].
[24] Ibid at [6(d)].
[25] Proceedings number: 2016/373183.
[26] Chapter 2; section 2.1.

conducting flood operations during the January 2011 Flood Event, namely Mr Terry Malone and Mr John Tibaldi.[27]

21 At all relevant times SunWater was a government owned corporation within the meaning of s 5 of the *Government Owned Corporations Act 1993* (Qld). It is a public company registered under the *Corporations Act 2001* (Cth). As at January 2011, SunWater was contracted to provide flood management services to Seqwater. SunWater was the employer of the one of the four flood engineers, Mr Robert Ayre. Mr Ayre was the Senior Flood Operations Engineer.

22 The State is sued as the employer of the fourth flood engineer, Mr John Ruffini.

23 Each of Messrs Malone, Tibaldi and Ayre gave evidence in the proceedings. Mr Ruffini did not.

The Plaintiff's Case: Overview

24 The following is just a brief précis of the principal contentions made by the plaintiff and the defendants.

25 The plaintiff sues each of the defendants in negligence, nuisance and trespass.[28] The plaintiff pleaded that each of Seqwater, SunWater and the flood engineers owed a class of persons, including itself and the other group members, a duty to take reasonable care in the conduct of flood operations at both dams to avoid the type of harm referred to in the group definition.[29] In the case of Seqwater and SunWater, the plaintiff contended that the duty of care they owed was a non-delegable duty, that is a duty to ensure reasonable care was taken in the conduct of flood operations, specifically by the flood engineers. Otherwise, the plaintiff contended that each of Seqwater,

[27] A dramatis personae is Appendix B to this judgment.
[28] It also seeks recovery from the State under former s 374(3) of the *Water Supply (Safety and Reliability) Act 2008* (Qld).
[29] 5ASOC at [144(a)] and [148(a)]; Chapter 11 at [3].

SunWater and the State are vicariously liable for any breaches of any duty of care owed by the flood engineers to the plaintiff and group members.[30]

26 At the heart of the plaintiff's case is the contention that during the period from 2 January 2011 to 10 January 2011 the flood engineers were obliged but failed to evacuate water from the dams in advance of rainfall predicted by rainfall forecasts. Critical to this allegation is the contention that the content of any duty of care owed by the flood engineers in relation to flood operations was governed by the Manual. The plaintiff contended that, irrespective of the approach at other dams, the Manual unambiguously required the use of forecasts in conducting flood operations, especially the selection of flood strategies by reference to predictions about reservoir levels based on rainfall forecasts and the making of releases from the dams, determined at least in part by reference to forecast rainfall. The plaintiff also contended that the Manual embodied an overall risk management approach to flood operations. This was said to require that releases from the Dams be made with a view to minimising the risk of urban damage, as well as dam failure, at the expense of the disruption to local communities caused by the inundation of bridges that span the upper part of the Brisbane River below Wivenhoe Dam as well as the risk to the water supply if the full supply level of water was not retained in the dams following the completion of flood operations.

27 The plaintiff contended that the flood engineers comprehensively failed to apply the Manual throughout the flood event. The plaintiff contended that they were obliged but failed to continue flood operations from 2 January 2011. The plaintiff contended that the flood engineers waited too long before resuming releases from Wivenhoe Dam on the afternoon of 7 January 2011 and thereafter made releases at too low a rate until well into 10 January 2011 when storage space in Wivenhoe Dam below EL 74.0m AHD was almost exhausted. The plaintiff contended that the loss of storage space in the dams from the flood engineers' conduct of flood operations culminated in releases having to be made at Wivenhoe Dam from above EL 74.0m AHD on 11 and 12 January 2011 to address dam safety concerns. The plaintiff contended

[30] 5ASOC at [365], [370] and [374].

that, contrary to the Manual, to the extent that the flood engineers applied any flood strategy in the Manual they did so by selecting a strategy based on the actual level of water in Wivenhoe Dam and not the level predicted by the use of rainfall forecasts.

28 Although the plaintiff made many complaints about the flood engineers' approach to releases, three related complaints predominated. The first was that, in determining the amount of water to release, the flood engineers only based their releases on an estimate of inflows determined by rain that had already fallen, so called "rain on the ground", and thus effectively ignored rain that was forecast. The second was that the flood engineers wrongly prioritised avoiding the inundation of the bridges just referred to at the expense of avoiding or minimising the risk of urban inundation. The third was that, while not considering any estimate of inflows based on forecasts in deciding to make releases, the flood engineers simultaneously modelled making releases for many days into the future which necessarily assumed that rain would not fall in significant amounts downstream of the dams and thus permit the releases to be made.

29 Although there was a great deal of expert evidence,[31] two expert witnesses were of particular significance to the plaintiff's case.

30 The first such expert was Dr Ronald Christensen, a civil engineer from Utah with expertise in hydrology. In his reports and oral evidence, Dr Christensen construed the Manual, critiqued the conduct of the flood engineers and set out ten different scenarios representing simulated alternative flood operations at Wivenhoe and Somerset Dams. The position of a flood engineer is in one sense sui generis in that it can be performed by persons with different forms of qualifications, specifically in engineering, hydrology and meteorology.[32] Whether Dr Christensen was suitably qualified to undertake such a role and comment on the conduct of others performing such a role was one of the issues in the proceedings. The plaintiff relied on Dr Christensen's evidence

[31] Appendix C to this judgment sets out the professional qualifications of the expert witnesses and the witnesses with expertise.
[32] See Chapter 3 at [11].

and simulations both as material informing its analysis of the allegations of breach of duty levelled at the flood engineers and as the basis for its case on causation. The plaintiff put forward Dr Christensen's simulations as embodying the counterfactual flood operations that it says a reasonably competent flood engineer would have undertaken during the January 2011 Flood Event but for the flood engineers' breaches of duty.[33]

31 The differences between the ten simulations put forward by Dr Christensen reflected different starting dates for the counterfactual flood operations and different governing assumptions, which in turn reflected different aspects of reasonably competent flood operations that the plaintiff contended should have been adopted. Two governing assumptions are of particular relevance. The first concerns what period of forecast, and thus what forecast product, a reasonably competent flood engineer was required to utilise in flood operations? The second is whether a reasonably competent flood engineer would have made releases below the full supply levels for each of the dams during flood operations and, if so, how far below?

32 As an indication of the extent of the dispute over Dr Christensen's evidence, he was cross examined for 22 days during the hearing. Over 370 pages of this judgment are devoted to a consideration of Dr Christensen's evidence and simulations as well as the defendants' attacks on both.

33 The second expert that was of particular significance to the plaintiff's case was Dr Mustafa Altinakar. Dr Altinakar is a highly qualified mathematician. He is the Director and Research Professor at the National Centre for Computational Hydroscience and Engineering at the University of Mississippi. Using his "DSS-WISE" software, Dr Altinakar undertook two-dimensional numerical modelling, simulation and mapping of the January 2011 Flood Event and its effects across the Brisbane River catchment. He produced a mathematical model which the plaintiff contended could be manipulated by

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[33] Save for the possibility referred to in *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 9)* [2017] NSWSC 1116 at [29] to [30].

altering the discharge outflows from Wivenhoe Dam to accord with Dr Christensen's simulations. The plaintiff contended that Dr Altinakar's modelling was sufficiently robust to enable findings to be made as to the depth of flooding under Dr Christensen's simulations for locations of 10m x 10m size within the area of the model and, to the extent necessary, for the actual flooding that ensued during the January 2011 Flood Event.

34 Thus the plaintiff contended that Seqwater, SunWater and the flood engineers breached the duty of care they owed to it, that the proper discharge of that duty required the adoption of at least one or more of Dr Christensen's simulations and that, using Dr Altinakar's modelling and supplemented by other evidence including that provided by Mr Rodriguez, if outflows from Wivenhoe Dam had substantially accorded with the relevant simulation, then the plaintiff's store and the shopping centre it formed part of would not have been inundated. The plaintiff then seeks to extend this reasoning to other group members.

The Defendants' Case: Overview

35 The defendants took issue with each and every aspect of the plaintiff's case. The defendants contended that the conduct of the flood engineers throughout the January 2011 Flood Event was consistent with both the Manual and accepted professional practice at other dams and amongst other flood engineers. They contended that, on its proper construction, the Manual did not require the use of forecasts in either the selection of flood strategy or the making of releases or, at the very least, the flood engineers reasonably believed that to be the case. They contended that rainfall forecasts were far too uncertain to be used for those purposes in flood operations. They contended that at least some of the flood strategies under the Manual were dictated by the actual level of the dams and that otherwise the only proper course, given the uncertainties in predicting and modelling forecast rainfall, was to model rain on the ground for the purpose of flood operations, including in making releases. They contended that the flood engineers used rainfall forecasts to ascertain a so-called "situational awareness" of the flood event

and in deciding to reduce releases on account of downstream flows. They contended that form of use of rainfall forecasts during the January 2011 Flood Event was more than sufficient to comply with the Manual.

36 The defendants also contended that the flood engineers' approach was supported by a number of experts that were called to give evidence as to the proper conduct of flood operations including expert flood engineers, as well as experts in meteorology and hydrology. To the extent that there was any ambiguity in the Manual, Seqwater and SunWater contended that the revision of the previous version of the Manual reinforced the reasonableness of the interpretation and approach adopted by the flood engineers. Further, the defendants contended that both the Manual and the relevant legislative regime precluded the flood engineers from making releases from below FSL at either of Wivenhoe Dam or Somerset Dam.[34]

37 The defendants were highly critical of Dr Christensen's evidence. They variously contended he was unqualified, dishonest and that he consciously or unconsciously used hindsight to tailor his opinions and simulations. They contended that his methodology was untested and unendorsed by any other expert, that it was affected by errors, inconsistent with the Manual and that its various assumptions were either falsified or not made out. Both Seqwater and SunWater contended that the plaintiff's pleaded case on breach of duty was tied to establishing that the flood engineers failed to act in accordance with one of those simulations and contended that the plaintiff's submissions did not reflect that.

38 The defendants also contended that Dr Altinakar's modelling was wholly unreliable for use in the manner contended for by the plaintiff. The various criticisms included that it was poorly calibrated, lacked the necessary verification to historical flooding and used incorrect or unreliable inflow discharges at two of its boundaries namely Lockyer Creek and the upper Bremer River.

[34] Save that both SunWater and the State accepted that it could be reduced FSL but only to allow for refill by baseflow: see Chapter 5 at [91].

39 Seqwater and SunWater denied that they owed any duty of care, much less a non-delegable duty. All of the defendants denied that the flood engineers owed any duty of care. Even if there was a duty owed, it was contended that each of the allegations of breach of duty had to be assessed by reference to s 36(2) of the *Civil Liability Act 2003* (Qld) ("CLA (Qld)"). That provision concerns proceedings "based on an alleged wrongful exercise of or failure to exercise a function of a public or other authority" and provides that any act or omission of such an authority does not constitute a wrongful exercise or failure "unless the act or omission was … so unreasonable that no public or other authority having the functions of the authority in question could properly consider the act or omission to be a reasonable exercise of its functions."

40 It was also contended that, to the extent that the flood engineers' conduct was being considered, then each of them "acted in a way that ... was widely accepted by peer professional opinion by a significant number of respected practitioners in the field as competent professional practice", such that by operation of s 22(1) of the *CLA* (Qld) the flood engineers could not be found to have breached any duty of care they owed.

41 Both Seqwater and the State denied that they were vicariously liable for any breaches of duty by the flood engineers they employed. All the defendants denied that there was any unreasonable interference with the use and enjoyment of the plaintiff's or any other group member's interest in land sufficient to amount to a nuisance.

The Hearing and Issues for Determination

42 The substantive hearing of this phase of the proceedings commenced with opening addresses on 4 December 2017. They continued until 12 December 2017. A view of the shopping centre in Fairfield and other relevantly affected properties, both dams, the downstream bridges and other relevant locations in the Brisbane River catchment was conducted over three days from 12 to 14 February 2018. The hearing resumed with the calling of the first witness, Mr Rodriguez, on 19 February 2018. It continued until September 2018. During

October and November 2018 over 1600 pages of written submissions were filed. Further evidence was filed and argument over the reception of that evidence took place on 27 November 2018. Oral submissions commenced on 28 November 2018 and concluded on 12 December 2018. Dr Altinakar gave further oral evidence from 18 to 20 March 2019. Further written submissions were filed after that. The last written submission was received on 10 May 2019.[35]

43 The transcript of the proceedings exceeds 10,000 pages. Over 2100 pages of written submissions were filed. The text of the witness statements and experts' reports occupies over 50 volumes. The electronic database contains over 26,000 documents including over 700 spreadsheets. It is appropriate to note that the task of considering this material and preparing this judgment would not have been possible without the tireless professionalism of my associate[36] and tipstaves.[37]

44 This phase of the hearing was directed to resolving four sets of issues that were (finally) identified by orders made by the Court on 14 September 2018. The first set is "all issues of fact and law that arise from the claims brought by the plaintiff in its personal capacity". The second set is "all issues of fact and law (except for assessment of damages)" that arise from the claims of a selected sample of the group members, namely Mr John and Mrs Betty Keller, Ms Lynch, Ms Sharon Visser and Ms Lynette Harrison (the "sample group members"). The third set of issues is the respective rights and liabilities of the defendants in the event that one or more of them is found to be liable to the plaintiff or one or more of the sample group members. The fourth set of issues are identified by a series of questions that mostly arise in the plaintiff's case but which affect all or at least most of the group members as well (ie, common questions).

[35] SBM.030.012.0001.
[36] Margaret Gaertner.
[37] Daniel Gorry and Erin Mangan.

Judgment Overview

45 This part of this Chapter summarises the effect of the findings in the balance of the judgment on the principal matters in dispute between the parties. It should not be taken as a substitute for or variation on the discussion and findings in subsequent Chapters.

The Manual

46 The starting point is the dispute over the meaning and application of the Manual. The relevant version of the Manual was approved by the Director General of the Department of Environment and Resource Management ("DERM") under s 371(2) of the *Water Supply (Safety and Reliability) Act 2008* (Qld) in December 2009 and gazetted in January 2010.[38] The Manual did not have the force of law, save that certain parts of it relating to the gate operating procedures at Wivenhoe Dam and Somerset Dam had effect as conditions of a development consent.[39]

47 Nevertheless, the Manual was of legal significance in three respects. First, the *Water Supply (Safety and Reliability) Act 2008* (Qld) exempted a dam owner who observed the operational procedures in the Manual from civil liability for any act or omission that was honestly made and without negligence.[40] If those conditions were met, any liability that the dam owner would otherwise incur is imposed on the State.[41] Second, in purporting to comply with the Manual, Seqwater conferred control over the dams on the flood engineers to commence and conduct flood operations. Third, the requirements of the Manual heavily informed the content of any duty of care owed by the flood engineers. One matter all the relevant experts agreed upon was the necessity for flood engineers to follow the Manual. A reasonably competent flood

[38] Chapter 4 at [157].
[39] Chapter 2 at [28].
[40] Section 374(2).
[41] Section 374(3).

engineer could not refuse to apply the approach stated in a flood mitigation manual because they disagreed with it.[42]

48 A vast number of issues were debated about the meaning and requirements of the Manual. At this point it suffices to state that, in large part, I accept the plaintiff's submissions as to its interpretation. Two particular matters should be noted.

49 First, any reasonable reader of the Manual, including any reasonably competent flood engineer, would have concluded that the Manual adopted an overall risk management approach to flood operations that acknowledged the uncertainties in forecasting rainfall and using forecasts to determine dam inflows and downstream flow but sought to address that uncertainty by requiring the flood engineers to address the flood objectives in their specified order. Thus, the Manual required the flood engineers conduct flood operations with the objective of ensuring dam safety and optimising protection against urban flooding ahead of the objectives of avoiding the inundation of rural bridges and retaining the dams at FSL at the conclusion of a flood event.

50 Second, any reasonable reader of the Manual, including any reasonably competent flood engineer, would have concluded that the Manual made rainfall forecasts a central component of the flood engineer's decision making processes. There are twelve references to rainfall forecasts in the Manual. Contrary to a suggestion of one witness, their inclusion in the Manual was certainly not a mistake.[43] The Manual unambiguously and stubbornly required that "best forecast rainfall" be used to make predictions for the purpose of determining the anticipated storage levels in the dams in order to select the applicable flood strategy.[44] The Manual directed that, within those strategies, consideration be given to the flood objectives in their order of priority. In turn, that required that rainfall forecasts be used in the determination of release rates, while still leaving some scope for professional judgment as to what

[42] Chapter 3 at [2].
[43] Chapter 4 at [160].
[44] Chapter 3 at [39].

forecast product to use and what those rates should be,[45] a matter I will return to.

51 As noted, one aspect of the defendants' case was that, even if it was considered that their suggested construction of the Manual was incorrect, the flood engineers nevertheless acted on a reasonable interpretation of the Manual and that it was open to a reasonably competent flood engineer to take the same approach. However, for the reasons explained in the balance of the judgment, even though Messrs Malone, Tibaldi and Ayre sought to explain their understanding of the disputed aspects of the Manual, it was to no avail for three reasons.[46] First, I was not persuaded that that was in fact their understanding during the January 2011 Flood Event. Second, I was not persuaded they gave effect to any such understanding during the January 2011 Flood Event. Third, in any event, the relevant understanding involved an unreasonable construction of the Manual. There was not a single instance where I was persuaded that any of the flood engineers took any impugned action during the January 2011 Flood Event based on a mistaken but reasonably held belief about the Manual's requirements.

52 In relation to their evidence generally, Mr Malone ultimately accepted in cross-examination that he had no recollection of how he interpreted and applied the Manual during the January 2011 Flood Event.[47] Otherwise, I found the evidence of Mr Tibaldi and Mr Ayre to be unreliable. I did not accept their evidence on any contested matter unless it was corroborated by independent evidence, which in most respects it was not.[48]

53 To that end, no support for any aspect of the flood engineers' evidence or approach was to be gained from considering their involvement in the process of revision of the Manual during 2009.[49] To the contrary, their deep involvement in its redrafting would only have reinforced to them the very

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[45] Chapter 3; section 3.3.8.
[46] Chapter 3 at [128].
[47] T 5353.36 (Malone); Chapter 7 at [454].
[48] See Chapter 7; section 7.16.
[49] Chapter 4; section 4.5.

significant changes that took place between the previous version of the Manual and the version the subject of these proceedings. The previous version of the Manual clearly provided that flood strategies and the range of release rates were determined by observed reservoir levels.[50] The contrast between that version and the Manual as in force during January 2011, with its emphasis on flood objectives, predicted reservoir levels and repeated references to the use of rainfall forecasts, was dramatic.

54 Two further matters should be noted about the findings concerning the Manual. First, as noted, there was a large debate in the evidence about the utility of using forecasts in flood operations bearing in mind the limitations on their accuracy, the difficulty in modelling dam inflows and downstream effects using predicted rainfall and the potential consequences of making decisions to release or not release water based on forecasts that prove to be inaccurate or just plain wrong. To a large extent, much of this debate was resolved by the Manual. It mandated that forecasts be used while acknowledging the limitations on their accuracy.

55 Second, the findings made about the Manual tore a large hole in the case of the three defendants and their attempts to defend the flood engineers' conduct. As noted, one line of defence was that the selection of strategies was dictated by actual and not predicted storage levels and, to the extent that predictions were required, they had to be or could only be formed by reference to rain on the ground modelling and not rainfall forecasts.[51] For some of the defendants, this line of defence wavered. In any event, many aspects of the conduct of flood operations during the January 2011 Flood Event bore little resemblance to any of the suggested interpretations of the Manual.[52] Further, many of the experts called by the defendants accepted the fundamental principle that a reasonably competent flood engineer was obliged to conduct flood operations in accordance with the relevant water control manual.[53] However, when these experts were taken to the words of the

[50] Chapter 4; section 4.2.
[51] Chapter 3 at [197].
[52] See Chapter 7 at [457] to [458] and [465] to [470].
[53] See Chapter 3 at [2].

Manual, they proved unable to explain how their postulated approach was consistent with its clear words. The result was that, to varying degrees, I treated their evidence with greater scepticism than I otherwise would have.

Full Supply Level

56 It was common ground that both dams were built and operated to provide for water supply and flood mitigation. As noted, one of the issues debated between the parties was whether the flood engineers were legally prohibited from making releases for flood mitigation from below the FSL for each dam and, if not, in what circumstances could such releases be made?[54] I find that they were not legally prohibited from doing so. In particular, in 2010 Seqwater specifically sought and obtained an approval under clause 13 of the Moreton Resource Operations Plan which specifically permitted such releases for the purposes of flood mitigation.[55] Seqwater's attempts to attack the validity of the approval it sought and obtained fails. I also find that the Manual did not preclude such releases during flood operations after the reservoir level at Wivenhoe Dam first exceeded EL 67.25m AHD.[56]

57 The defendants adduced evidence which was directed to establishing the existence of a practice at other dams, principally in the United States of America, of not making releases for flood mitigation from that part of a reservoir behind a dam that is designated as the water supply pool. However, that evidence rose no higher than establishing that the regulatory regime in force at those dams prevented such releases. Thus, the only practice that was established was of not releasing water from a supply pool that was inviolable.[57] In light of the findings about the regulatory regime applicable to Wivenhoe and Somerset Dams, the establishment of such a practice was irrelevant. Similar findings to those just noted were made in relation to the

[54] See Chapter 5 and Chapter 15 at [2].
[55] Chapter 5 at [29] to [73].
[56] Chapter 5; section 5.2.
[57] Chapter 5; section 5.3 and at [196].

flood engineers' evidence about their subjective beliefs in relation to making releases below FSL.[58]

58 Otherwise, the utility of making releases from below FSL in flood operations, especially when heavy rain was forecast, was acknowledged by a number of witnesses.[59] However, in making them, the reasonably competent flood engineer had to pay regard to the Manual's fourth objective, namely that there should be no reason why storage should not be retained at FSL at the conclusion of a flood event.

Flood Operations During the January 2011 Flood Event

59 Each day of the January 2011 Flood Event and each shift of flood operations during the period from 6 to 12 January 2011 is addressed in detail in Chapters 6 and 7. At this point, eight matters should be noted.

60 First, while the rain that fell in the period from 9 to 11 January 2011 generally exceeded the amount of rain that was forecast, the forecasts and internal assessments that were produced nevertheless pointed to a strong likelihood of very large falls occurring during that period in what was an already saturated catchment. At all relevant times, there was a reasonable possibility of rainfall in, around and below the upstream catchments in amounts higher, sometimes much higher, than the forecasted amounts and which approximated to the amount of rain that actually fell.[60]

61 Second, as noted, from 2 January 2011 flood operations ceased. The duty flood operations engineer, Mr Malone, did not declare another flood event under the Manual until 6 January 2011. Throughout that period, both dams were above their FSL, substantial rain was predicted and significant rain fell

[58] Chapter 5; section 5.4.
[59] Chapter 5 at [198].
[60] Chapter 6; section 6.2.

from 5 January 2011. The failure to continue the flood event and the failure to declare a new flood event was completely inconsistent with the Manual.[61]

62 Third, although a flood event was declared on the morning of 6 January 2011 and solid rain continued throughout that day with much more rain forecast, releases did not commence until the afternoon of 7 January 2011 after natural downstream flows inundated Burtons Bridge. The failure to commence releases earlier was an instance of the flood engineers subverting the priorities of the Manual by seeking to avoid the inconvenience occasioned by bridge closures at the expense of guarding against the risk of urban inundation.[62]

63 Fourth, even after releases commenced on the afternoon of 7 January 2011 and despite the forecasts worsening, until midnight on 10 January 2011 the flood engineers maintained their approach of prioritising keeping the remaining bridges open. By that time, the amount of rain that had fallen, the prevailing rainfall forecasts and the reservoir levels pointed to the virtual certainty that flooding of urban areas would occur. Although there was some increase in releases throughout the period from 7 to 9 January 2011 inclusive, they were always held at levels below that necessary to inundate the remaining bridges. Throughout the entire January 2011 Flood Event, not a single bridge was inundated by a decision of the flood engineers to increase releases.[63]

64 Fifth, to the extent that, during the period from 6 to 9 January 2011 inclusive, the flood engineers were operating in accordance with any flood strategy specified for Wivenhoe Dam in the Manual it was Strategy W1. That strategy is directed to minimising disruption to rural life and specifically keeping low lying bridges open.[64] This approach was inconsistent with any interpretation of the Manual, including that put forward at various times by the flood engineers and the defendants during the hearing, which was that strategies were

[61] Chapter 6; section 6.7.
[62] Chapter 6 at [211] and [255] to [267].
[63] Chapter 6; sections 6.12; 6.13; Chapter 7; sections 7.1 to 7.3; Chapter 7 at [472].
[64] Chapter 3 at [46] to [52].

determined by observed reservoir levels. That is so because the observed water level of Wivenhoe Dam exceeded the relevant maximum level for Strategy W1, namely EL 68.5m AHD, at 8.00 am on 8 January 2011.[65] However flood operations continued after that time in a manner that was only consistent with that strategy. If the flood strategies had been selected by reference to a predicted reservoir level that included rainfall forecasts, as the Manual required, then, irrespective of the period of the forecast product that might have been used, at the very least that would have required the selection of Strategy W3 at a much earlier time.[66] Strategy W3 prioritised the protection of urban areas from inundation.[67]

65 Sixth, on 10 January 2011 an increase in releases from Wivenhoe Dam was delayed because of a concern that combined flows at Moggill above $3500m^3/s$ might cause over the floor flooding whereas the Manual dictated that the relevant level was $4000m^3/s$.[68] Further, on 9 and 10 January 2011, there was an increase in releases from Somerset Dam that was disproportionate to the relatively low releases from Wivenhoe Dam. This contributed to the rise of Wivenhoe Dam levels.[69]

66 Seventh, although the flood engineers asserted that rainfall forecasts were used to acquire a so-called "situational awareness" and to curtail releases, in substance they ignored them. The flood engineers never determined the applicable flood strategy in the Manual based on a predicted reservoir level (much less a predicted reservoir level that utilised a rainfall forecast), never determined to release water because rainfall was forecast to fall in catchments above the dams, never determined a volume of water to be evacuated based on a rainfall forecast, never determined to increase releases because of a concern that forecast rain might fall downstream at a later time and impede releases at that time and did not undertake any modelling that used forecast rainfall as the basis for flood operations.

[65] Chapter 7 at [14].
[66] Chapter 7 at [94] to [105], [210], [254] to [260].
[67] Chapter 3 at [54].
[68] Chapter 7 at [328] to [336].
[69] Chapter 7 at [262] to [263], [326] to [327], [383] to [385].

67 In substance, the flood engineers' actions were, at best, only determined by rain on the ground assessments. In particular, the amount of water they determined to evacuate was always only based on a rain on the ground assessment which was directed to a planning horizon of no more than 12 to 15 hours ahead. That period was far too short having regard to both dams' capacity and the catchment flow times above and below the dams.[70] Although they may have remained cognisant of the rainfall forecasts, the flood engineers were always effectively assuming that no forecast rain would fall above the dams while at the same time assuming that forecast rain would or might fall below the dams but only during their short planning horizon of 12 to 15 hours with no rain to fall thereafter. This approach underestimated the amount of water that needed to be evacuated and overestimated the capacity of the dams to release water beyond that 12 to 15-hour period. This approach was fundamentally contrary to the Manual. It ignored the Manual's method of strategy selection and meant that "[w]ithin any strategy … decisions on dam releases" did not involve a consideration of the flood objectives in their order of priority.[71]

68 Eighth, there is no doubt that the conduct of flood operations during the January 2011 Flood Event was highly stressful and exhausting. In those circumstances, there was always the potential for honest but genuine mistakes to have been made. It follows that considerable caution needs to be, and has been, exercised against making post-event criticisms with the luxury of time and hindsight. However, the identified failings of the flood engineers do not concern decisions they made in the heat of the moment. Instead, they derive from a failure of approach, specifically a failure to follow the very Manual that they had drafted or participated in drafting almost 18 months previously.

[70] Chapter 7 at [469] to [470].
[71] Manual at 1 and 23.

Dr Christensen's Evidence

69 In light of these findings I come to Dr Christensen. It was ultimately accepted on the part of the plaintiff that it was not in itself sufficient to merely show a flood engineer could have, or might have, undertaken flood operations in accordance with one of Dr Christensen's simulations. Instead, it had to be shown that they would or must have done so.[72] I have approached his simulations in that manner and in accordance with the analysis of the appropriate standard of care relevant to a reasonably competent flood engineer.[73] However, the analysis of his evidence was undertaken in a context where the defendants did not seek to put forward some alternative methodology that was said to involve the use of rainfall forecasts and conform to the plaintiff's interpretation of the Manual. The defendants drew a battle line at the point of bitterly opposing the use of rainfall forecasts in flood operations in any manner other than the limited use made of them made by the flood engineers. They lost that battle.

70 In Chapter 8, I address and reject the attacks on Dr Christensen's honesty and impartiality. I accept that that he is sufficiently qualified to express the opinions he did, although his lack of experience in real-time flood operations and lack of detailed knowledge of Australian forecast products have affected my preparedness to accept particular aspects of his methodology.[74] I do not accept that he consciously constructed his methodology and simulations with the benefit of hindsight. Although I commenced my consideration of his evidence with a strong scepticism that his hindsight knowledge of how the January 2011 Flood Event transpired may have subconsciously affected his evidence, that scepticism slowly dissipated as Dr Christensen responded to a skilled forensic grilling over weeks in the witness box. I am satisfied that the approach he outlined in most respects flowed from his interpretation of the Manual's requirements, an interpretation I largely accept. In contrast to many of the defendants' witnesses, Dr Christensen addressed what the Manual actually states. He did not seek to make the express words of the Manual

[72] Chapter 9 at [2].
[73] Chapter 10 at [1].
[74] Chapter 8 at [19].

conform to his preconceptions of how dam operations should have been conducted.

71 Dr Christensen outlined a proposed methodology for flood operations which broadly involved conserving flood storage when catchment conditions and forecasts indicated that there was a risk that the storage volume may be insufficient to contain predicted inflows and then using the storage to reduce the magnitude (or peak) of the release of water from the dams, thus ensuring that the timing of the peak release did not coincide with high downstream flows.[75]

72 In essence, Dr Christensen's approach involved four steps. His first step was to select a strategy in the Manual based on modelling inflow volumes from the eight-day weather forecast for above the dams and predicting the likely storage level on the assumption that no releases are made. His second step was to make an assessment of whether reservoir storage should be created (ie, make releases greater than inflows) or filled (ie, allow inflows to exceed releases). If it was decided to increase storage, his third step was to select a release rate.[76] In some of his simulations, this was undertaken by selecting a "target level" to lower the reservoirs to. Using the four-day forecast, Dr Christensen predicted an inflow volume and then determined the period over which that amount would be released. The determination of that period and hence the release rate had regard to a number of factors including downstream conditions, the effect of shorter and longer term forecasts, reservoir levels and the extent to which releases might take the dams below their respective FSLs. In relation to the latter factor, in his primary simulations[77] Dr Christensen used the four-day inflow estimate as the outer limit to which the dams could be taken below FSL. The fourth step in Dr Christensen's proposed methodology was to regularly reconsider his

[75] Chapter 8 at [51].
[76] Chapter 8 at [52].
[77] Simulations A, E and I.

approach, especially in light of changing conditions including the publication of updated rainfall forecasts.[78]

73 As noted, in the end result Dr Christensen put forward ten simulated counterfactual flood operations for the January 2011 Flood Event. The simulations had different start dates and governing assumptions. Some of those assumptions were at variance from Dr Christensen's primary methodology as just outlined. Consistent with what I have stated already, the defendants' attacks on this methodology were ferocious and detailed. They are addressed in Chapter 9 and Chapter 10. What follows here is a brief précis of the findings concerning his simulations and those criticisms.

74 While I accept that Dr Christensen's overall methodology was consistent with the Manual, in the end result I am not persuaded that four particular aspects[79] of his approach represent aspects of flood operations that a reasonably competent flood operations engineer would have adopted.

75 First, I am not persuaded that a reasonably competent flood engineer was required to use an eight-day forecast for the purpose of predicting reservoir levels under the Manual to select strategy. The Manual refers to the use of "best forecast rainfall and stream flow information" for the purpose of determining the maximum storage levels in the Dams and determining peak flow rates downstream. The evidence suggested that the most accurate forecast was the one-day Quantitative Precipitation Forecast ("QPF") issued by the Bureau of Meteorology (the "BoM"). While that was the best forecast product available for assessing downstream flow rates it was not the best for predicting upstream dam inflows because the size and configuration of the upstream catchments means that 24 hours represents too short a planning period for determining strategy and making release decisions.

[78] Chapter 8 at [50] to [61].

[79] In addition to these four matters I was also not satisfied that a reasonably competent flood engineer would only end a flood event if the high end of the eight day PME forecast indicated that there was no reasonable possibility of exceeding FSL: Chapter 10 at [193].

76 That said the evidence concerning the reliability of the eight-day forecast was such that I consider that it would be open to a reasonably competent flood engineer to reject its use in determining strategies and releases under the Manual.[80] Nevertheless the evidence concerning the reliability of the four-day forecast[81] combined with the necessity to make assessments for periods longer than 24 hours meant that it represented the forecast product that a reasonably competent flood engineer was obliged to use for this purpose[82] provided that the approach to modelling and releases addressed its uncertainties, which Dr Christensen's does. Beyond this, there was debate about the manner of identifying a depth and location of rainfall from the four-day forecast and then the approach to modelling a predicted inflow volume from that forecast.[83] In the end result, I am satisfied that any legitimate debate about those matters is not material to my acceptance of three of Dr Christensen's simulations.[84]

77 Second, so far as making releases below FSL are concerned, I am not persuaded that a reasonably competent flood engineer would or must have adopted an approach of being prepared to make releases below FSL to the depth where they could be refilled by an estimate of inflows based on the four-day forecast.[85] However, I am satisfied that, at least in the circumstances prevailing in January 2011, a reasonably competent flood engineer would have conducted flood operations on the basis of releasing below FSL to an amount that was no more than the volume represented by the one-day forecast (ie, the QPF) if it was otherwise necessary to meet the Manual's objectives. In January 2011, the four and eight-day forecasts were pointing to much larger rainfall than the QPF and that was at a time that was only part way through a rainfall season influenced by a La Niña event. A flood engineer who released to below FSL by an amount that was no more than the predicted inflow from the QPF forecast would have had a very high level of

[80] Chapter 9 at [61].
[81] Ie, the four-day PME.
[82] Chapter 9 at [128].
[83] Which is addressed in sections 9.3 to 9.6.
[84] Namely, Simulation C, F and H.
[85] Chapter 10 at [222].

satisfaction to the point of almost certainty that, at the conclusion of the flood event or shortly afterwards, each dam would be at its respective FSL.[86]

78 Third, the defendants criticised many aspects of the approach in Dr Christensen's simulations on 11 January 2011 when reservoir levels would have approached and, in some simulations, exceeded EL 74.0m AHD. I reject the defendants' criticisms of his approach save that, in respect of those simulations in which the simulated reservoir level would have exceeded EL 74.0m AHD, I accept that a reasonably competent flood engineer could have adopted[87] certain alternative gate openings suggested by an expert called on behalf of SunWater, Mr Andrew Ickert.[88]

79 Fourth, two of Dr Christensen's simulations[89] assumed that the crest gates at Somerset Dam could be opened and closed during flood operations. Given the uncertainty associated with the failure level of Somerset Dam if the crest gates are closed, I do not accept that a reasonably competent flood engineer would have adopted that assumption.[90]

80 Otherwise, I note that a considerable amount of evidence was adduced concerning the practices at other dams in Australia and overseas.[91] This was undertaken with the general objective of establishing that Dr Christensen's approach, especially his use of forecasts, was a departure from a supposed usual or proper practice of only conducting flood operations based on rain on the ground modelling and was thus unreasonable. It was also adduced with the specific objective of supporting the invocation of s 22 of the *CLA* (Qld). It failed at both levels. No such practice was established in relation to Australian dams.[92] More significantly, what the evidence revealed is that whether or not rainfall forecasts are to be used in flood operations is a decision that is usually recorded in the relevant water control manual and not a decision made by the

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[86] Chapter 10 at [178].
[87] In the sense of being the most favourable to the defendants.
[88] Chapter 9; section 9.7 at [329].
[89] Simulations I and J.
[90] Chapter 9 at [346].
[91] Chapter 9; section 9.1.
[92] Chapter 9 at [5].

flood engineers conducting flood operations. Whether they are so used and recorded is usually a product of an analysis of conditions specific to the particular dam, including its location, purpose, priorities, timing of upstream flows, timing of downstream flows, catchment characteristics, dam capacity, forecast capacity and the stability of the seasonal weather.[93] In this case, the position of the Manual on the topic of rainfall forecasts was very clear.

81 The findings that were made about the operation of the crest gates at Somerset Dam invalidated two of Dr Christensen's simulations, namely Simulation I and Simulation J. The findings made about the use of the eight-day forecast, the use of the four-day forecast as a limit on releases below FSL, a residual concern about the use of Dr Christensen's "target" method, as well as concerns over the sensitivities of the calculation of inflow volumes based on four-day forecasts, were such as to leave me unsatisfied that a reasonably competent flood engineer would have conducted flood operations in accordance with Dr Christensen's Simulation A and Simulation E.[94]

82 Simulation C was modelled to commence on 2 January 2011. Unlike Dr Christensen's primary methodology, Simulation C used one-day forecasts as the basis for selecting strategy and making releases. In light of the finding about the use of four-day forecasts that assumption represented a conservative one from the plaintiff's perspective. Simulation C also used the one-day forecast as the outer limit at which it would seek to make releases below FSL. Although there was a debate about whether arithmetical errors in the calculation of inflow volumes based on one-day forecasts affected the validity of the simulation, that dispute falls away in light of the finding about the utilisation of the four-day forecast.

83 Both Simulations F and H were modelled to commence at midnight on 8 January 2011. Simulation F utilised eight-day forecasts to select strategies whereas Simulation H used one-day forecasts in a manner similar to

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93 Chapter 9 at [4].

94 Chapter 10; sections 10.3 and 10.5.

Simulation C. Nevertheless, both simulations were relevantly identical. This is so because from the evening of 7 January 2011 all forecasts of whatever duration required the adoption of at least Strategy W3 and the making of the maximum possible releases up to the point that the downstream threshold for non-damaging flows, namely 4000m^3/s at Moggill, was not exceeded. It follows that the finding about the utilisation of four-day forecasts supports both Simulations F and H.

84 With Simulations C, F and H, many of the defendants' objections to Dr Christensen's primary methodology and modelling either did not arise or, if they did, upon closer analysis they were either not established or not sufficiently material to invalidate them. Any scope for legitimate disagreement as to the interpretation of a particular forecast, the appropriate continuing loss rates, the estimation of inflow volumes, concerns over the capacity of Wivenhoe Dam to refill to FSL and the use of the "target" approach (or some other "quantitative" use of four-day forecasts to set releases) were immaterial to their acceptance.

85 Accordingly, for the reasons set out in the balance of the judgment, I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing as at midnight on 2 January 2011 would have, at a minimum, made flood releases substantially in accordance with Simulation C up to and including 9 January 2011 and made flood releases substantially in accordance with the simulation thereafter.[95] Similarly, I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing as at midnight on 8 January 2011 would have made releases substantially in accordance with Simulation F and Simulation H as varied by Table 18 to Mr Ickert's Response Report dated 30 November 2017.[96] Of these simulations, Simulation C represents the most favourable to the plaintiff and it is the appropriate counterfactual for causation purposes.

[95] Chapter 10 at [188].
[96] EXP.SUN.009.0001 at .0292; Chapter 10 at [56].

Duty of Care and Breach

86 I accept that Seqwater and each of the flood engineers owed a duty of care in the terms alleged by the plaintiff.[97] The exercise of control over releases at Wivenhoe Dam conferred a significant level of control over flows in the Brisbane River downstream of the dams, although the precise level of that control differed on whether the relevant river location was upstream or downstream of the confluence of the Brisbane River and Lockyer Creek and the confluence of the Brisbane River and the Bremer River. This level of control corresponded to a significant but not complete level of control over the risk of flooding from the Brisbane River breaking its banks. Persons who had an interest in real and personal property which by reason of its location downstream and its elevation was susceptible to flooding from the Brisbane River breaking its banks or flooding in the lower part of Lockyer Creek and the Bremer River were correspondingly vulnerable to any negligent exercise of the power of control over dam outflows exercised by Seqwater and the flood engineers. Although the class of persons to whom such a duty was owed was very large that did not render it indeterminate in the sense used in the authorities.[98] The matters raised by the defendants that were said to be inconsistent with the existence of such a duty of care did not negate its existence.[99]

87 I also accept that SunWater owed a duty of care but it was only owed only in respect of the provision of "flood management services" pursuant to its agreement with Seqwater.[100] I do not accept that either Seqwater or SunWater owed a non-delegable duty of care.[101]

88 Otherwise, I accept that each of Seqwater, SunWater and the State are vicariously liable for any breaches of the duty of care owed by the flood engineers that they each employed. The standard of care owed by the flood engineers was that of the reasonably competent flood engineer. In the end

[97] Chapter 11; sections 11.1 to 11.2.
[98] *Perre v Apand* (1999) 198 CLR 180; [1999] HCA 36 at [336]; Chapter 11 at [56].
[99] Chapter 11; section 11.2.
[100] Chapter 11; section 11.4.
[101] Chapter 11; section 11.3.

result, no issue under s 36(2) of the *CLA* (Qld) arises because the liability of each defendant is a true vicarious liability, that is a liability arising from a breach by a flood engineer in respect of a duty of care owed by a flood engineer. None of the flood engineers are "public or other authorities" for the purposes of s 36. Thus, no question arises as to the wrongfulness of the exercise of, or the failure to exercise, a function of a public or other authority before each flood engineer's liability is attributed to the defendants. In any event, in relation to each of the defendants it was not established that this was a proceeding that is based on an alleged wrongful exercise of, or failure to exercise, a function of a public or other authority.[102]

89 Section 22 of the *CLA* (Qld) is potentially engaged in respect of the breaches alleged against the flood engineers but all the attempts to invoke it fail as a matter of fact.[103]

90 The plaintiff's case in nuisance fails as it was not demonstrated that there was an unreasonable interference with its use and enjoyment of its interest in land.[104] The claim in trespass also fails.

91 In relation to negligence, the allegations of breach of duty are addressed in Chapter 12. I do not accept that the plaintiff's case on breach is tied to establishing that on each and every day of the January 2011 Flood Event the relevant flood engineer failed to act in accordance with one or more of Dr Christensen's simulations. Instead, the allegations of breach are addressed in a manner consistent with the findings concerning the Manual and so much of Dr Christensen's simulations and methodology that I have accepted were required of a reasonably competent flood engineer, that also being reflected in the acceptance of Simulations C, F and H.[105] In that regard, I am satisfied that Mr Malone committed breaches of duty during the period he was duty flood operations engineer from 2 to 6 January 2011, that thereafter each of the flood engineers committed breaches of duty while they were on shift during

[102] *CLA* (Qld); s 36(1); Chapter 11 at [191] to [213].
[103] Chapter 11 at [219] to [234].
[104] Chapter 11 at [257].
[105] Section 12.2.

the period from 6 to 10 January 2011 and that Mr Ayre committed a breach of duty when he was not on duty but still supervising flood operations as the Senior Flood Operations Engineer.

Causation

92 Beyond the acceptance of simulation C as the relevant counterfactual flood operation, two significant issues were litigated in relation to causation. The first was the utility of Dr Altinakar's modelling for the purpose of determining, on the balance of probabilities, what the level of inundation would have been had outflows from Wivenhoe Dam accorded with Dr Christensen's simulations, including Simulation C. The second was whether causation in respect of all "greater flooding" occasioned by the flood engineers' breaches of duty could be established in respect of a particular flood engineer, specifically Mr Ruffini, who was only on duty for a limited period during the January 2011 Flood Event.

93 In relation to the first issue, although there were criticisms of Dr Altinakar's modelling, the only expert evidence that was adduced in response to it raised only a few limited objections to his modelling. They are addressed in Chapter 13 along with the balance of the defendants' criticisms. Otherwise that expert, Mr Neil Collins, described Dr Altinakar's modelling as "pretty impressive",[106] although he also asserted that there was a superior hydraulic model available that was commissioned as a result of the Brisbane River Catchment Flood Study ("BRCFS"). That other model was not tendered such that the assertion as to its superiority is only that. However, the concession that Dr Altinakar's modelling was "pretty impressive" remained.

94 Overall I am satisfied that Dr Altinakar's modelling is sufficiently reliable that, when considered with other evidence, it supports findings on the balance of probabilities as to whether or not the plaintiff's store would have been inundated by flood water if the flood engineers had conducted flood

[106] Chapter 13 at [102].

operations substantially in accordance with Simulation C.[107] Leaving aside Ms Harrison,[108] the same applies in relation to Dr Altinakar's modelling of the inundation of the homes of the other sample group members, although it is not possible at this stage to address every aspect of the causation component of their cases. That must await the identification of the "particular harm" they each seek to recover damages in respect of. However, Dr Altinakar's modelling is not to be treated as determinative of the precise level of flooding under Simulation C at every downstream location. There were some aspects of uncertainty demonstrated with his modelling, specifically its simulated flood levels within two kilometres of an inflow discharge[109] and a discrepancy of up to 200m^3/s at the peak of a boundary inflow discharge utilised by the modelling on the Bremer River just past its confluence with Warrill Creek.[110] Instead, Dr Altinakar's modelling must be considered together with all the other evidence concerning flooding at a particular location. The framework for that assessment, should it be necessary to undertake, is set out in Chapter 13.[111]

95 In relation to the second issue concerning causation, I am satisfied that each of the flood engineer's breaches of duty, including those of Mr Ruffini, were necessary to complete a set of conditions that were jointly sufficient to account for the occurrence of the particular harm at the plaintiff's store and such other forms of particular harm at, or to, group members' property that is proven to be the result of the difference in outflows between the events that happened and Simulation C. This is sufficient to satisfy s 11(1)(a) of the *CLA* (Qld) in respect of each flood engineer's breaches of duty. Subsection 11(1)(b) is also satisfied.[112]

[107] Chapter 13 at [2], [254].
[108] Ms Harrison's home was not inundated under Simulation C: see Chapter 13, section 13.4.8.
[109] Chapter 13 at [60].
[110] Chapter 13 at [225] and [237].
[111] Section 13.4.9.
[112] Chapter 13; section 13.5.

96 In relation to the property of the plaintiff and the sample group members, I am satisfied on the balance of probabilities that:[113]

(i) in respect of all relevant loss and damage proven to have been suffered by the plaintiff from the inundation of its store and the shopping centre that it formed part of, duty, breach and causation have been established against each of the defendants;

(ii) in respect of such loss and damage that was occasioned to Mr and Mrs Keller, Ms Visser and Ms Lynch from the inundation of their homes (and Ms Lynch's shed and cottage), duty, breach and causation have been established against each of the defendants; and

(iii) it has not been established on the balance of probabilities that, but for the defendants' breaches of duty, the flooding would not have reached above the ground level of the storage facility at which Ms Harrison's shipping container was stored.

97 For the reasons set out in Chapter 13, should it be necessary, the balance of the causation issues in respect of the sample group members should be litigated together with all quantum issues concerning them.

Quantum and Cross-Claims

98 A number of issues concerning the quantum of the plaintiff's claim were litigated. All of them are addressed in Chapter 14. Two of the issues were said to have implications for group members. The first was the effect on the plaintiff's claim for damages of certain grants received from the Queensland Rural Adjustment Authority under the "Special Disaster Assistance (November 2010 to January 2011) Scheme". As discussed in Chapter 14, those grants were paid under a statutory scheme that effectively conferred an entitlement on small businesses to be reimbursed for particular costs incurred as a result of flood damage during the January 2011 Flood Event.[114] To the extent that

[113] Chapter 13 at [4]; section 13.4.3 to 13.4.8.
[114] See Chapter 14 at [43] to [50].

the plaintiff and other group members seek recovery of a cost item or invoice in respect of which they received a grant, then their damages will be reduced accordingly. I am satisfied that the Legislature did not intend that a flood victim recover twice in respect of the same invoice or cost item.

99 The second issue was whether the plaintiff can recover the commercial cost of the time spent by Mr Rodriguez and various volunteers known as the "mud army" in cleaning up its store and cleaning and repairing stock. For the reasons given in Chapter 14,[115] the answer is "yes".

100 Each of the defendants filed cross-claims against each other. The plaintiff has only been successful in negligence and that part of its claim is an "apportionable claim" within the meaning of s 28(1) of the *CLA* (Qld).[116] It follows from that conclusion that all of the cross-claims for contribution fail.[117] Seqwater's cross-claim against SunWater also included a claim for damages for breach of the agreement between them. The damages claimed are for any liability that Seqwater incurs in favour of the plaintiff and group members as well as its costs of defending the proceedings. These forms of damage are all forms of "consequential loss" which Seqwater is contractually excluded from recovering from SunWater.[118] Accordingly, Seqwater's cross-claim against Sunwater fails.

Further Conduct of the Proceedings

101 It follows from these findings that the plaintiff succeeds in its negligence claim against all of the defendants, as will presumably many, but not all, of the group members. After I pronounce answers to the common questions, I will make orders standing the proceedings over to February 2020 to allow the parties to consider the judgment and plan the next steps in the litigation.

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[115] Chapter 14 at [75] to [77].
[116] Chapter 14; section 14.2.
[117] Chapter 14 at [94].
[118] Chapter 14 at [104].

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CHAPTER 2: BACKGROUND

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CHAPTER 2: BACKGROUND

1 This Chapter describes the statutory scheme for water supply and flood mitigation. It also sets out various background material that places in context the conduct of flood operations at Wivenhoe and Somerset Dams during the January 2011 Flood Event and the plaintiff's criticisms of those operations. Most of the following is not contentious, save as to the finding that in conducting flood mitigation Seqwater was not carrying out a statutory function and the finding as to the time of the day at which the Bureau of Meteorology ("BoM") published its four and eight-day forecasts on its websites.[1]

2 Otherwise, the material in this Chapter confirms:

(i) the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam[2] does not have statutory force (other than its gate opening procedures);

(ii) the volatility of Brisbane's climatic conditions;

(iii) that from the time of their design and construction each of Somerset Dam and Wivenhoe Dam had both a water storage and flood mitigation function;

(iv) that there is a relatively short time frame for rain falling in the catchments above the dams to arrive at their storage reservoirs; and

(v) the relatively small impact of the inundation of bridges at flow rates of $550m^3/s$ or less in the Brisbane River below Wivenhoe Dam.

2.1: Statutory Scheme for Water Supply and Flood Mitigation

3 There are three pieces of legislation governing flood mitigation and water supply which are of relevance to these proceedings: the *South East Queensland Water (Restructuring) Act 2007* (Qld) ("Restructuring Act") which

[1] See [126] to [134].
[2] QLD.001.001.0146.

was Seqwater's enabling statute,[3] the *Water Supply (Safety and Reliability) Act 2008* (Qld) ("Safety and Reliability Act") which regulated flood mitigation activities[4] and the *Water Act 2000* (Qld) ("Water Act") which regulated water supply.[5]

The Restructuring Act

4 The relevant parts of the *Restructuring Act* commenced on 16 November 2007.[6]

5 Section 3 specified that the Act's purpose was "to facilitate a restructure of the water industry in south east Queensland to deliver significant benefits to the community, including … more efficient delivery of water services; … and a clearer accountability framework for water supply security." It was common ground that at the time of its enactment Queensland was in serious drought.

6 Section 6 of the *Restructuring Act* established each of Seqwater and the SEQ Water Grid Manager as a "new water entity" but not as a body corporate and not as a body that represents the State. As a "new water entity", s 7(1) conferred on Seqwater the "powers of an individual", including the power to "enter into contracts"[7] and to "acquire, hold, dispose of, and deal with property".[8] Subsections 7(2) and 7(3) confirmed that, as a new water entity, Seqwater had the powers given to it and was subject to any limitations under any Act. Subsection 7(4) provided for Seqwater's ability to sue and be sued.

7 Subsection 9(2) of the *Restructuring Act* specified the functions of new water entities such as Seqwater (but not the Water Grid Manager). It provided:

> "A new water entity has the following functions to the extent they are consistent with its operational and strategic plans –

[3] LAW.700.003.0001.
[4] LAW.700.013.0001.
[5] LAW.700.009.0001.
[6] The Reprint applicable throughout January 2011 was Reprint 2. Unless stated otherwise, references are to provisions as they appear in Reprint 2.
[7] S 7(1)(a).
[8] S 7(1)(b).

(a) carrying out *water activities* and other ancillary activities;

(b) supplying water services and other ancillary services;

Example of an ancillary service –
delivering a community education program relating to the entity's functions

(c) supplying other services relating to the water industry, including –

(i) engineering services; and

(ii) services for operating or maintaining infrastructure; and

(iii) business management services; and

Example -
services for managing government or business initiatives to save water

(iv) energy generation; and

(v) scientific services;

(d) developing water supply works;

(e) improving the supply, delivery and quality of water, including by way of-

(i) riverine area protection; and

(ii) soil erosion control; and

(iii) land degradation treatment and prevention; and

(iv) nutrient management; and

(v) vegetation management;

(f) using or managing the entity's land in ways that benefit the community, including for recreational purposes;

(g) anything else likely to complement or enhance a function mentioned in paragraphs (a) to (f);

(h) another function conferred under an Act." (underlined emphasis added; italicised emphasis in original)

8 The expression "water activity" was defined in the dictionary in Schedule 3 to the *Restructuring Act* to mean "an activity mentioned in the *Water Act 2000,* schedule 4*,* definition water activity." The definition of "water activity" in schedule 4 of the *Water Act* was as follows:

"… water activity, for a water authority, includes an activity for the following:

(a) water conservation;

(b) *water supply*;

(c) irrigation;

(d) drainage, including stormwater drainage;

(e) *flood prevention*;

(f) *floodwater control*;

(g) underground water supply improvement or replenishment;

(h) sewerage;

(i) anything else dealing with water management." (emphasis added)

9 This definition is directed at a "water authority". Subsection 550(1) of the *Water Act* provides that a water authority "is a body corporate". As Seqwater is not a body corporate, it is not a water authority. However, the designation of Seqwater as a new water entity that carried out water activities was not affected by their want of status as a water authority, as Schedule 3 of the *Restructuring Act* defines "water activity" to mean an activity "mentioned" in the above definition. As such, the defined activities are capable of applying to new water entities such as Seqwater.

10 Subsection 67(1) of the *Restructuring Act* enabled the relevant Minister by gazette notice to transfer certain assets, liabilities and instruments to Seqwater. On 26 June 2008, a number of transfer notices were published in the Queensland Government Gazette.[9] It was common ground that the effect of these notices included the transfer of ownership of Somerset and Wivenhoe Dams to Seqwater with effect from 1 July 2008.[10]

11 Seqwater pointed to the combination of s 9(2) of the *Restructuring Act* and the definition of "water activity" as the source of its authority to engage in flood operations, as well as flood prevention, floodwater control, water

[9] Queensland *Government Gazette*, No 55, 26 June 2008 (at 1130); ROD.900.001.0003.
[10] Fifth Amended Statement of Claim (5ASOC), [61], particular A (PLE.010.001.0001 at .0024); Seqwater's Amended Defence (Amended Defence), [119] (PLE.020.012.0001 at .0050).

conservation, water supply and managing land for recreational purposes.[11] The plaintiff disputed this. It contended that, as Seqwater had not demonstrated that there was any relevant operational or strategic plan, the conferral of functions provided for by s 9(2) was not engaged.[12] On the plaintiff's approach, this meant that Seqwater's responsibility for the conduct of flood operations followed from its status as the owner of the dams conferred with the powers of an individual (and whatever followed from the granting of various licences and permissions).[13]

12 The Dictionary in Schedule 3 to the *Restructuring Act* defines an "operational plan" of a new water entity as the "entity's operational plan *in force* under Chapter 2, Part 4, Division 4" of the Act. The definition of "strategic plan" is expressed in similar terms. Within Chapter 2, Part 4, Division 4, subsection 45(1) of the *Restructuring Act* provides that before 31 March of each year the board of a new water entity must prepare and submit to the responsible Ministers "for their agreement" a draft strategic and a draft operational plan for the entity for the financial year. Section 48 provides that when the draft strategic plan or operational plan has been agreed to by the Minister in writing "it becomes the entity's strategy or operational plan for the relevant financial year".

13 No operational plan or strategic plan for Seqwater was tendered. Senior Counsel for Seqwater advised the Court that "we can't find any evidence" of any statutory approval for any "operating and regulatory plan".[14] Senior Counsel for the plaintiff stated that "[a]s we understand it, there aren't any [plans]".[15]

14 I accept that the conferral of functions engaged by s 9(2) of the *Restructuring Act* is conditioned on the existence of an operational or strategic plan, as defined, relevant to the particular activity. If there is no such plan then it

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[11] Closing submissions of the first defendant, SBM.020.004.0001 ("Seqwater subs") at [31].
[12] T 10059.11; T 10124.18.
[13] See Chapter 11.
[14] T 9482.20 - .27; T 9479.10.
[15] T 10059.1 - .25.

cannot be determined that a particular function is conferred to any "extent". This is in contrast to a provision that confers a function subject to it being not inconsistent with any operational or strategic plan. In this case, no such plan was tendered and both relevant parties could not locate a plan "in force". The party seeking to invoke s 9(2) was Seqwater, principally as an aspect of its reliance on s 36 of the *Civil Liability Act 2003* (Qld).[16] Given the above concession, I am satisfied that no relevant operational or strategic plan was in existence at the time of the January 2011 Flood Event. It follows that I am not satisfied that, in carrying out flood operations and flood mitigation, Seqwater was carrying out or performing any function conferred on it by s 9(2) of the *Restructuring Act*.

The Safety and Reliability Act 2008 (Qld)

15 The *Safety and Reliability Act* commenced (relevantly) on 1 July 2008.[17] Seqwater noted that this coincided with the transfer of assets to Seqwater, including the dams.[18]

16 Section 3 of the *Safety and Reliability Act* provided:

> "(1) The purpose of this Act is to provide for the safety and reliability of water supply.
>
> (2) The purpose is achieved primarily by –
>
> (a) providing for –
>
> (i) a regulatory framework for providing water and sewerage services in the State, including functions and powers of service providers; and
>
> (ii) a regulatory framework for providing recycled water and drinking water quality, primarily for protecting public health; and
>
> (iii) the regulation of referable dams; and
>
> (iv) *flood mitigation responsibilities*; and

[16] Seqwater's amended defence; see for example PLE.020.010.0001 at .0187, [361(c)].
[17] The reprint applicable throughout January 2011 was Reprint 1L. Unless stated otherwise, references are to provisions as they appear in Reprint 1L.
[18] Seqwater subs at [35].

> (b) protecting the interests of customers of service providers." (emphasis added)

17 Part 2 of Chapter 2 outlines the functions of the "Regulator". Section 10 defines the Regulator as the Chief Executive (of the then Department of Environment and Resource Management, "DERM"). The Regulator's general functions included monitoring compliance with the Act (s 11(1)(c)); making guidelines for failure impact assessments for dams (s 342(1)(b)); making guidelines for applying safety conditions to dams (s 354(2)); and approving flood mitigation manuals (s 371(2)).

Dam Safety and Referable Dams

18 Chapter 4 of the *Safety and Reliability Act* is entitled "Referable dams and flood mitigation". Part 1 of Chapter 4 concerns "Referable dams". It is directed towards regulating dams the failure of which would have significant consequences for public safety and amenity.

19 Subsection 341(1) provided that a dam was a "referable dam" if:

> "(a) a failure impact assessment of the dam … is required to be carried out under this part; and
>
> (b) the assessment states that the dam has … a category 1 or category 2 failure impact rating; and
>
> (c) the chief executive has … accepted the assessment."

20 Section 343 set out various circumstances when either the dam owner or a person who proposes to build a dam was required to obtain a failure impact assessment. Seqwater noted[19] that it provided:

> "(1) A person who proposes to construct a dam must have the dam failure impact assessed if the dam, after its construction, will be more than 8m in height and have:
>
> (a) a storage capacity of more than 500ML; or

[19] Seqwater subs at [41], although note that the version of s 343 cited by Seqwater was from reprint 1H, current as to 22 June 2010. However, s 343 in reprint 1L, which was current during the January 2011 Flood Event, was not materially different.

(b) a storage capacity of more than 250ML and a catchment area that is more than 3 times its maximum surface area at *full supply level*."

21 The expression "fully supply level" was defined in the Dictionary in Schedule 3 of the *Safety and Reliability* Act as "… mean[ing] the level of the water surface of the dam when the water storage is at maximum operating level and the dam is not affected by flood".[20] Seqwater contended that by equating the "maximum operating level" with the situation where "the dam is not affected by flood", this was reflective of an (apparently inviolable) distinction between dam compartments below the "maximum operating level" or "FSL", which was set aside for "operating" purposes, and the dam compartments above "maximum operating level" or "FSL", which was set aside as "flood storage capacity to be utilised when the dams were affected by flood".[21] If this is meant to provide support for the contention that releases for flood mitigation can never be made from below FSL then I do not accept that such a large proposition can be discerned from such a limited reference to "full supply level". The definition does not exclude the possibility that such releases can be made or that a dam can be affected by a (threatened) flood event when below FSL. Otherwise, this issue is addressed in Chapter 5.

22 The concept of a failure impact rating, as referred to in the definition of referable dam, is explained in s 346, which provided:

"(1) An existing dam has, or a proposed dam after its construction will have, the following failure impact rating if a failure impact assessment, accepted by the chief executive under section 349, for the dam, or the proposed dam after its construction, states that *the population at risk* is –

(a) for a category 1 failure impact rating - 2 or more persons and not more than 100 persons;

(b) for a category 2 failure impact rating - more than 100 persons.

(2) In this section –

[20] The same definition appeared in the dictionary to the *Water Act*, and like the *Safety and Reliability Act* it was also only employed in the context of failure impact assessments: see s 1070 of the *Water Act*.
[21] Seqwater subs at [43].

> ***population at risk*** means the number of persons, calculated under the failure impact assessment guidelines, whose safety will be at risk if the dam, or the proposed dam after its construction, fails." (italic emphasis added)

23 Both Wivenhoe and Somerset Dams were referable dams with category 2 failure impact ratings.[22]

24 Division 3 of Part 1 of Chapter 4 concerns the safety conditions imposed on referable dams. Subsection 355(1) provides that, when the Chief Executive decides to impose safety conditions for a dam, he or she must give notice of the proposed conditions to the owner of the dam and the relevant local government for the area of the dam. If there is a development permit for the dam then the safety conditions "are taken to be conditions attaching to the permit" (s 355(2)) and, if there is not, the Chief Executive's decision is taken to be a development permit and the safety conditions are taken to be conditions attaching to that permit (s 355(3)). Section 356 confers a power on the Chief Executive to change the safety conditions.

25 Seqwater noted that the Explanatory Notes to the *Safety and Reliability Act* explained (at page 117) that the approach of deeming the safety conditions to be conditions of a development permit was undertaken to allow: "*…the chief executive to utilise the offence and enforcement provisions under the* Integrated Planning Act *in respect to conditions about the safety of a referable dam.*"[23] To that end, until 18 December 2009, under s 4.3.3 of the *Integrated Planning Act 1997* (Qld) it was an offence to contravene a condition attaching to a development permit.[24] After that time, contravention of a development permit was an offence under s 580 of the *Sustainable Planning Act 2009* (Qld).[25]

26 On about 12 May 2009, the delegate of the Chief Executive decided pursuant to s 356 to apply changed conditions to Wivenhoe Dam and notified Seqwater

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[22] SEQ.200.003.4434 at .4438; SEQ.001.001.7854 at .7864.
[23] Seqwater subs at [48].
[24] LAW.700.007.0001 at .0291.
[25] LAW.700.008.0001 at .0383.

accordingly.[26] The changed conditions included "Condition DS 17 – Gate Operation" which provided: "*All gates must be operated as per the latest flood mitigation manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam approved by the dam safety regulator.*"

27 Similarly, on 22 May 2009, the delegate of the Chief Executive decided pursuant to s 356 to apply changed conditions to Somerset Dam and notified Seqwater accordingly.[27] The changed conditions included "Condition DS 17 – Gate Operation" which provided: "*All gates must be operated in accordance to latest approved 'Manual of Operational Procedures for Flood Mitigation of Wivenhoe Dam and Somerset Dam*'" (the "Manual").

28 The terms of the Manual, including the provisions dealing with gate openings, are addressed in detail in Chapter 3.[28] At this point, it suffices to note that there was some debate about how much of the Manual's prescribed procedures were given the force of law as conditions of a development permit by these provisions. These conditions do not specify that flood mitigation must be undertaken in accordance with the Manual, only that the "gates must be operated" in accordance with the Manual. As at May 2009, the relevant version of the Manual of Operational Procedures for Flood Mitigation of Wivenhoe Dam and Somerset Dam was Version 6.[29] It addressed flood mitigation but also included specific sections addressing the process for opening and closing gates at both dams by, for example, limiting the speed at which they may be opened.[30] Version 7 replaced Version 6 with effect from 22 December 2009.[31] It contains similar provisions.[32] Subject to one possible matter, I am satisfied that the changed conditions are only referring to that part of the Manual in force from time to time which addresses the manner in which the Dams' gates are opened and closed. The balance of the Manual is not given statutory force as a condition of a development permit.

[26] SEQ.200.003.4434 and SEQ.200.002.7450.
[27] SEQ.001.001.7854; LAY.SEQ.014.0001 at .0063, [97].
[28] Chapter 3 at [65].
[29] QLD.005.001.0554; Chapter 4 at [13].
[30] QLD.005.001.0554 at .0580 to .0582 (section 8.4), at .0592 (section 9.3).
[31] QLD.001.001.0146; see Chapter 4 at [157].
[32] QLD.001.001.0146 at .0182 (section 8.6) and .0193 (section 9.3).

29 The one matter of possible exception concerns Seqwater's contention that one part of the Manual incorporated into the conditions of the development permit includes so much of clause 3.2 that specifies that the "structural safety of the dams must be the first consideration in the operation of the dams for the purpose of flood mitigation".[33] I reject that contention. The specification of a priority is not a "gate opening procedure". It is difficult to envisage the specification of a priority being sensibly enforced as a condition of development permit.

Flood Mitigation

30 Part 2 of Chapter 4 of the *Safety and Reliability Act* dealt with flood mitigation. Subsection 370(1) provided that a regulation could nominate an owner of a dam "as an owner who must prepare a manual (a flood mitigation manual) of operational procedures for flood mitigation for the dam".[34] Subsection 371(1) obliged a dam owner to provide the manual to the Chief Executive (of DERM) and subsection 371(2) empowered the Chief Executive to approve the manual "by gazette notice". The approval is for a period that cannot exceed five years (s 371(3)). Section 372 enables the approved manual to be amended and s 373 obliges the owner of the dam to review and, if necessary, update the manual before the approval period expires.

31 As explained in Chapter 4, Version 6 of the Manual was reviewed and updated during 2009. Version 7 was then approved by the Chief Executive pursuant to s 371 and the approval was duly notified in the Queensland Government Gazette on 22 January 2010.[35]

32 Section 374 of the *Safety and Reliability Act* provides:

> "(1) The chief executive or a member of the [advisory council who may have advised the Chief Executive] does not incur civil liability for an

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[33] T 9560.43; Chapter 3 at [21] to [23].
[34] The parties did not refer to any regulation nominating Seqwater as an owner required to prepare a manual. However, the plaintiff pleaded and the defendants admitted that the Manual was approved under s 371: 5ASOC at [378]; Seqwater defence, PLE.020.010.0001 at [483A]; SunWater defence, PLE.030.008.0001 at [378]; State defence, PLE.040.067.0001 at [318].
[35] Queensland *Government Gazette*, No 15, 22 January 2010 (at 127); see Chapter 4 at [157].

act done, or omission made, honestly and without negligence under this part.

(2) An owner of a dam who observes the operational procedures in a flood mitigation manual, approved by the chief executive, for the dam does not incur civil liability for an act done, or omission made, honestly and without negligence in observing the procedures.

(3) If subsection (1) or (2) prevents civil liability attaching to a person, the liability attaches instead to the State.

(4) In this section:

owner of a dam includes:

(a) the operator of the dam;

(b) a director of the owner or operator of the dam;

(c) an employee of the owner or operator of the dam;

(d) an agent of the owner or operator of the dam.

33 One aspect of the plaintiff's case sought to attribute liability to the State under s 374(3).

34 Seqwater contended that, save for the obligation to comply with the dam safety conditions, the *Safety and Reliability Act* does not include any provision expressly imposing a positive obligation to comply with an approved flood mitigation manual.[36] I accept that contention. The scheme of Part 2 of Chapter 4 of the *Safety and Reliability Act* is that the State identifies a particular dam, whether privately or publicly owned, as having a role in flood mitigation and thereby imposes on the owner an obligation to prepare a flood mitigation manual for approval by the Chief Executive. The owner is not obliged *by statute* to comply with the manual but gains a protection from s 374 such that, if they do comply, then any civil liability that would otherwise attach to them will be assumed by the State. Section 374 clearly does not confer a right of action against a dam owner as defined for a failure to comply with an approved flood mitigation manual. Equally though, it does not exclude such a person from being held civilly liable, including in negligence, for the conduct of flood operations. In particular, it does not assume that the imposition of a duty

[36] Seqwater subs at [57].

of care on such a person in the conduct of flood operations is necessarily inconsistent with the *Safety and Reliability Act*. Further, as explained in Chapters 3 and 12,[37] the terms of any manual are highly significant to ascertaining the content of any duty of care that may be owed because of the uniformity of expert opinion over the necessity for a flood engineer to comply with the relevant water control manual.

The Water Act

35 The *Water Act* was enacted as Act No. 34 of 2000 but was amended frequently in the period to January 2011, especially during the drought.[38] The Act's preamble states that it provides for, inter alia, "the sustainable management of water and other resources".

36 The *Water Act* contains a number of provisions restricting interference with a watercourse and which are otherwise designed to preserve the supply of drinking water. These provisions are addressed in Chapter 5, which deals with the contention that releases from Wivenhoe and Somerset Dams below FSL during flood operations were prohibited. At this point it suffices to note (and accept) Seqwater's contention that during 2006 the *Water Amendment Act 2006* was enacted to address the effect of the ongoing drought.[39] This inserted a new Chapter 2A into the Act, which thereby established the Queensland Water Commission ("QWC"), whose functions included "facilitat[ing] and implement[ing] regional water security programs" and "ensur[ing] compliance with the programs and with commission water restrictions" (s 345(a)(iii) and (iv)). In performing its functions, the QWC was required to act on the "general principle" that water "is to be managed on a sustainable and integrated basis to provide secure and reliable supplies of water" (s 346(2)) and a number of "specific principles", including that flood

[37] Chapter 3 at [2] and [124] to [129]; Chapter 12, section 12.1.
[38] The reprint applicable throughout January 2011 was not given a reprint number. It operated between reprints 7G and 8A, and included all amendments that commenced on or before 10 December 2010. Unless stated otherwise, references are to provisions as they appear in this unnumbered reprint.
[39] Seqwater subs at [62] to [63].

mitigation and dam safety “should be considered in the preparation of assessments of regional water supply” (s 346(3)(g)).

2.2: The Brisbane River Catchment[40]

37 The Brisbane River catchment is bounded by the Great Dividing Range to the west and a number of smaller coastal ranges to the east and the north. Its headwaters are at the northern extent of the catchment, bounded by the Brisbane and Jimna Ranges. From there it meanders in a generally south-easterly direction, before running almost north-easterly to enter Moreton Bay near Brisbane. About half of the Brisbane River catchment lies downstream from Wivenhoe Dam.

38 The north portion of the catchment of the Brisbane River, and particularly that lying upon the slopes of the bordering ranges, is generally rugged and heavily timbered, with but few flat lands. Further to the south, near Mt Brisbane and Cressbrook Creek, lies undulating open country interspersed with isolated steep hills and short sudden ranges. Still further south from a line forming the northern boundary of the catchment of Lockyer Creek, the terrain is generally of a much lower altitude, and does not reach (except on the fringing hills) the altitudes as in the north of the catchment.

39 The total catchment has an area of some 13,570km^2 and comprises five main sub-catchments: (a) Upper Brisbane River (above Wivenhoe Dam); (b) Stanley River (above Somerset Dam); (c) Lockyer Creek; (d) Bremer River (including Warrill and Purga Creeks); and (e) Lower Brisbane River. The following diagram provides a simple overview of the placement of these sub-catchments (or catchments) within the total Brisbane River catchment system:[41]

[40] Unless otherwise stated, the description of the Brisbane River catchment is taken from a statement of facts agreed to by the plaintiff, Sunwater and the State (AID.500.028.0001) and partially agreed to by Seqwater (AID.500.023.0001_2).
[41] EXP.ROD.011.0011 at .0024 (some additions to the original diagram have been made).

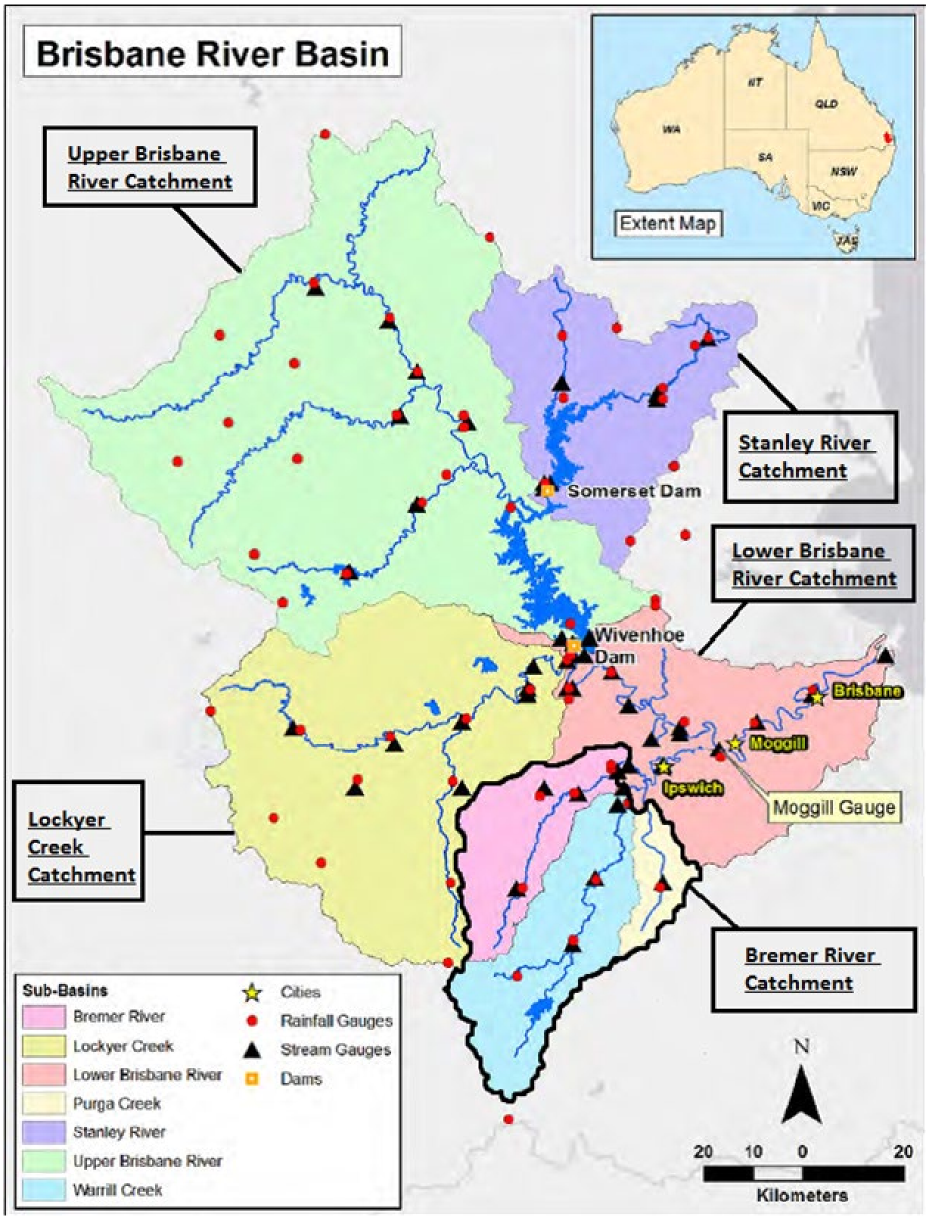

Figure 2-1: Map of Brisbane River Basin

40 The Upper Brisbane River and Stanley River catchments (ie, the catchments that flow into Wivenhoe Dam) are approximately 7,000km^2. The major tributaries of the Upper Brisbane River (Cooyar, Emu and Cressbrook Creeks) flow in an easterly or north-easterly direction and join the Brisbane River upstream of its junction with the Stanley River.[42]

41 The largest tributary of the Upper Brisbane River, the Stanley River, has a catchment which is much wetter than that of the Brisbane River. It is the

[42] See below at [104].

principal tributary entering the northern bank of the Brisbane River. Together with its tributaries, including Kilcoy Creek, Sheep Station Creek and Delaney Creek, the Stanley River drains an area of approximately 1,320km^{2}[fn43] to Somerset Dam. Riparian vegetation remains in the upper reaches of the Stanley River, while the mid reaches have been extensively cleared for the grazing of beef and dairy cattle.

42 The catchment of Stanley River encompasses parts of the Moreton Bay, Sunshine Coast, and Somerset Regional Councils, as well as various towns. The catchment is traversed by a number of roads, including the Esk-Kilcoy Road and the D'Aguilar Highway. Bridges located on these roads can be affected by elevated lake levels in Somerset Dam.

43 In the Lockyer Creek catchment, Lockyer Creek forms the largest tributary of the Brisbane River in terms of catchment size, constituting a drainage area of about 2,964km^{2}.[44] The Lockyer Creek catchment encompasses a number of towns, including Grantham and Helidon. Lockyer Creek drains into the Brisbane River immediately downstream of Wivenhoe Dam near Lowood. Lockyer Creek has a number of tributaries. The upper regions of the Lockyer Creek catchment to the south and west are generally steep and mainly forested while the lower floodplains are generally wide and flat, and mainly cleared for grazing and intensive agriculture purposes. As such, the lower flood plains contain a number of small population centres across the area.

44 The Bremer River has a catchment area of about 2,032km^{2} to its junction with the Brisbane River. The Bremer's headwaters lie in the Little Liverpool Range to the south-west, and drain in a north-easterly direction into the Bremer River, which then drains into the Brisbane River at Moggill. The Bremer River catchment is generally hilly and lightly forested, except the lower north-eastern areas which drain through the City of Ipswich. Most of the catchment is rural, with the majority of the catchment cleared for cattle grazing but with

[43] Mr Malone described it as being 1328km^{2} (see [104]).
[44] Or 3163km^{2} according to Mr Malone (see [104]).

some areas of natural bush remaining in the upper catchment. The lower catchment is mostly urbanised.

45 The Lower Brisbane River catchment extends from Wivenhoe Dam to the river mouth in Moreton Bay and has an area of either 1,299km^{2}[fn45]or 1,499km^{2}[fn46]. The Brisbane River travels some 70km through an incised channel from Wivenhoe Dam to a junction where it meets the Bremer River. From its confluence with the Bremer River near Moggill, the Brisbane River meanders its way to Moreton Bay in a generally north-easterly direction. The City of Brisbane encompasses almost the whole of the Lower Brisbane River flood plain from this point.

46 There are a number of population centres within the catchment upstream of Brisbane. The Lower Brisbane River catchment comprises grazing and agricultural areas as well as the urbanised areas of Brisbane City and its suburbs with a population of approximately 1.9 million people. In addition to Lockyer Creek and the Bremer River, the Brisbane River catchment below Wivenhoe Dam is drained by numerous tributaries.[47] The catchment downstream of Wivenhoe Dam to just below Mt Crosby Weir Bridge is crossed by a number of roads, including the Brisbane Valley Highway. Downstream of Moggill, there are numerous high-level foot, road and rail bridges which traverse the Brisbane River.

2.3: Climate

47 The BoM described Brisbane's climate as "a sub-tropical humid type with a hot-wet summer and a mild-dry winter".[48] Professor Manton said there were a variety of sources for summer rain, such as onshore winds, tropical cyclones and tropical monsoons.[49]

[45] According to Mr Malone (see [104]).
[46] AID.500.023.0001_2 at .0002.
[47] See Chapter 13.
[48] AID.500.028.0001 at [82]; EXP.SEQ.004.0131 at .0140; February 2015 Report, EXP.ROD.001.0016 at [59(5)].
[49] EXP.SEQ.004.0131 at .0140.

Droughts and Floods

48 The rainfall patterns affecting the Brisbane River catchment are not stable from year to year.[50] Professor Manton described south-east Queensland as a "land of droughts and flooding rains".[51] He stated that the inter-annual variability of rainfall in South East Queensland (and much of Australia) is higher than most parts of the world and "it is largely due to the influence of the El Niño - Southern Oscillation phenomenon" which "represents a large scale interaction between the atmosphere and ocean across the Pacific Ocean".[52] Included in his report was a table of annual rainfall across south-east Queensland since 1900. It varied from 448mm in 1902 to 1570mm in 1974 with a long-term mean of 1024mm.[53] He concluded that the "annual rainfall of south east Queensland ... is extremely variable by global standards with extremes in wet and dry spells being natural aspects of the climate".[54]

49 Consistent with this, the agreed facts note the occurrence and reoccurrence of drought events in south-east Queensland from the early 1980s. It states that so-called "El Niño" events tend to lead to dry summers due to reduced onshore winds as well as reduced cyclone and monsoon activity, whereas "La Niña" events involve the opposite conditions.

50 The effect of an El Niño event is illustrated by the following extract from the agreed facts which is an important aspect of the context in which flood operations came to be undertaken in 2010 to 2011:[55]

> "From 2001 to 2009, South East Queensland experienced a long period of drought conditions, referred to as the 'Millennium Drought'. This drought has been described as the longest and most severe drought in the South East Queensland region since European settlement and was exacerbated by rapid population growth in South East Queensland. Between 1971 and 2011, the South East Queensland population grew by 2.5% per annum…
>
> The Millennium Drought affected most of the country and much of the Murray-Darling Basin. It included two severe drought years in 2002 and 2006 with the

[50] February 2015 Report, EXP.ROD.001.0016 at [59(2)].
[51] EXP.SEQ.004.0131 at .0140.
[52] Ibid at .0141.
[53] Ibid at .0140 to .0141.
[54] Ibid at .0141.
[55] AID.500.028.0001 at [85] to [88].

remaining years recording near-to-below-average rainfall. The El Niño phenomenon was a major contributor to the Millennium Drought.

Declining regional storage levels at the time threatened the security of water supply and the maintenance of water quality in South East Queensland water storage facilities.

The Millennium Drought was declared over in South East Queensland on 20 May 2009 when Wivenhoe, Somerset and North Pine Dams reached 60 percent of their combined storage capacities."

51 As noted above, flooding is also especially common in the Brisbane River catchment. The weather conditions that prevailed during the January 2011 Flood Event are described in Chapters 6 and 7. The flood frequency analyses of two of the experts are referred to in Chapter 7 at [377]. In summary, I accept Dr Christensen's assessment that it was in "the order of a 40-year to 50-year flood".[56]

52 Based on material from the BoM, Dr Christensen noted flooding occurring in some part of the Brisbane River catchment at least every few years during the twentieth century. In terms of large or extreme floods, the relevant episodes occurred in 1841, 1893, 1931, 1955, 1974 and 2010-2011. Dr Christensen stated that the January 2011 Flood Event was the third largest in flood volume behind the 1841 and 1893 floods.[57] The 1893 flood yielded higher runoff volumes and a higher recorded river height at the Port Office gauge in Brisbane city than the 2010-2011 flood.[58] The 1841 flood resulted in a river height at that gauge that was 8cm higher than the 1893 flood[59] and 2.98m higher than the 1974 flood.[60] However, the rainfall and runoff volumes produced in the January 2011 Flood Event exceeded that of the 1974 flood.[61] Dr Christensen noted that during the 1974 flood Wivenhoe Dam had not yet been built and that more rainfall was centred on the coastal areas of the Stanley River, Bremer River and Lower Brisbane River catchments. The

56 February 2015 Report, EXP.ROD.001.0016 at .0522, [2197].
57 Ibid at [70], [74] to [75].
58 February 2015 Report, EXP.ROD.001.0016 at [74]; EXP.ROD.001.0583 at .0605.
59 February 2015 Report, EXP.ROD.001.0016 at [70]; EXP.ROD.001.0583 at .0606.
60 EXP.ROD.001.0583 at .0606.
61 February 2015 Report, EXP.ROD.001.0016 at [76].

January 2011 Flood Event involved more widespread rain with relatively heavier falls in the Upper Brisbane River and Stanley River catchments.[62]

2010

53 The weather in calendar year 2010 was very different from the weather in the preceding decade. During 2010, the Queensland Water Commission declared that the "Millennium Drought is now behind us" and that the "water supply is secure, due to [South East Queensland] dams currently [sitting] at or near full capacity".[63]

54 Commencing from around June 2010 and continuing until December 2010, the effect of both "seasonal outlooks" published by the BoM and specific advice provided by the BoM to the flood engineers were warning of the potential for well above average rainfall due to the development of "La Niña" weather conditions.[64]

55 On 4 October 2010, the BoM issued a public media release warning that Queensland may experience "above average tropical cyclone activity this coming season" due to a "La Niña Climate phase" which would be the "dominating influence through the Spring and Summer months".[65] There was widespread media reporting of the effect of La Niña and the likelihood of high rainfall throughout September until the end of December 2010.[66]

56 Mr Ayre described the seasonal outlook as "creat[ing] a general awareness of the severity of the upcoming wet season".[67] Mr Malone's evidence was to similar effect.[68] Professor Manton noted that research after the event suggested the La Niña event was not a "normal" event but instead "substantially intensified by other factors operating in the Indian Ocean and

[62] February 2015 Report, EXP.ROD.001.0016 at [81].
[63] Ibid at [68].
[64] ROD.537.004.0007; ROD.537.004.0009; ROD.537.004.0015; ROD.537.004.0005; SEQ.001.018.9367.
[65] QLD.001.001.0376.
[66] See for example SEQ.016.011.1900 at .1916 to .1917; EXP.QLD.001.0881_3 at .0913.
[67] LAY.SUN.001.0001 at [582].
[68] LAY.SEQ.007.0001_OBJ at [127] to [128].

the Southern Ocean".[69] As discussed in Chapter 6, he described the rainfall events of 9 to 11 January 2011 as "unprecedented in the North catchment".[70] However, Professor Manton agreed that the fact that in December 2010 "a La Niña" event was taking place meant that it was known or foreseeable that it was likely there would be "above normal" rain, with the higher rainfall likely to continue to Autumn in 2011.[71]

2.4: Somerset Dam

57 Somerset Dam is built across the Stanley River in a rocky gorge between Mount Brisbane and Little Mount Brisbane at a point a few miles above its junction with the Upper Brisbane River. It is around "138 miles [222km] by river from the mouth of the Brisbane River in Moreton Bay".[72]

58 Both government reports and legislation directed to water supply and flood mitigation preceded its construction. On 7 July 1927, the Commonwealth Director of Public Health Engineering was appointed as Commissioner of an Inquiry into Brisbane Water Supply. He reported in 1928 and recommended the "formulation of a scheme having for its objective joint water supply and flood prevention works".[73] A report to the Brisbane City Council from its Chief Engineer in 1930 identified the "proposed storage reservoir on the Stanley River at Little Mount Brisbane" as "eminently suited for water supply [and] for flood mitigation".[74] In June 1934, a report from the Bureau of Industry on Brisbane's Water Supply and Flood Prevention was tabled in the Queensland Parliament. It noted that "[o]nly one thing is certain: that floods must be expected to recur".[75]

59 The *Bureau of Industry Acts Amendment Act 1934* (Qld) ("BIA Amendment Act") was assented to on 29 November 1934. Section 9 of the *BIA Amendment Act* inserted a new s 6(c)(1) in the principal Act, approving and

[69] EXP.SEQ.010.0001 at [13].
[70] EXP.SEQ.010.0001 at [13].
[71] T 3618.40 to T 3619.9.
[72] SEQ.004.036.8859 at 8861.
[73] SBM.040.001.0001 at 0005.
[74] Ibid at .0006.
[75] Ibid at .0007.

authorising the Bureau or a delegated Crown corporation to undertake the "construction of a dam across the Stanley River" for the "purpose of ensuring an adequate storage for the supply of water to the City of Brisbane and the City of Ipswich, and for the purpose of preventing as far as may be destruction by floodwaters in or about the said cities".[76]

60 The first concrete pour for Somerset Dam took place in October 1937, although design and excavation work took place well prior. Construction work on the dam was suspended in around November 1942 due to World War II, although by that time it was able to function for the provision of water supply. It was commissioned to supply water in 1943.[77] Construction work resumed in January 1948. It was commissioned for partial flood mitigation operations in 1950 and the last structural concrete pour was in 1953. During that year, a small hydroelectric power station was commissioned at Somerset Dam. It was connected to the south-east Queensland power grid in 1953. Somerset Dam was fully commissioned for flood mitigation in 1956. Ownership of Somerset Dam was transferred to the Council of the City of Brisbane on 1 July 1959.[78] As described below, in 1979 the Brisbane and Area Water Board (the "Water Board") assumed control of Somerset Dam.[79] As noted, by gazettal notices made under the *Restructuring Act*, ownership of Somerset Dam was vested in Seqwater with effect from 1 July 2008.

61 The relevant features of Somerset Dam are best explained by reference to the following diagram:[80]

[76] Ibid at .0008.
[77] LAY.SEQ.002.0001 at [45].
[78] Ibid at [45].
[79] SBM.040.001.0001 at [66].
[80] Manual at .0188 (Arrows indicating the position of monoliths A-G and R-W have been added to the original diagram).

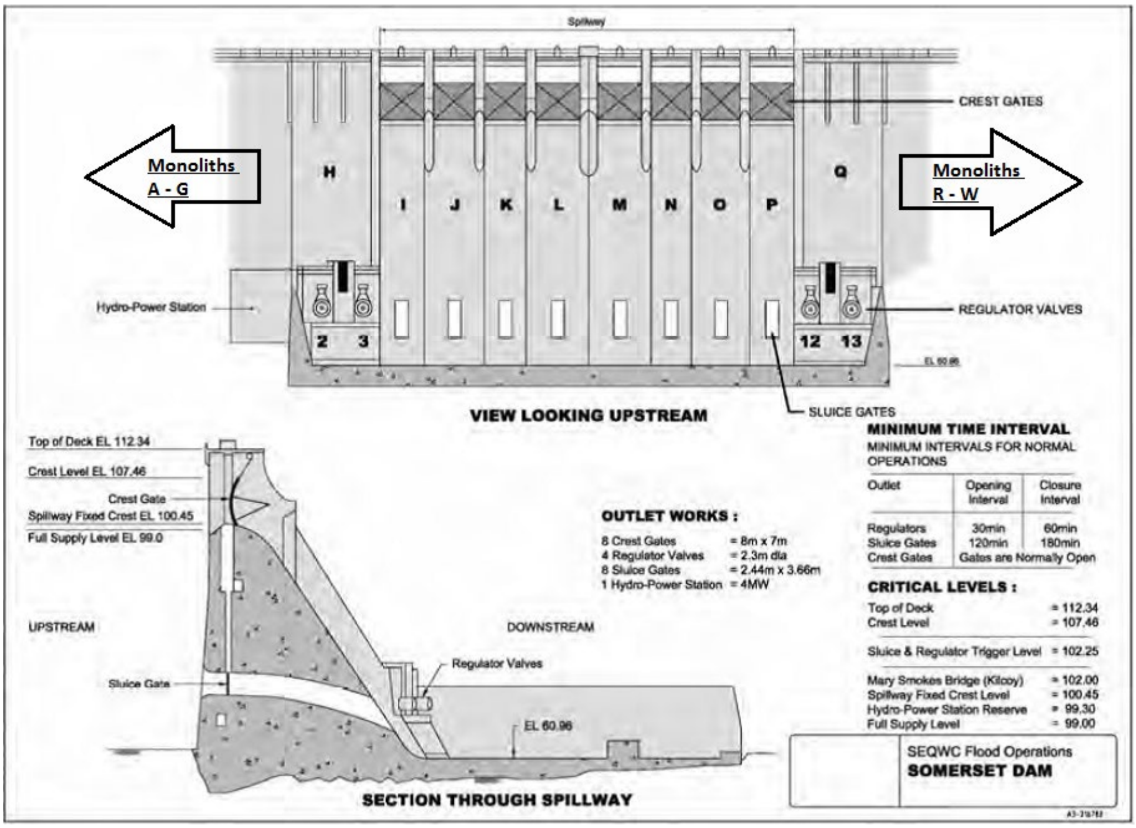

Figure 2-2: Somerset Dam

62 The vertical sections marked "H" to "Q" are 10 of 22 monoliths which comprise the Dam structure. Monoliths A to G, to the left of monolith H, directly abut the surrounding valley. Monoliths R to W are to the right of monolith Q. Monoliths "I" to "P" are located within the spillway and are often referred to as the "overflow monoliths".[81] Overflow monoliths J, L, M and O are each 11.378m wide. Overflow monoliths I, K, N and P are each 7.925m wide.

63 The above diagram depicts eight radial or "crest gates" for Somerset Dam, which sit at the top of the dam structure. The gates have a central pivot point. They are curved and when opened water spills underneath the raised crest gate.[82] As discussed later, those crest gates usually remain open, even during flood operations. Just below the bottom of each gate is the fixed crest for the spillway, which sits at EL 100.45m AHD and which is 1.45m above the full supply level of EL 99.0m AHD ("FSL"). With the crest gates open,

[81] LAY.SEQ.002.0001 at [52].
[82] Ibid at [56].

uncontrolled spillage occurs at dam levels above EL 100.45m AHD. The fixed crest for the non-overflow section of the dam (ie, monoliths A-G and R-W) sits at EL 107.45m AHD.[83] The Manual refers to Somerset Dam as being able to withstand overtopping above EL 107.45m AHD by up to 2.25m.[84]

64 Somerset Dam has eight sluice gates which are depicted as apertures at the bottom of overflow monoliths I to P in the above diagram. Each sluice gate is a tunnel through the dam wall and drains water from the bottom of the dam. The sluice gates are located 27.4m below the spillway crest.[85] A Seqwater engineer, Mr Barton Maher, explained that the sluice gates are not designed to remain partially open or closed, except for when transitioning from fully open to fully closed or vice versa.[86] The rate that water is released from a sluice gate is generally a product of water pressure and thus the water level of Somerset Dam.

65 Somerset Dam also has four regulator valves, two at the bottom of monolith H and two at the bottom of monolith Q. Water is discharged from these valves in a dispersed fashion to avoid damage to the dam or the downstream channel.[87]

66 As noted, the FSL of Somerset Dam is EL 99.0m AHD. At that point, Somerset Dam holds 379,800ML of water.[88] As the water level of the dam increases above (and decreases below) FSL, its storage capacity increases (and decreases) at a non-linear rate.[89]

2.5: Wivenhoe Dam

67 In 1971, the Queensland Department of the Coordinator-General of Public Works published a report entitled "Proposed Dam on the Brisbane River at Middle Creek or alternatively at Wivenhoe and Flood Mitigation for Brisbane

[83] Ibid at [48].
[84] Manual at 41 TO 42.
[85] LAY.SEQ.002.0001 at [58].
[86] Id.
[87] Ibid at [59].
[88] Manual at 59.
[89] Id.

and Ipswich". It recommended, inter alia, the development of a multi-purpose dam in the Brisbane River system "which will serve for both water supply and flood mitigation" noting that there "is still a very serious flood risk in Brisbane, Ipswich and the lower valley generally".[90] It recommended that the location of such a dam be at Wivenhoe "and that it be built to serve water supply and flood mitigation".[91] Later that year, the Queensland Government decided that the next urban water supply storage for the greater Brisbane area would be sited at Lake Wivenhoe, just upstream of the junction with Lockyer Creek.[92] The agreed facts record that the primary objectives of Wivenhoe Dam, as "identified in planning of the project in the early 1970s" were to "[p]rovide an assured water supply" and "[p]rotect communities along the Brisbane River from overbank flooding".[93]

68 In January 1974 the Lower Brisbane River valley experienced its worst flooding since 1893, which in turn was only exceeded by the flooding in 1841.[94] Between 25 and 29 January 1974, flooding peaked at 5.45m AHD at the Port Office gauge in downtown Brisbane. In Ipswich "some 2,000 homes and properties were affected, many being totally destroyed, countless others were affected, many beyond repair and business, property and damage to services running into millions of dollars".[95] Two people died as a result of this flooding.

69 Construction of Wivenhoe Dam commenced in October 1976 and was completed in February 1984. An evaluation report for the proposed dam at Wivenhoe Dam undertaken for the Co-ordinator General's Department in 1977 identified the water storage function of the dam but also stated that the "proposed Wivenhoe Dam, as one of its major impacts, will reduce the flood hazard in the lower Brisbane River valley".[96]

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[90] SBM.040.001.0001 at .0009.
[91] Id.
[92] Ibid at .0010; SEQ.001.014.2912 at .2925.
[93] SBM.040.001.0001 at .0011.
[94] SEQ.001.014.2912 at .3008; SBM.040.001.0001 at [55].
[95] SBM.040.001.0001 at [57].
[96] SEQ.001.014.2912 at .3008.

70 On 20 June 1979, both the *Wivenhoe Dam and Hydro-Electric Works Act 1979* (Qld) (the "Works Act")[97] and the *Brisbane and Area Water Board Act 1979* (Qld) (the "Water Board Act")[98] were assented to. The former dealt with the construction phase of the then developing Wivenhoe Dam and the latter with its use after completion. Both recognised its flood mitigation function. Section 6 of the *Works Act* vested the Co-ordinator General with responsibility for the construction of the Wivenhoe Dam project until it was completed and certified as complete. Section 8 provided for a relinquishing of control over the completed elements of the project by the Co-ordinator General to the Water Board once they were effectively useable. Upon that occurring, the Water Board was taken to be the occupier of the works comprising the project (s 9(2)). On completion of the project and the publication of a notice in the gazette, all property that was part of the project vested in the Water Board (s 10). During the construction of the project, a flood manual was required to be prepared "for the purpose of flood mitigation pending completion of the Wivenhoe Dam project" (s 32) and which, if approved and complied with, provided an immunity for liability for damages claimed in respect of loss or injury (s 34(a)). This provision's operation was similar to s 374(2) of the *Safety and Reliability Act*.

71 Section 22 of the *Water Board Act* vested the Water Board with various functions, including the supply of water and "reduc[ing], so far as practicable, the effects of flooding" (s 22(1)(e)). Section 106(1) required an "Advisory Committee" established under the Act to prepare a "manual of operational procedures in relation to each reservoir that is under the control of the Board for the purpose of flood mitigation". Once the manual was approved, s 107 required that it "shall be observed by the Board and its employees". Section 108 provided an exemption from liability for claims in respect of loss or injury arising from carrying out the procedures set out in the manual, similar to s 34(a) of the *Works Act*.

[97] No 32 of 1979.
[98] No 33 of 1979.

72 Wivenhoe Dam is located downstream of Somerset Dam on the Brisbane River. When Wivenhoe Dam is at its FSL of EL 67.0m AHD, water in Lake Wivenhoe abuts the face of Somerset Dam. The following diagram locates Wivenhoe Dam relative to Somerset Dam:[99]

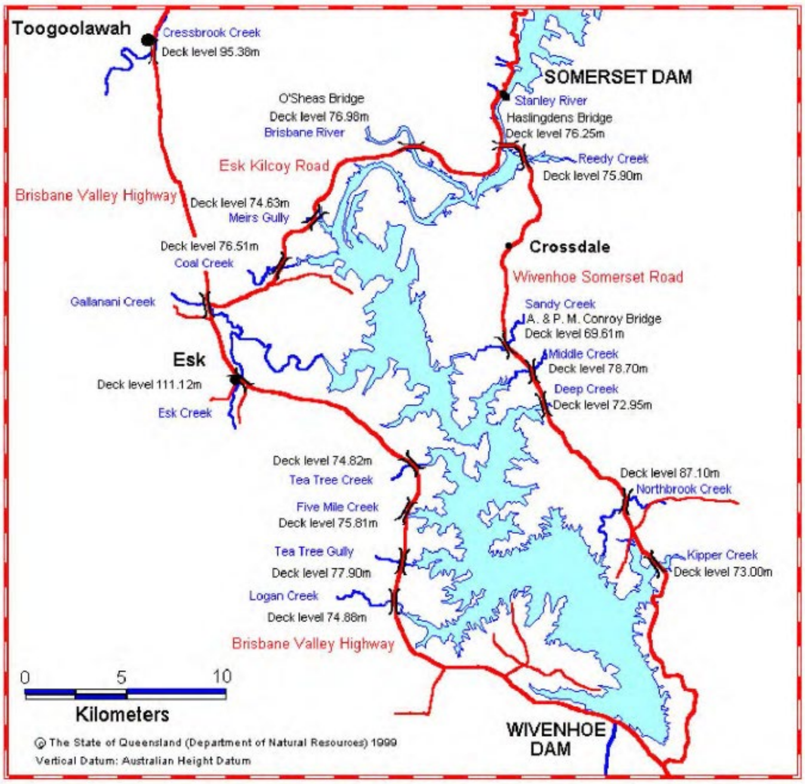

Figure 2-3: Map depicting location of Wivenhoe Dam relative to Somerset Dam

73 Wivenhoe Dam is a "zoned earthfill embankment dam which is made out of sandstone and common compacted clay, with sand and gravel filters".[100] Wivenhoe Dam has a primary spillway and auxiliary spillway that was constructed in 2005.[101] The following is a diagram of the primary spillway taken from the Manual:[102]

[99] Manual at 69.
[100] LAY.SEQ.002.0001 at [197] to [199].
[101] Manual at 20.
[102] Id.

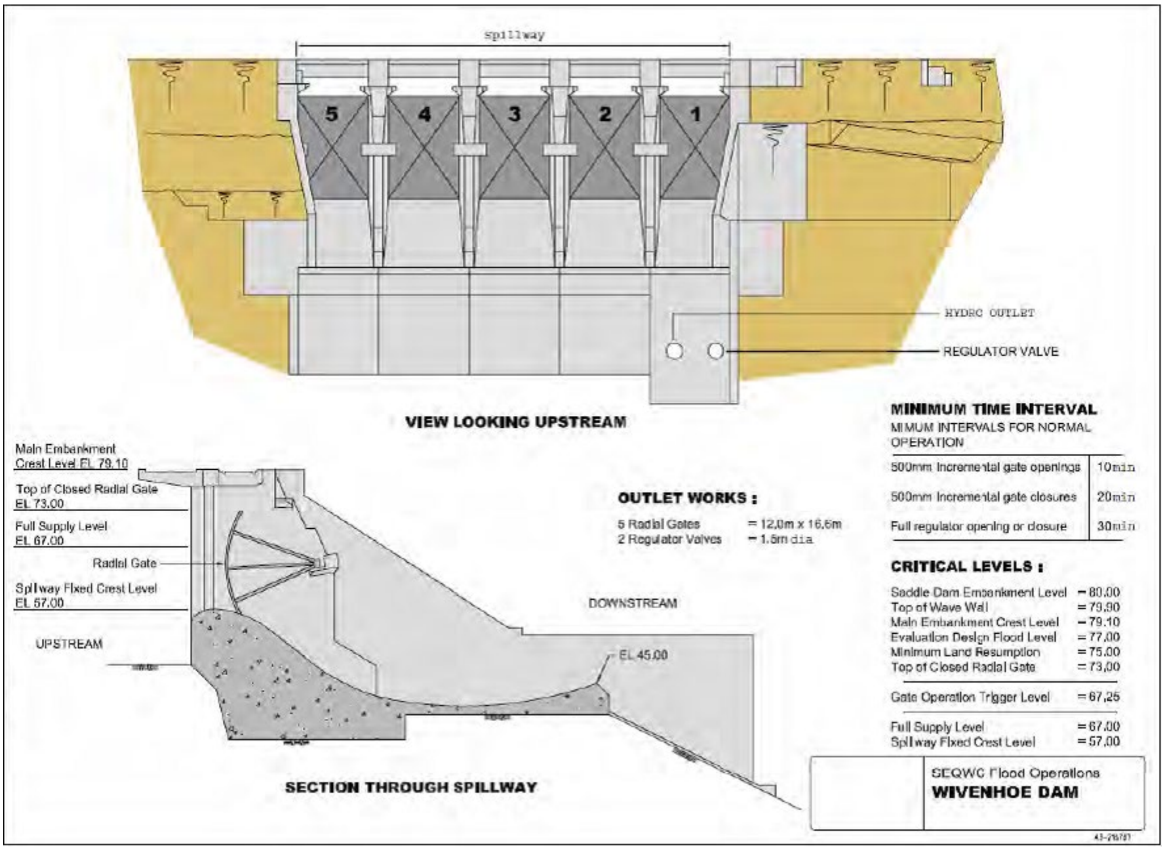

Figure 2-4: Wivenhoe Dam primary spillway

74 Mr Maher described the primary spillway as “a concrete gravity structure with a curved crest with five radial gates”.[103] The embankment level of the dam (that is, the highest point of the dam structure, which aligns with the earthen embankments that abut the dam wall on either side), is at EL 80.0m AHD, which also represents the overtopping level of the dam. The Manual states that, as Wivenhoe Dam is a “central core rockfill dam”, it is not resistant to overtopping,[104] such that the overtopping level of EL 80.0m AHD represents the “likely failure level” for Wivenhoe Dam.[105] It states that a structural failure of Wivenhoe Dam “would have catastrophic consequences”.[106] Mr Maher stated that “the probability of failure is dependent upon the duration of the flow, the depth of overtopping and the likely extent of scouring of the crest”.[107]

[103] LAY.SEQ.002.0001 at [202].
[104] Manual at 9.
[105] Ibid at 41.
[106] Ibid at 9.
[107] LAY.SEQ.002.0001 at [208].

75 Each of the radial gates (also referred to as "crest gates") at Wivenhoe Dam has a central pivot point. They are curved and have support arms that allow the gate to pivot around a pin attached to the bridge pier on either side of the gate. When opened, water spills underneath the raised crest gate. The radial gates are numbered "1" to "5" in the above diagram. The Manual states that when they are fully closed the bottom of each radial gate is at EL 56.36m AHD and the top of each gate is at EL 73.0m AHD.[108] The Manual provides that, under normal operations, the gates are to be opened by 0.5m increments, one at a time and at minimum intervals of ten minutes.[109] It specifies a gate opening sequence that starts with opening the middle gate, gate 3, to a level of 3.5m upwards, before opening any other gate.[110] The gates can be opened to 17.5m each, in which case the top of each gate would be at a height of EL 80.35m AHD, which is above the overtopping level of the dam.[111] The Manual states that the radial gates are designed to withstand overtopping but it should be avoided, as "once overtopped, the gates become inoperable when the lifting tackle is fouled by debris from the overflow".[112]

76 Wivenhoe Dam has one regulator valve situated in the primary spillway structure. Mr Maher noted that, as with the regulator valves at Somerset Dam, the valve allows the dam operator to disperse water safely in order to avoid damage to the dam or the downstream river channel.[113]

77 There are two hydroelectric power generation facilities associated with Wivenhoe Dam. One is incorporated into the structure of the primary spillway structure as depicted in Figure 2-4. The other is a dam facility located at Splityard Creek Dam on the eastern side of Wivenhoe Lake. Mr Maher described that dam's capacity as 28,000ML.[114]

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[108] Manual at 57.
[109] Ibid at 33 to 34.
[110] Ibid at 34.
[111] Ibid at 36, 57.
[112] Ibid at 62.
[113] LAY.SEQ.002.0001 at [206].
[114] Ibid at [248] to [249].

78 At its FSL (ie, EL 67.0m AHD), Wivenhoe Dam stores 1,165,000ML of water.[115] Like Somerset Dam, as the water level increases above FSL (and decreases below FSL) its storage capacity increases (and decreases) at a non-linear rate.

The Auxiliary Spillway and the "Fuse Plugs"

79 By 2005, construction of an auxiliary spillway on the right abutment of Wivenhoe Dam was completed.[116] It is situated to the left of the diagram set out above (and to the west of the primary spillway). The auxiliary spillway included three "fuse plug embankments". Mr Maher described them as "an embankment dam that impounds water until the water rises to a predetermined level at which point the embankment overtops and erodes in a controlled manner".[117] Once a fuse plug embankment erodes there is a large uncontrolled discharge of flows, although the discharge emanating from Wivenhoe Dam can still be controlled through the radial gates.[118] Mr Maher stated that the "purpose of the three fuse plugs constructed at Wivenhoe Dam was to enhance the safety of the dam by increasing the spillway capacity available when the lake level has risen above the trigger levels for the fuse plugs".[119] The trigger levels for the erosion of the three fuse plug embankments are EL 75.7m AHD, EL 76.23m AHD and EL 76.78m AHD.[120] Each has a crest level of EL 67.0m AHD so that if they erode, uncontrolled discharge will occur from that level until they are rebuilt.[121] The Manual indicates that if the dam level is EL 76.0m AHD, then the discharge rate from the first fuse plug embankment to trigger would be 1873m^3/s. If the dam level is EL 77.0m AHD, then the discharge rate from the second and third embankments to trigger would be around 4,000m^3/s each.[122]

[115] Manual at 53.
[116] AID.500.028.0001 at [79]; Manual at 2.
[117] LAY.SEQ.002.0001 at [235].
[118] Ibid at [237].
[119] Ibid at [236].
[120] Manual at 20 to 21.
[121] Id.
[122] Ibid at 58.

2.6: The Downstream Bridges and Flow Times

80 The above description of the Brisbane River catchment makes reference to various bridges and roads that cross the Brisbane River above and below the dams. As explained in Chapter 3, the Manual describes various flood sub-strategies by reference to the inundation level of a subset of bridges downstream of Wivenhoe Dam, namely Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge, Kholo Bridge, Mt Crosby Weir Bridge and Fernvale Bridge. It also designates certain flow rates at Lowood and Moggill on the Brisbane River as determining the thresholds for urban inundation. Lowood is just below the junction of Lockyer Creek with the Brisbane River and thus measurements of flow rates at Lowood capture outflows from Wivenhoe Dam and Lockyer Creek as it merges with the Brisbane River. Moggill is just below the junction of the Bremer River with the Brisbane River and thus measurements of flow rates at Moggill capture outflows from all of Wivenhoe Dam, Lockyer Creek and Bremer River as it flows into the Brisbane River.

81 The following map taken from the Manual indicates the position of these bridges vis-á-vis as much of the Brisbane Valley Highway that extends at least as far as Wivenhoe Dam and that travels down the Brisbane Valley:[123]

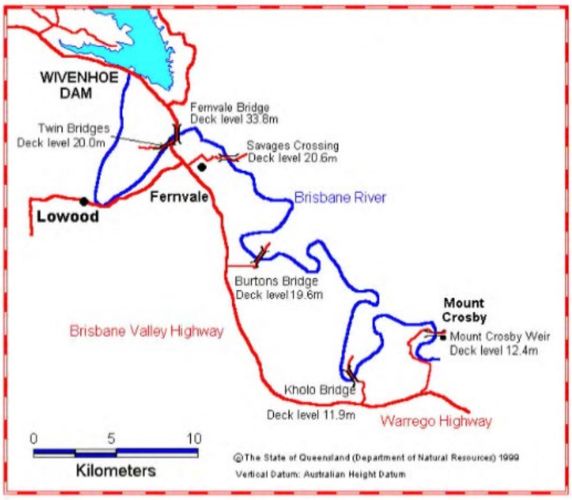

Figure 2-5: Map depicting location of bridges below Wivenhoe Dam

[123] Manual at 70.

82 The parties agreed that the following schematic diagram of the Brisbane River and its tributaries "shows a rough guide of the various times it takes for flows downstream of Wivenhoe Dam to reach the Brisbane Port Office gauge".[124] The parties also agreed that "these times will vary as they depend upon stream height and corresponding in-stream and floodplain storage volume as well as actual flows occurring in real time in the Brisbane River and its tributaries".

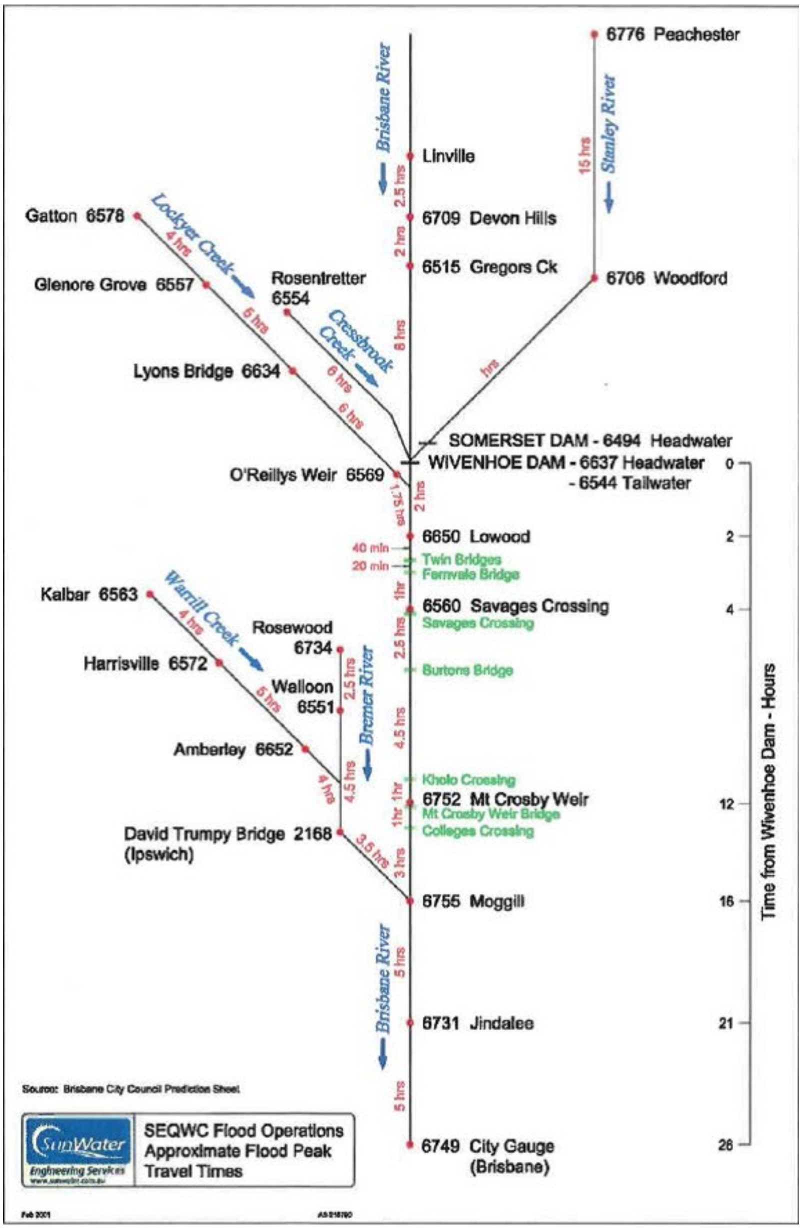

Figure 2-6: Flow times in the Brisbane River catchment

[124] AID.500.028.0001 at .0001, .0019; EXP.ROD.001.0583 at .0601.

83 The “City Gauge” referred to in this diagram is a location in downtown Brisbane. One important feature of this diagram is the relatively short time that it takes upstream flows to arrive at either Somerset Dam or Wivenhoe Dam. This diagram indicates the maximum time is approximately 15 hours, although this does not account for the time between when the rain falls and it arrives at a stream. Nevertheless, as explained in the balance of the judgment, those upstream flow times represent a relatively short planning period if flood operations are determined based only on rain that has already fallen.

2.7: Bridge Closure

84 Given that an aspect of the plaintiff’s case is that the flood engineers acted unreasonably during the January 2011 Flood Event in failing to increase releases from Wivenhoe Dam to a level sufficient to inundate some of the bridges referred to above at [80], it is necessary to summarise the evidence concerning the impact of their inundation. These bridges (and other features of the Brisbane catchment) were inspected by the Court on a “view” undertaken in accordance with s 53 of the *Evidence Act 1995* on 13 February 2018. The Court is entitled to draw any reasonable inference from what it observed during that view (s 54).

85 In terms of the time it takes for released flows to move down the Brisbane River (flow time), Twin Bridges is approximately two hours and forty minutes below Wivenhoe Dam, 40 minutes below Lowood and 20 minutes above Fernvale Bridge.[125] It has an inundation level of 50m^3/s. On the inspection, there was no flow out of Wivenhoe Dam. It was elevated above a low water level by around a metre.[126] It appeared to only be able to accommodate light traffic. Mr Ayre described it as a “minor crossing that conveys local traffic between Wivenhoe Pocket and Fernvale”.[127]

[125] LAY.SUN.001.0001 at [105(a)]; AID.500.028.0001 at .0019.
[126] Consistent with the photo at EXP.ROD.001.0583 at .0619.
[127] LAY.SUN.001.0001 at [105(a)].

86 Savages Crossing is located approximately four hours flow time downstream of Wivenhoe Dam.[128] It is inundated by flows of 130m^3/s or above. Like Twin Bridges, the view revealed that the bridge had a low elevation and only appeared suited to light traffic.[129] It had only one lane. Mr Ayre described it as a "local road that conveys traffic between Fernvale and Banks Creek".[130]

87 Colleges Crossing is located approximately thirteen hours flow time downstream of Wivenhoe Dam and only one hour downstream of Mt Crosby Weir Bridge. It has an inundation level of between 175m^3/s to 200m^3/s. Again, it is low lying and does not appear suited to use by substantial traffic.[131] Mr Ayre described it as a "relatively low, but highly trafficked, bridge" that "conveys traffic between Ipswich and the western suburbs of Brisbane".[132] Both Twin Bridges and Colleges Crossing are located near substantial bridges across Brisbane River (Fernvale Bridge and Mt Crosby Weir Bridge respectively).

88 Burtons Bridge is located approximately 2.5 hours flow time downstream from Savages Crossing and approximately 6.5 hours downstream of Wivenhoe. It straddles farming properties on either side of the Brisbane River. It is a single lane paved bridge with at least one road to the bridge unsealed.[133] In cross-examination, Mr Tibaldi agreed that the inundation of Burtons Bridge results in approximately 32 households being isolated[134] and that otherwise drivers have to travel further to cross the Brisbane River.[135]

89 Kholo Bridge is eleven hours downstream flow time from Wivenhoe Dam and is one hour flow time upstream of Mt Crosby Weir Bridge. It is inundated by flow rates of 550m^3/s or higher. It is another single lane paved bridge.[136] Mr

[128] LAY.SUN.001.0001 at [105(c)].
[129] Consistent with photo at EXP.ROD.001.0583 at .0618.
[130] LAY.SUN.001.0001 at [105(c)].
[131] Consistent with photo at EXP.ROD.001.0583 at .0614.
[132] LAY.SUN.001.0001 at [105(g)].
[133] Consistent with photo at EXP.ROD.001.0583 at .0613.
[134] T 5551.43 to T 5552.2 (Tibaldi); LAY.SUN.001.0001 at [112].
[135] T 5551.39 (Tibaldi).
[136] EXP.ROD.001.0583 at .0616.

Ayre described it as a “local road that connects Kholo with Ipswich”.[137] As discussed in Chapter 6, it was unusable during the January 2011 Flood Event.

90 Mount Crosby Weir Bridge is located approximately twelve hours flow time downstream from Wivenhoe Dam.[138] The Manual states that it has an inundation level of 1900m^3/s.[139] Seqwater operates a pumping station near the bridge. The bridge links parts of Ipswich to areas north of Brisbane River. Mr Ayre described it as a “limited capacity bridge”.[140]

91 Fernvale Bridge is located approximately three hours flow time downstream from Wivenhoe Dam. It has an inundation level of 2000m^3/s. It is a substantial structure well elevated from the river level at the time of observation. It is evident from the diagram at [81] that the closure of Fernvale Bridge cuts the areas of Wivenhoe Dam and above from access to the Brisbane Valley Highway. Mr Ayre described it as an “important access route for traffic travelling up the Brisbane Valley and it connects Wivenhoe Dam to Fernvale”.[141]

92 Dr Christensen noted that with all these bridges, reasonable alternative access is available to all the rural areas serviced by these bridges (except for the areas accessed by Burtons and Mt Crosby Weir Bridges).[142]

93 At this point, I note that in his statement Mr Ayre also described the various impacts on downstream rural communities from releases from Wivenhoe Dam, including those resulting from making releases at flow rates below what the Manual describes as the threshold for non-damaging flows downstream.[143] These include the cessation of ferry operations at Moggill at

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137 LAY.SUN.001.0001 at [105(e)].
138 Ibid at [105(f)].
139 Revised after the event to 1800m^3/s.
140 LAY.SUN.001.0001 at 105(f); see EXP.ROD.001.0583 at .0617.
141 LAY.SUN.001.0001 at [105(b)].
142 February 2015 Report, EXP.ROD.001.0016 at [96].
143 LAY.SUN.001.0001 at [106] to [118]; see Chapter 3.

flow rates of 350m^3/s or higher[144] and the inundation of a sand and gravel business on the north side of Fernvale at flow rates of 1500m^3/s.[145]

2.8: Modelling a Catchment Runoff Response

94 It is necessary to note three matters relevant to modelling the relationship between rainfall and runoff in a given catchment. The first is that assuming a constant rainfall intensity on a typical small catchment that does not consist of either a hard surface or a watercourse, the infiltration and runoff response can generally be represented by complementary curves similar to the following:[146]

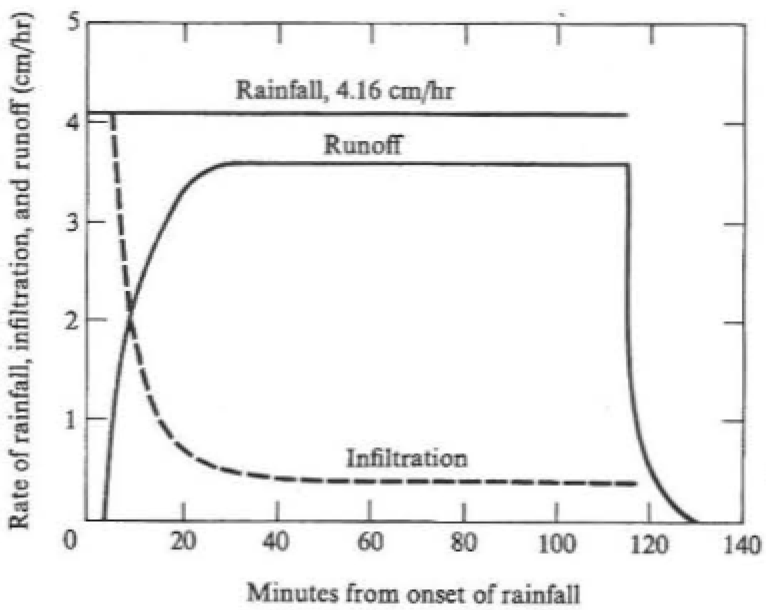

Figure 2-7: Rainfall runoff and infiltration curves for an artificial storm of constant intensity

95 As catchments become larger, infiltration rates vary with ground conditions. Further, given that actual rainfall will never be spatially or temporally uniform over a large area and given variations in catchment ground conditions, a measurement of the runoff response of a large catchment to a lengthy period of rainfall will not display anything like the smoothness of the above diagram. However, its basic feature will still hold, namely that as the catchment

[144] LAY.SUN.001.0001 at [115].
[145] Ibid at [110].
[146] MSC.010.053.0001 at .0004; T 2810.29 (Christensen).

becomes wetter, infiltration rates drop and the rate of runoff increases towards a saturation level.

96 Second, one method of modelling runoff responses from catchments such as those above and below Wivenhoe Dam during a flood event is by using an “initial loss” (IL) and “continuing loss” (CL) modelling method. With this method, at a given point in time, each catchment or sub-catchment is attributed with an initial loss rate and a continuing loss rate. The initial loss rate represents the depth of rain that must fall in the catchment or sub-catchment at the start of (or prior to) the flood event before any runoff is generated. Initial loss rates are catchment specific and vary over time as the catchment becomes drier or wetter. Once initial losses are “satisfied” and runoff commences, they generally become irrelevant to the modelling of predicted inflows. Typical initial loss rates for the sub-catchments above and below Wivenhoe Dam employed by the flood engineers during the January 2011 Flood Event varied between 0mm and 40mm of rainfall.

97 A continuing loss rate represents the depth of rainfall that must fall within a specified time period before runoff will be generated. Continuing loss rates are typically measured in millimetres of rainfall per hour. Consistent with the response curve noted above, continuing loss rates will generally reduce as more rainfall occurs and the catchment becomes saturated. At some point, as the catchment approaches complete saturation, these rates will achieve or trend closely near the horizontal portion of the above curves. However, one difficulty for a flood engineer is that through the course of a flood event, even as they calibrate loss rates to observed conditions, they may not know whether a saturation point has been reached. At the most extreme, the continuing loss rate of a hard surface such as concrete or rain failing directly on a reservoir is 0mm/hr. The continuing loss rates used by the flood engineers to model inflows from rain that had already fallen (“rain on the ground”) above and below Wivenhoe Dam during the January 2011 Flood Event generally varied between 0.5mm/hr and 2.5mm/hr.

98 Thus, a simple example consists of a catchment with an initial loss rate of 20mm and a continuous loss rate of 2mm/hr that receives 5mm of rain per hour uniformly for ten continuous hours. Such a catchment would record 18mm of runoff in total, as the first four hours would see the catchment absorb (or "satisfy") the initial loss of 20mm and, for the remaining six hours, 2mm/hr (ie, a total of 12mm of rainfall) would be lost to absorption. If the catchment was 100km^2 then the volume of rain that would runoff would be 1800ML. In this simple example, the volume of runoff is particularly sensitive to the hourly distribution of rain and the selected loss rates. If the same amount of rain fell continuously over twenty hours (ie, at 2.5mm per hour) then the catchment would only record 6mm (or 600ML catchment-wide) of runoff.[147] If the rainfall period remained at ten hours but the initial loss rate was reduced to 10mm and the continuing loss rate to 1mm/hr then the catchment would record 32mm (or 3200ML catchment-wide) of runoff.[148] The sensitivity of modelling predicted flood inflows to variations in rainfall depth, loss rates as well as the differences in spatial and temporal distributions of rainfall was a significant issue in this case. It is addressed in Chapters 6 to 10.

99 Third, as explained in subsequent chapters, one aspect of forecasting inflows is to account for so called "baseflow". Although in one part of its submissions the plaintiff sought to impute a different meaning to the concept,[149] it appears that the common understanding of "baseflow" is that portion of inflows that is not runoff from rains or streams but is instead the product of seepage of water from the ground into a channel over a longer time frame than surface runoff.[150] As the flow time for baseflow is slower from surface runoff,[151] it has to be accounted for differently in inflow modelling. An example of how different

[147] Initial losses would take 8 hours to be satisfied and thereafter only .5mm of rain would run off per hour = 12 x 0.5 = 6mm.
[148] The first 2 hours would satisfy initial losses and thereafter 4mm of rain would run off per hour = 8 x 4 = 32mm.
[149] See Chapter 3 at [74].
[150] LAY.SEQ.007.0001, [107]; Response Report, EXP.ROD.015.0001 at [249].
[151] February 2015 Report, EXP.ROD.001.0016 at [44].

assumptions about baseflow and approaches to modelling interact with the modelling of runoff is discussed in Chapter 9.[152]

2.9: The Real Time Flood Model ("RTFM")

100 The provisions of the Manual are addressed in detail in Chapter 3. At this point, it is necessary to refer to so much of it as describes the Real Time Flood Model ("RTFM") that was available to, and used by, the flood engineers during the January 2011 Flood Event. Section 5.2 of the Manual states that the Senior Flood Operations and Flood Operations Engineers use the RTFM for flood monitoring and forecasting during the flood events to operate the dams in accordance with the Manual.

101 Section 5.1 of the Manual describes the RTFM as follows:

> "A real time flood monitoring and forecasting system has been established in the dam catchments. This system employs radio telemetry to collect, transmit and receive rainfall and stream flow information. The system consists of more than 100 field stations that automatically record rainfall and/or river heights at selected locations in the dam locations….
>
> The rainfall and river height data is transmitted to Seqwater's Flood Operations Centre in real time. Once received in the Flood Operations Centre, the data is processed using a Real Time Flood Model (RTFM) to estimate likely dam inflows and evaluate a range of possible inflow scenarios based on forecast and potential rainfall in the dam catchments. The RTFM is a suite of hydrologic and hydraulic computer programs that utilise real time data to assist in the operation of the dams during flood events."

102 The following description of the constituent elements of the RTFM is largely taken from Seqwater's submissions, which in turn were taken from Mr Malone's statement.[153] The RTFM has three components: "FloodCol", being its data collection system; "FloodOps", being its flood simulation system; and a "Gate Operations Spreadsheet" ("GOS"), being an excel spreadsheet exported by the system for use on a personal computer.[154]

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[152] Chapter 9 at [250] to [257].
[153] Seqwater subs at [1073] to [1076]; LAY.SEQ.007.0001 at [56] to [123].
[154] LAY.SEQ.007.0001 at .0017, [57].

103 FloodCol collects real time rainfall data via a network of rainfall sensors and water level stations (or streamflow gauges) in six key regions above and below the dams, namely: the Upper Brisbane River; the Stanley River (also known as Somerset Dam); the Middle Brisbane River; Lockyer Creek; the Bremer River; and the Lower Brisbane River.[155]

104 FloodOps is a computer program, apparently written in FORTRAN,[156] that simulates flood behaviour via a series of 23 linked models that represent different parts of the Brisbane River basin.[157] These models cover the six key catchment regions, which were divided further into 23 smaller sub-catchments, with a model for each of the 23 sub-catchments as follows:[158]

Region	Representative Catchment Models	Catchment Area (km^2)
Stanley River to Somerset Dam	SDI	1,328
Upper Brisbane River to Wivenhoe Dam (excluding Stanley River)	COO, LIN, EMU, CRE, GRE, WDI	5,673
Lockyer Creek	HEL, TEN, LAI, GAT, LYO, SAV	3,163
Bremer River to Ipswich	WAL, KAL, AMB, PUR, IPS	2,032
Lower Brisbane River	MTC, JIN, POG, ENO, BUL	1,299

Table 2-1: Catchments modelled in the RTFM

105 The location of these sub-catchments is indicated by the following diagram:[159]

[155] Ibid at .0018 - .0020, [63] and [64].
[156] Software code for Formula translation.
[157] LAY.SEQ.007.0001 at .0021 - .0023, [70] to [74].
[158] Ibid at .0022 - .0023 and .0025 - .0026, [73], [74] and [79]; “Upper Brisbane River to Wivenhoe Dam” includes Upper Brisbane River and Middle Brisbane River.
[159] Ibid at .0023.

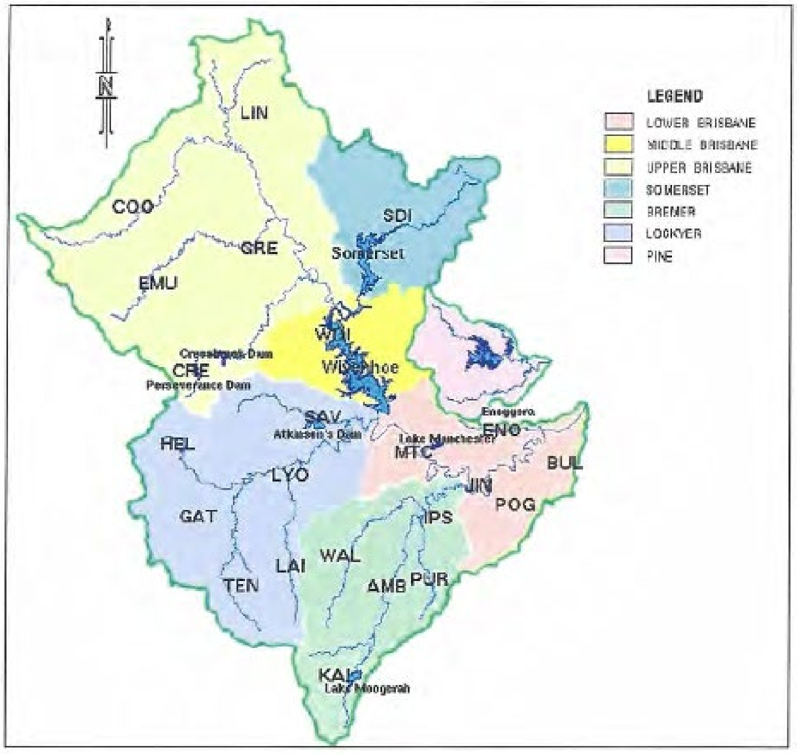


Figure 2-8: Map of RTFM sub-catchments

106 Each such model consists of a “rainfall runoff model”, which estimates the volume of runoff from the rainfall input and a “runoff routing model”, which routed the runoff (also referred to as “excess rainfall” by Mr Malone in his statement) to points of interest.[160]

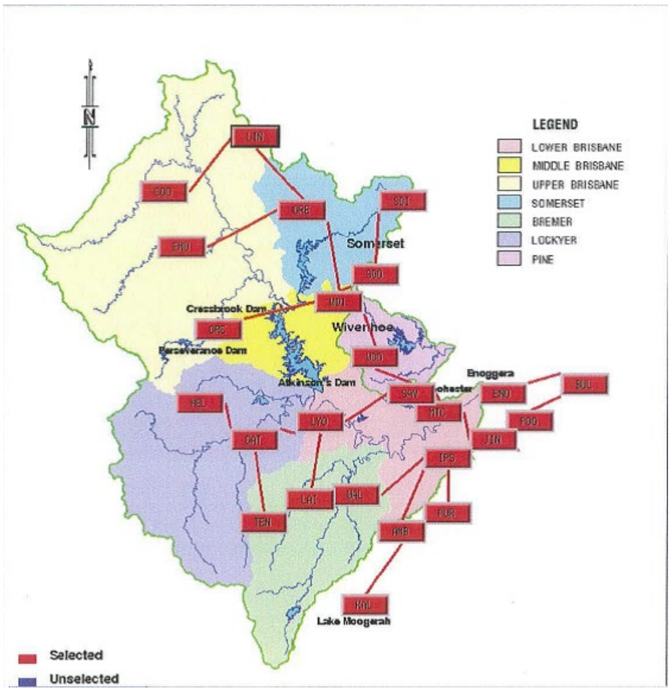
107 The rainfall runoff model adopts the initial loss/continuing loss modelling approach described above. Mr Malone stated that the approach adopted by the flood engineers in selecting initial loss rates to use in the RTFM was estimating initial loss rates from the Australian Precipitation Index (API) model at the start of a rainfall event and adjusting this figure during the early stages of a flood to match recorded rises at gauging stations.[161] He stated that continuing loss rates were selected based on historical calibrations and any recent experience,[162] and were also adjusted as more data was received to match the rated flows and/or the water levels in the dams.[163] This is further

[160] Ibid at .0027, [87].
[161] Ibid at .0028 TO .0029, [91(a)]; see also Chapter 9, section 9.5.
[162] Ibid at .0036, [115(d)].
[163] Ibid at .0029, [92].

addressed in Chapters 6 to 9. Screenshots from particular applications of FloodOps were tendered.[164] Some are set out in Chapter 6.[165]

108 The runoff routing model routed runoff from a sub-catchment to the outlet of that sub-catchment[166] and cumulated the results from all of the sub-catchments to take account of the temporal and spatial variation of rainfall over the total catchment.[167] It produced flow hydrographs, which could be converted to heights at points in the catchment where ratings were available.[168] (An example of these hydrographs is set out in Chapter 9 at [247]). Mr Malone noted that the modelled levels could be compared directly with observed levels as recorded from the gauging stations within FloodCol.[169]

109 In his third affidavit, Mr Ayre sets out a screenshot from the RTFM depicting the routing of water flows within the RTFM as follows:[170]



[164] For example MSC.010.354.0001.
[165] At [275], [300] and [305].
[166] LAY.SEQ.007.0001 at .0031, [100].
[167] Id.
[168] Ibid at .0031, [100] to [101].
[169] Ibid at .0031, [101].
[170] LAY.SUN.007.0001 at .0013.

Figure 2-9: Routing of water flows in the RTFM

110 Mr Ayre explained this was a "simple conceptual representation of catchment storage effects". In relation to the sub-catchments above the dams, Mr Ayre said that the RTFM models routed flows emanating from COO to flow into and combine with the flows at LIN, with those combined flows from LIN flowing into and combining with flows at GRE. He said that flows from EMU also flow into and combine with the flow at GRE and the combined flow at GRE combines with the flow at WDI, with flows from CRE also flowing into and combining with the flow at WDI. Further flows emanating from SDO then combine with the combined flows at WDI.[171]

111 Typically the GOS produced by the flood engineers contained imported runoff data and runoff hydrographs from FloodOps.[172] The GOS numerically and graphically represent Somerset Dam inflows (SDI), (ie, from the Stanley River into Somerset Dam), Wivenhoe Dam inflows (WDI) (ie, inflows from the Upper Brisbane River into Wivenhoe Dam (excluding Somerset Dam outflows)), Lockyer Creek outflows (LYO) into the Brisbane River and Bremer River outflows (IPS)[173] into the Brisbane River.

112 The GOS allows the flood engineer to include a component for baseflow[174] and convert the inflow hydrograph to a height or elevation level (EL). The modelled water level could then be compared to the water level as recorded by the Dam Operators. The GOS enabled the flood engineers to plan and record proposed gate settings for future releases and calculate predicted outflows from the dams, predicted combined downstream flows and predicted dam levels based on those proposed outflows and the inflow hydrograph.[175] A number of GOS that were created during the January 2011 Flood Event by

[171] Ibid at [28].
[172] LAY.SEQ.007.0001 at .0032, [103] to [104].
[173] Ibid at .0032, [104].
[174] Ibid at .0032, [105].
[175] Ibid at .0038, [115(k)].

the flood engineers were preserved and tendered,[176] as were a number created afterwards.[177]

113 The RTFM has the capacity to undertake modelling based on forecast rainfall. A flood engineer can select a rainfall depth to be inserted into a particular catchment or sub-catchment with a particular temporal pattern.[178] As discussed in later chapters, the RTFM contains a number of pre-programed temporal patterns, although the user could input their own. The flood engineer could also select the relevant initial and continuing loss rates they proposed to incorporate into the modelling process.

2.10: Available Rainfall Products

114 At the heart of the plaintiff's case is the contention that the Manual required the flood engineers to utilise rainfall forecasts in the selection of flood strategies and in making releases during the January 2011 Flood Event, that they did not, and that one or more of Dr Christensen's simulations encompassed the use of forecasts that a reasonably competent flood engineer was obliged to undertake. Those contentions, including an assessment of the reliability of the forecast products, are addressed in subsequent chapters. At this point it suffices to simply describe the forecast products that were available to the flood engineers.

PME Forecasts

115 Prior to and during the January 2011 Flood Event, there was available to the flood engineers a number of forecast products, specifically the Bureau of Meteorology (BoM) Probability Matched Ensemble ("PME")[179] forecasts, the Quantitative Precipitation Forecasts ("QPFs") and SILO Meteograms

116 According to Professor Manton, the PME system "is a computer-generated product that combines the rainfall predictions of eight numerical weather

[176] Eg SUN.002.002.3612.
[177] Eg SUN.002.002.2634.
[178] LAY.SEQ.007.0001 at .0030, [95]; T 5102.9 - .21.
[179] Also known as the "Poor Man's Ensemble"; T 3631.21 (Manton).

prediction models from around the world to provide an estimate of daily rainfall across Australia at a spatial resolution of 0.5 degrees (about 50km)".[180] Two of the eight models are run by the BoM itself, namely the ACCESS-R and ACCESS-G models.[181]

117 PME forecasts were first placed on the BoM website in August 2009. They were upgraded in 2010 when the spatial resolution of the product was increased from 1 degree to 0.5 degrees.[182] At the relevant times, there were two grid points in the catchments above the dam, two in the Lockyer Creek catchment and one in each of the Lower Brisbane River and Bremer River catchments.[183]

118 The BoM website made daily PME forecasts available for five individual days ("daily PME's") with the forecast for the first day being the "one-day PME", as well as forecast rainfall totals for days one to four (the "four-day PME"), days five to eight, and days one to eight (the "eight-day PME").[184]

PME Measurement

119 The forecast information in a PME was not displayed in a textual or digital format but in Australia-wide contour maps that provided a range of rainfall represented by a colour. For example, the following is a one-day PME for 10 January 2011:[185]

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[180] EXP.SEQ.004.0131 at .0145.
[181] Ibid at .0144.
[182] Ibid at .0146.
[183] Ibid at .0144.
[184] Ibid at .0146.
[185] EXP.ROD.014.0034 at .0038.

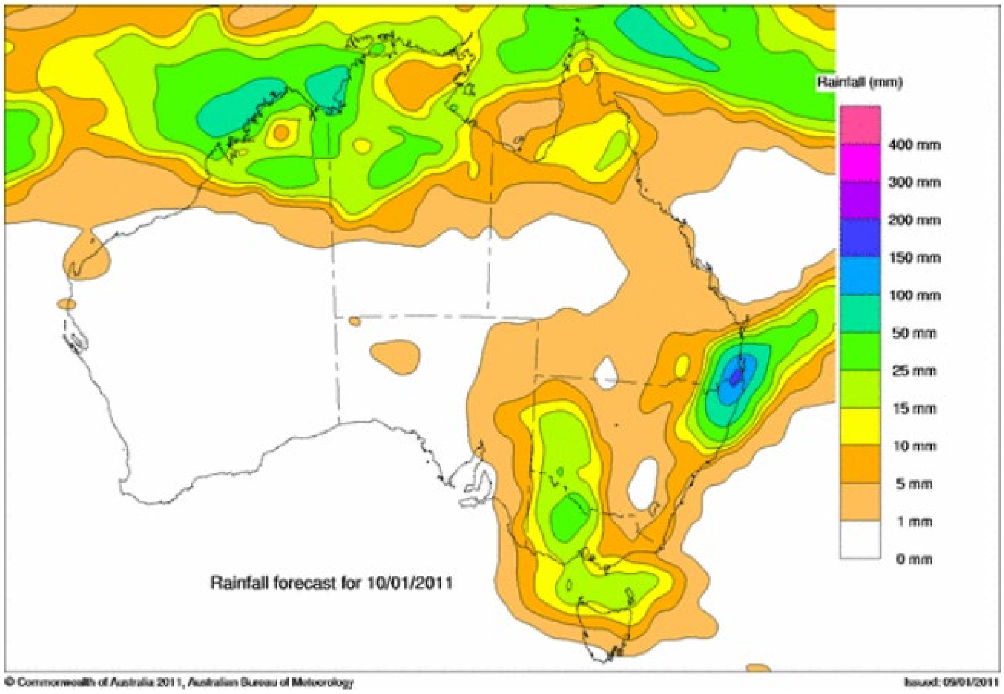

Figure 2-10: Example of a one-day PME forecast

120 Similarly, an eight-day PME for the same date was as follows:[186]

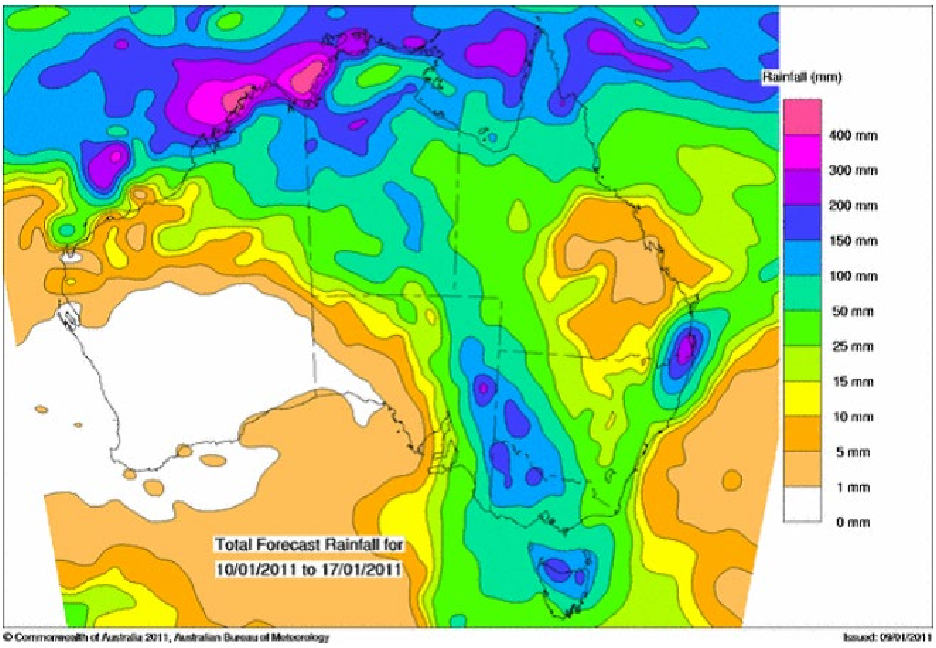

Figure 2-11: Example of an eight-day PME forecast

[186] EXP.ROD.014.0034 at .0038.

121 The area that corresponds to south-east Queensland in the above is coloured purple, indicating the large amount of rain that was forecast to fall over eight days as at 10 January 2011.

122 During January 2011 these contour style maps were available to the flood engineers on the world wide web and could be expanded to effectively "zoom in" on the areas above, below and around the dams to ascertain a range of predicted rainfall.[187] The map did not include specific location identifiers such as cities or the catchment boundaries so a flood engineer would have to superimpose those locations on the map.[188] For the purpose of these proceedings, Dr Nathan compiled the various PME forecasts in a manner that focused on the catchment areas above, below and around the dams.[189] He was able to expand the images so that they were presented in a manner similar to that readable by the flood engineers during the January 2011 Flood Event. However, he also had the assistance of geo-referencing software which allowed him to superimpose the catchment and sub-catchment areas onto the maps, as well as streamflow and rainfall gauge locations. For example, the following is the map Dr Nathan produced of the four-day PME forecast available at midnight on 7 January 2011.[190]

[187] T 1414.28 (Christensen).
[188] T 1414.38 to T 1415.2 (Christensen).
[189] EXP.SEQ.014.0219 at .0222 to .0224.
[190] EXP.SEQ.014.0366.

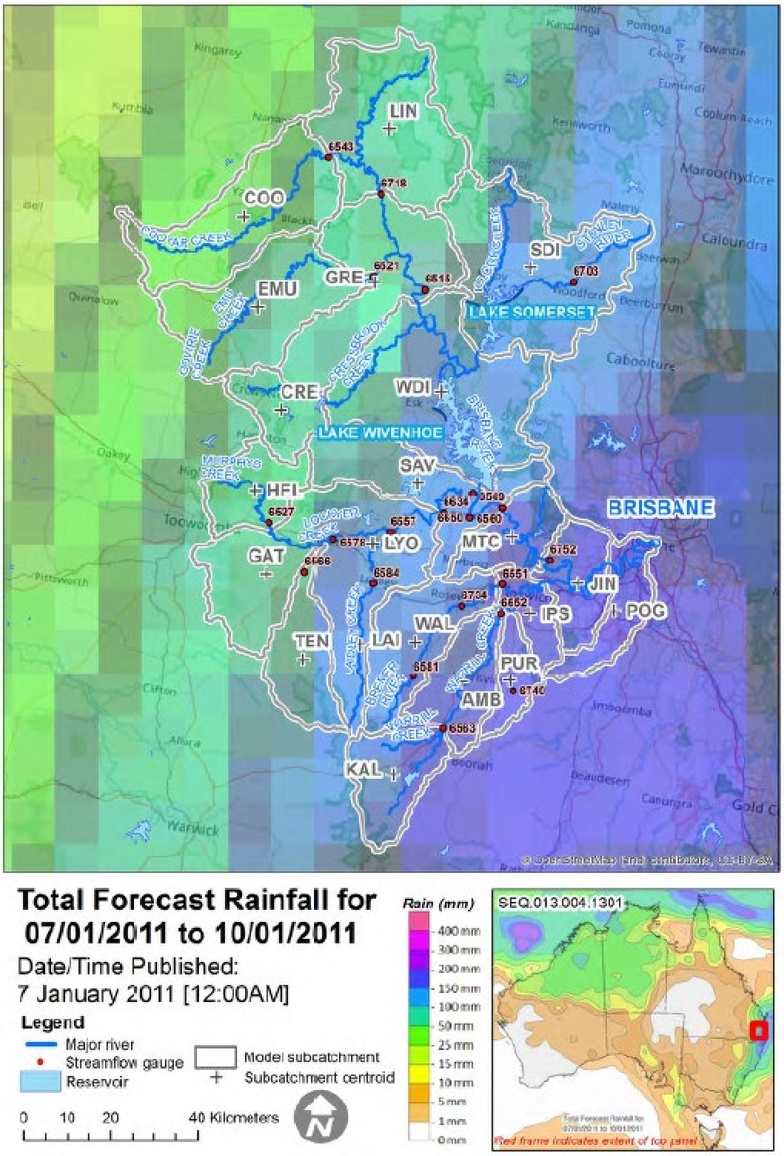

Figure 2-12: Sample four-day georeferenced PME forecast

123 As explained in Chapter 9, although there was a large amount of evidence about the difficulties in interpreting PME forecasts, in the end result the respective interpretations of the four and eight-day PMEs by the parties and the expert witnesses were all within a relatively narrow range.[191] Further, as explained in Chapters 6 and 7, there is some objective evidence as to what the flood engineers ascertained from the PME forecasts during the January 2011 Flood Event in the situation reports they issued from time to time.

[191] See Chapter 9 at [138] to [163].

124 Professor Manton stated that the contour style PME maps were generated by an algorithm that "smoothed" the results at each grid point produced by the modelling through the use of a "graphics package".[192] Professor Manton explained that the interpolation by that package between the grid points is accurate, although the selection of the amount of rainfall represented by a particular contour line was "arbitrary",[193] which made interpreting rainfall on contour lines between grid points more difficult.[194]

Probability of Exceedance ("POE") Forecasts

125 The PME forecast suite also included probability of exceedance forecasts, those being predictions of the probability of rainfall over a certain amount eventuating. According to Professor Walsh, these probabilities were derived from a statistical evaluation of the different predictions of the constituent models of the PME "to determine the level of agreement between them on the likelihood of a certain predicted rainfall amount". They included predictions of the probability of rainfall exceeding certain thresholds of 1, 5, 10, 15, 25 and 50mm per day.[195] Professor Manton stated that the POE percentage at a given grid point is simply the ratio of the number of constituent models with rainfall exceeding the threshold to the total number of models that comprise the PME.[196]

PME Availability

126 Ascertaining times associated with a PME forecast was not straightforward. The period over which rainfall is predicted by a daily PME forecast commences at 10.00pm in the evening and finishes at 10.00pm on the subsequent day. This is to be distinguished from what Professor Manton identified as the "start time for a [PME] forecast (10am or 10pm one day)" which he called the "base time".[197] The times of 10.00am and 10.00pm correspond to 00UTC and 1200UTC respectively. Professor Manton

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192 EXP.SEQ.004.0131 at .0144 to .0145; EXP.SEQ.010.0011 at [22].
193 T 3638 to T 3640.13.
194 T 3639.36.
195 EXP.SEQ.010.0001 at [33]; EXP.ROD.014.0034 at [1.7].
196 EXP.SEQ.010.0001 at [34].
197 EXP.SEQ.004.0131 at .0146.

described the "base time" as the "[s]tart time and date for a forecast" in the glossary to his report.[198] However, this is not synonymous with "the period over which rainfall is computed". Instead, it appears to be a reference to the point in time from which data is taken to prepare the forecasts.[199] Hence, Professor Manton noted the "lag" between the base time (eg, 10.00am for the one-day 00UTC PME) and the issue time (eg, 6.00pm for one-day 00UTC PME) is "due to … the need to wait for NWP [Numerical Weather Prediction] model output to become available from both the BOM and overseas operators … and … computer processing time for priority products".[200]

127 It was not in dispute that the one-day, four-day and eight-day PME forecasts with a base time of 10.00pm (ie, 1200UTC) were available to the flood engineers (and the public) at around 6.00am the next morning.[201] Thus, for example, at 6.00am on 4 January 2011 there was available to the flood engineers one-day, four-day and eight-day PME forecasts with a base time of 10.00pm on 3 January 2011 (ie, 1200UTC). Those forecasts concerned the relevant periods of time that commenced at 10.00pm on 3 January 2011, ie, the base time and the start of the period over which rainfall was forecast coincided,[202] but the forecasts were issued around eight hours after that period commenced.

128 It was also not in dispute that the one-day PME forecasts with a base time of 10.00am (ie, 00UTC) were available from 6.00pm on the same day.[203] For example, a one-day 00UTC PME forecast concerning rainfall in the period from 10.00pm on 4 January 2011 to 10.00pm on 5 January 2011 was available on the BoM website at 6.00pm on 4 January 2011. Although it was a 24-hour forecast, the base time for that forecast was 10.00am on 4 January 2011 (ie, 00UTC 4 January 2011).

198 EXP.SEQ.004.0131 at .0185.
199 Ibid at .0146.
200 Ibid at .0147.
201 SBM.010.013.0001 at [2]; see also EXP.SEQ.004.0131 at .0160.
202 See figure 5 at EXP.SEQ.004.0131 at .0146.
203 See SBM.010.013.0001 at [3]; see also EXP.SEQ.004.0131 at 0160.

129 There was, however, a dispute as to whether the four-day and eight-day 00UTC (ie, base time 10.00am) forecasts were issued at midnight or 6.00pm, the latter time being when the 24-hour PME 00UTC forecast was posted on the BoM's website.

130 The plaintiff noted that an archived version of the BoM website from July 2009 provided that the "4-day total maps are updated at midnight".[204] However, it submitted that this was superseded by a BoM bulletin issued on 30 November 2010 which outlined the effect of the operational upgrades to, inter alia, the PMEs described above.[205] It included the following statement:[206]

> "Currently the lores daily PME products in graphic format are delivered to external users at the [Water and Land website]. Products are available at around 08:00UTC [i.e. 6pm] for 00Z run [i.e. 00UTC] and 19:50UTC [i.e. 5.50am] for 12Z [ie, 1200UTC] run."

131 The plaintiff submitted that this did not differentiate between PME products and was thus equally applicable to one-day, four-day and eight-day PMEs.

132 Professor Manton referred to the statement on the website and noted that it was inconsistent with a BoM bulletin issued in February 2010 which referred to the 00UTC runs having an issue time of 0700UTC (ie, 5.00pm).[207] That bulletin is consistent with the bulletin relied on by the plaintiff.[208] Professor Manton reconciled the apparent inconsistency as follows:[209]

> "However, it appears that BOM has introduced a scheduling strategy to maintain up-to-date information on the web site, while avoiding confusion with major changes in forecasts during each day. Figure 14 gives a schematic description of the forecast schedule for a typical day (Tuesday - Tue), with the following steps:
>
> - At 6 am on Tuesday, all the PME forecasts are updated to the values given from the forecast run at 10 pm on Monday [ie the 1200UTC forecasts]. Day 1 is Tuesday, Day 2 is Wednesday, etc, noting that the forecast days are from 10 pm to 10 pm rather than midnight to

[204] MSC.010.263.0001; SBM.010.013.0001 at [4].
[205] SBM.010.013.0001 at [5] to [7].
[206] SEQ.013.006.0001 at .0026.
[207] EXP.SEQ.004.0131 at .0160; ROD.537.002.0044 at .0046.
[208] See SEQ.013.006.0001 at .0006 and ROD.537.002.0044 at .0046; cf SBM.010.013.0002 at [11].
[209] EXP.SEQ.004.0131 at .0161.

midnight. The 4-day forecast is from Tuesday to Friday, and the 8-day forecast is from Tuesday to next Tuesday.

- At 6 pm on Tuesday, the forecasts for *Wednesday* [ie commencing 10pm Tuesday], *Thursday* [ie commencing 10pm Wednesday], *etc* are updated to the values from the forecast run at 10 am on Tuesday [ie the 00UTC run]. For that run, Day 1 is Wednesday, Day 2 is Thursday, etc. There is no new information on the forecast for Tuesday, and so that forecast is unchanged. *Moreover, because the 4-day and 8-day forecasts on Tuesday include Tuesday, those forecasts are not updated*.

- At midnight on Tuesday, the current day becomes Wednesday, and so all forecasts are set to the values from the 10 am run on Tuesday. Day 1 is Wednesday, Day 2 is Thursday, etc. The 4-day forecast is from Wednesday [ie from 10.00pm Tuesday] to Saturday, and the 8-day forecast is from Wednesday [ie 10.00pm Tuesday] to next Wednesday.

- At 6 am on Wednesday, the cycle begins again with all forecasts updated to the values from the run at 10 pm on Tuesday." (emphasis added)

133 The plaintiff contended that this evidence only represents Professor Manton's surmise from the BoM publications that are in evidence and submitted that the Court can and should independently determine their effect. It also submitted that this part of Professor Manton's evidence is inconsistent with an earlier statement in his report that "forecasts with 10am base time are available around 6pm [citing Bulletin 85]".[210] In relation to the former proposition, Professor Manton is a highly qualified expert and can be taken to have some familiarity with the BoM's processes. In relation to the latter, he was not cross-examined on the suggested inconsistency and on close examination there is none. In the above extract, Professor Manton accepts that the 00UTC PME "forecasts for Wednesday, Thursday etc" are made available at 6.00pm but concludes that the four-day and eight-day 00UTC PMEs are not updated with those forecasts until midnight to avoid any confusion arising from the inclusion of the one-day PME that expired at 10.00pm (ie, two hours prior) in the previous four-day and eight-day PME. Earlier in his report, he explains that the "web site includes daily rainfall forecasts for days 1 to 5" and states that "it is assumed that the 4-day and 8-day totals are simply computed by

[210] EXP.SEQ.004.0131 at .0160.

summing the 24-hr forecasts over four to eight days".[211] This suggests, and I so find, that at 6.00pm each evening the BoM uploaded the daily PME 00UTC forecasts for each of the following five days with the forecast period for the first day of those five forecasts commencing at 10.00pm that evening (ie, "Wednesday, Thursday etc"). At midnight, the four-day and eight-day PME forecasts were updated, and they concerned forecast periods that commenced two hours previously. (Dr Nathan's presentation of the PME forecasts augmented by his georeferencing software had time annotations that accorded with this finding.[212])

134 The significance of this dispute over the publication times of PME forecasts concerned their availability as part of Dr Christensen's modelling exercise in that, in some of his simulations, he reconsiders the position at midnight. However, in the end result it has no significance for two reasons. First, because consistent with Professor Manton's evidence,[213] at the very least, by 6.00pm a flood engineer could calculate the four-day PME totals for the period commencing 10.00pm that evening by accessing the individual daily PME 00UTC forecasts. Second, Dr Christensen could still use the midnight four-day and eight-day PME forecasts to apply his methodology sufficiently quickly such that it would not make any material difference to the recalibration of his simulations at midnight. Mr Ayre's evidence was that an RTFM run could be undertaken in 15 to 20 minutes.[214]

QPFs

135 Quantitative Precipitation Forecasts ("QPFs") are rainfall predictions specifically prepared by the BoM for a particular location or region. They are based on numerical weather prediction model outputs (including the PMEs) and "then modified by human forecaster judgment, based on their experience".[215] During the January 2011 Flood Event, the BoM sent updated

[211] EXP.SEQ.004.0131 at .0146.
[212] EXP.SEQ.014.0219 at .0229 to .0268.
[213] EXP.SEQ.004.0131 at .0146.
[214] T 7987.20.
[215] EXP.ROD.014.0034 at [1.15]; EXP.SEQ.004.0131 at .0152.

QPFs to the flood engineers twice daily for the catchments upstream of Wivenhoe and Somerset Dams.[216]

136 Most of the QPF forecasts provided a range of predicted rainfall. For example, the QPF forecast issued at 10.03am on 8 January 2011[217] stated "Forecast of catchment average rainfall for the 24-hour period to 9am Sunday: 30-50mm". In a few cases additional comments were provided. For example, the QPF forecast issued on the afternoon of 11 January 2011[218] stated "50 to 100mm this evening and overnight, easing to less than 30mm during Wednesday".

SILO Meteograms

137 In a submission to the QFCI, the BoM stated that various multi-day rainfall products were made available on its website that Seqwater used during the January 2011 Flood Event, including "ACCESS meteograms [that predicted] forecast rainfall (based on the Bureau ACCESS Model)", "Interactive weather and wave forecast rainfall maps (based on [the BoM] ACCESS Model)" and "WATL - Water and land forecast rainfall (based on an ensemble of several numerical weather prediction models)". The first of these products are the SILO meteograms and the third of these are the PME forecasts.[219]

138 A SILO meteogram forecast consists of a single page output of graphs of forecast data for any designated point or region in Australia. The data fields consist of air temperature, mean sea level pressure, wind, precipitation, cloud cover, relative humidity and evapotranspiration.[220] The data is displayed in the following format:[221]

[216] EXP.SEQ.004.0131 at .0153.
[217] QLD.001.001.2486.
[218] SUN.002.003.6266.
[219] ROD.519.001.0527 at .0592 to .0593.
[220] EXP.ROD.011.0011 at .0031, [62].
[221] Eg ROD.519.001.0527 at .0593; LAY.SUN.007.0001 at .0005.

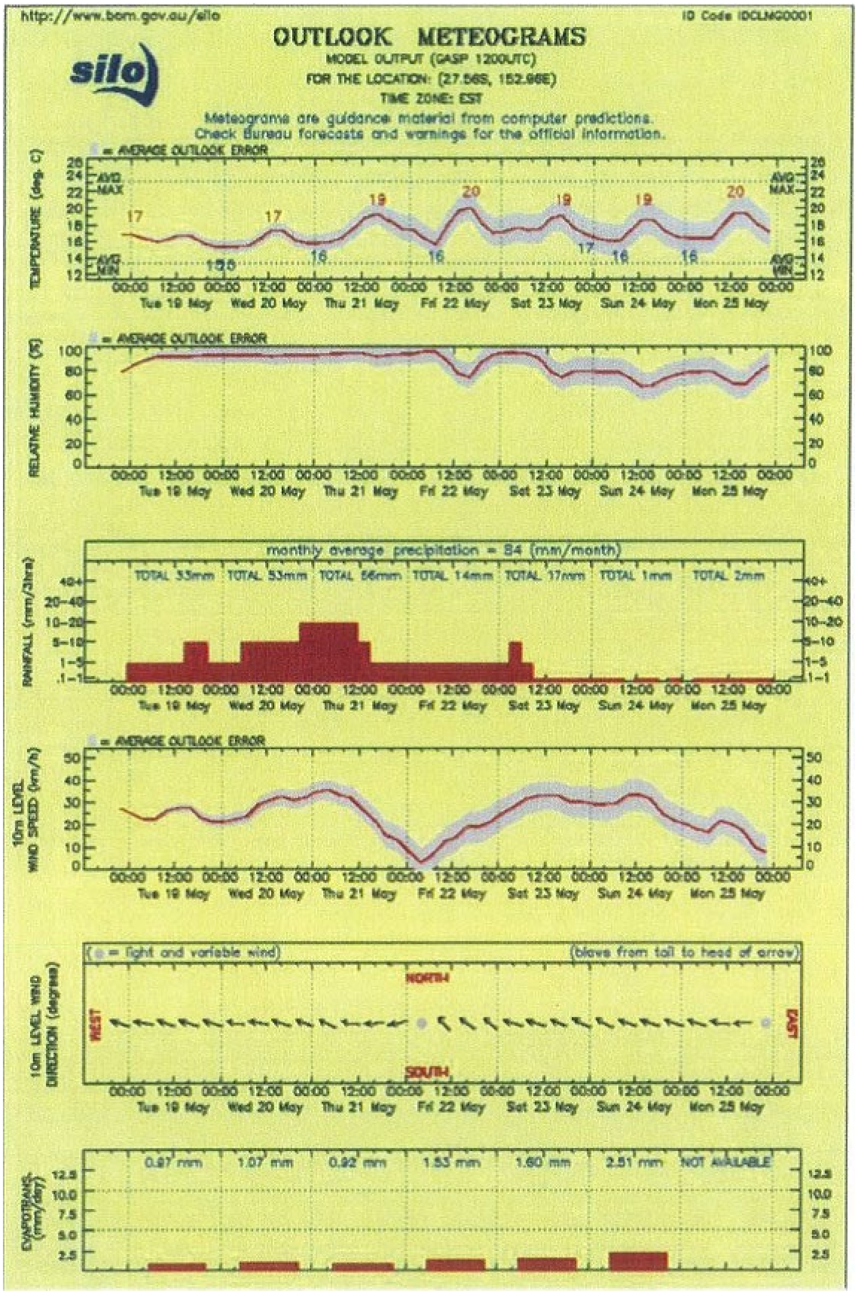

Figure 2-13: Example SILO meteogram

139 The third of the above sets of readings is rainfall. In his affidavit, Mr Ayre stated that SILO meteograms were available to the flood operations centre via the “BOM Registered User Service” but that they were generally only accessed by the flood engineers “if other forecast products such as the QPFs and PMEs indicated that a significant amount of rain was likely to fall”.[222] He nominated the period from 7 to 8 January 2011 as an example of a time when

[222] LAY.SUN.001.0001 at .0148, [597] to [598].

they were accessed and said that he regarded the 72-hour SILO meteogram "to be more useful than either the 4 or 8-day PMEs".[223] In his oral evidence, Mr Ayre stated, with some hesitation, that the meteograms were updated at 6.00am and 6.00pm every day ("something like that").[224]

140 None of the SILO meteograms that were said to have been accessed by the flood engineers during the flood event appear to have been retained and, in any event, none were tendered.[225]

141 One issue in the proceedings concerns the content and publication of SILO meteograms during the period from the evening on 7 January 2011 to late 8 January 2011. During that time, it appears that three 72-hour forecast runs were undertaken on the RTFM. The defendants contended that those runs utilised predicted rainfall figures obtained from up-to-date SILO meteograms. Those contentions are addressed in Chapter 6.[226]

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[223] Ibid at [601].
[224] T 7734.43.
[225] LAY.SUN.007.0001 at [12].
[226] At [279] to [296].

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CHAPTER 3: THE FLOOD OPERATIONS MANUAL AND THE FLOOD PROCEDURE MANUAL

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CHAPTER 3: THE FLOOD OPERATIONS MANUAL AND THE FLOOD PROCEDURE MANUAL

3.1: The Flood Operations Manual

1 The Flood Operations Manual (the "Manual")[1] identifies, or at least outlines, the circumstances in which flood operations are declared at Wivenhoe and Somerset Dams, the general methodology by which they are conducted and the manner and circumstances in which gate operations are concluded. The Manual's principal feature is the specification of various "strategies" for each of the dams, which in the case of Wivenhoe Dam impose limits on the rate at which water can be released, and in the case of Somerset Dam directs flood operations in tandem with Wivenhoe Dam. The invocation and implementation of those strategies is said to depend on prevailing water levels and stream flow conditions and, more controversially, predicted dam storage levels and conditions downstream of Wivenhoe Dam formed by reference to forecast rainfall. The Manual does not prescribe release rates. Instead, within the constraints of the dam strategies, and such other constraints as are found in the Manual, the flood engineers must exercise professional judgment concerning the amount of water to release having regard to the Manual's flood objectives and their order of importance.

2 The significance of the Manual to these proceedings cannot be overstated. About the only matter that all the experts across a variety of disciplines agreed upon was the necessity for flood engineers to follow the Manual during flood operations save for the possibility of following its own procedures for departure from its requirements when the safety of the dams is threatened.[2] The Manual itself declares that its provisions must be complied with (see [5]). A corollary of that proposition is that a flood engineer cannot refuse to apply the approach stated in a manual because they disagree with it.[3] The plaintiff sought to extract from this unanimity the proposition that *any* departure from

[1] QLD.001.001.0146.
[2] Eg, T 1367.4, T 1329.46, T 2485.2, T 2541.46, (Christensen); T 4152.5 - .44 (Dreverman); T 6783.16 - .27, T 6781.9, T 6782.38 - .41 (Pokarier); T 7317.39, T 7327.7, T 7333.11, T 7338.30, T 7343.3, T 7351.31, T 7366.21, (Swain); T 8975.36 (Fagot); Schleiss 1, EXP.ROD.012.0073, [14]; Swain 1, EXP.SEQ.008.0065_OBJ at .0079.
[3] T 7343.28; T 7346.31 (Swain); Fagot 1, EXP.QLD.001.0232 at [36(b)]; T 6781.14 - .36; T 6826.17 (Pokarier); T 8976.41 (Fagot).

the Manual constitutes a failure to act "reasonably", that is a breach of any duty of care that may be owed.[4] I address that proposition at [124] to [129].

3 As I will explain, the parties were in sharp dispute about a vast number of issues concerning the construction and application of the Manual. Each of those issues is addressed below. However, they can only sensibly be addressed by first describing each of the Sections of the Manual in some detail and, regrettably, extracting a number of passages at length relevant to those issues.

4 The Manual is divided into ten sections and eleven appendices. Amongst other matters, the appendices specify technical data concerning the dams and flood operations generally.

3.1.1: Section 1 of the Manual – Introduction

5 Section 1.1 of the Manual is entitled "Preface" and recites the Manual's status as having been approved under the *Safety and Reliability Act*. Section 1.5 describes the operation of s 374. Section 1.1 also records that "[g]iven their potential significant impact on downstream populations, it is imperative that Wivenhoe and Somerset Dams be operated during flood events in accordance with clearly defined procedures to minimise impacts to life and property" and identifies the Manual as "outlin[ing] those procedures". Similarly, section 1.7 is entitled "Observance of Manual" and records that the Manual "*must be used* for the operation of the dams during flood events." (emphasis added)

6 Section 1.1 identifies the objectives of the flood procedures in the Manual (the "flood objectives") as follows:[5]

> "The primary objectives of the procedures contained in this Manual are essentially the same as those contained in previous Manual versions. These objectives in order of importance are:
>
> *(1)* Ensure the structural safety of the dams;

[4] Plaintiff Written Closing Submissions, SBM.010.001.0001 ("Plaintiff subs") at [388].
[5] Manual at 1.

(2) Provide optimum protection of urbanised areas from inundation;
(3) Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;
(4) *Retain the storage at Full Supply Level at the conclusion of the Flood Event*.
(5) Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

In meeting these objectives, the dams must be operated to account for the potential effects of closely spaced Flood Events. Accordingly, normal procedures require stored floodwaters to be emptied from the dams within seven days of the flood event peak passing through the dam.

Wivenhoe Dam and Somerset Dam are operated in conjunction so as to maximise the overall flood mitigation capabilities of the two dams. The procedures outlined in this Manual are based on the operation of the dams in tandem." (numerals and emphasis added)

7 As I will explain, the objective of "retaining the storage at full supply level" following the conclusion of a flood event was not included in previous versions of the Manual. "Full Supply Level" ("FSL") is defined as meaning "the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge". The plaintiff[6] (and Dr Christensen[7]) contended, and the defendants denied,[8] that this objective contemplates that, during a flood event, the water level in the dams could fall below FSL while achieving the overall objective of "retaining the storage" at FSL at the conclusion of the event. The plaintiff also contended that the subordination of the objective of retaining water at FSL following a flood event to the higher flood objectives such as dam safety and optimising protection against urban inundation necessarily means that, in some circumstances, the former objective can be sacrificed to meet the latter.

8 Section 1.2 of the Manual contains various definitions. It includes a definition of a "flood event" as a "situation where the Duty Flood Operations Engineer *expects* the water level in either of the Dams to exceed" FSL. "Duty Flood Operations Engineer" ("DFOE") is defined as the "Senior Flood Operations Engineer [SFOE] or Flood Operations Engineer [FOE] rostered on duty to be in charge of Flood Operations at the dams". "Senior Flood Operations

[6] Plaintiff subs at [411].
[7] Reply Report, EXP.ROD.004.0005 at [171] to [175].
[8] Seqwater subs at [194(e)]; closing submissions of the second defendant, SBM.030.002.0001 ("SunWater subs") at [683] to [686].

Engineer" is defined as a "person designated in accordance with section 2.3 of this Manual under whose *general direction* the procedures in this Manual must be carried out".

9 Section 1.3 recites the purpose of the Manual as being to define procedures for the dams to "reduce, so far as practicable, the effects of flooding associated with the dams". It recognises the limitations on achieving that objective by stating:

> "The procedures in this Manual have been developed on the basis that the community is to be protected to the maximum extent practical against flood hazards recognising the limitations on being able to:
>
> - Obtain *accurate forecasts of rainfall* during flood events;
> - Accurately estimate flood run-off within the dam catchments;
> - Identify all potential flood hazards and their likelihood;
> - Remove or reduce community vulnerability to flood hazards;
> - Effectively respond to flooding;
> - Provide resources in a cost effective manner." (emphasis added)

10 This is the first reference in the Manual to rainfall forecasts. There are eleven others.

3.1.2: Section 2 of the Manual – "Direction of Operations"

11 Sections 2.3 to 2.5 specify the qualifications of flood engineers and the "designation" and responsibilities of senior flood engineers and flood engineers. To be eligible for designation as a flood engineer a person must hold a certificate of registration as a "Registered Professional Engineer of Queensland". As events transpired one of the flood engineers, Mr Ruffini, did not hold such a certificate.[9] Also, a flood engineer must have knowledge of the "design principles related to the structural, geotechnical and hydraulic design of large dams" and at least five years of experience and expertise in at least two of four areas of expertise being: the investigation, design or

[9] Closing submissions of the Third Defendant, SBM.040.002.0001 ("State subs"), [109].

construction of major dams; the operation and maintenance of major dams; hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology; and applied hydrology with particular reference to flood forecasting.

12 Under these provisions, Seqwater is obliged to designate one or more such engineers to undertake the roles of SFOE and FOE. Those nominations must be approved by the "Chief Executive" being the Director General of the Department of Environment and Resource Management ("DERM") or their nominated delegate. During the 2011 Flood Event, Mr Ayre and Mr Ruffini were the designated Senior Flood Operations Engineers and Messrs Malone and Tibaldi were regular flood operations engineers.[10] (Mr Ruffini was an alternate to Mr Ayre as SFOE.)

13 Sections 2.3 and 2.4, as well as an aspect of section 2.2, describe the respective roles of a SFOE and FOE as follows:

> "2.2 For the purposes of operation of the dams during Flood Events, Seqwater must ensure that:
>
> …
>
> - A Senior Flood Operations Engineer is designated to be in charge of Flood Operations at all times during a Flood Event.
> - Release of water at the dams during Flood Events is carried out under the direction of the Duty Flood Operations Engineer.
>
> …
>
> 2.3 When rostered on duty during a Flood Event, the responsibilities of the Senior Flood Engineer are as follows:
>
> - Set the *overall strategy* for management of the Flood Event in accordance with the objectives of this Manual.
> - Provide instructions to site staff to make releases of water from the Dams during Flood Events that are in accordance with this Manual.
> - Apply *reasonable discretion* in managing a Flood Event as described in Section 2.8.

[10] Tibaldi 1, LAY.SEQ.004.0001_OBJ, [69].

2.4 When rostered on duty during a Flood Event, the responsibilities of the Flood Engineer are as follows:

- Direct the operation of the dams during a flood event in accordance with the *general strategy* determined by the Senior Flood Operations Engineer.

- Follow any direction from the Senior Flood Operations Engineer in relation to applying *reasonable discretion* in managing a Flood Event as described in Section 2.8. Unless otherwise directed, a Flood Operations Engineer is to follow this Manual in managing Flood Events and is not to apply *reasonable discretion* unless directed by the Senior Flood Operations Engineer or the Chief Executive.

- Provide instructions to site staff to make releases of water from the Dams during Flood Events that are in accordance with this Manual….". (emphasis added)

14 The references to "reasonable discretion" in these extracts is to section 2.8 of the Manual which contemplates the possibility that a SFOE might form the opinion that it "it is necessary to depart from the procedures set out in this Manual *to meet the flood mitigation objectives*". In such a case, the SFOE is required to make a "reasonable attempt" to consult with both the Chief Executive and the Chairperson of Seqwater. If, in turn, the Chief Executive or Chairperson cannot be contacted within a reasonable time, the SFOE can proceed with the proposed procedure. These are the only provisions in the Manual that contemplate a departure from its terms. There was no suggestion that they were invoked during the January 2011 Flood Event[11] (although it was considered on the evening of 10 January 2011).[12]

15 There was debate, principally amongst the defendants, about the respective roles of the SFOE and DFOE and, in particular the scope of the "overall strategy" set by the SFOE and the "general strategy" given to the DFOE. This is addressed in section 5.3.10.

16 As noted, section 2.2 imposes various obligations on Seqwater including an obligation to provide a sufficient number of suitably qualified personnel and flood engineers to manage a flood event, ensure that a SFOE is "designated

[11] Ayre 1, LAY.SUN.001.0001_OBJ, [305].
[12] See QLD.002.001.8660, entry for 9.00pm on 10 January 2011.

to be in the charge of Flood Operations at all times during a Flood Event" and ensure that "[r]elease[s] of water at the dams during Flood Events [are] carried out under the direction of the Duty Flood Operations Engineer". Critically, section 2.2 also provides that, in respect of periods outside a Flood Event, Seqwater is obliged to ensure that:

> "A Duty Flood Operations Engineer is on call at all times. The Duty Flood Operations Engineer must constantly review *weather forecasts* and catchment rainfall and *must declare* a Flood Event if the water level of either Wivenhoe or Somerset Dam is expected to exceed Full Supply Level as a result of prevailing or *predicted weather conditions*." (emphasis added)

17 For the operation of a dam with a flood mitigation objective, the aspect of forecasted or predicted weather that is most significant is rain. Thus, these are the second and third references to forecast rainfall in the Manual. When read with the definition of "Flood Event", it suggests that the "expectation" referred to in that definition is one formed by a Duty Flood Operations Engineer ("DFOE") and that it is done so on the basis of prevailing and predicted catchment rainfall. No discretion is reposed in the DFOE. Upon forming the relevant expectation, they must declare a flood event. The DFOE on call during the period 2 January 2011 to 6 January 2011 was Mr Malone.

18 Section 2.2 also obliges Seqwater to ensure that "[s]ufficient numbers of suitably qualified personnel are available to operate the Flood Operations Centre if a Flood Event occurs". The "Flood Operations Centre" ("FOC") is defined in clause 1.2 as the "Centre used … by Flood Engineers to manage Flood Events".

3.1.3: Section 3 of the Manual – Flood Mitigation Objectives

19 Section 3.1 effectively repeats the statement in section 1.1 of the Manual extracted above by specifying the five flood objectives "in descending order of importance". It then refers to the necessity to account for "closely spaced Flood Events" and to that end states "[a]ccordingly, normal procedures require stored floodwaters to be emptied from the dams within seven days of the flood event peak passing through the dams". It also states that, if possible, "gate

operations at both Wivenhoe and Somerset Dams should be formulated to prevent operation of the fuse plug" at Wivenhoe Dam, given the extra flooding downstream that may be occasioned if the fuse plug is triggered. Dr Christensen placed great emphasis on the objectives and their order of priority.[13]

20 Subsections 3.2 to 3.6 address the five flood objectives in turn.

21 In relation to dam safety, section 3.2 states that the "structural safety of the dams must be the first consideration in the operation of the dams for the purpose of flood mitigation". Section 3.2 refers to the potential for catastrophic consequences if the dams should fail. Wivenhoe Dam is described as not resistant to overtopping (ie water level above EL 80 AHD) and that is said to result from an event with a 1 in 100,000 "annual exceedance probability" ("AEP"), that is the probability of that level being exceeded in any year is 1 in 100,000. Somerset Dam is described as a "mass concrete dam" which "could withstand at least 2.2 metres of overtopping without failure, provided all radial gates are fully open". That level of overtopping is said to equate to an event "centred on the Somerset Dam catchment with a 1 in 20,000 AEP".

22 Section 3.2 includes the following passage:

> "Extreme Floods and Closely Spaced Large Floods
>
> As indicated in the previous section, techniques for estimating extreme floods show that floods are possible which would overtop both dams. In the case of Wivenhoe Dam such an overtopping would most likely result in the destruction of the dam. Such events however require several days of intense rainfall to produce the necessary runoff.
>
> Historical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane River system within a short time of each other. *Therefore, unless determined otherwise by the Senior Flood Operations Engineer in accordance with Section 2.8, the aim during a Flood Event should be to empty stored floodwaters within seven days after the flood peak has passed through the dams*. In a very large flood, this time frame may not be achievable because of downstream flood conditions and it may be necessary to extend the emptying period by several days.

[13] February 2015 Report, EXP.ROD.001.0016 at .0109 to .0110.

> The discharges from the dams should be regulated so as to have little impact on the urban reaches of the Brisbane River, taking into account inflows into the river downstream of the dams. However the seven day drainage requirement may result in submergence of some bridges. Regardless*, the level of flooding as a result of emptying stored floodwaters after the peak has passed is to be less than the flood peak unless accelerated release is necessary to reduce the risk of overtopping*." (emphasis added)

23 An expert flood operations engineer called by the State, Mr Kevin Fagot, placed great emphasis on the emphasised passages in this extract. He interpreted them as imposing a "constraint" operating throughout a flood event which precludes dam releases that would result in a flow downstream greater than had been experienced downstream to that time[14] depending on whether the flooding originates downstream or upstream.[15] The plaintiff contended that these passages are simply a direction as to emptying of flood water stored above FSL after the peak of the flood event has passed through Wivenhoe Dam.

24 Section 3.3 states that the "*prime purpose* of incorporating flood mitigation measures into Wivenhoe Dam and Somerset Dam" is to reduce flooding in urban areas of the flood plains below Wivenhoe Dam. Section 3.4 notes that the use of the dams for flood mitigation purposes may inundate bridges upstream of the dams and adds that "[d]ownstream of the dam, bridges and lower river terraces will be submerged" but adds that "[t]he operation of the dams should not prolong this inundation unnecessarily". The plaintiff contended that the acceptance that the bridges may be inundated confirms the subordination of the third of the flood objectives listed above to the second of the flood objectives which concerns protection against urban inundation.

25 Section 3.5 addresses the objective of retaining storage at FSL at the conclusion of the flood event. It states:

> "**3.5 Retain the storage at Full Supply Level at the Conclusion of the Flood Event**.
>
> As the dams are the primary urban water supply for South East Queensland, it is important that all opportunities to fill the dams are taken. *There should be*

[14] EXP.QLD.001.0232 at [98], [250], [278] and [289]; T 9031.18.
[15] T 9048.7 to T 9049.18.

no reason why the dams should not be full following a Flood Event." (emphasis added)

26 The plaintiff contended that this passage contemplates both the possibility that the dams may be below FSL during a flood event and after a flood event although the latter result should be avoided if possible.[16] The defendants submitted that it suggested the opposite.[17] The defendants contended that the dams could never be operated below FSL during a flood event save that SunWater and the State conceded that, at the end of a flood event, they could be reduced to allow refill by baseflow.[18]

3.1.4: Sections 4 to 7 of the Manual – Flood Classification, RTFM, Communications and Review

27 Section 4 defines four classifications of the magnitude of a flood: minor flooding, moderate flooding, major flooding and extreme flooding. Minor flooding is described as "caus[ing] inconvenience" and that "[m]inor roads may be closed and low-level bridges submerged". Moderate flooding is described as potentially requiring the "evacuation of some houses" and that "[m]ain traffic routes may be impacted". With Major Flooding, "extensive rural areas and/or urban areas are inundated", properties and towns are likely to be isolated and major traffic routes likely to be closed, and evacuations may be required. The 1974 flood event is classified as a major flood. The Manual states that extreme flooding causes impacts that are equal to, or in excess of, what has previously been experienced such that the "general evacuation of people from significant populated areas is likely to be required".

28 Section 5 briefly describes the rainfall and stream gauges throughout the Wivenhoe and Somerset catchments and the RTFM. This part of the Manual was described in Chapter 2. Of present relevance is the extract from the Manual set out in Chapter 2 at [101] which includes the fourth reference to forecast rainfall in the Manual. Seqwater contended that passage only contemplates the estimation of likely dam inflows based on "received rain",

[16] Plaintiff subs at [413].
[17] State subs at [26]; Seqwater subs at [259].
[18] See SBM.500.001.0001, Q1.

that is “rain on the ground”, and then the calculation of “possible inflow scenarios” using forecast rainfall with only the former used for “operational decisions” such as the selection of strategy or the determination of amounts to release.[19] The plaintiff contended that the reference to forecast and potential rainfall contemplates modelling of the forecast amount of rain and potential rainfall in excess of (and less) than the amount forecast.[20]

29 Section 6 of the Manual addresses communications and section 7 concerns review of the Manual and flood operations. Section 7.4 provides that, within six weeks of a “significant flood event”, Seqwater must submit a report to the Chief Executive “on the effectiveness of the operational procedures” in the Manual. In accordance with this provision, in May 2011 Seqwater submitted a Flood Event Report concerning the October and December flood events (the “2010 FER”)[21] and on 2 March 2011 submitted a Flood Event Report concerning the January 2011 Flood Event (the “January FER”).[22]

3.1.5: Section 8 – Wivenhoe Dam Flood Operations

30 A resolution of the various debates over the proper construction of section 8 of the Manual is critical to the outcome of the proceedings. Section 8 is divided into eight subsections. Section 8.1 records that “[m]aximum overall flood mitigation effect will be achieved by operating Wivenhoe Dam in conjunction with Somerset Dam”. It also states:[23]

> “*The reservoir volume above FSL of EL 67.0 is available as temporary flood storage*. How much of the available flood storage compartment is utilised, will depend on the initial reservoir level below FSL, the magnitude of the flood being regulated and the procedures adopted.” (emphasis added)

31 The defendants contended that the emphasised portion of this passage supports their contention that the Manual precludes releases from Wivenhoe

[19] See the cross-examination of Mr Kane at T 3180.39 to T 3185.2.
[20] Plaintiff subs at [443].
[21] ROD.650.003.6506.
[22] SUN.016.001.0280.
[23] Manual at 19.

Dam below FSL for flood mitigation purposes.[24] They submitted that, if releases below FSL were permitted, then in effect part of the "reservoir volume" below FSL would also be made available as temporary flood storage. The plaintiff contended that this does not follow in circumstances where the Manual contemplates Wivenhoe Dam returning to FSL at the end of the flood event and flood waters above FSL not being replenished but instead evacuated within seven days. It contended that this part of the Manual is doing no more than emphasising that water is not to be stored permanently above FSL but only temporarily and thus, *at a minimum*, the space above FSL will always be available for the temporary, and not permanent, storage of flood water.[25] The plaintiff noted that this passage does not expressly state that the storage space below FSL may not be used for flood storage and, to the contrary, the second sentence expressly contemplates some part of dam storage below FSL would or could be used to store flood waters.[26]

32 Section 8.2 describes the flood infrastructure. The relevant parts have already been summarised in Chapter 2, sections 2.4 and 2.5.

Section 8.3: Initial Flood Control Action

33 Section 8.3 addresses the action to be taken at the commencement of a flood event. It provides:

> "**8.3 Initial Flood Control Action**
>
> Once a Flood Event is declared, an assessment is to be made of the *magnitude* of the Flood Event, including:
>
> - A prediction of the maximum storage levels in Wivenhoe and Somerset Dams.
> - A prediction of the peak flow rate at the Lowood Gauge excluding Wivenhoe Dam releases.
> - A prediction of the peak flow rate at the Moggill Gauge excluding Wivenhoe Dam releases.

[24] See T 7001.6 (Pokarier); T 8294.22 (Ickert); T 4952.36 to T 4953.3 (Malone); T 9076.6 - .26 (Fagot); State subs at [26(b)].
[25] Plaintiff subs at [438].
[26] Ibid at [439].

The spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding EL 67.25." (emphasis added)

34 Thus, at the commencement of a flood event, an assessment must be made of its "magnitude". Releases from Wivenhoe Dam's spillway gates cannot be made until the level exceeds EL 67.25m AHD although they can be made through the regulator.

35 Four issues arose concerning the interpretation and application of this provision, some of which are also apposite to section 8.4. First, the plaintiff's primary contention was that the EL 67.25m AHD threshold restriction on gate releases only applied during the period of initial assessment of the flood event as envisaged by section 8.3.[27] On this approach once the assessment was complete then, even if Wivenhoe Dam is below EL 67.25m AHD, gate releases can commence. I reject this interpretation. Nothing in the text of the Manual supports this construction. The process of allowing Wivenhoe Dam to rise to EL 67.25m AHD is itself part of the assessment process.

36 Second, the defendants contended, and the plaintiff denied, that the EL 67.25m AHD threshold reinforced the Manual's apparent prohibition on releases below FSL. The plaintiff contended that, if its primary contention was rejected, then this is still only an initial threshold before releases through the Wivenhoe gates can occur to allow the magnitude of the flood event to be assessed. According to the plaintiff, once the threshold is overcome releases to take Wivenhoe Dam below FSL can be made consistent with the flood objectives.

37 Third, the parties were in dispute over how an assessment of the maximum storage level was to occur. The plaintiff contended that this could only be undertaken by adopting a "no release assumption", that is by modelling the volume of inflows on the basis that the spillway or crest gates would not be opened. This was especially so, said the plaintiff, because at the point that this assessment is undertaken the gates cannot be opened prior to

[27] T 9377.9.

EL 67.25m AHD. The defendants contended that an assessment of the maximum storage levels is to be undertaken by an iterative process that models inflow volumes but also plans likely gate operations to deal with that inflow so as to achieve a likely net volume of inflow and consequential height of Wivenhoe Dam. The plaintiff characterised that method as involving a “can release assumption”.

38 Fourth, the parties were in dispute as to the basis upon which the inflow volumes would be calculated in predicting the maximum storage levels. At least some of the defendants’ witnesses contended that, given the uncertainties inherent in rainfall forecasts, a reliable assessment could only be made based on actual lake levels and RTFM modelling of rain that had fallen in the catchment but not yet run off into the dams (“rain on ground”). The plaintiff contended that the assessment must be undertaken having regard to forecast rainfall bearing in mind the numerous references to such forecasts throughout the Manual including its consideration in determining whether there is a flood event (see [16]) and the determination of the applicable strategy (see [39]ff). They contended that to only use rain on ground would not yield a “prediction of the maximum storage level” in the Dams.

Section 8.4: Wivenhoe Flood Operations Strategies

39 Section 8.4 commences by noting that there are four flood strategies for Wivenhoe Dam being W1 to W4 which are “based on the Flood Objectives” in the manual. It then (again) recites those objectives “in descending order of importance” and notes that “[w]ithin *any strategy*, consideration is *always given* to these objectives *in this order*, when making decisions on dam releases” (emphasis added). In relation to the choice of strategy the Manual then provides (emphasis added):

> “The strategy chosen at any point in time will depend *on the actual levels in the dams and the following predictions*, which are to be made using the *best forecast rainfall* and stream flow information available at the time:
>
> - Maximum storage levels in Wivenhoe and Somerset Dams.

- Peak flow rate at the Lowood Gauge (excluding Wivenhoe Dam releases).

- Peak flow rate at the Moggill Gauge (excluding Wivenhoe Dam releases).

Strategies are likely to change during a flood event as *forecasts change* and rain is received in the catchments. It is not possible to predict the range of strategies that will be used during the course of a flood event at the commencement of the event. Strategies are changed in response to changing *rainfall forecasts* and stream flow conditions to maximise the flood mitigation benefits of the dams.

When determining dam outflows within all strategies, peak outflow should generally not exceed peak inflow. A flowchart showing how best to select the appropriate strategy to use at any point in time is shown below:

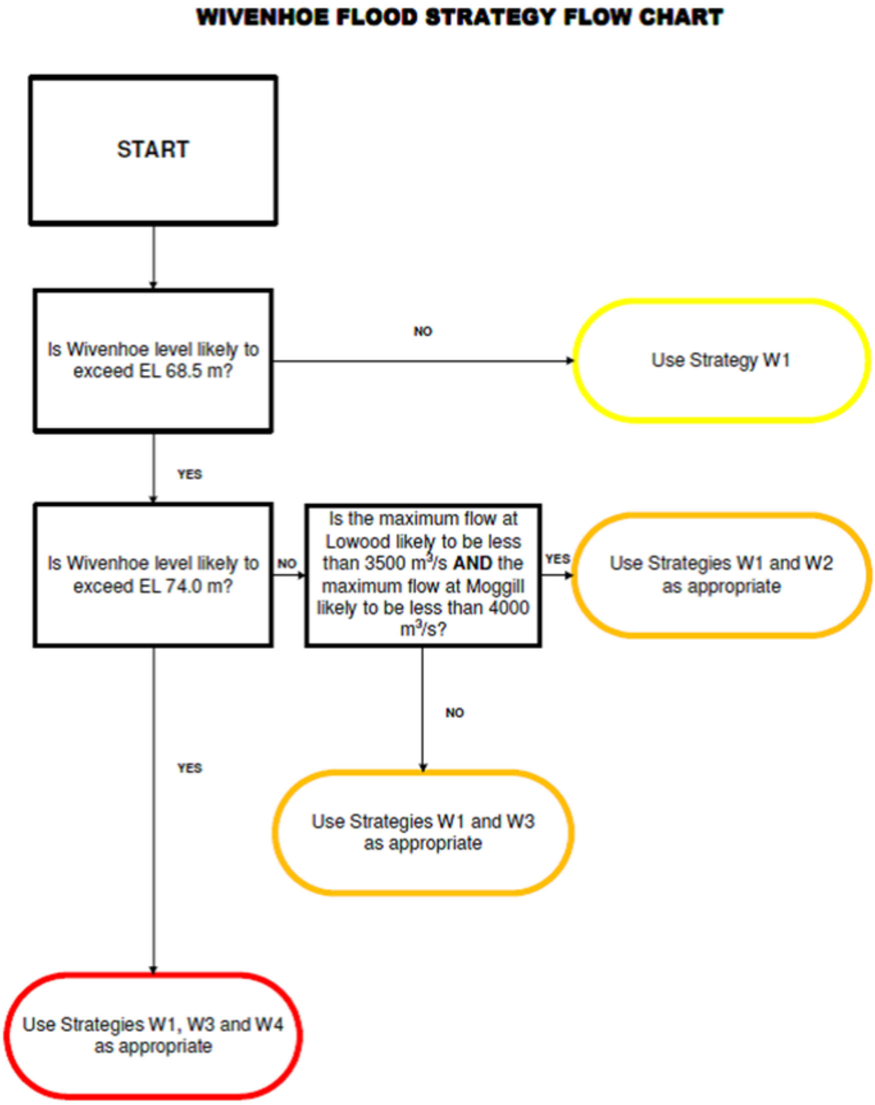

Figure 5-1: Flood Manual Strategy Flow Chart

40 The above passage contains the fifth, sixth and seventh references to rainfall forecasts in the Manual.

41 A number of issues arose in relation to the construction of the above passage some of which also arose in relation to section 8.3, namely, whether the maximum storage level in Wivenhoe Dam was calculated using a no release assumption, whether that (and downstream flows) was to be calculated using rainfall forecasts and not just rain on the ground and, if forecasts are used, how and what constitutes the "best" forecast.

42 Three other issues also arose in relation to the above extract which also relate to the details of the strategies which are discussed below.

43 First, the parties disputed whether the selection or invocation of all, or even any, of the strategies were dependent on a prediction of the peak level of Wivenhoe Dam during the flood event on the one hand, or the observed lake level on the other (or both). In relation to the above passages the plaintiff pointed to the references to "predictions", "forecasts" and the "likely" levels in the above flowchart. The defendants relied on the reference to actual levels in the above passage as perhaps indicating that a selection of at least some of the strategies or sub-strategies may turn on an observation of the actual level of Wivenhoe Dam.

44 Second, if the choice of strategy was to be made having regard to inflows calculated by reference to rainfall forecasts then were rates of discharge also to be determined by reference to inflows calculated by reference to such forecasts and, if so, how?

45 Third, the parties disputed the scope of the limitation imposed by the statement that "*peak outflow should generally not exceed peak inflow"?* In particular is "peak inflow" a reference to the peak rate of inflow to Wivenhoe Dam that has been observed to date or is it a reference to the predicted peak rate of inflow into the dam over the course of the flood event? If it is the latter,

is the prediction of peak inflow to be made based on modelling of rain on the ground or does it include forecast rainfall?

Strategy W1

46 Within section 8.4, Strategy W1 comprises five sub-strategies namely W1A, W1B, W1C, W1D and W1E, each of which relates to the submergence level for various bridges downstream of Wivenhoe Dam.

47 The Manual states as follows in relation to W1 and W1A:

"***Strategy W1 - The Primary Consideration is Minimising Disruption to Downstream Rural Life***

Conditions	• **Wivenhoe Storage Level *predicted* to be less than 68.50 m AHD** • **Maximum release predicted to be less than 1,900 m^3/s** • **The primary consideration is minimising disruption to downstream rural life**

The intent of Strategy W1 is to not to submerge the bridges downstream of the dam prematurely (see Appendix I). The limiting condition for Strategy W1 is the submergence of Mt Crosby Weir Bridge that occurs at approximately 1,900 m^3/s.

[The Manual includes a map of the downstream bridges and their submergence levels and continues …]

…

The following strategies require a great deal of control over releases and knowledge of discharges from Lockyer Creek. In general, the releases from Wivenhoe Dam are controlled such that the combined flow from Lockyer Creek and Wivenhoe Dam is less than the limiting values to delay the submergence of particular bridges. The diagram above shows the location of the impacted bridges and the approximate river flow rate at which they are closed to traffic.

Strategy W1A **Twin Bridges, Savages Crossing and Colleges Crossing**

***Lake Level greater* than 67.25 m AHD**

[Maximum Release 110 m^3/s]

Firstly, endeavour to maintain Twin Bridges trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 50 m^3/s.

> Once Twin Bridges is closed to traffic, endeavour to maintain Savages Crossing trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 110 m^3/s.
>
> Once Savages Crossing is closed to traffic, endeavour to maintain College's Crossing trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of $175m^3/s$. Note that College's Crossing can be impacted by tidal influences.
>
> When the flood event subsides, all gates are to be closed when the dam achieves FSL in accordance with Section 8.5." (bold emphasis in original, italicised emphasis added)

48 One matter to note is that the opening conditions of the strategy refer to a predicted lake level less than 68.5m AHD but the sub-strategies refer to "Lake Level greater" than a specified level.

49 The flow rates of $50m^3/s$, $110m^3/s$[28] and $175m^3/s$ referred to in the above correspond to the submergence levels for Twin Bridges, Savages Crossing and College's Crossing respectively. W1B and W1C are expressed in similar terms to W1A although with different lake levels, being 67.50m and 67.75m respectively, and different maximum flow rates for the bridges being $430m^3/s$ for Burtons Bridge and $550m^3/s$ for Kholo Bridge respectively.[29]

50 The Manual then states:

> "<u>**Strategy W1D**</u> **Kholo Bridge and Mt Crosby Weir Bridge**
>
> **Lake Level greater than 68.00 m AHD**
>
> **[Maximum Release 1900 m^3/s]**
>
> No consideration is given to maintaining Burtons Bridge open.
>
> Endeavour to maintain Kholo Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 550 m^3/s.
>
> Once Kholo Bridge is closed to traffic, endeavour to maintain Mt Crosby Weir Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 1900 m^3/s.

[28] Although the diagram in the Manual refers to $130m^3/s$ as the submergence flow for Savages Crossing: Manual at 25.

[29] There appears to be a typographical error in the heading to W1C which suggests that the maximum permissible release rate for W1C is $500m^3/s$ although the submergence level for Kholo Bridge is $550m^3/s$: Manual at 27.

<u>Strategy W1E</u>   Mt Crosby Weir Bridge and Fernvale Bridge

Lake Level greater than 68.25 m AHD

[Maximum Release 1900 m^3/s]

No consideration is given to maintaining Kholo Bridge open.

Endeavour to maintain Mt Crosby Weir Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 1900 m^3/s.

Once Mt Crosby Weir Bridge is closed to traffic, endeavour to maintain Fernvale Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 2000 m^3/s.

If the level reaches EL 68.5 m AHD in Wivenhoe Dam, switch to Strategy W2 or W3 as appropriate." (all emphasis in original).

51 The most intense dispute concerning the construction of this part of the Manual concerned whether W1 or any of the sub-strategies W1A to W1E were invoked on the basis of predicted or actual lake levels. The plaintiff contended that all the references to lake levels in W1 were to predicted lake levels (and that such predictions were formulated by reference to rain on the ground and forecast rain). The plaintiff pointed to the general statement concerning the invocation of strategies set out above (see [39]), the word "likely" in the flowchart and the reference to "predicted" in the conditions box at the commencement of the above extract.

52 Seqwater and SunWater pleaded[30] that the invocation of W1 and the sub-strategies was solely based on actual lake levels, although Seqwater's ultimate submission was that a flood engineer could either use predictions or actual lake levels.[31] In support of an approach based on actual lake levels, Mr Ayre, Mr Pokarier and Mr Fagot pointed to the references to "Lake Level greater than" within each sub-strategy[32] and the reference to the "level reach[ing] EL 68.5m AHD" at the end of the above extract which triggers a

[30] Seqwater Defence, PLE.020.012.0001 at [169(a)(ii), (iii), (iv)]; SunWater Defence; PLE.030.008.0001 at [109].
[31] Seqwater subs at [672].
[32] Ayre 1, LAY.SUN.001.0001_OBJ at [343]; T 6859.17 - .40 (Pokarier); EXP.QLD.001.0524_2 at [178].

transition to W2 or W3.[33] The plaintiff contended that the last statement simply acknowledges that a prediction that a lake level will be less than EL 68.5m AHD may prove wrong and if the actual lake level reaches EL 68.5m AHD then there must be a transition to W2 or W3.[34]

Strategies W2 and W3

53 The Manual describes Strategy W2 as a "Transition Strategy" in which the "primary consideration" changes from "Minimising Impact to Downstream Rural Life to Protecting Urban Areas from Inundation." The conditions for the strategy are that Wivenhoe Dam's storage level is "predicted to be between 68.50 and 74.00m AHD" and that the "Maximum Release [is] predicted to be less than 3,500m^3/s". The Manual specifies that "[l]ower level objectives are still considered when making decisions on water releases" and that "[o]bjectives are always considered in order of importance". The Manual then states:

> "The intent of Strategy W2 is limit the flow in the Brisbane River to less than the naturally occurring peaks at Lowood and Moggill, while remaining within the *upper limit of non-damaging floods at Lowood (3,500 m^3/s*). In these instances, the combined peak river flows should not exceed those shown in the following table: (emphasis added)

LOCATION	TARGET MAXIMUM FLOW IN THE BRISBANE RIVER
Lowood	The lesser of: • the natural peak flow at Lowood excluding Wivenhoe Dam releases, and; • 3,500m^3/s
Moggill	The lesser of: • the natural peak flow at Moggill excluding Wivenhoe Dam releases, and; • 4,000m^3/s

[33] Ayre 1, LAY.SUN.001.0001_OBJ at [343]; T 6859.17 - .40 (Pokarier); EXP.QLD.001.0524_2 at [179].
[34] Plaintiff subs at [519].

54 The Manual states that the "primary consideration" for Strategy W3 is "Protecting Urban Areas from Inundation". As with W2, one of the conditions for the strategy is that the Wivenhoe Dams storage level is "predicted to be between 68.50 and 74.00m AHD" and the Manual also states that "[l]ower level objectives are still considered when making decisions on water releases" and "are always considered in order of importance". The release condition is that the "Maximum Release should not exceed 4,000m^3/s".

55 The Manual then states:

> "The intent of Strategy W3 is to limit the flow in the Brisbane River at Moggill to less than 4000 m^3/s, noting that 4000 m^3/s at Moggill is *the upper limit of non-damaging floods downstream*. The combined peak river flow targets for Strategy W3 are shown in the following table. In relation to these targets, it should be noted that *depending on natural flows from the Lockyer and Bremer catchments, it may not be possible to limit the flow at Moggill to below 4000 m^3/s*. In these instances, the flow at Moggill is to be kept as low as possible. (emphasis added)

TIMING	**TARGET MAXIMUM FLOW IN THE BRISBANE RIVER**
Prior to the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases)	The flow at Moggill is to be minimised.
After the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases)	The flow at Moggill is to be lowered to 4,000m^3/s as soon as possible.

56 Strategy W2 seeks to limit the releases from Wivenhoe Dam so that the combined flow downstream does not exceed the lesser of the peak or those limits. If that cannot be sustained then W3 is engaged. The Manual is explicit that, for both Strategies W2 and W3, lower level objectives, specifically minimising disruption to rural life and retaining the dams at full supply level, must be considered although optimising the protection of urban areas from inundation predominates. Further, as W3 contemplates that the flows may be above 4000m^3/s at some point but should then be lowered to 4000m^3/s "as

soon as possible", it follows that the strategy is directed to both protecting against, and minimising, the inundation of urban areas.

57 There were three issues between the parties concerning W3.

58 The first concerns the reference to "non-damaging floods". These parts of the Manual identify the "upper limit of non-damaging floods" for Lowood as $3500m^3/s$ and for Moggill as $4000m^3/s$. One issue between the parties was whether it was open to the flood engineers to conduct flood operations on the basis that (urban or over floor) damage would occur at lower rates of flow.

59 The second issue in relation to W2 and W3 concerned whether the strategies were invoked by predicted lake levels or actual lake levels. The plaintiff contended[35] that W2 and W3 are engaged by a predicted lake level. A number of defendant witnesses contended that it was invoked by actual levels.[36] It was also contended that the necessity to choose between W2 and W3 by reference to whether the maximum flow at Lowood was likely to be less than $3500m^3/s$ and at Moggill was likely to be less than $4000m^3/s$ (see the flowchart at [39]) was inconsistent with the no release assumption in that the strategy could not be invoked without making a prediction of what the level of Wivenhoe Dam releases would be.

60 The third issue concerned the first row of the box for W3 which is directed to operations prior to the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases) and requires that the "flow at Moggill [is to] be minimised". The plaintiff contended, and the defendants denied, that this row is addressed to the circumstance discussed immediately above and below it, namely when downstream flows at Moggill cannot be kept below $4000m^3/s$.

Strategy W4

61 Strategy W4 is directed to the safety of Wivenhoe Dam which arises for consideration when the level of Wivenhoe Dam either exceeds, or is predicted

[35] Plaintiff subs at [526], [530].
[36] T 5559.45 (Tibaldi) (at least initially); T 6823.25 (Pokarier); T 7455.26 - .29 (Ayre).

to exceed, EL 74m AHD. It has two sub-strategies, W4A which concerns storage levels above EL 74m AHD where a fuse plug initiation at EL 75.5m AHD is not expected, and W4B where such an initiation may occur. Neither sub-strategy imposes a maximum limit on rates of release.

62 As a number of Dr Christensen's simulations depend upon a contested interpretation of W4 it is necessary to set out the text of the strategy in full:

"Strategy W4 - The primary consideration is Protecting the Structural Safety of the Dam

Conditions	• **Wivenhoe Storage Level predicted to exceed 74.00m AHD** • **No limit on Maximum Release rate** • **The primary consideration is protecting the structural safety of the dam** • **Lower level objectives are still considered when making decisions on water releases. Objectives are always considered in order of importance**

The intent of Strategy W4 is to ensure the safety of the dam while limiting downstream impacts as much as possible.

This strategy normally comes into effect when the water level in Wivenhoe Dam reaches 74.0 m AHD. However, the Senior Flood Operations Engineer may seek to invoke the discretionary powers of Section 2.8 if earlier commencement is able to prevent triggering of a fuse plug.

Under Strategy W4 the release rate is increased as the safety of the dam becomes the priority. Opening of the gates is to occur generally in accordance with the requirements of Section 8.6, until the storage level of Wivenhoe Dam begins to fall.

There are no restrictions on gate opening increments or gate operating frequency once the storage level exceeds 74.0 AHD, as the safety of the dam is of primary concern at these storage levels. However, the impact of rapidly increasing discharge from Wivenhoe Dam on downstream reaches should be considered when determining gate opening sequences.

<u>**Strategy W4A – No Fuse Plug Initiation Expected**</u>

Lake Level between 74.0 and 75.5 m AHD
[No Maximum Release]

Strategy 4A applies while all indications of the peak flood level in Wivenhoe Dam are that it will be insufficient to trigger operation of the first bay of the fuse plug by reaching 75.5 m AHD.

Gate openings are generally to occur at the minimum intervals and sequences as specified in Section 8.6 until the storage level of Wivenhoe Dam begins to fall. However, to protect the safety of the dam, minimum opening intervals can be reduced and gate opening sequences can be modified.

<u>Strategy W4B – Fuse Plug Initiation Possible</u>

Lake Level greater than 75.5 m AHD
[No Maximum Release]

Strategy W4B applies once indications are the peak flood level in Wivenhoe Dam may exceed EL75.5 and trigger the fuse plug under normal operations. Two scenarios are possible under this strategy. The first scenario is where it may be possible to prevent fuse plug initiation by early opening of the gates. The second scenario is where fuse plug initiation cannot be avoided. The actions associated with these scenarios are contained in the following table:

SCENARIO	ACTION
Potential to keep lake level below EL 75.5 by early opening of the gates and/or varying the operational procedures at Somerset.	The following actions can be used to prevent initiation of the fuse plug provided the safety of the dams is not compromised: • Retain water in Somerset Dam (See Somerset Dam Strategy S3 for guidelines). • Bring the gate operation sequence forward to increase discharge from the dam. In addition to dam safety issues, the impact of rapidly increasing discharge from Wivenhoe Dam on downstream reaches should be considered when determining the rate of gate openings.
Fuse plug initiation cannot be avoided	<u>PRIOR TO FUSE PLUG INITIATION</u> If possible, the gates are to be raised at a rate to ensure they are out of the water before the initiation of the first fuse plug. The gates should be in the fully open position before the dam water level reaches 75.7 m AHD. <u>FOLLOWING FUSE PLUG INITIATION</u> The impact of rapidly changing discharge from Wivenhoe Dam on downstream reaches should be considered when

	determining the rate of gate closings in these circumstances. However, once a fuse plug is initiated, the flood storage at the dam is to be drained as quickly as possible within the gate closure sequence.

(emphasis in italics added; underlined emphasis and bold in original)

63 The above refers to the "strategy *normally* com[ing] into effect when the water level in Wivenhoe Dam reaches 74.0m AHD" suggesting that there was scope for the strategy to be engaged prior to then. Ultimately it was common ground amongst at least the plaintiff and many of the defendants' witnesses that the references to "Lake Level" under the headings W4A and W4B were to predicted and not actual lake levels.[37] This follows from the general statements in section 8.4 and the flow chart noted in [39], the word "predicted" in the conditions for the strategy, the reference to "indications" in each of the first sentences under the heading "W4A" and "W4B" and the fact that the first "scenario" and "action" in the table for sub-Strategy W4B refers to the "potential to keep [the Wivenhoe] lake level below EL 75.5".

64 The principal issue that arose concerning W4 was the action that was required to be taken when the level of Wivenhoe Dam reached 74.0m AHD, and, specifically, what was required by the statement concerning the opening of gates "generally in accordance with the requirements of section 8.6". Seqwater contended that when the outflow rate was less than 4000m^3/s gates had to be opened at a rate of six increments per hour.

65 Two parts of section 8.6 are of present relevance. One part, entitled "Radial Gate Opening Operations", provides that when "dam outflows are less than 4,000m^3/s, the aim in opening radial gates is to operate the gates one at a time at intervals that will minimise adverse impacts on the river system". A table is provided that "shows the target minimum interval for gate operations" when dam outflows are less than 4,000m^3/s although it provides that this "target interval can be reduced if the gates are at risk of being overtopped or

[37] See T 5559.24 (Tibaldi); T 6862.21, T 6862.39, T 6863.37 (Pokarier); T 7582.47 (Ayre); Ayre 1, LAY.SUN.001.0001_OBJ, [343].

the safety of the dam is at risk". The table is entitled "Target Minimum Interval for Radial Gate Opening (Downstream River Flows < 4000m^3/s)" and specifies a time interval of ten minutes between gate increments of half a metre (ie, maximum six increments an hour). The other relevant part of section 8.6 is entitled "Normal Gate Operation Sequences". It addresses the order in which gates are to be opened although "[v]ariations are allowed at any time to protect the structural safety of the dam".

66 The plaintiff contended that Strategy W4, and especially W4A, enables the flood engineers to exercise discretion as to whether to immediately open Wivenhoe Dam gates and the rate at which that occurs once the level in Wivenhoe Dam reached EL 74.0m AHD. The plaintiff pointed to the word "generally" in the above passages and the reference to considering lower level objectives in the conditions to the strategy. In relation to the latter, the plaintiff contended that, if gates had to be opened in the virtually automatic manner contended for by the defendants, then lower level objectives such as the protection of urban areas from inundation could not be considered.[38] The defendants contended that those objectives could be considered when W4 is engaged prior to the actual lake level reaching EL 74.0m AHD and when considering whether to accelerate the gate opening sequence but not otherwise. Seqwater went further and contended that where the Wivenhoe Dam level exceeded EL 74.0m AHD, was rising and dam outflows were less than 4000m^3/s, then gates had to be opened at a minimum rate of six increments an hour.[39]

67 This issue is of significance to a number of Dr Christensen's simulations which involve Wivenhoe Dam operating above EL 74.0m AHD. At that point in his simulations, Dr Christensen did not assume he had to raise the Wivenhoe Dam crest gates at the rate of six increments an hour or even at the same rate as the flood engineers did when they confronted rises in Wivenhoe Dam's storage levels above EL 74.0m AHD on 11 January 2011.

[38] Plaintiff subs at [539] to [551].
[39] T 9757.15.

Section 8.5 – Gate Closing Strategies

68 Section 8.5 addresses the approach to be taken in relation to the closing of gates as well as the conclusion of flood operations. It relevantly states:

> "In general, gate closing commences when the level in Wivenhoe Dam begins to fall and is generally to occur in the reverse order to opening. *The final gate closure should occur when the lake level has returned to Full Supply Level*. The following requirements must be considered when determining gate closure sequences:
>
> - Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.
> - The maximum discharge from the dam during closure should generally be less than the peak inflow into Wivenhoe Dam experienced during the event. The discharge from Wivenhoe Dam includes discharge from triggered fuse plugs, gates, regulator cone dispersion valve and hydro release.
> - …
> - The aim should always be to empty stored floodwaters stored above EL 67.0m within seven days after the flood peak has passed through the dams. However, provided a *favourable weather outlook* is available, this requirement can be relaxed for the volume between EL 67.0m and EL 67.5m, to obtain positive environmental outcomes.
> - If the flood storage compartments of Wivenhoe Dam and Somerset Dam can be emptied within seven days, the maximum flow in the Brisbane River at Lowood should not exceed 3,500 m^3/s.
> - …
>
> *There may be a need to take into account base flow when determining final gate closure. This may mean that the lake level temporarily falls below Full Supply Level to provide for a full dam at the end of the Flood Event*." (emphasis added)

69 The reference to "favourable weather outlook" is the eighth reference to forecast rainfall in the Manual.

70 The parties addressed this provision at great length in relation to the issue as to whether the Manual contemplated the possibility that during flood operations Wivenhoe Dam could be reduced below FSL. The defendants contended that the exhortation to close gates when the level of Wivenhoe Dam returned to FSL and the express reference to that level falling below FSL

so as to allow “baseflow” to return the dam to FSL presumably with the gates closed meant that was the only circumstance envisaged by the Manual when the lake level can drop below FSL and that can only occur at the end of flood operations.[40]

71 The plaintiff contended that the parts of the Manual relied on by the defendants are only concerned with “Final Gate closure” which occurs “at the end of the Flood Event” and it is not directed to what happens during flood operations. It also contended that the first two sentences of section 8.5 should be read together such that they are not a command to close gates at FSL during flood operations. Instead, it was contended they simply provide that gate closing should commence when the level of Wivenhoe Dam begins to fall and gates should be closed with the last gate closing occurring when the dam reaches FSL.[41] The plaintiff also noted that the first sentence has two qualifiers, “in general” and “generally”.

72 On the plaintiff’s approach, the opening of gates to reduce the Wivenhoe lake level during a flood event is not engaged by this provision during a Flood Event (but even if it was the word “in general” would allow the flood engineer to avoid having to close the gates again). Further, according to the plaintiff the reference to final gate closure at Wivenhoe Dam “return[ing] to Full Supply Level” (subject to baseflow) addresses both the circumstance of Wivenhoe Dam coming down to FSL as flood operations are wound back and Wivenhoe Dam returning back up to FSL in the scenario that the rain stops and forecasts clear during flood operations below FSL. With the latter that could occur if the dam is below FSL and the weather has cleared but (say) rain on the ground in the catchment is still sufficient to fill up the dam to or above FSL if the gates were closed. In that event the gate closing sequences would commence and the lake level would rise with the final gate closure occurring

[40] Eg, Malone 1, LAY.SEQ.007.0001_OBJ at [345]; Tibaldi 1, LAY.SEQ.004.0001_OBJ at [310]; Fagot 1, EXP.QLD.001.0232_3 at [113] to [114]; SunWater subs at [675] to [694].
[41] Plaintiff subs at [557].

either at or just below FSL[42] depending on the level of baseflow and the necessity to address positive environmental outcomes.

73 In that regard the reference to "positive environmental outcomes" as a basis for retaining water above FSL in the above extract includes closing the gates to allow fish recovery on the spillway below the dam.[43] As I will explain, in the period 2 January 2011 to 5 January 2011 Wivenhoe Dam gates were closed and flood operations ceased notwithstanding that the dam level was above 67.0m (although it remained below EL 67.25m AHD). The SFOE, Mr Ayre, asserted that at least so far as 2 January 2011, it was justifiable to close the gates (and end flood operations) because there was a "favourable" weather outlook.[44]

74 Two further points should be noted about section 8.5. First, it appears that the common understanding of "baseflow" is that it means that portion of inflows that is not runoff from rains or streams but is instead the product of seepage of water from the ground into a channel over a longer time frame than surface runoff.[45] However during oral submissions, the plaintiff contended that baseflow was a reference to all rain on ground inflows, that is rain that had fallen but was yet to flow into Wivenhoe Dam.[46] If that was correct it would allow the release of more water below FSL even if flood operations below FSL were otherwise prohibited. In the absence of that contention being raised with the various witnesses, I do not accept it.

75 Second, as Seqwater contended that any water release below FSL for flood mitigation purposes was contrary to the Moreton Resource Operating Plan ("the Moreton ROP"), it accepted that it followed that any releases below FSL at Wivenhoe Dam to allow it to refill to FSL via baseflow were also contrary to the Moreton ROP.[47] Thus, on this approach, section 8.5 appeared to be

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[42] With the possibility that any residual baseflow above FSL after final gate closure be released through a regulator.
[43] T 7858.19 (Ayre).
[44] T 7858.8 - .21 (Ayre).
[45] Malone 1, LAY.SEQ.007.0001 at [107]; February 2015 Report, EXP.ROD.015.0001 at [44].
[46] T 9446.36.
[47] T 9656.41.

sanctioning an aspect of flood operations that was contrary to law. This is addressed in Chapter 5.

<u>Sections 8.6 to 8.8</u>

76 The gate opening sequences in section 8.6 have already been referred to. Section 8.6 also includes a table specifying the usual order in which gates should be opened. Section 8.7 modifies the flood operating procedures in the event a fuse plug triggers and section 8.8 modifies the procedures in the event that a subsequent flood event occurs prior to the reconstruction of the collapsed fuse plug.

3.1.6: Section 9 of the Manual – Somerset Dam Flood Operations

77 The technical data in section 9.1 of the Manual has already been addressed. Section 9.2 is entitled "Initial Flood Control Action". Upon the declaration of a flood event, all of the crest or radial gates are to be opened and the sluice gates and regulator valves closed. (The evidence suggests that it is most unlikely that the crest gates would be closed at that time.) Similar to section 8.3, an assessment is to be made of the magnitude of the flood event "including a prediction of the maximum storage levels in Wivenhoe and Somerset Dams".

78 Section 9.3 discusses the three Somerset Dam flood strategies. It states:

> "There are three strategies used when operating Somerset Dam during a flood event as outlined below [ie, S1, S2 and S3]. These strategies are based on the Flood Objectives of this manual. The strategy chosen at any point in time will depend on predictions of the maximum storage levels in Wivenhoe and Somerset Dams which are to be made using the *best forecast rainfall* and stream flow information available at the time.
>
> Strategies are likely to change during a flood event as *forecasts* change and rain is received in the catchments. It is not possible to predict the range of strategies that will be used during the course of a flood event at the commencement of the event. Strategies are changed in response to *changing rainfall forecasts* and stream flow conditions to maximise the flood mitigation benefits of the dams.

> When calculating the impacts of flood releases from Somerset Dam, the gate opening sequences outlined in Section 9.5 should be used to determine likely outflow rates from the dam." (emphasis added)

79 The Manual then sets out a flow chart for the selection of Somerset Dam strategies. The flow chart first asks whether the level of Wivenhoe Dam is "likely to exceed its FSL". If the answer is "no", then Strategy S1 is selected. If the answer is "yes", then the flow chart asks whether a fuse plug at Wivenhoe Dam is "likely to be initiated"? If the answer is "no" then the selected strategy is Strategy S2. If the answer is "yes", then the selected strategy is Strategy S3.

80 The above extract makes no reference to "actual levels". It contains the ninth, tenth and eleventh references to forecast rainfall in the Manual.

<u>Strategy S1</u>

81 Strategy S1 is invoked when Somerset Dam is "expected" to exceed FSL (EL 99.00m AHD) but Wivenhoe Dam is not expected to exceed FSL. The intention of the strategy is to return Somerset Dam to FSL while minimising the impact on rural life upstream of the Dam. Strategy S1 requires that the crest gates be opened and the regulator valves and sluice gates be used to release water into Wivenhoe Dam to maintain Somerset Dam below EL 102m AHD and that the "release rate from Somerset dam is not to exceed the peak inflow into the Dam".

<u>Strategy S2</u>

82 Strategy S2 is invoked when both Somerset Dam and Wivenhoe Dam are "expected" to exceed their respective FSLs but Wivenhoe Dam is not expected to exceed the level that would initiate a fuse plug, ie, EL 75.5m AHD. The intention of the strategy is stated as maximising the "benefits of the flood storage capabilities of the dams while protecting their structural safety".

83 The Manual sets out a table specifying the operating conditions and actions for S2 as follows (emphasis added):

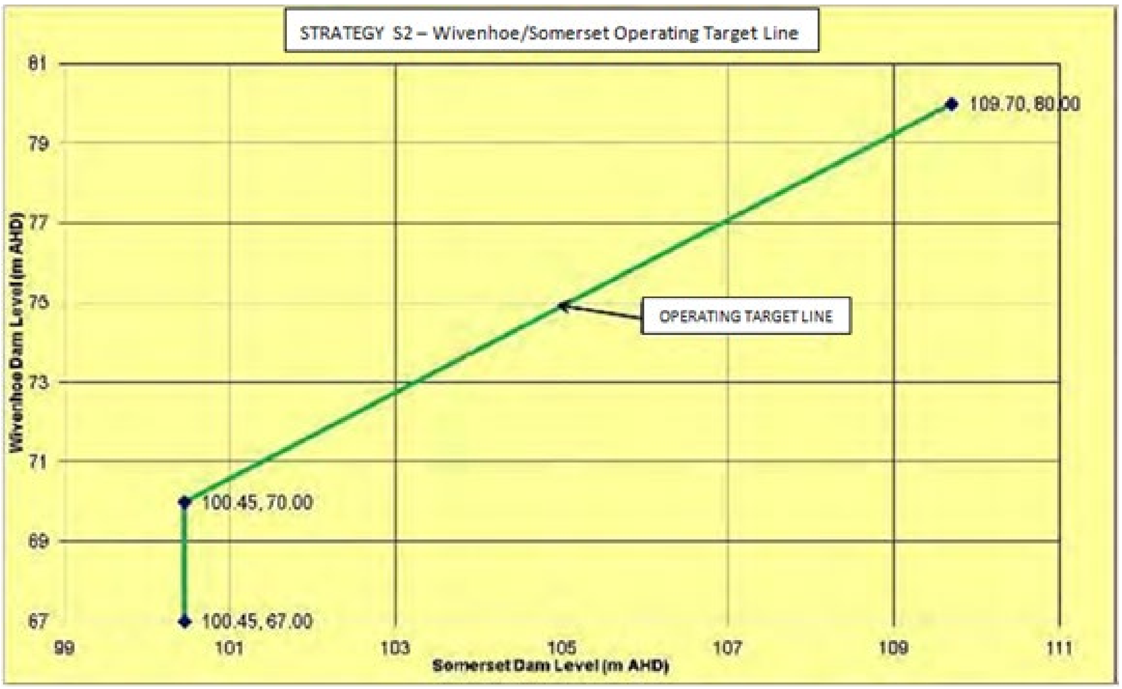
CONDITION	**ACTION**
Wivenhoe rising and Somerset level below EL 100.45.[48]	The crest gates are raised to enable uncontrolled discharge. The low level regulators and sluices are *generally* kept closed.
Wivenhoe rising and Somerset level above EL 100.45.[49]	The crest gates are raised to enable uncontrolled discharge. Operations are to target a correlation of water levels in Somerset Dam and Wivenhoe Dam as set out in the *graph below*. *The operations target line shown on this graph is to generally be followed as the flood event progresses*. The release rate from Somerset Dam is *generally* not to exceed the peak inflow into the dam.
Wivenhoe falling and Somerset level above EL 100.45.[50]	The opening of the regulators and sluices *generally* should not cause Wivenhoe Dam to rise significantly. The release rate from Somerset Dam is *generally* not to exceed the peak inflow into the dam.
The Flood has emanated mainly from the Stanley River catchment without significant runoff in the Upper Brisbane River catchment.[51]	The crest gates at Somerset Dam are raised to enable uncontrolled discharge. The Regulator Valves and Sluice gates are to be used to maintain the level in Somerset Dam below EL 102.0 (deck level of Mary Smokes Bridge). The release rate from Somerset Dam is *generally* not to exceed the peak inflow into the dam.

84 It can be seen from the liberal use of the word "generally" in this part of the Manual that a significant level of discretion is conferred on the flood engineers

[48] The first condition of S2.
[49] The second condition of S2.
[50] The third condition of S2.
[51] The fourth condition of S2.

operating in S2. Otherwise as indicated by these conditions, the raising of the crest gates will allow an uncontrolled discharge from above 100.45m AHD although further discharge can occur through the sluice gates and regulator.

85 The second S2 condition is most likely to be engaged on the rising limb of the hydrograph in a significant flood event. It envisages dam operations correlating in some way to an "operation target line" which seeks to spread the risk of dam failure between both dams (also known as the "operating target line"). The graph containing the operating target line and the accompanying text are as follows[52]:



"Notes:

- The Operating Target Line was selected following an optimisation study. The Target Line was selected based on the following factors:
  - Equal minimisation of flood level peaks in both dams in relation to their associated dam failure levels.
  - Minimisation of flows in the Brisbane River downstream of Wivenhoe Dam.
  - Consideration of the time needed at the onset of a Flood Event to properly assess the magnitude of the event and the likely impacts,

[52] Manual at 41.

so that the likely optimal strategy to maximise the Flood Mitigation benefits of the storages can be selected.

- The levels of 109.70 m AHD and 80.00 m AHD represent the likely failure level for Somerset Dam and the level at the top of the Wivenhoe Dam Wave Wall respectively. Note that the failure level of 109.70 m AHD for Somerset Dam assumes all radial gates are fully open and this failure level will be reduced if this cannot be achieved.

- The *target point* on the operating target line at any point in time is based on the maximum storage levels in Wivenhoe and Somerset Dams using the *best forecast rainfall* and stream flow information available at the time.

- Gate operations will enable the movement of the *duty point* towards the target line in a progressive manner. It will not necessarily be possible to adjust the *duty point* directly towards the target line in a single gate operation." (emphasis added)

86 The first two points explain the background and rationale for the adoption of the operating target line. The optimisation study which, inter alia, sought to find a means of minimising flood level peaks in both dams by reference to the relative dam failure levels was undertaken by Mr Tibaldi and Mr Malone in 2009.[53] The uncertainty surrounding the dam failure level for Somerset Dam is addressed in the second dot point above.

87 The reference to "best forecast rainfall" in the third point is the twelfth reference to forecast rain in the Manual.

88 It is not immediately clear what is meant by the "target point" and the "duty point" in the third and fourth points. Ultimately, it seems to have been accepted that the reference to the "duty point" is the point on the graph that reflects the current height level of both dams. In most cases that will not be a point on the operating target line. As its name implies the "target point" appears to be a point on the line that flood operation engineers orientate towards. It appears to be selected by determining the maximum storage levels in Wivenhoe and Somerset Dams and then adjusting releases with the objective of reaching a target point on the line,[54] but does not necessarily

[53] SEQ.001.001.3434.
[54] See Plaintiff subs at [572] to [578]; T 4977.11 - .30 (Malone); T 5820.40 to T 5822.24, T 5826.10 - .31 (Tibaldi); T 7585.1 - .13, T 7596.22 - .44 (Ayre); T 7047.6 to T 7049.36 (Pokarier) T 8461.39 to T 8463.41 (Ickert).

require flood operations be conducted along the line.[55] It is noteworthy that the target point is determined by reference to forecasts.

89 There are a number of obstacles to reaching such a point during a flood event. It must be remembered that water can be released from Somerset Dam into Wivenhoe Dam but not vice versa and that when the water level in Somerset Dam is above 100.45m AHD with the crest gates open there is an uncontrolled discharge from Somerset Dam into Wivenhoe Dam over the crest level. The application of the operating target line is further complicated by the fact that the target point will necessarily be revisited as forecasts and stream flow information are revised from time to time. Further, the projected pattern of inflows for a given flood and conditions downstream of Wivenhoe Dam may make it difficult to align Somerset Dam levels with Wivenhoe Dam levels towards a target point on the operating target line. Presumably for these and perhaps other reasons Strategy S2 confers on the flood engineers a significant amount of discretion in that the operating target line is only "generally" to be followed. The last point in the above notes contemplates that some period of flood operations might move dam levels away from the operating target line.

Strategy S3

90 Strategy S3 is invoked when the level of Somerset Dam is "expected" to exceed EL 99.00m AHD and the level of Wivenhoe Dam is expected to result in a fuse plug initiation (ie, exceed 75.5m) during a flood event. The intent of the strategy is said to be the maximisation of the benefits of the "flood storage capabilities of the dam while protecting the structural safety of both dams".

91 The operating target line in the above graph passes through the point at which Wivenhoe Dam is at EL 75.5m AHD and Somerset Dam is at EL 105.5m AHD without contemplating any adjustment of operations to account for the effects of a fuse plug initiation (or breach) at Wivenhoe Dam which would occur at that point. Consistent with Strategy W4B, Strategy S3 seeks to address this

[55] T 8463.40 - .46 (Ickert).

by providing that, in addition to the protocols in S2, to prevent a fuse plug initiation, “consideration can be given to temporary departure from the operating protocols” in S2 provided firstly that the “safety of Somerset Dam is the primary consideration and cannot be compromised” and secondly that the peak level in Somerset Dam “cannot exceed EL 109.7”.

92 A number of issues concerning Strategies S2 and S3 that arise in the context of Dr Christensen’s simulated flood operations are addressed in Chapter 9.

Section 9.4: Somerset Dam Gate Closing Strategy

93 Section 9.4 is expressed in similar terms to section 8.6 although the range of factors to be considered in making decisions concerning the closure of gates is less than for Wivenhoe Dam as water released from Somerset Dam flows into Wivenhoe Dam and not downstream estuaries. As with section 8.6, section 9.4 provides that “[i]n general, gate closing commences when the level in Somerset Dam begins to fall”, that the “final gate closure should occur when the lake level has returned” to FSL, that the “aim should be to empty stored floodwaters within seven days after the flood peak has passed through the dams” and that, having regard to baseflow, the Somerset Dam “lake level [may] temporarily fall below [FSL] to provide for a full dam at the end of the Flood Event”. The observations made at [70] to [75] apply to these provisions.[56]

3.1.7: Section 10 – Emergency Procedures

94 Section 10 addresses two emergency situations that may arise during a flood event.

95 The first is the overtopping of the dams. Section 10.2 provides that “[w]hatever the circumstances, every endeavour must be made to prevent overtopping of Wivenhoe Dam by the progressive opening of operative spillway gates”. To that end, it also states that:

[56] Section 9.5 concerns the gate opening sequences for Somerset Dam. No issue arose concerning its construction.

> "Somerset Dam should not be overtopped by flood water, but if Wivenhoe Dam is threatened by overtopping, the release of water from Somerset Dam is to be reduced at the risk of overtopping Somerset Dam in order to prevent the overtopping of Wivenhoe Dam."

96 Second, section 10.3 addresses the consequences of a communications failure between the flood operations centre and the staff at either dam. In that event, the relevant "Dam Supervisor" is required to assume responsibility for flood releases. The Manual then specifies the flood operations the Dam Supervisor must conduct. It is notable that the specified procedures operate by requiring various gate openings determined by reference to actual lake levels or "storage levels" and not by reference to "predicted" lake levels.[57] This is understandable because, where communications with the flood operations centre are lost, the onsite Dam Supervisor will not have access to any modelling of predicted inflows from the RTFM. Instead the only relevant data available will be the observed lake levels.

97 The specified gate opening sequences in this part of the Manual provided for no radial or sluice gate openings at storage levels corresponding to FSL in the Somerset and Wivenhoe Dams.[58] Seqwater contended that this was consistent with the Manual not contemplating flood releases below FSL. However, those gate operations must be considered in the context of flood operations being conducted by a Dam Supervisor operating by reference to observed lake levels with no access to the RTFM. At most, the specification of no gate openings at FSL means that a Dam Supervisor, who is not a flood engineer, does not have the capacity to draw the dams below FSL in emergency conditions.

3.1.8: The Appendices

98 The appendices include various types of technical data concerning the operation and capacity of the dams. It is only necessary to refer to three aspects.

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[57] "When the storage level is less than 74.0m AHD" – at 45, "Dam level < EL 74.0" – at 45; "Level in Somerset Dam is below EL 100.45, Level in Wivenhoe Dam is below EL 70.0" – at .49.
[58] Table 10.2 at 45; Case 1 Procedure at 49.

99 First, there are various entries that the defendants contended support the conclusion that the Manual does not countenance drawdowns below FSL during a flood event. Thus, they referred to a table for Wivenhoe Dam which has a column headed "Flood Capacity" and which has no entries for height levels below 67.0m AHD and the entry "0" at 67.00m AHD.[59] A footnote to this column states "[t]he temporary storage above normal Full Supply Level of EL 67.0".[60] A table for Somerset Dam has a column entitled "Temporary Flood Storage" with similar entries.[61] The plaintiff contended that references to temporary flood storage should be construed in the manner noted at [31].

100 Second, the plaintiff pointed to two passages which it contended contemplated the possibility that the crest gates at Somerset Dam could be closed during flood operations. Thus, a discussion of the technical data for Somerset Dam states that the radial gates are "*normally* kept open"[62] and another Appendix states that the "*normal* operating procedure for Somerset Dam in the event of a flood requires the spillway gates to be raised".[63]

101 Third, the Appendices to the Manual include information enabling the calculation of the volume of water in each dam from their actual levels and the maximum discharge levels at various dam levels.[64] They also include a rating table showing the amount each crest gate at Wivenhoe Dam will release at a certain water elevation and if opened to a particular height.[65] These tables are utilised in some of the calculations described in Chapters 8 to 10.

[59] Appendix C to the Manual at 53.
[60] Manual at 54.
[61] Manual at 59.
[62] Appendix D to the Manual at 60.
[63] Appendix F to the Manual at 66.
[64] Manual at 53 and 59.
[65] Manual at 55.

3.2: The Flood Procedure Manual

102 The plaintiff also tendered a document entitled the "Flood Procedure Manual" ("FPM") which bore the date January 2010 and was described as "controlled copy no 9".[66] There was some doubt about its status.

103 The January FER recorded that Seqwater had prepared a "Flood Procedure Manual" that assigned "responsibilities to Seqwater personnel for flood event preparation, mobilisation and operation, in relation to Seqwater's Dams, including Somerset and Wivenhoe Dams".[67] An accompanying flowchart describes the FPM as an "Internal document" and records its distribution to various Seqwater personnel including the SFOE even though the SFOEs, Messrs Ayre and Ruffini, were not Seqwater employees.

104 The January FER also outlined the requirements of the FPM for the mobilisation of the Flood Operations Centre ("FOC") and the conduct of flood operations.[68] Thus, Section 2 of the FPM is entitled "Flood Operations Centre – Staffing Arrangements and Centre Administration". Amongst other matters, it outlines the responsibilities of the DFOE prior to the mobilisation of the FOC. It includes the following in section 2.2:[69]

> **"Responsibilities (Pre-Mobilisation)**
>
> It is the responsibility of the Duty Flood Operations Engineer to declare a Flood Event and mobilise the Flood Operations Centre. If the Duty Flood Operations Engineer *considers it possible* for the Full Supply Level of Wivenhoe Somerset or North Pine Dam *to be exceeded as a result of rainfall occurring in the dam catchments*, the Flood Operations Centre is to be mobilised.
>
> If significant *rainfall is forecast or appears possible* the Duty Flood Operations Engineer is to adopt a conservative approach in mobilising the Flood Operations Centre (ie when in doubt, mobilise the Centre). The decision to mobilise is to be *based on BOM forecasts* and available rainfall and streamflow data. The reasons for mobilisation or non mobilisation are to be recorded in the Event Log located in the Flood Operations Centre.

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66 SEQ.004.028.0001.
67 SUN.016.001.0280 at .0334.
68 Ibid at .0336 to .0339.
69 SEQ.004.028.0001 at .0012.

In instances where catchment runoff is likely to be low and the full supply level of a storage is likely to be exceeded by less than 100 millimetres, consideration can be given to not mobilising the Flood Operations Centre and managing the event through operational releases. Such an approach should not be used if *BOM forecasts* and catchment conditions provide for any possibility of catchment runoff that may result in the full supply level of a storage being exceeded by 100 millimetres." (emphasis added)

105 Self-evidently these provisions contemplate reliance on rainfall forecasts in determining whether to declare a flood event.

106 Section 3 of the FPM is entitled "Flood Operations Centre – Flood Model Maintenance and Flood Event Actions". It is primarily directed to what happens at the FOC upon the declaration of a flood event and during a flood event. Section 3.2 is entitled "Mobilisation" and includes the following:[70]

"Responsibilities

Once the decision has been made to mobilise the Flood Operations Centre, the Duty Flood Operations Engineer is to ensure the following actions are undertaken:

- A start time for the event is established. This time will generally be 9.00am on the day preceding the commencement of the event rainfall.
- …..
- Inflow hydrographs are to be derived for the following locations as appropriate:

- Wivenhoe Dam.
- Somerset Dam.
- North Pine Dam.
- Lockyer Creek Catchment.
- Bremer River Catchment.

These derived inflow hydrographs are also to be examined using a variety of rainfall scenarios. The following cases can be used as a guide:

- Actual rainfall.
- *Actual rainfall plus 100% of forecast rainfall.*
- *Actual rainfall plus 50% of forecast rainfall.*
- *Actual rainfall plus 200% of forecast rainfall*.

- Input the derived inflow hydrographs for Wivenhoe Dam, Somerset Dam[...], Lockyer Creek Catchment and Bremer River Catchment into Wivenhoe and Somerset Operations Spreadsheet and run this program. *Based on the resulting data from the operations spreadsheet and in accordance with the strategies outlined in the*

[70] SEQ.004.028.0001 at .0018.

Flood Mitigation Manual determine gate operations strategies for Wivenhoe and Somerset Dams." (emphasis added)

107 Section 3.3 is entitled "Normal Operations" and specifies a procedure that applies to the operations of the FOC during a flood event. It states the following concerning the responsibilities of the DFOE:[71]

> "Prior to the flood peak being understood, the Duty Flood Operations Engineer is to ensure *that the actions contained in Section 3.2 (above) are undertaken on an hourly basis*. To summarise, these actions are:
>
> - Ensure rainfall and streamflow input data integrity.
> - Derive required hydrographs.
> - Update gate operations spreadsheets.
> - *Determine gate operations strategies* in accordance with the Flood Mitigation Manuals.
> - Advise Emergency Response Agencies and Seqwater of gate operations strategies.
> - Direct gate operations at the dams.
>
> Once the flood event peak is understood, these actions can be undertaken at time intervals of longer than one hour as appropriate." (emphasis added)

108 Again, these provisions clearly require that consideration be given to the use of rainfall forecasts in determining whether to declare a flood event and thus mobilise the FOC and in the preparation of hydrographs which are then used to both determine "gate operations strategies" and also to "direct gate operations".

109 To an extent, the status of the FPM was disputed by the defendants. Mr Ayre said that the FPM was used during the 2011 Flood Event and that the procedures in the FPM are "*consistent with and supplement the requirements of*" the Manual.[72] In his first affidavit Mr Tibaldi stated that the FPM had been drafted but as at 31 January 2011 it had not been "formally endorsed by the Senior Flood Operations Engineer or the Queensland Dam Safety Regulator". He said he did not recall using it during the January 2011 Flood Event or

[71] SEQ.004.028.0001 at .0020.
[72] Ayre 1, LAY.SUN.001.0001_OBJ, [216].

observing other flood engineers using it.[73] However, in his third affidavit Mr Tibaldi noted that it had been entered into Seqwater's internal document control system prior to 2010 and accepted that it was "probably in use" in December 2010 and January 2011.[74] In his first affidavit Mr Malone said that, so far as he was aware, the FPM was issued for comment but it was never "formally handed over to Mr Ayre or Mr Ruffini" and "nor was it approved by the Headworks Operator".[75] However, in his oral evidence Mr Malone stated that he did not recall receiving the particular document but did recall receiving "something at some stage"[76] and later accepted that he was aware of its contents.[77]

110 I am satisfied that throughout the 2011 Flood Event all of the flood engineers were fully cognisant of the FPM, including its statements as to the role of the forecasts, and that the FPM was meant to complement and reflect the terms of the Manual. That knowledge makes their adherence to a construction of the Manual that rejects the use of forecasts (as well as predictions) that much more unreasonable.

111 As explained in Chapter 4, both Mr Malone and Mr Tibaldi drafted the FPM in late 2009 and early 2010. The January FER asserted that the flood engineers followed the FPM during the 2011 Flood Event.[78] That statement was blatantly incorrect.

3.3: Construction of the Manual

3.3.1: Interpretative Approach and Reasonable Interpretations

112 Many of the expert witnesses in the fields of hydrology, flood forecasting, dam operations and dam engineering gave evidence concerning the proper construction of the Manual. Some of those witnesses had experience in the drafting of manuals for the operation of dams with a flood mitigation objective

[73] Tibaldi 1, LAY.SEQ.004.0001_OBJ, [298]-[300].
[74] Tibaldi 3, LAY.SEQ.017.0001_OBJ, [3].
[75] Malone 1, LAY.SEQ.007.0001_OBJ, [44]).
[76] T 5045.39 (Malone).
[77] T 5048.10 (Malone).
[78] See, eg January 2011 Flood Event Report, SUN.016.001.0280 at .0328-0330, .0334-0337, .0339-0340.

and the remainder had at least reviewed them in the course of their professional practice.

113 However, other than the last witness called, Mr Fagot, none of the witnesses purported to enunciate any general principles concerning the proper interpretation of flood mitigation manuals or even suggested that there were any, save for the uncontroversial suggestion that the Manual must be read as a whole[79] and (implicitly) that authority to reduce dam storage levels below FSL would require a clear statement and supporting procedures to that effect in the Manual. Many of the witnesses were taken to various operational manuals applicable to dams in the United States of America as part of an inquiry into the proper practice for operating flood mitigation dams. The questions and answers proceeded on the assumption that those manuals were to be interpreted according to their plain terms having regard to the characteristics and operating conditions of the relevant dam and surrounding catchment and, in some cases, the river or dam system that it formed part of.

114 In his evidence Mr Fagot suggested two general principles or approaches concerning the interpretation of flood operations manuals. First, Mr Fagot suggested that the proper approach to the interpretation of the Manual (and other flood control manuals) was to identify whatever "constraints" were imposed by the Manual and then consider how such matters as the flood objectives could be achieved within those constraints.[80] I address Mr Fagot's evidence concerning the Manual separately below. At this point it suffices to state that, as a general proposition, it can be accepted that if a manual specifies "constraints", that is, limitations and prohibitions, then they must be observed even if it is thought that doing so might impede the achievement of the flood objectives. However, that presupposes that the relevant constraints have been correctly identified.

115 Second, Mr Fagot suggested that the Manual should be interpreted on the understanding that it would be read by flood engineers who understood

[79] See for example Fagot 1, EXP.QLD.001.0232 at .0235, [11]; T 8239.43 (Ickert); T 7350.26 (Swain).
[80] T 9016.37 to T 9018.22; T 9029.13.

certain "shared reservoir engineering concepts".[81] To similar effect, in its written submissions SunWater identified four principles of flood mitigation that it contended informed an interpretation of the Manual.[82] I also address this evidence below but it suffices to state that the engineering concepts being referred to might be shared within the dams that Mr Fagot is exposed to but they are mostly a product of those dam systems and their manuals which clearly express them.

116 In addition, there was a debate in the submissions as to whether the Manual should be interpreted as an "engineer's manual" or a "legal document" and whether there was any difference of substance between the two.[83] I did not find the attempt to draw a distinction between the two helpful. It can be accepted that its principal audience is flood engineers. However, the Manual is also a document the breach of which has legal consequences. In relation to the latter and leaving aside the relationship between the terms of the Manual and the content of any duty of care owed by the flood engineers, a finding by a Court that there was failure to "observe the operational procedures" in the Manual removes any protection that otherwise might be afforded by s 374(2) of the *Safety and Reliability Act*.

117 In considering how the Manual is to be construed and applied it must be borne in mind that it must be applied by flood engineers (and Dam Supervisors) who are conducting flood operations in real time. Such engineers will be taken to have the expertise noted in the Manual and a detailed understanding of the Dams, the upstream and downstream catchments, the RTFM and the available information including rainfall forecasts. The Manual must be interpreted on the basis that the flood engineer's task is to read and apply its text regardless of whether they personally agree with its various prescriptions or rationale, its underlying approach or the order of flood objectives. In short, if ever a document was required to be read according to its plain terms and not by reference some

[81] T 9002.12; (Fagot).
[82] SunWater subs at [82] to [109].
[83] See, for example, State subs at [11] and SunWater subs at [2591].

unwritten understanding between the flood engineers or by undertaking some historical inquiry to examine whether the approach that prevailed in the past has continued, then it is a flood operations manual such as the Manual. The identity of the flood engineers will change over time and that could happen on short notice during the course of a flood event, especially given the physical and mental stresses involved.[84] A flood engineer engaged on reasonably short notice could reasonably expect to be able to consult the Manual (and the FPM) for the guidance they need and receive it.

118 Four related points should be noted.

119 First, it follows that I do not accept that the Manual is to be interpreted according to the subjective understandings of the flood engineers. Thus, for example, in his affidavit Mr Malone asserted that "there was an implicit understanding among the Flood Engineers" that the fulfilment of the definition of a flood event required that "not only would the dams exceed FSL but flood releases through gates would also be required".[85] Even if the existence of such an understanding was demonstrated, which it was not, then, subject to what follows, it is irrelevant to the construction of the Manual.

120 Second, at various points in the defendants' submissions, reference is made to the "intent" of the Manual in a sense that appears to be divorced from what was apparent or discernible on a plain reading of its text. The most obvious example was the strident efforts of some witnesses to assert that it was not the "intent" of the Manual to require that rainfall forecasts be considered in making *any* operational decisions such as the selection of *any* strategy even though section 8.4 is unambiguously clear that they must be considered. To the extent that I can discern, this asserted "intent" is said to be ascertainable from reviewing the history of the drafting of version 7 of the Manual and the repeated assertions in the affidavit evidence of three of the four flood engineers who drafted it. It follows from what I have stated that that approach is misconceived.

[84] See State subs at [12] to [13].
[85] LAY.SEQ.007.0001 at [183] (subject to an order under s 136 of the *Evidence Act 1995* (NSW)).

121 In any event, to the extent that this contention is said to be supported by the history of the drafting of version 7, it fails at a factual level because a consideration of that history does not support that assertion (see Chapter 4).

122 Third, contrary to the plaintiff's submissions,[86] I do not regard the FPM as any form of aid to the interpretation of the Manual. Instead, consistent with what is stated in the January FER, it is an internal document that is of assistance to the flood engineers in implementing the Manual. Its relevance to the interpretation of the Manual and the issues in the proceedings is that, on an evidentiary level, it is yet another document prepared by, or provided to, the flood engineers in late 2009 to early 2010 and which they were cognisant of during the 2011 Flood Event. The FPM is inconsistent with any suggestion that they did not "intend", much less realise, that rainfall forecasts were to be used in making operational decisions during flood operations. It is (yet) another document that refutes the suggestion that the inclusion of references to forecasts in the Manual was a "drafting error".[87]

123 Fourth, the above illustrates the overwhelming need for clarity in the drafting of the Manual. The possibility that during flood operations flood engineers might be uncertain or worse squabble over what the Manual required of them is the antithesis of good flood operations. In some respects, the Manual is not clear. There was a sharp dispute about the significance of any ambiguity in the Manual which may have informed any reasonably open but incorrect interpretation of the Manual adopted by any of the flood engineers.

Strict or Reasonable Interpretation?

124 The plaintiff contended that, because it was common ground amongst all the experts that a reasonably competent flood engineer would be obliged to follow the Manual (see [2]), then that meant that "an engineer who fail[ed] to adhere to the requirements of the relevant manual, properly construed, has necessarily failed to act reasonably".[88] The plaintiff also contended that "the

[86] Plaintiff subs at [430].
[87] T 9871.21.
[88] Plaintiff subs at [388].

Manual can only be regarded as an objective standard against which the conduct of the Flood Engineers is to be measured" and that it follows that the "the Court must first determine what that objective standard is and, having done so, must implicitly find that any other purported standard is unreasonable".[89]

125 Seqwater and SunWater contended that, even if the construction of the Manual adopted by the flood engineers was erroneous, their constructions fell within a range of reasonable constructions, such that operating in accordance with those constructions was not negligent.[90] SunWater contended that the relevant question is not the "proper" or "correct" construction of the Manual but whether "it was reasonably open to the Flood Engineers to interpret it in the way they did".[91] Seqwater framed the inquiry in similar terms.[92] They also submitted that, because s 9(1)(c) of the *Civil Liability Act 2003* (Qld) (the "CLA (Qld)") requires an assessment of the precautions that a reasonable person "in the position of" the defendant would have taken, the reasonableness of the Flood Engineers' constructions is to be assessed having regard to the Flood Engineers' own knowledge and experience. They submitted that the assessment of what is reasonable must take into account the flood engineers' subjective state of mind based on their own experience in operating the dams previously and their involvement in the process of drafting Revision 7 of the Manual.[93]

126 I accept that, in light of the legislative significance of the Manual and the unanimity of views amongst the experts, that the Manual is, as the plaintiff contends, an "objective standard against which the conduct of the Flood Engineers is to be measured". However, I do not accept that any departure from the Manual necessarily establishes that the flood engineer has failed to act in accordance with the standard expected of a reasonably competent flood engineer. The Manual is not a vehicle for imposing strict liability. Thus, if in

[89] Plaintiff subs at [389].
[90] Seqwater subs at [595] to [605], [644] to [645]; SunWater subs at [208] to [209].
[91] SunWater subs at [209].
[92] Seqwater subs at [641] to [647].
[93] Seqwater subs at [644] to [646]; [665] to [671]; SunWater subs at [212] to [213].

some material respect, the flood engineers acted on a good faith interpretation of some part of the Manual that I consider was reasonably open but ultimately incorrect, then that *may not* amount to a breach of any duty of care that they owed. In that circumstance I might not be satisfied that the actions of the engineer were below the standard of a reasonably competent flood engineer in the circumstances as they faced them.[94] Ultimately, whether it was would depend on, inter alia, the provision being interpreted, the reason the interpretation was adopted and its significance to flood operations. In considering that issue, a reasonably competent flood engineer would, if faced with reading a Manual that revealed an apparent ambiguity or inconsistency, seek to resolve it by considering the entirety of the Manual and its underlying emphasis on objectives and strategies. Further, such an engineer would not assume that the requirements for flood operations remain unchanged when the Manual has been substantially rewritten. Otherwise, whether or not a failure to comply with the Manual constitutes a breach of a duty of care must be determined in accordance with the *CLA* (Qld).

127 However, in the end result, this debate, including any debate over the scope of s 9(1)(c) of the *CLA* (Qld) and whether it could include some belief formed by a flood engineer during the 2009 review, does not arise on my findings. Even though Messrs Malone, Tibaldi and Ayre sought to explain in their evidence what their understanding of the disputed aspects of the Manual was, ultimately it was to no avail because (i) I am not persuaded that was their understanding during the flood event;[95] (ii) I am not persuaded they gave effect to any such understanding during the flood event,[96] and (iii) otherwise, the relevant understanding involved an unreasonable construction of the Manual.[97] In the end result, there was not a single instance where I was persuaded that any of the flood engineers took any impugned action during the January 2011 Flood Event based on a mistaken but reasonably held belief about the Manual's requirements.

[94] See *Marsh v Baxter* [2015] WASCA 169 at [654] per Newnes and Murphy JJA.
[95] See Chapter 5 at [141], [157], [166]; Chapter 7 at [452], [460] to [461].
[96] See for example Chapter 7 at [457] to [459].
[97] See below and Chapter 5 at [167] to [177].

128 The evidence in relation to the flood engineers' subjective understanding of the contentious aspects of the Manual is addressed in the balance of this Chapter, as well as in Chapters 4 to 7. In short, Mr Malone ultimately accepted that he had no recollection of how he interpreted and applied the Manual during the January 2011 Flood Event.[98] Mr Tibaldi's evidence was to similar effect[99] and, in any event, I found his evidence was generally unreliable.[100] Mr Ayre, however, maintained that the interpretation of the Manual set out in his affidavits represented his belief during the January 2011 Flood Event.[101] However, I also found his evidence unreliable. With both Mr Ayre and Mr Tibaldi I did not accept their evidence on a contested matter unless it was corroborated by independent evidence.[102]

129 Otherwise, I address the reasonableness of each of the asserted constructions in the balance of this chapter and Chapter 5 which concerns releases below FSL.

3.3.2: Flood Objectives

130 The flood objectives and their order of importance are repeated three times in the Manual.[103] The sections concerning strategy selection at Wivenhoe Dam and Somerset Dam, ie, sections 8.4 and 9.3, both reference the flood objectives and section 8.4 requires that consideration be given to the objectives in making decisions on releases from Wivenhoe Dam within any strategy. The passages from section 3 of the Manual set out in section 3.1.3 above confirm the necessity to operate the dam in accordance with the flood objectives. Section 5.2 requires the flood engineers to "optimis[e] releases of water from the dams to minimise the impacts of flooding in accordance with the objectives and procedures contained in this Manual". The significance of the flood objectives is illustrated by section 2.8, which enables a departure from the procedures in the Manual but only to satisfy the "flood mitigation

[98] T 5353.36 (Malone); Chapter 7 at [454].
[99] T 6445.9 (Tibaldi).
[100] See Chapter 7, section 7.16.
[101] T 7985.26 (Ayre).
[102] See Chapter 7, section 7.16.
[103] Section 1.1 at 1; section 3.1 at 9; section 8.4 at 23.

objectives". Thus, the procedures in the Manual may give way if section 2.8 is followed, but the flood objectives may not.

131 Having regard to the importance placed on the objectives by the plain words of the Manual, the plaintiff contended that a number of propositions concerning their effect on the construction of the Manual followed, namely that: "the overall approach to flood mitigation adopted by the Manual is objective-based"; in effect the strategies are designed to give effect to those objectives; that the Manual is to be "construe[d] … consistently with the Manual's objectives"; to the extent that the Manual's provisions are ambiguous then a construction that "best serves achieving the Manual's objectives in their order of importance" is to be preferred; and conversely "it would be unreasonable to construe the Manual in a manner that would impede achieving the Manual's objectives unless no alternative reasonable construction was available".[104] I agree. To the extent that any assistance can be gained from the revision process in 2009 that led to the Manual being gazetted, something I doubt, then it only supports those contentions.[105]

132 Another matter follows from the objective based approach mandated by the Manual, namely, that to the extent that the Manual requires the exercise of professional judgment by a flood engineer then the flood engineer must act consistently with those objectives and their order of importance. In respect of some matters, the Manual expressly (and perhaps implicitly) requires the relevant flood engineer to act (such as declaring a flood event when it is expected that FSL will be exceeded). On other matters the Manual expressly (and perhaps implicitly) prohibits the flood engineer from acting (such as overtopping Wivenhoe Dam). However, in many respects the Manual is silent, leaving the relevant decision to the flood engineer to exercise their professional judgment. The most obvious example is the determination of the amount of water to be released ("decisions on dam releases").[106] Subject to the analysis in section 3.3.8, the Manual does not prescribe any method for

[104] Plaintiff subs at [395].
[105] See Chapter 4, section 4.5.
[106] Section 8.4.

determining how much water to release but instead only specifies the objectives to be achieved by the releases within a strategy and limits on the amount than can be released. The determination of the amount to be released is left to the flood engineer's judgment but in making that assessment the flood objectives must be considered in their stated order.

133 Three further matters about the flood objectives should be noted. First the significance of the objective of "retain[ing] the storage" at FSL to the question of whether the Manual precludes releases from either dam below FSL is addressed in Chapter 7.

134 Second, like the other objectives, the objective of minimising disruption to rural life leaves scope for the exercise of judgment by the flood engineer as to how that objective might be achieved. The level of disruption occasioned by the closure of rural bridges is addressed in Chapter 2. In a particular circumstance a flood engineer might choose to release water from Wivenhoe Dam at a higher rate with a view to keeping more bridges closed for a shorter period so that all or most bridges could open sooner and another flood engineer might release at a lower rate with the intention of keeping more bridges open in the short term while accepting that the lower level bridges would be inundated longer. Mr Ayre recognised as much in an email to Mr Malone on 20 December 2010 when he advocated larger releases in the short term to enable all bridges to be open by Christmas Day.[107] Either way, each engineer would be attempting to minimise disruption to rural life.

135 Third, in their submissions, the defendants characterised aspects of the debate between themselves and the plaintiff and Dr Christensen as a contest over whether higher priority should be afforded to the statement of objectives in the Manual or the various constraints in the Manual. In doing so they placed great emphasis on Mr Fagot's evidence.[108] I am doubtful that this truly encapsulates the real difference between the parties. In any event I have

[107] SEQ.001.019.3620.
[108] See SunWater subs at [229] to [240].

explained how the Manual's objectives and constraints interrelate at [114]. I address Mr Fagot's evidence in section 5.4.

3.3.3: Commencement and End of a Flood Event

136 I have described the provisions dealing with the declaration of a flood event and gate closing in [16ff] and [68ff].

137 In relation to the commencement of a flood event, the effect of the combination of the definition of a "Flood Event" in section 1.2 and the duties imposed on the DFOE in section 2.2 are clear. The DFOE is *obliged* to declare a flood event if, based on "prevailing or predicted weather conditions", either dam is expected to exceed FSL. If that expectation relates to Wivenhoe Dam then section 8.3 requires the closure of all gates and the undertaking of an assessment of the magnitude of the "Flood Event". In the meantime, until the water reaches EL 67.25m AHD, no releases are to be made from the gates at Wivenhoe Dam (though there is nevertheless a flood event). Further, the Manual does not preclude releases from the regulators at Wivenhoe Dam before it reaches EL 67.25m AHD.[109] However, just because such releases are made from the regulators does not mean that they are "operational releases" if that is meant to be different from releases for flood mitigation purposes and does not mean that a flood event has not commenced. I do not consider that any contrary interpretation is reasonably open.

138 If the DFOE expects that Somerset Dam will exceed FSL then section 9.2 requires all radial gates to be opened and all sluice gates and regulator valves to be closed while a similar assessment is made. There is no equivalent to Wivenhoe Dam's EL 67.25m AHD threshold before making releases from Somerset Dam. Instead, once the assessment is made, and if Wivenhoe Dam is not expected to exceed FSL, then S1 authorises releases through the regulator valves and sluice gates. If Wivenhoe Dam is expected to exceed FSL then releases must be made consistent with S2. As described in

[109] T 4953.20 (Malone).

Chapter 4, in March 2010 a flood event was declared in relation to Somerset Dam and flood releases were made from Somerset Dam from below FSL (and then above FSL) as per Strategy S1.

139 The Manual does not expressly identify when a flood event ceases. Both of sections 8.5 and 9.4 contemplate a "final gate closure" at both dams after the flood peak has passed and which can occur when the lake level has returned to FSL or below FSL in contemplation that base flow will fill the dams up to FSL "to provide for a full dam at the end of the Flood Event". It follows that the end of a flood event may not be necessarily synonymous with the "final" gate closure, although they appear to be closely related.[110]

140 In considering when a flood event ceases, these provisions should be read together with the definition of "flood event" and section 2.2. It would make little sense if a flood event ceased with a final gate closure at or around FSL but then, based on predicted weather conditions, the DFOE was obliged to immediately declare a flood event because they expected FSL to be exceeded. Instead, in such a scenario and as suggested by Dr Christensen,[111] the gates at Wivenhoe Dam might be closed but the flood event would not cease until the flood engineer no longer expected FSL to be exceeded having regard to actual and predicted weather. In such circumstances nothing in the Manual precludes releases being made from the regulator at Wivenhoe Dam and the cone valves at Somerset Dam (although whether that was justified would depend on prevailing conditions). However, the significance of the flood event continuing is that the flood engineer would not be subject to the EL 67.25m threshold in section 8.3 before making releases in the event that inflows increase.

141 Five further points should be noted.

[110] Cf SunWater subs at [270]; T 9839.
[111] February 2015 Report, EXP.ROD.001.0016 at [365].

142 First, when sections 8.5 and 9.4 are read together with section 2.2, it follows that a flood event cannot end while either Dam remains above FSL. Any contrary view is unreasonable.

143 With Wivenhoe Dam, the notes to section 8.5 provide that the requirement to drain down within 7 days could be relaxed and "final gate closure" could occur if the dam is between EL 67.0m AHD and EL 67.5m AHD provided "a favourable weather outlook is available" in order to obtain "positive environmental outcomes". In such a case, "final gate closure" might occur to enable, say, fish recovery and thereafter releases might be made through the regulator to bring the dam down to FSL, but the "flood event" would not be over until it was not expected that the dam would rise above FSL. Even then, such an approach could only be justified if the estimates of inflows and rainfall conditions warranted that conclusion.

144 Second, in his oral evidence, Mr Malone stated that a DFOE has a discretion to not declare a flood event if the DFOE thought that doing so would not be using resources in a cost-effective manner.[112] He also said that his understanding of the words "*Flood Event*" was that "*it is a situation where the dam operations engineer expects the water level of either dam to exceed full supply level and to make gated releases*";[113] that is exceed 67.25m AHD. Mr Malone's evidence on this topic is further set out in Chapter 6. It suffices to state that both of those contentions were completely untenable. Neither Mr Ayre nor Mr Tibaldi agreed that there was a discretion to not declare a flood event.[114] Mr Pokarier attempted to support Mr Malone's interpretation, but conceded that this interpretation was inconsistent with the terms of the Manual and the FPM.[115]

145 Third, as noted, in justifying his role in bringing flood operations to an end on 2 January 2011 while Wivenhoe Dam was above FSL, Mr Malone raised concerns about the cost, inconvenience and stress on the staff of maintaining

[112] T 4754.1 - .10.
[113] T 4754.11 - .14.
[114] T 5707.8-25, T 5730.10 - .22, T 5925.6 - .37 (Tibaldi); T 7579.26 - .32 (Ayre).
[115] T 6796.16; T 6798.14 - .23.

the FOC open when the dams were just above FSL.[116] The Manual clearly contemplates that the FOC will be staffed and resourced during a Flood Event but it does not specify what that level of staffing and resourcing must be. The types of concern raised by Mr Malone do not bear upon the proper meaning of the Manual. They do bear upon the obligations of Seqwater in providing resources to enable the Manual to be complied with but that is a different matter. However, in circumstances where none of the defendants have sought to justify any departure from the Manual, that is irrelevant.

146 Fourth, the plaintiff contended, and at least Messrs Pokarier and Tibaldi agreed, that the threshold of EL 67.25m AHD only applies at the commencement of a flood event, such that if during the flood event the storage level of Wivenhoe Dam falls below that level (but say above FSL) then section 8.3 does not require the closure of the Wivenhoe Dam gates.[117] I agree.[118]

147 Fifth, in relation to the declaration of a flood event, SunWater submitted that provided the FOC was mobilised prior to Wivenhoe Dam reaching a gate trigger level of 67.25m AHD then there was no practical consequence in delaying declaring a flood event even though it was expected that one or either of the dams would exceed FSL.[119] In many respects that may be correct, although it overlooks the potential for a flood engineer to make (and increase) flood releases from Somerset Dam to bring Wivenhoe Dam over the threshold to enable gate operations at Wivenhoe Dam to commence. Provided that action is undertaken in conformity with S1 while Wivenhoe Dam is below FSL, and thereafter S2, there is nothing in the Manual to preclude that occurring and, depending on the forecast outlook, it may be appropriate, or even necessary.

[116] See LAY.SEQ.016.0001 at [91(e)]; T 4753.40 – .46; T 4936.36; T 4936.46 to T 4937.6; T 5116.15 - .20 (Malone).
[117] T 6121.15 - .21 (Tibaldi); T 6998.11 - .43 (Pokarier).
[118] Releases below FSL are addressed in Chapter 5.
[119] SunWater subs at [269].

3.3.4: Predicted v Actual Lake Levels

148 I have set out in the numerous references to “predicted”, “likely” or “expected” dam levels in the Manual above. Having regard to those references, section 8.4 and the flowchart on page 24 of the Manual, the plaintiff contended that each of the strategies, including the W1 sub-strategies, was engaged by a predicted lake level and not an actual level.[120] Before addressing that contention, it is necessary to address a suggested construction that only emerged clearly in Seqwater’s final written submissions.

Defendants’ Submissions: “Two streams”

149 In its defence, Seqwater denied that W1 was engaged by a prediction that the storage level of Wivenhoe Dam would not exceed EL 68.5m AHD. Instead, Seqwater pleaded that Strategy W1 and its sub-strategies operated by reference to the actual storage level of Wivenhoe Dam and higher strategies could not be engaged prior to the storage level exceeding EL 68.5m AHD.[121] Seqwater opened its case in a manner consistent with that pleading.[122] However, in its written submissions, Seqwater submitted that it was at least a reasonable interpretation of the Manual that it provided for “two streams for the application of Wivenhoe strategies” that “operate concurrently”, namely a “choice of strategy by [the] flood engineer based upon predicted level” and use of “the actual level to determine strategy”.[123] In oral submissions, Seqwater confirmed the dual streams approach was only applicable to W1, and its sub-strategies, and the transition to W2/W3.[124] On this approach, absent a “choice for a higher strategy” made by a flood engineer then the prevailing strategy is dictated by actual lake levels[125] and the making of that choice “relies heavily on the judgment of the flood engineer”.[126] The

[120] Plaintiff subs at [513], [526], [530] and [535].
[121] Seqwater Defence, PLE.020.012.0001, [169(a)(ii), (iii), (iv)]; SunWater Defence, PLE.030.008.0001, [109].
[122] T 377.20.
[123] Seqwater subs at [704].
[124] T 9652.19.
[125] Seqwater subs at [702].
[126] Ibid at [703].

submissions contend that this approach was operative throughout the flood event.[127]

150 Seqwater also contended that section 8.4 is more of a "commentary" on the approach to adopt in selecting strategies and not an instruction.[128] It submitted that section 8.4 contemplates a flood engineer exercising a choice to make a strategy and that, contrary to the plaintiff's interpretation, it is not possible for such a decision to be based on both the actual level in the dam and the predicted maximum storage level.[129] Instead, W4 was said to enable a choice as to whether the strategy was engaged prior to reaching EL 74.0m AHD ("the strategy normally comes into effect when the actual level [in Wivenhoe Dam] reaches EL 74.0m").[130] According to Seqwater, W1 also allows a choice such that when the flood engineer "forms a judgment that the dam level is likely to exceed EL 68.5, the flood engineer has the option to engage W2 or W3, but it is not mandatory to do so".[131]

151 SunWater submitted that the Manual was generally ambiguous as to whether strategies were selected by reference to predicted or actual lake levels. It contended that, given the history of the revision of the Manual, especially the alleged circumstances in which Mr Allen is said to have directed the reintroduction of actual lake levels into the draft of the Manual,[132] that it was reasonable for Mr Ayre to interpret the W1 sub-strategies as being engaged by actual levels and, when EL 68.5m AHD was exceeded, then use predictions of downstream flows to choose between W2 and W3.[133] SunWater submitted that the impacts of releases in W1 were not to be "trivialised"[134] and that the storage space between EL 67.0m AHD and EL 68.5m AHD were "reserved for the primary consideration of minimising disruption to downstream rural life".[135] In the alternative SunWater submitted, like

[127] Ibid at [706].
[128] Ibid at [681].
[129] Ibid at [679].
[130] Ibid at [674].
[131] Ibid at [675]; T 9616.
[132] See Chapter 4, section 4.5 especially at [127] to [138].
[133] SunWater subs at [280] to [284].
[134] T 9835.19.
[135] T 9837.24 - .26.

Seqwater, that the Manual conferred a choice on the flood engineers to use actual or predicted lake levels.[136] The State did not specifically address this topic, preferring to adopt the submissions of Seqwater and SunWater in relation to the Manual generally[137] while focussing on specific aspects of the Manual it claims Dr Christensen violated in his simulations.[138]

152 Seqwater's apparent change in position appears to have followed from what it contended was an "acceptance" by Mr Tibaldi that the Manual "also offers to the flood engineer the ability to choose a strategy based on a future dam level".[139] In fact, that "acceptance" was part of a pattern of generally inconsistent and times incoherent evidence given by Mr Tibaldi. In his first affidavit and then initially in cross-examination, Mr Tibaldi stated that W1 operated by reference to actual levels[140] and that a transition to W2/W3 based on a predicted level above EL 68.5m AHD was not permissible while the actual level was below that.[141] However, he later said that an engineer could bypass W1 if the engineer made a judgment call that it was reasonable to do so[142] which could include the circumstance that it was "certain" that the dam would reach EL 74m AHD[143] or EL 73m AHD.[144] The plaintiff contended that this approach was "novel" and apparently devised in the witness box.[145] Whatever its origins, it did not reflect what was suggested in Mr Tibaldi's first affidavit, does not reflect flood operations during the January 2011 Flood Event and does not fully correspond with Seqwater's two stream approach. Mr Tibaldi's evidence was a tenuous evidentiary basis for Seqwater's suggested construction.

153 A footnote to Seqwater's submissions notes that Mr Malone was "not asked about 'this' in cross-examination".[146] If the 'this' being referred to was

[136] SunWater subs at [285].
[137] State subs at [2].
[138] Ibid at [3] – [18] and [494] to [568].
[139] Seqwater subs at [672].
[140] Tibaldi 1, LAY.SEQ.004.0001_OBJ, [249]; T 5557.25, T 5559.41.
[141] T 5729.1 - .7.
[142] T 5773.26 - .39.
[143] T 5771.28.
[144] T 5771.37.
[145] Plaintiff subs at [524].
[146] Seqwater subs at [672; fn 609].

Seqwater's suggested construction, then that is not surprising since it only appears to have developed over time and after he gave evidence. In any event, Mr Malone's evidence was inconsistent with Seqwater's suggested construction. Mr Malone accepted that rainfall forecasts were meant to be used to select strategy (but not to make decisions on how much to release),[147] accepted that selection of strategy required predictions about maximum height levels[148] and accepted that words at the end of W1 operate as a failsafe if prediction as to height proves incorrect.[149]

154 For the sake of completeness I note that Mr Ayre contended that Strategy W1 and its sub-strategies operated by reference to the actual prevailing storage level in Wivenhoe Dam, and not by reference to predictions. He said the references to "Lake Level greater than" in the sub-strategies W1A to W1E, as well as the sentence at the conclusion of W1 which requires a transition to Strategy W2 or W3 if the "level reaches EL 68.5m AHD", indicated that the invocation of Strategy W1 and the sub-strategies were dependent on actual lake levels and not predicted lake levels.[150]

155 Seqwater's submissions on this topic referred to the evidence of Mr Fagot, Mr Pokarier and Mr Ickert.[151] Seqwater's summary of Mr Fagot's evidence does not suggest that Mr Fagot supported a "two streams" approach, only that he accepted that there was an ambiguity in the Manual and that it was open to interpret W1 as tied to actual lake levels.[152]

156 As Seqwater's submissions concede, Mr Pokarier did not support any suggested "two streams" approach.[153] He said that the Manual required Strategies W1 to W3 to be implemented based on the actual storage levels in Wivenhoe Dam, rather than predicted levels[154] but agreed that his interpretation was "*inconsistent*" with the statements on page 23 of the

[147] T 4750.39.
[148] T 4845.40.
[149] T 4963.34.
[150] Ayre 1, LAY.SUN.001.0001_OBJ, [343].
[151] Seqwater subs at [709] to [713].
[152] Ibid at [713]; see Fagot 2, EXP.QLD.001.0524_2, [178].
[153] Seqwater subs at [710].
[154] T 6818.12 - .34; T 6823.25.

Manual about how strategies were determined and changed according to forecasts.[155] Mr Pokarier accepted that reading the "*Lake Level*" references in respect of Strategies W1-W3 as references to *predicted* water levels was consistent with other parts of the Manual[156] and was inconsistent with his construction of the equivalent language in relation to W4.[157]

157 Only Mr Ickert provided some support for Seqwater's suggested construction and it was not much. In his reports, Mr Ickert was not asked to and did not address whether the Wivenhoe strategies in the Manual were engaged by actual or predicted lake levels. However, the issue was taken up in cross-examination of his views on no release modelling.[158] Mr Ickert accepted that the invocation of W1 is governed by a prediction that the lake level will be less than EL 68.5m AHD but, if that condition held, then the choice of sub-strategies depends on actual lake levels. On this approach, if at any time the predicted lake level is EL 68.5m AHD or higher or, if the actual lake level reaches EL 68.5m AHD, then W2 or W3 is engaged. What is not clear from Mr Ickert's evidence is whether he accepted that the invocation of W2 or W3 is a matter of choice for the engineer when the prediction is that the height of Wivenhoe Dam will exceed EL 68.5m AHD or is mandated; ie, whether he accepts a "two streams" approach or only "one stream".

158 In any event, Seqwater's construction finds no support in the Manual. There is nothing in the Manual which suggests that the flood engineer has a choice of methodologies in determining strategy. Seqwater's construction of the Manual is inconsistent with the flowchart and that part of section 8.4 which provides that "[s]trategies *are changed* in response to changing rainfall forecasts and stream flow conditions…".[159] On Seqwater's construction, the engineer's choice or judgment dictates whether those matters will result in a change of strategy. If, as Seqwater contends, the Manual entrenches two different approaches for the flood engineer then the flowchart on page 24 would have

[155] T 6859.42.
[156] T 6861.30.
[157] T 6863.44 to T 6864.1; see also T 6859.17 - .40 (Pokarier).
[158] It emerged from the cross-examination of Mr Andrew Ickert on 26 July 2018 at T 8249.39 to T 8250.38.
[159] Manual at 23 (QLD.001.001.0146 at .0173).

been different and the emphatic language on page 23 would have been qualified. It would have been a relatively simple exercise in drafting to provide that the default position is that actual levels dictate strategy unless the flood engineer determines to the contrary. Instead, where the Manual makes strategy selection (solely) dependent on actual levels, it does so expressly and in clear terms.[160]

159 Overall, a "concurrent streams" approach has little to commend it. It could yield inconsistent approaches between different flood engineers working successive shifts and disagreements over methodology for choosing strategies between flood engineers on the same shift. Further, to the extent that it is relevant, the rejection of the flowchart set out in Draft 4 of the revision process of the Manual in 2009[161] is inconsistent with the Manual making the determination of strategy a matter of "choice" or discretion on the part of the flood engineers.

160 Seqwater's approach to the construction of the Manual elides the difference between a Manual that is (arguably) ambiguous and a Manual that expressly provides two different methodologies for the selection of strategy. Faced with ambiguity in a Manual, a reasonably competent flood engineer would seek to resolve it,[162] not embrace it as Seqwater seeks to do. I reject Seqwater's construction. No reasonably competent flood engineer could interpret the Manual in the manner it suggested.

Proper or Reasonable Construction

161 There remains to consider the plaintiff's submission noted in [148] and SunWater's primary submission that it was at least reasonable for Mr Ayre to interpret the W1 sub-strategies as being engaged by actual levels and, when

[160] Eg, the emergency provisions in section 10.3: "[w]hen the storage level is below 74.0m AHD" etc; Manual at 45.
[161] See Chapter 4 at Figure 4-4 and [124].
[162] T 6864.3 (Pokarier).

EL 68.5m AHD was exceeded, then use predictions of downstream flows to choose between W2 and W3.[163]

162 Both the flow chart on page 24 of the Manual and the reference to predicted levels in the governing conditions for each of Strategy W1 to W4 firmly point to the selection of strategies being dependent on predicted lake levels and not existing lake levels. Further, subject to one possible matter, section 8.4 points to each of the strategies being selected by predicted height levels (as well as predicted peak flow rates downstream in selecting between W2 and W3). In particular, and as already noted, the statement that "[s]trategies are changed in response to changing rainfall forecasts and stream flow conditions…" is inconsistent with any suggestion that any particular strategy was (solely) dependent on the actual lake level.

163 One potential countervailing indication in section 8.4 is the reference to the strategy chosen depending "on the *actual levels* in the dams and the following predictions" including a prediction of the maximum storage levels. As noted, the defendants contend that this leaves open the possibility that the selection of at least one of the strategies was dependent on actual levels. The plaintiff contended that the reference to "actual levels" merely reflects the proposition that any prediction must commence with the current storage level. One matter tending against that is that the equivalent passage in section 9.3 concerning Somerset Dam does not refer to "actual levels". The other possible countervailing indications are the references to "lake level greater than" in the sub-strategies of W4 and W1 and the statement at the conclusion of W1 that "[i]f the level reaches EL 68.5m AHD in Wivenhoe Dam, switch to Strategy W2 or W3 as appropriate".

164 Any consideration of these potentially countervailing suggestions must take into account the discussion in sections 3.3.1 and 3.3.2, including the need to consider the Manual as a whole, to construe the Manual consistently with its objectives and that a reasonably competent flood engineer should seek to resolve potential ambiguities in the Manual and not exacerbate them.

[163] SunWater subs at [280] to [284].

165 In relation to the references in W4 to “Lake Level between 74.0 and 75.5m AHD” under the heading to Strategy W4A and “Lake Level greater than 75.5m AHD” under the heading to Strategy W4B, for the reasons given at [63] they can only sensibly be read as references to predicted levels. I do not accept that a reasonably competent flood engineer could take a contrary view. The discussion of W4 in the Manual expressly refers to the strategy “normally” coming into effect when the water level in Wivenhoe Dam reaches EL 74.0m AHD, which clearly contemplates the possibility of the strategy being invoked prior to that time. In this respect, this reference to the “water level in Wivenhoe Dam reach[ing] 74.0m AHD” is an instance where section 8.4 makes the selection of strategy at least partially dependent on “actual levels”.

166 A similar analysis for W1 leads to the conclusion that the references to “Lake Level greater than” with each of the W1 sub-strategies are, like the same phrases in W4, a reference to predicted lake levels. To treat the references to “Lake Level greater than” as references to actual levels is not reconcilable with the general statement concerning the selection of strategy in section 8.4, the reference to “likely levels” in the flow chart and the reference to “Wivenhoe Storage Level *predicted* to be less than 68.50m AHD” in the opening passage to W1. This inconsistency is exemplified by the evidence of Mr Pokarier who said that the Manual required Strategies W1, W2 and W3 to be implemented based on the actual storage levels in Wivenhoe Dam, rather than the predicted levels[164] but agreed that his interpretation was “inconsistent” with the statements on page 23 of the Manual.[165] Mr Pokarier accepted that reading the “Lake Level” references in respect of Strategies W1-W3 as references to *predicted* water levels was consistent with the Manual[166] and was inconsistent with his construction of the equivalent language in relation to W4.[167]

167 The statement at the conclusion of W1 is not inconsistent with the sub-strategies being invoked by predicted lake levels. Instead, it operates as

[164] T 6818.12 - .34; T 6823.25.
[165] T 6859.42.
[166] T 6861.30.
[167] T 6863.44 to T 6864.1.

a failsafe such that if the predicted lake level for Wivenhoe Dam is less than 68.50m AHD but the prediction is proved incorrect by inflows, then higher strategies are engaged. When this statement is seen as operating in this manner it then becomes another instance of a circumstance when the selection of a strategy at least partly depends upon an “actual level” as contemplated by section 8.4.

168 The conclusion that W1 is invoked by predicted rather than actual lake levels is reinforced by considering the interaction between the requirement to consider all of the flood objectives in their specified order within any strategy and the statement in the conditions box for W1 that the primary consideration is “minimising disruption to downstream rural life”. The apparent tension between these two statements dissolves if the relevant levels that invoke the strategies and sub-strategies are treated as predictions rather than actual lake levels. If they are predictions then, while the predicted level of Wivenhoe Dam remains less than EL 68.5m AHD, flood operations can be directed to minimising disruption to downstream rural life on the understanding that if the prediction is revised above EL 68.5m AHD higher strategies will be engaged and that objective will be subordinated to dam safety and optimising protection for urban areas. However, if W1 is interpreted so that either its invocation or the invocation of the various sub-strategies are solely dependent on actual lake levels then that would risk subordinating dam safety and optimising protection for urban areas to the objective of minimising disruption to downstream rural life. In that event, in circumstances where the actual level of Wivenhoe Dam was less than EL 68.5m AHD but the predicted level was well in excess of that, say EL 73m or 74m AHD, then the capacity of the flood engineer to make large discharges to create storage space for the expected inflows would be inhibited by the maximum discharge amounts specified for the various sub-strategies in W1. This would exacerbate rather than reconcile the tension between the “primary objective” of W1 and its subordination to three higher flood objectives.

169 Further, if the W1 sub-strategies are engaged by actual lake levels and not predicted lake levels, then that will not only undermine the giving of effect to

all of the flood strategies in their stated order of importance "within any strategy" but it would also undermine the achievement of the "primary objective" of W1, namely, minimising disruption to downstream rural life. A flood engineer seeking to minimise disruption to downstream rural life could reasonably take the view that it was preferable to discharge water at a higher rate for a shorter period of time rather than at a lower rate for a longer period in order to open bridges earlier. An interpretation of W1 that makes the maximum release rates dependent on actual levels will tend to impose greater restrictions on the flood engineer's capacity to make higher releases earlier compared with an interpretation that makes the maximum release rates at any given time dependent on predicted levels.

170 Ultimately the plaintiff's construction seeks to address and resolve the inconsistencies suggested in [166]. The references to "Lake levels greater than" are, properly analysed, predictions. The suggestion that lake levels in section 8.4 depend in some way on actual levels embraces not just the proposition that predictions commence with the existing actual levels but the two matters noted in [165] and [167]. In contrast, SunWater's suggested "reasonable interpretation" makes no attempt to reconcile the use of actual lake levels for W1 with section 8.4, the flowchart and the reference to prediction in governing conditions. They are all left hanging. Flood engineers may not be lawyers but the Manual required close analysis on their part so it could be applied in real time flood operations without disputes emerging about how strategies were invoked.

171 It follows that I accept the plaintiff's proposed construction. I note that this accords with Dr Christensen's approach.[168] I consider that a construction that makes any of the strategies, including the W1 sub-strategies, solely dependent on actual lake levels to be unreasonable.

172 Three further matters should be noted.

[168] February 2015 Report, EXP.ROD.001.0016 at [314] to [319].

173 First, contrary to SunWater's submissions, no support for its suggested reasonable interpretation can be derived from the events surrounding the revision of the Manual in 2009 (see Chapter 4).

174 Second, as explained in Chapter 7,[169] during 8 and 9 January 2011 the flood engineers did not conduct flood operations as though they were in Strategy W3 even though the actual level of Wivenhoe Dam exceeded EL 68.5m AHD.

175 Third, a further issue that arose concerns the interrelationship between the concept of predicted "*maximum* storage level" as a basis for strategy selection as referred to in section 8.4 and the references to "likely" in the flow chart and "predicted" levels in the introduction to each strategy. This issue is addressed below in relation to the no release assumption.

3.3.5: Forecasts and Best Forecast Rainfall

176 Once it is concluded that the Wivenhoe strategies are determined by predicted levels the next question that arises is whether the Manual stipulates how those predictions are made and, in particular, does it only involve RTFM modelling of rain on the ground or must forecast rainfall be considered? On that the Manual is clear. To the extent that predictions are required to be made then sections 8.4 and 9.3 unambiguously state that such predictions are to be made "using the best forecast rainfall and stream flow information". No reasonably competent flood engineer could form a contrary view.

177 The only textual matter said to support the basing of predictions by only using rain on the ground is section 5.1 which describes the RTFM (see [28]). In its written submissions, Seqwater noted that the provision contemplates an estimation of "*likely* dam inflows" using only "rainfall and river height data" and then "a range of *possible* inflow scenarios" based on "forecast and potential rainfall".[170] It submitted that these passages suggested that it was not mandatory under the Manual to transition to higher strategies (or determine

[169] At [450] to [453].
[170] Seqwater subs at [1071].

release rates) based on RTFM runs that used forecast rain.[171] The submissions refer to an acknowledgement by a Senior Water Resources Engineer called by the plaintiff, Michael Kane, that section 5.1 could be interpreted in that way.[172] However it fails to address sections 8.4 and 9.3 which are the operative provisions (and the balance of the references to forecast rainfall in the Manual). When all of those provisions are read together and bearing in mind that section 5.1 is a "general" section describing the RTFM then, at most, the section is simply providing a broad description of how the flood engineers might undertake the task of making the predictions referred to in sections 8.4 and 9.3 using both "best forecast rainfall" and "stream flow information".

178 Beyond that nothing in the Manual supports a contrary view. As stated, there are twelve references to the forecast rainfall or the like throughout the Manual. Of particular significance is that section 1.3 acknowledges the limitations on obtaining accurate forecasts and estimating flood run-off. Thus, the Manual acknowledges the inherent uncertainties in estimating inflows based on rainfall forecasts but compels the flood engineers to use them in the selection of strategy anyway.

179 SunWater accepted that a literal reading of section 8.4 required the use of forecasts in the selection of strategy but submitted that it should not be given effect to because: (i) the dams had not been operated on the basis of forecasts in the past and during the 2009 review Mr Tibaldi stated that there would be no relevant change under the new manual; (ii) the use of rainfall forecasts is "beset by unreliability"; and (iii) it was "no part of accepted flood engineering practice to use rainfall forecasts qualitatively in flood operations".[173] However, in relation to (i) releases based on predicted rain were made during the 2009 and 2010 flood events and the Manual review process made it absolutely clear that forecasts would be utilised.[174] In relation to (ii), the Manual expressly acknowledges that unreliability but mandates that

[171] Ibid at [1069].
[172] T 3182.22 to T 3184.47; Seqwater subs at [1067].
[173] SunWater subs at [286] to [290].
[174] See Chapter 4, section 4.5.

forecasts were to be used. In relation to (iii), I do not accept that the evidence about flood engineering practices rises above what is reflected in the applicable manual for each dam or dam system in question. In this case, this Manual is emphatic when it comes to using forecasts.

180 What is the “best forecast rainfall … information”? Each of sections 8.4 and 9.3 refer to the use of the “best forecast rainfall” and streamflow “information available” in determining strategy and, in particular, in making predictions as to the “maximum storage levels” and, in the case of section 8.4, the downstream flows at Lowood and Moggill without Wivenhoe Dam releases.

181 The forecast products available during the January 2011 Flood Event are discussed in Chapter 2 (and their reliability is addressed in Chapter 9). In short, there was only one forecast available for an eight-day period and one available for a four-day period, namely the eight-day PME and four-day PME forecasts. There was a 72-hour forecast product available, namely the SILO meteograms. There were two available over a 24-hour period, namely, the 24-hour QPF forecast for the catchment area above the dams and the daily PME forecasts. It appeared to be widely accepted that for the area above the dams the 24-hour QPF was superior to the daily PME forecast because it was catchment specific.

182 The plaintiff contended that identification of the “best forecast rainfall … information” will “necessarily depend on the task for which the information is to be used”.[175] The plaintiff noted Mr Malone’s concessions that the maximum storage level was a reference to a “prediction about the maximum level that each of those dams will reach during this particular flood event”[176] and the “best forecast rainfall … for something that might happen in three or four or five days’ time is not the 24 hour QPF” (“It doesn’t give me a long enough time window, I agree”).[177] Thus the plaintiff submitted that it follows that the phrase, “best forecast rainfall… information available”, does not refer to a specific type of forecast product, nor to the most accurate or skilful or reliable

[175] Plaintiff subs at [457].
[176] T 4955.31.
[177] T 4957.45.

forecasts, but instead refers to the best forecast available for the relevant time period which must be considered to make the predictions required by section 8.4.[178] The plaintiff asserted that Mr Malone conceded a flood event of several days' duration would necessitate consideration of a multi-day forecast.[179] Dr Christensen contended that it required a consideration of "all rainfall forecasts and forecast stream flows".[180]

183 SunWater submitted that "best" forecasts are those which are the most accurate and the only ones directly applicable to the catchment", i.e., the 24-hour QPFs.[181] Seqwater submitted that the best forecast rainfall was not so "narrowly defined" as to be solely dependent on the selected time frame for the prediction. It also contended that it was "not necessarily ... contained in the 8-day and 4-day PME products" but that instead a "good argument can be made that the best forecast rainfall information was in the 24-hour QPF forecasts".[182]

184 As there were differing interpretations of Mr Malone's evidence in the plaintiff's submissions compared with Seqwater's submissions,[183] it is necessary to consider his evidence on this in further detail. Mr Malone accepted that a PME might give the "best information" for four or five or six days, but their accuracy decreases rapidly after several days[184] and agreed that the answer to what is the best forecast rainfall depends on the task that you want the information for, "taking into account the uncertainty associated with that prediction".[185] Ultimately he agreed:[186]

> "Q. I'm not saying a PME is the best available. I'm saying any form of forecast beyond 24 hours answers the description of best available better than a 24 hour QPF if the question you're asking is what would the maximum storage level in three or four or five days time?

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178 Plaintiff subs at [458].
179 T 4956.15, T 4957.42 (Malone); Plaintiff subs at [457].
180 February 2015 Report, EXP.ROD.001.0016 at [302].
181 SunWater subs at [294].
182 Seqwater subs at [761].
183 Compare Plaintiff's subs at [458] with Seqwater subs at [778] to [779].
184 T 4956.15 - .21.
185 T 4956.33 - .36.
186 T 4957.28 - .45.

A. No, not necessarily because you're assuming that rain is going to fall in the catchments and I can't be guaranteed of that.

…

Q. The best forecast rainfall information available today for something that might happen in three or four or five days time is not the 24 hour QPF, is it?

A. It doesn't give me a long enough time window, I agree."

185 The significance of these passages is that Mr Malone did accept that, at least on some occasions, 24 hours represents too short a planning horizon for the conduct of flood operations. As explained in Chapter 6, all of the spreadsheets prepared by the flood engineers during the January 2011 Flood Event projected a release of flood waters over a period of time greater than that. Seqwater's and SunWater's submissions on this topic fail to address the ultimate purpose of why the relevant forecasts might be used. If it is necessary to obtain the best information about predicted rainfall beyond 24 hours then self-evidently the 24-hour QPF will not be the best forecast rainfall, although the greater accuracy of the QPF forecast might warrant the adoption of an approach to flood operations that maximises reliance on that forecast compared to less accurate forecasts. Accordingly, I accept the plaintiff's contention and the reasoning in support of it as far it goes, although I do not accept that the selection of a suitable time frame for the prediction exhausts the meaning of "best forecast rainfall ... information" and the scope for the exercise of engineering judgment in selecting such a forecast. Four matters should be noted.

186 First, if circumstances warrant the obtaining of best forecast rainfall information for a period in which more than one forecast is available, then an exercise of engineering judgment would be required as to what constitutes the best; ie, is it one or the other or a combination of both?

187 Second, section 8.4 does not dictate that any of the predictions referred to will be arrived at using only one forecast period. There is scope for engineering judgment to generate predictions based on different periods and then compare and analyse them to determine what prediction flows from the "best

forecast rainfall [and streamflow] information". Such judgment could include a consideration of the reliability of the forecast product and could allow a flood engineer to determine that a particular forecast warranted little consideration.

188 Third, as already noted, the selection of the best forecast rainfall information may be interdependent with the flood engineer's chosen approach to flood operations. For example, Dr Christensen's approach to considering downstream flows was to monitor them on a 24-hour basis given that the forecast for that period downstream was the most accurate and that 24 hours represented the period in which current releases could combine with downstream flows.[187] Hence, on his approach the "best forecast rainfall information" for assessing downstream flows is the QPF. However, if the chosen approach to flood operations required detailed knowledge of downstream flows over a greater period then it may be that a different forecast product would be, or at least form part of, the best rainfall forecast information relevant to downstream predictions (although the flood engineer would have to account for the greater uncertainty that was introduced into their operations by the use of a longer term forecast).

189 Fourth, notwithstanding these points, a flood engineer was not entitled to simply reject all use of upstream (or downstream) forecasts in the selection of strategy (and, as discussed below, in making releases). In his evidence, Mr Tibaldi stated that he formed the view that all of the forecasts generated during the January 2011 Flood Event were so unreliable he could disregard them in selecting strategies.[188] He contended that, as the flow chart used the word "likely", it was open to him to conclude that RTFM modelling derived from rain on the ground modelling would produce the most likely storage levels.[189] I address the relationship between the word "likely" and "predicted maximum storage level" below. However, at this point it suffices to state that, given the emphasis on the use of forecasts in the Manual, I do not accept that

[187] Reply Report, EXP.ROD.004.0005 at [71].
[188] T 5441.30 to T 5442.1.
[189] T 5800.2 to T 5801.29; T 5924.26 - .39.

the use of the word “likely” left it open to the flood engineer to wholly disregard forecasts in selecting strategies and making release decisions with strategies.

190 Further, I do not accept that this evidence reflects Mr Tibaldi’s actual reasoning process during the January Flood Event; that is, I do not accept that he was attempting to address the “likely” storage level and somehow considered that circumstances justified the wholesale disregarding of forecasts. Mr Tibaldi’s first shift during the event was on the evening of 8 January 2011. As at that time, all the rainfall forecasts were suggesting large rainfall over the ensuing days.[190] No reasonable person could have ever concluded at that point that rain on the ground modelling would produce *the likely* or even the *most likely* maximum storage level when compared to a run that used some amount of forecast rainfall.

191 Instead, and although most of Mr Tibaldi’s oral evidence was confused and at times contradictory, aspects of his evidence suggests that his position in relation to forecasts was that they would not be used unless the forecast-based results were certain to occur, not merely “*likely*” to occur.[191] Mr Tibaldi said that he “*may*” have used forecasts to make release decisions if the BoM had advised him that the dams were “*definitely going to get a certain amount of rain*”.[192] Otherwise, Mr Tibaldi stated that he did not “*strictly apply*” the flow chart[193] and instead made a judgment call as to what strategy to choose.[194]

192 The analysis of what constitutes the best forecast rainfall information is addressed further in Chapter 9. At this point, it suffices to state that given the dam and catchment characteristics, the “best forecast rainfall information” for determining maximum storage levels, had to extend beyond forecasts for a 24-hour period.

[190] See Chapter 7 at [76] to [82].
[191] See Chapter 9 at [98] to [99] and [434] to [436].
[192] T 6076.14 - .19.
[193] T 5774.9 - .17, T 5775.2 - .6.
[194] T 5775.2; T 5781.18 - .23.

3.3.6: Significance of Conclusions to this Point

193 At this point I note four matters about the significance to the overall case of the conclusions about the Manual that have been reached so far bearing in mind that I consider the contrary constructions to be completely untenable; ie, unreasonable. To recap, those findings concern the approach to the interpretation of the Manual, the importance of the flood objectives and their order of priority, the requirement to use predicted storage levels in the selection of strategies and to make the predictions by reference to stream flow information and best forecast rainfall.

194 First, these conclusions confirm that the Manual adopted an overall risk management approach that acknowledges the uncertainties in forecasting rain and dam inflows as well as down stream flows and seeks to address that uncertainty by requiring the flood engineers to address the flood objectives in their specified order. Thus, the flood engineer should err on the side of promoting dam safety and optimising protection against urban inundation ahead of avoiding disruption to rural life downstream (and retaining the dams at FSL at the conclusion of the flood event). In effect the Manual agrees with one of the plaintiff's experts, Professor Dr Anton Schliess, who stated "[i]t's not sufficient to have situational awareness" when considering forecasts "[i]f you see a certain danger with a certain probability or uncertainty, then you take action to manage actively a flood, to have the chance on your side".[195] The Manual identifies the dangers and their order of priority. It acknowledges the "probability or uncertainty" in estimating inflows and downstream flows with forecasts. It requires the flood engineers to put that "chance" on their "side". If the cost of optimising protection against urban inundation is the inundation of rural bridges which, with the benefit of hindsight proves to have been unnecessary, then so be it.[196]

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[195] T 2950.41 - .44 (Schleiss).
[196] Cf SunWater subs at [251] to [264].

195 Second, bearing in mind the necessity to construe the Manual as a whole, these conclusions have flow on effects in relation to the remaining disputed aspects of the Manual addressed below.

196 Third, as the material discussed in Chapter 9 reveals, there is a large debate about the utility of using forecasts in flood operations bearing in mind the limitations on their accuracy, the difficulty in modelling inflows and downstream effects using forecasts and the potential consequences of making decisions to release or not release water based on forecasts that prove to be inaccurate or just plain wrong. Overall, this debate must be considered in the context that, to a large extent, the Manual addressed those issues by compelling their use while acknowledging the limitations on their accuracy.

197 Fourth, the above conclusions tear a large hole in the case of the three defendants and their attempts to defend the flood engineers' conduct. One line of defence was based on the evidence of at least Messrs Tibaldi and Ayre that the selection of strategies was dictated by actual and not predicted storage levels[197] and, to the extent that predictions were required, they had to be or could only be formed by reference to rain on the ground modelling and not rainfall forecasts.[198] As previously stated, Seqwater modified these contentions and its position became more fluid. In the end, a number of aspects of the conduct of flood operations during the January 2011 Flood Event bore little resemblance to any of the suggested interpretations of the Manual.[199] Left stranded were many of the defendants' experts who either construed the Manual as requiring strategies to be chosen by actual lake levels[200] or as requiring predictions to be made based only on the rain on the ground, ie, not using forecasts.[201] Not one of them was able to mount any

[197] See [152] and [154]; Tibaldi 1, LAY.SEQ.004.0001_OBJ at [249]; Ayre 1, LAY.SUN.001.0001_OBJ at [343].
[198] Eg, Ayre 1, LAY.SUN.001.0001_OBJ at [345]; EXP.QLD.001.0232 at .0398, [338] to [339]; T 9018 to T 9020 (Fagot).
[199] See Chapter 7 at [458] to [459] and [466] to [471].
[200] See [155] to [157] re Pokarier, Fagot and, to an extent, Ickert.
[201] Eg, T 9018 to T 9020 (Fagot); T 7335.38 - .42 (Swain, see [199]); T 6834 to T 6835 (Pokarier).

rational defence of their construction of the Manual[202] that was tied to the clear written words of the Manual with the result that, to varying degrees, I treated their evidence with greater scepticism than I otherwise would have.[203]

198 This is exemplified by aspects of the evidence of Mr Swain, a hydrological engineer, called by Seqwater with experience in reviewing and conducting technical and independent reviews of hydrological projects as well as drafting guidelines for such projects. In his affidavits Mr Swain did not address the relevant parts of the Manual that concern forecasts as his evidence was directed to widespread practice in relation to the use or non-use of rainfall forecasts in flood operations.[204] He opined that "precautionary releases are never made out of … flood control storage based on … QPF or PME rainfall forecasts to estimate reservoir inflows".[205] These aspects of Mr Swain's reports are addressed in Chapters 5 and 9.[206]

199 In cross-examination, Mr Swain was taken to parts of the Manual that expressly dealt with forecasts but he maintained that they were not be used to make any decisions ("... you looked at the manual, you read it and you decided that based on its terms, it does not require the use of forecast rainfall; is that what you are saying? A. Yes").[207] He adamantly maintained this position despite having the numerous references to forecasts in the Manual shown to him. Thus, he was asked as follows:

> "Q. You will see that it says, in the second paragraph of section 8.4 of the Manual underneath the bullet points: The strategy chosen at any point in time will depend on ... Several things, one of which is a prediction made using the best forecast rainfall information available at the time; do you see that?
>
> A. Yes.
>
> Q. And you agree, don't you, that what the manual is there telling an engineer to do is to use predictions made using forecast rainfall to select a strategy?

[202] T 9018.14 - .33 (Fagot); T 7339.2 - .28 (Swain); T 6835.21 – 6836.23 (Pokarier).
[203] Namely, Fagot (see section 3.3.4), Pokarier and Swain.
[204] See EXP.SEQ.008.0001 at .0018; EXP.SEQ.015.0001 at .0012; EXP.SEQ.019.0001 at .0005.
[205] EXP.SEQ.008.0001 at .0044.
[206] Chapter 5, section 5.3; Chapter 9, section 9.1.
[207] T 7335.38 - .42.

A. When I read the manual, *my interpretation of this part of the manual is that you are using rain on ground to make your decisions; you aren't using the forecast information*. And part of that is, I kind of go back to section 5 of the same manual, on page 13. The title of the section is “Flood Monitoring and Forecasting System”. The system is explained as to what the system is and what you should be using. There is no QPF or PME reference in there on using rainfall. The section is basically talking about your system of stream gauges and your system of rain gauges and the flood model that you are supposed to be using. So that's what I would be taking as using for my forecasting system, exactly what's in the manual.”[208]

“Q. As I have mentioned, we will come to operations shortly, but do you agree, having now read the sentence, “Strategies are changed in response to changing rainfall forecasts”, that it is clear that the manual is saying that the selection of strategy is to depend on predictions made using rainfall forecasts?

A. *I still - when I read the whole manual and looking at the intent of the manual, I always come back to that it looks to me like it's mostly a rain on ground thing, not so much the PMEs or QPF forecasts*, and partly because if that was what the intent was, it would have been very easy to write that into the manual, and it wasn't, and the manual has been updated a lot of times and this was very recent for the event.”[209] (emphasis added)

200 In the first emphasised answer, Mr Swain is referring to the description of the RTFM in section 5.1 of the Manual. That description expressly refers to forecasts. In both questions Mr Swain was shown section 8.4 of the Manual which has three references to rainfall forecasts yet somehow, he contrived to read all three references out of existence and read in references to rain on the ground modelling. His evidence was especially unconvincing in this respect and I afforded it no weight. It appears to involve simply transposing his experience in the USA to Wivenhoe and Somerset Dams and, effectively, ignoring the Manual.

3.3.7: Predicted Maximum Storage, No Release Assumption and “Likely” Storage Levels

201 As noted, a significant issue between the parties was whether or not the predictions of “maximum storage levels” referred to in sections 8.3 and 8.4 of the Manual, the assessment of “likely levels” referred to in the flowchart on page 24 of the Manual and the “predicted” levels referred to in the conditions

[208] T 7339.2 - .28.
[209] T 7350.20 - .33; see also T 7348.

for each strategy were to be made by assuming no releases from Wivenhoe Dam during the flood event (the "no release assumption") or after modelling releases. Dr Christensen construed the Manual as though those predictions were made without modelling releases.[210]

Section 8.3

202 The plaintiff submitted that it "appear[ed] to be common ground" that the calculation of the predicted maximum storage levels referred to in section 8.3 was required to be undertaken without regard to any possible releases from Wivenhoe Dam.[211] Whether it was common ground is unclear. None of the defendants addressed this aspect of section 8.3 in their submissions.[212] The Plaintiff correctly noted that Mr Tibaldi accepted this[213] and Mr Ayre said it was "common practice at the start of a flood event to run models without outflows from Wivenhoe in order to gain an appreciation of the magnitude of the event".[214] The gate operations spreadsheet exported from the first RTFM run undertaken by Mr Malone after he declared a flood event on 6 January 2011 modelled the effect of inflows without gate releases.[215] Mr Ickert would not agree that the assessment referred to in section 8.3 was to be undertaken without releases but struggled to explain why.[216] Mr Pokarier disagreed with Mr Tibaldi[217] and denied that the assessment in section 8.3 was undertaken by assuming no releases.[218] He asserted that the determination of the predicted maximum height in section 8.3 required the flood engineer to select a strategy and determine release rates.[219]

203 As part of the initial flood control action, section 8.3 requires an assessment of the "magnitude" of the flood event including a prediction of the "maximum storage levels" in both dams. At the time that prediction is being made, the

[210] Reply Report Vol 1, EXP.ROD.004.0005 at [209] to [211].
[211] Plaintiff subs at [445].
[212] In oral submissions, Senior Counsel for Seqwater said "it might or it might not": T 9880.9.
[213] T 6537.35 - .39; see also T 5810.24 - .46.
[214] Ayre 1, LAY.SUN.001.0001_OBJ at [1844].
[215] T 5175.39 to T 5176.1, T 5177.4 - .8, T 5379.6 - .22; QLD.001.001.2274.
[216] T 8235.10 to T 8236.11.
[217] T 6808.17 - .31.
[218] T 6805.31.
[219] T 6810.26.

Wivenhoe Dam gates are closed as they are below the level of EL 67.25m AHD. One matter that would be particularly useful for flood engineers to ascertain at this point is whether Wivenhoe Dam could accommodate the entirety of the predicted flood event inflows. Otherwise, the structure of the Manual makes it clear that the assessment in section 8.3 is undertaken well before any strategies are selected much less releases "within any strategy", they being the subject matter of section 8.4. In those circumstances, it is self-evident that the predicted maximum height referred to in section 8.3 must be determined without regard to releases from Wivenhoe Dam. Mr Pokarier's evidence to the contrary revealed an adamancy on his point not to concede any matter that might be seen as supporting Dr Christensen's approach. This aspect of his evidence significantly undermined my preparedness to accept the various opinions he expressed on the Manual and the proper conduct of flood operations.

204 Mr Ickert, who was not overly familiar with the Manual, was initially reluctant to concede that the assessment of predicted maximum storage was to be made on a no releases basis[220] but eventually conceded the logic of an "initial assessment" of the magnitude of a flood event on that basis.[221]

Submissions on Section 8.4

205 The plaintiff submitted that four matters suggested that the prediction referred to in section 8.4 should be made using a no release assumption.[222] The first was that it resulted in consistency between the approach in section 8.4 and section 8.3 with the result that the assessment required by section 8.3 is repeated under section 8.4 "*as forecasts change and rain is received in the catchments*".[223] Second, the plaintiff contended that this construction is consistent with the purpose of determining the "maximum" storage level in section 8.4, namely to "choose the correct strategy in which to operate Wivenhoe Dam" and that releases are determined "within any strategy" but they cannot be determined before "any strategy". The plaintiff contended that

[220] T 8233.5 to T 8234.13.
[221] T 8236.44 - .47.
[222] Plaintiff subs at [461] to [464].
[223] Plaintiff subs at [461].

its approach is “conservative” in that it facilitates “operations [being] directed towards achieving higher level objectives, particularly urban protection, at an early stage of the flood event.[224] Third, the plaintiff contended that its approach “maximise[s] the flood mitigation benefit of the dams” by allowing the flood engineer to ascertain whether the dam can store the entire flood without releases (noting that Mr Pokarier agreed that a flood engineer would always want to know whether the dam is capable of storing the whole flood without releases).[225] The fourth reason was either a repetition of, or a variation on, the second in that the plaintiff said that the objectives of the Manual will be better achieved if the higher level strategies (W3 and W4) are triggered by an expectation of higher predicted maximum storage levels in Wivenhoe Dam bearing in mind that that those higher level strategies do not dictate any minimum rates of release and allow consideration of lower level objectives.[226]

206 As stated, the defendants contended that the proper approach to, or at least a reasonable interpretation of, section 8.4 was that the maximum storage level be assessed by reference to the likely releases over the course of the flood.[227] They advanced a variety of textual and practical reasons for doing so.

207 First, SunWater noted that there is no express reference in the Manual to making the no release assumption.[228] The State noted that the references to “peak flow rate[s]” in the two dot points in section 8.4 specifically excluded Wivenhoe Dam releases and contended that this suggested that the reference to “maximum storage levels” did not.[229]

208 Second, the defendants contended that section 8.4 should be read together with the flowchart which refers to the “likely” level of the dam. They submitted that in circumstances where it is inevitable or even probable that flood

[224] Plaintiff subs at [462].
[225] T 6875.27; Plaintiff subs at [463].
[226] Plaintiff subs at [464].
[227] Seqwater subs at [685]; SunWater subs at [336] to [340].
[228] SunWater subs at [323].
[229] State subs at [29] to [30].

releases will be made then it follows that an assessment of what is the "likely" storage level at Wivenhoe Dam must include the proposed releases by the adoption of an iterative modelling process.[230] To do otherwise was said to "distort" the "likely" lake levels based on forecast inflows.[231] SunWater submitted that the reference to "maximum" storage levels is "obviously intended to be the 'likely' levels".[232]

209 Third, the defendants pointed to what they contend is the almost uniform chorus of evidence, other than Dr Christensen, to the effect that "no release" modelling is unheard of in the field of flood operations whereas iterative modelling is commonplace.[233]

Witnesses

210 As noted, Dr Christensen said he construed the references in the Manual to predicted maximum storage levels as referring to predictions determined by reference to a no release assumption principally because to take releases into account in strategy selection involves circular reasoning.[234] Seqwater submitted that his approach "ignore[d]" the use of iterative routing which it contended overcame this,[235] a submission addressed below. Seqwater also submitted that various "concessions" made by Dr Christensen in cross-examination undermined his adherence to the no release assumption. This included an alleged denial by Dr Christensen "that there was a distinction between choosing a strategy and determining releases".[236] However in the answer that Seqwater relied on, Dr Christensen was merely stating that the choice of strategy and determination of releases were related such that if forecasts are used to choose strategy then they are used to determine releases. Seqwater also noted that Dr Christensen agreed that it was necessary to ascertain likely releases, or at least existing releases, to determine if the limiting condition to W1 of releases under 1900m^3/s was

230 State subs at [31].
231 Seqwater subs at [699].
232 SunWater subs at [323].
233 Seqwater subs at [688(a)]; SunWater subs at [330].
234 Reply Report Vol 1, EXP.ROD.004.0005 at [210].
235 Seqwater subs at [687].
236 Ibid at [688(e)]; T 1148.22.

engaged,[237] whether the conditions to W2 could be met[238] and to decide between W2 and W3.[239] However, they are different parts of the Manual to those presently under consideration which concern the references to predicted maximum storage levels, likely levels and predicted levels. Seqwater also contended that Dr Christensen agreed that the "selection of a strategy using the flow chart on p 24 of the [Manual] – is the outcome of both the predicted inflows and the predicted releases".[240] This contention mischaracterises his evidence. The relevant question did not refer to the Manual or the flowchart. ("That wasn't my question. My question was: if you are looking to see what is the most likely lake level, what level the dam is most likely to reach, that's the outcome of both the predicted inflows and the predicted releases, isn't it? A. If you use the RTFM, yes").[241]

211 All of Mr Malone, Mr Ayre and Mr Tibaldi rejected the use of a no release assumption and instead maintained that an iterative approach of balancing outflows and inflows was appropriate[242] (although in cross-examination Mr Ayre described selecting strategy by reference to upstream "flow volume").[243] In addition, both of Seqwater and SunWater relied on Mr Fagot's evidence criticising Dr Christensen's use of a no release assumption.[244] Mr Fagot's evidence generally is addressed below. However at this point, it suffices to note that Mr Fagot's description of using releases to make pool elevations was said to be part of developing a "release strategy" which appears to correspond with a release decision and be a different concept from the determination of whether one of Strategies W1 to W4 in the Manual is invoked.[245] Similarly Seqwater noted that the use of an iterative approach to modelling was "recommended by the USACE in Engineering Manual EM 1110-2-3600".[246] However that only begs questions as to whether: that

[237] Seqwater subs at [688(f)]; T 1264.28 (but note T 1267.46).
[238] Seqwater subs at [688(g)]; T 1269.10.
[239] Seqwater subs at [688(h)]; T 1272.27 to T 1273.25.
[240] Seqwater subs at [689]; T 1267.6 - .28.
[241] T 1267.23.
[242] Malone 1, LAY.SEQ.007.0001_OBJ at [115(k)]; Ayre 1, LAY.SUN.001.0001_OBJ at [1844]; T 5801.20 (Tibaldi).
[243] T 7534.30.
[244] Seqwater subs at [691]; SunWater subs at [327] and [338].
[245] See EXP.QLD.001.0524_2 at [119] to [120] which is invoked at EXP.QLD.001.1311 at [52].
[246] Seqwater subs at [691].

approach represents a statement of general flood operations principles or just a policy approach of the USACE; how such statements in the USACE manuals related to the idiosyncratic nature of the Manual; and, in particular, whether it is referable to the selection of a strategy as opposed to ascertaining the amount to release. Seqwater also noted Mr Swain's evidence to the effect that the "*normal* way for choosing a strategy would be to have sort of an iterative approach where you get all your inflows and your outflows all considered".[247]

212 Unlike most of the defendants' experts, Mr Ickert genuinely sought to engage with the points made to him in cross-examination on this topic and was prepared to make concessions when appropriate. In his first report Mr Ickert stated that *"[a]ssuming no release when predicting water surface elevations is not common modelling practice".*[248] In his second report he responded to Dr Christensen's contention that modelling releases to determine strategy involved circular reasoning, stating:[249]

> "In paragraph 210 of Dr. Christensen's Reply Report, he claims an illogical circularity in suggesting that his selection of Strategy should take into account the very issue (releases) that he is trying to determine. Based on my experience of developing real-time decision support tools for reservoir systems, the actual operation is an iterative process which starts with current conditions (lake levels, inflows, releases, etc..) and a prediction of future reservoir inflows to determine if release adjustments will be needed. These releases are used in conjunction with the predicted future inflows to predict future lake levels. This process is frequently updated as conditions change both upstream and downstream of the reservoir. I continue to maintain that selecting a Strategy by not assuming any releases into the future is not the proper operation of a dam based on my experience developing and working with flood forecasting decision support tools."

213 Four aspects of the cross-examination of Mr Ickert on this topic should be noted.

214 First, in relation to the last sentence of the above extract the cross-examination illustrated that there is a substantive difference between assuming no releases to determine the relevant strategy and assuming no

[247] T 7322.2; Seqwater subs at [691] and [1785].
[248] Ickert 2, EXP.SUN.008.0001_OBJ at .0006.
[249] Ickert 2*,* EXP.SUN.008.0001_OBJ, [81].

releases or using iterative routing to determine a release decision (ie, the amount to be released). Mr Ickert stated earlier in the same report that he was "*not aware of any organizations that forecast water levels to set operational [s]trategies by automatically assuming zero releases over the next eight days regardless of current pool levels and current releases*".[250] In cross-examination, however, he stated that he was aware of only one dam operation that used predicted levels to "set operational strategy", namely Mansfield Dam.[251] A water control plan for Mansfield Dam in effect from 1979 was tendered but not addressed by any of the parties.[252] By reference to predicted water levels, it specified the precise release rates a flood engineer should adopt (subject to not exceeding certain downstream flow limits).[253] Another water control manual for Mansfield Dam bearing the date 2013 was expressed in similar terms, although it referred to minimum release rates.[254] Thus, these manuals are very different from the Manual in that they move immediately from a predicted height to a specified or minimum release rate. While the manner of determining predicted heights was not expressly stated, if water control manuals are expressed in those terms then the use of an iterative process to determine predicted heights by modelling specified or minimum releases should always produce the same predicted height and the outcome will not be dependent on the exercise of judgment by the flood engineer; ie, the circularity identified by Dr Christensen will not arise.

215 Second, in cross-examination it emerged that part of Mr Ickert's reasoning for rejecting the no release assumption was that he did not accept the proposition that strategies are first selected and then release decisions are made within strategies.[255] In turn, this rejection was predicated on his assertion that some of the strategies are based on actual levels and not predicted levels so that determining a predicted maximum height was not necessary to determining a strategy[256] and thus the reasoning behind a "can release" assumption is not

[250] Ickert 2, EXP.SUN.008.0001_OBJ, [68].
[251] T 8215.14.
[252] SUN.300.001.0763.
[253] SUN.300.001.0763 at .0764.
[254] SUN.300.001.0446 at .0519 to .0521; see T 8316.27.
[255] T 8238.3 to T 8239.24.
[256] T 8239.35; T 8249.37

truly circular. I have already rejected the premise that strategies are not chosen based on predicted levels.

216 Third, Mr Ickert agreed that, if all strategy decisions depended on predicted and not actual lake levels, then making a prediction by assuming or modelling certain releases could lead to different flood engineers being confronted with the same external conditions but, modelling different releases, and thereby selecting different strategies.[257] Ultimately, Mr Ickert agreed as follows:[258]

> "Q. Mr Ickert, do you agree that a reasonable engineer would not interpret the manual in a way that would give rise to the possibility that different strategies may be applicable at the same time and in the same circumstances by reason of different future proposed release decisions?
>
> A. Yes, I agree with that. I may have misspoken and misunderstood [in his earlier answers]"

217 Fourth, one issue Mr Ickert identified with no release modelling of rainfall forecasts is that the strategy will depend on the choice of the forecast and the longer the forecast period the more likely a higher strategy will be chosen.[259] In cross-examination he stated that he was not aware of a forecast product longer than the eight-day PME and otherwise agreed that the selection of the forecast period would be a matter for engineering judgment based on the "amount of time required to deal with forecast inflows in the circumstances of the particular dam and catchment".[260]

218 Mr Pokarier interpreted the references in the Manual to "expected", "likely" and "maximum" water levels at Wivenhoe and Somerset Dams as requiring the use of "storage routing techniques" (ie, iterative modelling).[261] Similar to Mr Ickert, Mr Pokarier considered that the selection of strategy was dependent on actual and not predicted levels[262] such that, putting aside W4, for Mr Pokarier the prediction of maximum heights was irrelevant to strategy

[257] T 8251.18 to T 8252.24.
[258] T 8258.29.
[259] Ickert 2, EXP.SUN.008.0001_OBJ, [69].
[260] T 8260.5.
[261] Pokarier 1, EXP.SEQ.016.0012, [64] to [66].
[262] T 6861.19.

selection[263] and only relevant to modelling the effect of releases.[264] In effect, Mr Pokarier's approach to the Manual predictions as to maximum storage levels is undertaken for a completely different purpose from Dr Christensen's. Dr Christensen uses them to select strategy, whereas Mr Pokarier only uses them to model the effect of releases within strategies. Given those differences it is not surprising that the former assumes no releases and the latter modelled releases. That said, Mr Pokarier maintained that, even if strategies were selected based on predicted levels, then releases would still be modelled. While he accepted this meant that a determination of which strategy applies may differ depending on an individual flood engineer's proposed releases,[265] he asserted that it would make little practical difference because "in the real world it doesn't happen as dramatic as that".[266] Given that Mr Pokarier's experience is confined to Seqwater operations,[267] that he never utilised the Manual in flood operations and only received instruction concerning it from the flood engineers after the event[268] and he subscribes to the use of actual levels to select strategies, it is unclear what "real world" is being referred to ("I've never operated under this manual. I've never had to interpret this in real time").[269]

219 Otherwise it should be noted that one of Mr Pokarier's criticisms was that by not using storage routing, and instead using a no release assumption, Dr Christensen "reduc[ed] any capability to estimate future water levels" to properly apply the operating target line at Somerset Dam in Strategy S2. This was said to be so because, as Dr Christensen does not "model the impact of inflow on dam levels and therefore has no ability to demonstrate how the predicted water levels are expected to change over time", he "is unable to

[263] T 6865.42 to T 6866.5.
[264] T 6866.24.
[265] T 6869.25.
[266] T 6869.44.
[267] See Appendix C and Chapter 5 at [114] to [117].
[268] T 6738.42 to T 6739.1.
[269] T 6858.14.

assess whether the proposed operations [at both dams] are expected to trend towards the interaction line as required under Strategy S2".[270]

220 Two matters should be noted. First, at most this is a criticism of Dr Christensen's approach to modelling releases and does not relate to the use of a no release assumption in predicting maximum storage levels at Wivenhoe to select strategies. Second, I do not accept that it is necessary to prepare an hour-by-hour set of future gate operations to determine the trajectory of tandem gate operations in relation to the operating target lines. Instead, such an assessment can be made relatively simply by someone familiar with the effect of current releases and the proposed direction of flood operations.

Section 8.4 Requires No Release Modelling

221 To the extent that the various defence witnesses resisted the use of a no release assumption on the basis that iterative modelling was in effect common industry practice, I am not satisfied they were describing anything other than a common (or even uniform) approach to determining *release* rates or modelling their effect. I am not satisfied that iterative modelling represents any form of standard approach to the selection *of strategies* under a Manual that specifies strategies by reference to predicted heights (or that there is even any suggested standard approach). Of all the various flood procedures and manuals that were tendered or referred to, none of them suggested anything similar to the requirement in the Manual that flood engineers were required to predict *maximum* storage levels having regard to, inter alia, rainfall forecasts and that in turn those predicted heights determined strategies which determined maximum release rates. What emerged from the evidence is that a water control manual that uses predicted water levels to select strategies and does not prescribe rates of releases within strategies is relatively unique so far as water control manuals are concerned. That said, the evidence suggested that no release modelling of some kind was undertaken and regarded as having utility. As noted, Messrs Tibaldi, Malone and Ayre said that it was usual at the commencement of a flood event to assess the

[270] EXP.SEQ.016.0012, [154]; Seqwater subs at [696].

maximum storage levels in the dams without taking planned releases into account (see above).[271] Further Mr Tibaldi agreed that an engineer may want to know if he or she can fully close the Wivenhoe gates in order to maximise the flood mitigation benefit downstream and that would be determined by calculating the maximum storage level of the reservoir with no releases.[272]

222 It follows that a determination of whether no release modelling is required to make the predictions in sections 8.3 and 8.4 turns upon a consideration of the terms of the Manual and the circumstances of Wivenhoe and Somerset Dams*.*

223 I agree that the phrases "predicted maximum storage level" in sections 8.3 and 8.4 and "likely" storage level are referring to the same prediction, and in turn is the same prediction as referred to in the "conditions" box for each strategy. This is consistent with the mandate in section 8.4 that the strategies are to be made using the specified predictions. The Manual should not be construed so as to make the determination of strategy dependent on inconsistent predictions.[273] Further, the requirement that the storage level in Wivenhoe Dam be determined without considering releases is consistent with the requirement that it is the "maximum" storage level to be ascertained. By definition, the "maximum" level is reached if there are no releases. This approach is also consistent with the other two predictions referred to in section 8.4 which expressly require assessments of downstream flows without regard to Wivenhoe Dam releases.

224 The principal, and insurmountable, difficulty with the defendants' proposed construction is the circularity that inures in having release constraints determined by strategies, determining strategies by reference to maximum storage levels and determining maximum storage levels by reference to proposed releases. The circularity was acknowledged by Mr Malone,[274] Mr

[271] See also T 6806.21-23 (Pokarier); T 8243.22 to T 8244.4, T 8245.15 to T 8246.32 (Ickert).
[272] T 5803.2 - .46; see also T 6887.11 to T 6888.3 (Pokarier).
[273] Cf T 10021.34 - .40 (the State).
[274] T 4961.21; see also T 4978.2.

Tibaldi[275] and Mr Pokarier.[276] Mr Malone accepted that the use of proposed releases resulted in "*great difficulty*" in determining strategies.[277] Contrary to the defendants' submissions, the circularity is not overcome by storage routing or iterative modelling. In fact, it yields absurdities and, as submitted by the plaintiff, ultimately undermines the objectives of the Manual. To utilise proposed releases in the determination of the maximum storage levels would, as the plaintiff submitted, ultimately make the "selection of strategy dependent of the subjective decisions of the engineer, not the objective circumstances affecting the dams".[278] This is so because, as Mr Ickert acknowledged, in modelling proposed releases over the anticipated period of the flood event different flood engineers acting reasonably might utilise different release plans and thus yield different maximum heights. None of the defendants' submissions grappled with this difficulty. The discussion in Chapter 6 of the various gate operations spreadsheets produced by RTFM runs conducted by the flood engineers during the January 2011 Flood Event illustrates the effect upon maximum height levels of modelling differing release strategies.

225 By way of illustration of the problem with predicting maximum storage levels by modelling releases, the plaintiff instanced the example of an engineer who was "relatively unconcerned" by a flood, who determined not to make any releases or only low releases thereby generating a higher maximum storage level and contrasted that with another engineer who determined to make larger releases but would be constrained from doing so because their modelling yielded lower maximum storage levels and thus a lower strategy. The better approach would be for the application of the Manual to place two flood engineers facing the same circumstances in the same strategy with the same constraints and then allowing them to exercise judgment within that strategy. As noted, Mr Ickert agreed that a reasonable engineer "*would not interpret the [M]anual in a way that would give rise to the possibility that different strategies may be applicable at the same time and in the same*

[275] T 5802.19.
[276] T 6881.17 - .36.
[277] T 4960.2.
[278] Plaintiff subs at [474].

circumstances by reason of different future release decisions".[279] To the extent that it is relevant, the history of the drafting of the Manual reveals that a proposal for the flood engineers to choose the strategy they would operate in below a predicted height of EL 74.0m AHD was rejected (see Chapter 4 at [129].

226 A further problem with modelling maximum storage levels based on releases is that it introduces much more uncertainty than modelling inflow volumes based either on rain on the ground or forecasts. As the discussion in Chapter 6 illustrates, the modelled storage levels in the gate operations spreadsheets produced by RTFM runs conducted by the flood engineers were based on assumed gate operations for many days into the future. Those assumed releases were always subject to change based on various factors, especially downstream flows. There are obvious uncertainties in selecting strategies based on modelled inflow volumes to Wivenhoe Dam derived from rain on the ground or rain on the ground and rainfall forecasts. However, even more uncertainties are introduced by selecting strategies based on assumptions about making releases for many days in the future which necessarily make assumptions about rainfall downstream. This is exacerbated if the estimate of inflows is only based on rain on the ground because it will yield a set of gate operations that will inevitably have a tendency to underestimate future inflows and overestimate the capacity to make releases some days into the future.

227 The problem with the defendants' interpretation, and the desirability of an engineer ascertaining whether an entire upstream flood event can be stored, is best illustrated by considering the flash flooding that occurred in the Lockyer Valley in the late afternoon and evening of 10 January 2011[280] and an engineer who determined a flood strategy some days prior to that based on an assessment of maximum storage using planned releases. In the period between the assessment and the flash flood they would, or at least may, have found themselves in a lower strategy than they otherwise would have (and

[279] T 8258.29.
[280] See section 7.5 of Chapter 7.

thereby made lower releases) because they assumed that they could make releases during the period of the flash flooding. This would, or at least could, have hampered their ability to ameliorate downstream flooding by closing the Wivenhoe Dam gates during the flash flooding or at least reducing outflow. A flood engineer who selected strategies based on an assumption that releases would not be made would be in a better position to act to cease releases if circumstances require it.

228 Further, contrary to the defendants' submissions, I do not accept that the adoption of a no release assumption for the prediction of a maximum storage level is inconsistent with the reference to "likely" in the flow chart for strategy selection. The use of the phrase "likely" in that flow chart simply reflects the uncertainties in making a prediction as to maximum storage levels and requires that the flood engineers determine the "likely" maximum storage level without releases. It is not meant to require some assessment of the outcome of flood operations conducted within the strategies that it is directing the flood engineer to adopt. Put another way, the questions in the flow chart as to whether Wivenhoe Dam is "likely to exceed" a specified level are in effect asking whether, *in the absence of releases*, the dam is likely to exceed a specified level. If it were read any different way then the circularity described above and all its problems would be evident.

229 The position is not altered by considering the box in the flowchart on page 24 of the Manual, which asks whether the "maximum flow at Lowood [is] likely to be less than 3500m^3/s and the maximum flow at Moggill [is] likely to be less than 4000m^3/s". It can be accepted that this requires that consideration be given to outflow levels from Wivenhoe Dam. The plaintiff accepted as much, although it contended that "[c]onsidered in context, however, the third question [in the box] can be answered without the development of any detailed release plan".[281] This was said to be so because the conditions in W2, meant that "it will only be permissible to operate in W2 if the releases from Wivenhoe Dam, when combined with downstream flows, do not cause a higher peak at Lowood and Moggill than would otherwise occur" and "[t]hat

[281] Plaintiff subs at [496].

can be determined relatively easily by considering the magnitude of the downstream peaks excluding Wivenhoe releases, and assessing whether combined releases in excess of those peaks are prudent".[282]

230 Whether or not the plaintiff is correct in this regard is irrelevant for present purposes which concern the method of determining the "likely" and predicted maximum storage levels. The flow chart makes it clear that a determination of the likely level of the dam is separate from and anterior to any assessment of the maximum flow rate at Lowood and Moggill. The discussion of W2 and W3 in the Manual is consistent with this. To assess predicted maximum storage levels or likely storage levels by reference to an assessment of downstream flows that include Wivenhoe Dam releases would introduce unnecessary and illogical circular reasoning into the application of the Manual.

231 Five further matters should be noted.

232 First, there was some evidence adduced by the defendants as to the likelihood of higher strategies being engaged, perhaps unnecessarily, if the maximum or predicted storage levels were assessed based on a no release assumption. Mr Pokarier prepared a table which he contended showed the impractical impact of adopting a no release approach in terms of needlessly putting flood operations into a higher strategy.[283] Mr Pokarier asserted that "W4 would be likely to be adopted often".[284] (Mr Giles expressed a similar view although it was not tied to any attempt to construe the Manual.)[285] However, Mr Pokarier's table shows that, assuming no releases, an inflow volume of around 910,000ML above FSL is required to take Wivenhoe Dam above EL 74.0m AHD and trigger W4.[286] Of the twenty major flood events since 1887, around eight had inflow volumes less than a million and, of the six since 1974, four had inflow volumes less than a million.[287] Allowing for the difference between 910,000ML and one million ML, this does not suggest that

282 Plaintiff subs at [496].
283 EXP.SEQ.016.0012 at .0037; table 4.1.
284 EXP.SEQ.016.0012 at [69].
285 EXP.QLD.001.1359 at [475].
286 EXP.SEQ.016.0012 at .0037; table 4.1.
287 T 6911.40 to T 6912.4; MSC.010.332.0001.

the adoption of no release volumes would repeatedly and unnecessarily place flood operations into W4.

233 Second, at the risk of stating the obvious, just because the Manual requires an assessment to be undertaken on a no release basis does not mean that the flood operations engineers were precluded from modelling gate operations to determine the release rate and the likely height of the dams that would result if certain release rates were adopted. Mr Pokarier expressed opposition to the no release assumption because it "doesn't demonstrate a plan" to address the inflow of water.[288] However no release modelling is not in itself meant to be a release "plan". It is simply the first step in applying the Manual, namely, an ascertainment of maximum storage height for the purpose of selecting a strategy. Depending on the approach to flood operations, modelling the effect of proposed gate operations, including via a GOS produced by the RTFM, may be a prudent part of the process of determining releases. However, every iteration begins somewhere and, as noted, the first saved RTFM run at the commencement of the January 2011 Flood Event did not assume flood releases. In some cases, perhaps many, the adoption of the no release assumption to choose strategies will not yield any different outcome in terms of releases from the selection of strategy based on a modelled process derived from an iterative process where the first iteration had no releases. This is so because all of the higher order objectives require that consideration be given to lower order objectives. Thus it is quite conceivable, but not inevitable, that a flood engineer who determines that W3 is engaged based on a no release assumption may nevertheless decide to, say, keep Kholo bridge open by limiting flows to, say, 530m^3/s and another flood engineer might through iterative modelling determine a predicted maximum height of between EL 67.75m AHD and EL 68.0m AHD using releases at a maximum rate of 530m^3/s and thus find themselves in W1D. The only difference between the two is that, subject to the matter addressed next, the former has the capacity to increase release rates whereas the latter does not.

[288] T 6888.47.

234 Third, as noted, if a no release assumption is required then in a context where the predictions involve a consideration of forecast rainfall, the determination of the predicted maximum height will depend on the chosen forecast period. While this introduces an element of subjectivity into the determination of strategy it does not involve the circular reasoning that considering outflows must. Ultimately the length of the forecast period is a matter for engineering judgment bearing in mind the relative accuracy of the forecast. This is addressed further in Chapter 9 where I reject the contention that it was obligatory to use an eight-day PME forecast for this purpose.[289]

235 Fourth, Seqwater pointed out[290] that, in one of his simulations, Simulation I, Dr Christensen took into account releases from Somerset Dam in predicting the maximum storage level of Wivenhoe Dam.[291] Dr Christensen explained that this was necessary because in Simulation I the Somerset Dam crest gates were able to be closed[292] and thus there was greater control over Somerset Dam outflows. Dr Christensen's simulations are addressed in Chapters 8 to 10. It suffices to state that I do not accept that the flood engineers were obliged to act substantially in accordance with either of Dr Christensen's simulations that involve the closure of Somerset Dam crest gates.[293]

236 Fifth, in that part of its submissions that concerned Dr Christensen's methodology, Seqwater contended that the no release assumption was "unrealistic and incorrect" in circumstances where it was intended or overwhelmingly likely that releases would be made because, inter alia, releases are currently being made and planned to be made, the Manual requires the Wivenhoe Dam gates to be raised above EL 73m to avoid the gates being overtopped as well as the making of releases above EL 74.0m AHD and releases from Somerset Dam flow directly into Wivenhoe Dam.[294] At the risk of repetition, the significance of those factors concerns the

[289] See Chapter 9 at [128].
[290] Seqwater subs at [690(c)].
[291] T 1837.5.
[292] T 1837.27.
[293] Ie, Simulation I and Simulation J; see Chapter 9, section 9.8.
[294] Seqwater subs at [2154].

determination of the appropriate release rate. The use of no release rise modelling is directed to the determination of strategy which in turn determines release limits and the relevant priorities. Until the prevailing release limits and priorities are determined the various steps pointed to by Seqwater cannot be properly planned for.

237 Accordingly, I am satisfied that the reference to "predicted maximum storage level" in sections 8.3 and 8.4, the reference to the "likely" level of Wivenhoe Dam in the flowcharts for each of Wivenhoe Dam and Somerset Dam and the reference to "predicted" level for each of the Wivenhoe Dam and Somerset Dam strategies in the Manual all refer to the same concept, namely an assessment of the dam level that uses inflows derived from rain on the ground and rainfall forecasts and assumes no releases from the dams.

3.3.8: Use of Forecasts in Making Gate Releases

238 The next issue that arises is whether the Manual requires that rainfall forecasts be "used" in making release decisions within strategies. The plaintiff submitted that "it would be nonsensical for the Manual to direct the engineers to consider forecasts in determining the strategy in which to operate the dam" while also permitting or requiring them to ignore forecasts in making release decisions.[295] They noted Dr Christensen's evidence which was to the effect that if rainfall predicted to fall is not released then it is being stored.[296]

239 Seqwater contended that, while the Manual may permit certain qualitative uses of forecasts in making release decisions, such as moderating downstream flows, there was nothing in the Manual which mandated their use in a "quantitative" manner. Seqwater asserted that the plaintiff contended for a "quantitative" use, which it described as "requir[ing the flood engineer] to decide on gate operations that will release a volume of water calculated by reference to estimated inflows from the rain that is forecast to fall above the dams".[297] Seqwater submitted that the Manual was silent on the issue and

[295] Plaintiff's submissions at [479].
[296] T 2585.26.
[297] Seqwater subs at [715(b)].

that a “reasonable interpretation” of the Manual is that it leaves to the discretion of the flood engineers the issue of “what, if any reliance to place on rainfall forecasts in making decisions as to releases”.[298] One matter they call in aid of that approach is the unreliability of rainfall forecasts.[299] However, as explained, to a large extent that is acknowledged by the Manual and addressed by the prioritisation of the flood objectives.

240 Like Seqwater, SunWater noted that section 8.4 did not expressly state how release decisions were to be made and contended that the Manual left a large degree of scope for engineering judgment, including as to the use of rainfall forecasts. However, unlike Seqwater, SunWater did not attribute to the plaintiff a construction of the Manual that required the release of an amount of water calculated by reference to an inflow volume calculated by reference to rainfall forecasts.[300] The State submitted that section 8.4 did not require “rainfall forecasts to be quantitatively used in setting gate releases in the manner propounded by the Christensen methodology”.[301]

Witnesses

241 The relationship between the Manual, forecast rainfall and release decisions was addressed by a number of witnesses. Dr Christensen’s methodology is address in detail in Chapters 8 to 10. It suffices to state that he described the “method [as] basically … figur[ing] out what reasonable drawdown might need to be made given the forecasts”.[302] He said that the “manual told [the flood engineer] to operate from forecasts” that is “[w]hat had to be done was to operate from forecasts, and you [the flood engineer] had to determine how to operate from those forecasts … because it wasn't in the manual, it was left up to the discretion of the flood operations engineer.”[303] Consistent with this, Seqwater submissions noted that his methodology allows scope for the flood engineer to choose to fill the dams or expand or contract the release

[298] Seqwater subs at [716].
[299] Seqwater subs at [717].
[300] SunWater subs at [299] to [311].
[301] State subs at [34] and [41].
[302] T 1144.39.
[303] T 1145.41 (Christensen).

period.[304] This can be accepted but it does not mean that he did not operate from rainfall forecasts or that he did not, adopting Seqwater's terminology, use them "quantitatively".

242 As noted, Mr Malone agreed that the Manual required the consideration of rainfall forecasts in the selection of strategy, but denied that it required they be considered when making decisions as to how much water to release from the dams,[305] although he added that if he had "100 per cent confidence in the forecast rainfall" he would consider the forecast in making release decisions.[306] That said, Mr Malone agreed that he did not consider forecasts in selecting strategy either.[307] Seqwater contended that, as Mr Malone's interpretation of the Manual was "not challenged in cross-examination", that "strongly supports accepting his interpretation as one that a reasonable person might form".[308] I disagree. First, the contrary interpretations were taken up with Mr Malone in cross-examination.[309] Second, in any event, and as already stated, Mr Malone accepted that he could not recall what his interpretation of the Manual was during the January 2011 Flood Event. At best, this aspect of his evidence is simply a post-event conclusion on his part. It was extracted in cross-examination and not elaborated upon in either his statements or re-examination.

243 Although Mr Tibaldi considered that no weight was afforded to rainfall forecasts in selecting strategy,[310] he also asserted that forecasts were "considered" but "given its unreliable nature, [he] did not take it into account to make decisions about dam releases".[311] The balance of the relevant evidence he gave on this topic and my assessment of that is set out in section 3.3.5.

244 Mr Fagot's evidence on this was consistent with his constraints based approach that has been described. He did not object per se to the use of

[304] Seqwater subs at [719].
[305] T 4750.47 to T 4751.7, T 4751.23 - .26, T 4752.4.
[306] T 5167.1.
[307] T 5323.1, T 5339.46, T 5299.14 - .28.
[308] Seqwater subs at [725].
[309] T 4750.29 to T 4751.12 and T 5166.15 to T 5167.41.
[310] T 5508.24.
[311] T 5514.31.

rainfall forecasts in the making of release decisions provided that the decision conformed with the constraints that he identified in the Manual ("So I don't have a problem making release decisions based on forecasted rainfall, but it has to fit within the constraints of the [M]anual").[312] In his second report he sought to identify various constraints in the Manual which he contended precluded the release of water based on rainfall forecasts,[313] before ultimately concluding that dam operations during the January 2011 Flood Event "were conducted in a manner that was appropriate with respect to rainfall forecasts and in accordance" with the Manual.[314] Seqwater contended that Mr Fagot's evidence in this respect was not challenged.[315] I address Mr Fagot's evidence in section 5.4 including the assertion that his evidence was unchallenged and his identification of the relevant constraints. It suffices to state that the only aspect of his evidence that is of assistance on this topic is his lack of in principle objection to the use of forecasts in making release decisions.

245 Seqwater also referred to the evidence of Mr Swain on this topic which was to the effect that the Manual did not require the use of forecasts in making any decisions.[316] I have addressed his evidence in section 3.3.6.

246 There was a debate about the effect of some evidence given by Mr Pokarier on this topic. In its written submissions Seqwater referred to Mr Pokarier's refutation of the use of rainfall forecasts in his written statement and asserted that his approach to section 8.4 was "not challenged".[317] This aspect of Mr Pokarier's evidence was predicated on an acceptance of his approach to the interpretation of the Manual which was taken up with him and which he unimpressively and unpersuasively defended. Otherwise, the cross-examiner did take up this issue with Mr Pokarier by asking him to accept the assumption that the strategies were chosen by predictions informed by rainfall

[312] T 9023.11; see also T 9018.31.
[313] Fagot II, EXP.QLD.001.0524 at [172] and [183].
[314] Fagot II, EXP.QLD.001.0524 at [190].
[315] Seqwater subs at [741].
[316] Seqwater subs at [742] to [745].
[317] Seqwater subs at [733] to [734].

forecasts.[318] Mr Pokarier agreed that there was an "obvious and direct" relationship between release decisions and the applicable strategy;[319] ("Yes, they are connected") and that, if a strategy was chosen by reference to forecasts, then it must follow that the release constraints are identified by reference to forecasts.[320] However, when pressed on whether, if contrary to his evidence, rainfall forecasts had to be used for strategy selection then it would follow, "as a matter of inevitable logic, that forecast rainfall predictions should also be used for the purpose of informing release decisions within the strategy", Mr Pokarier stated that he could not answer because he was "uncomfortable with that assumption".[321]

247 In its written submissions, Seqwater contended that the effect of the evidence given by a hydro meteorologist called by the plaintiff, Mr Kane, was that the Manual required the flood engineer to consider forecasts in making releases from 9 January 2011 onwards but not "actually determin[ing] releases either calculated from the forecast information or based on the forecast information" which was said to be similar to Mr Tibaldi's approach.[322]

248 However, Seqwater's submissions on Mr Kane overlook the limitations on Mr Kane's expertise which he observed in giving evidence, and otherwise misstate the effect of what he said. In relation to the former, in *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 12)* [2018] NSWSC 415 ("Rodriguez (No 12)"), it was accepted that Mr Kane was qualified to express an opinion **"**criticising a refusal of the flood engineers to consider forecasts generally in making operational decisions" but it was not accepted that he was qualified to "suggest... a particular operational decision".[323] Similarly, it was noted that Dr Kane did not purport "to state an overall methodology for dam operations" in his reports and was not qualified

318 T 6914.26ff. Seqwater wrongly asserted that this part of his cross-examination concerned the no release assumption: Seqwater subs at [733].
319 T 6915.37.
320 T 6914.41.
321 T 6917.46.
322 Seqwater subs at [737].
323 *Rodriguez (No 12)* at [15].

to do so[324] and, in particular, did not "purport to describe how a release strategy should be either determined or implemented".[325]

249 Consistent with these limitations on his expertise, in his report Mr Kane referred to various parts of the Manual and the FPM and concluded that "[t]he Manual clearly requires the use of precipitation forecasts for consideration in operational decisions".[326] Similarly, in his oral evidence he stated that the flood engineers should have taken inflow forecasts, calculated by reference to rainfall forecasts, into account,[327] ("informing the decision"[328]), but reiterated that he was not qualified to state what the outcome of doing so should have been on release decisions.[329]

250 In its written submissions,[330] Seqwater noted (correctly) that Mr Kane accepted that the Manual left it to the flood engineer's judgment in making release decisions based on rainfall forecasts.[331] However, it also contended that Mr Kane stated "that his interpretation of the Manual was that the flood engineer was not obliged to make a release decision based on the forecasts"[332] and that "based on a host of factors … the flood engineer might properly make a decision not to act on the forecasts in determining releases".[333] Mr Kane did not agree with either proposition. With the former, he asserted that "information on inflows should be used [by the flood engineer] to come up with the best decision" on releases but reiterated that what that decision should be was outside his expertise.[334] With the latter, the high point for the cross-examiner was an acceptance by Mr Kane that the flood engineer might choose not to use the inflows derived from forecasts in a quantitative way but in a "qualitative way in making release decisions".[335] This

[324] Ibid at [24].
[325] Id.
[326] EXP.ROD.011.0011 at [75].
[327] T 3190.42.
[328] T 3187.31.
[329] T 3190.35 and T 3190.47.
[330] Seqwater subs at [736]; see also Seqwater subs at [2050].
[331] EXP.ROD.011.0011 at [170]; T 3185.24 to 3186.19.
[332] Citing T 3190.12 – .43.
[333] Citing T 3257.2 to T 3258.38.
[334] T 3190.9 - .47.
[335] T 3258.32.

concession did not advance the matter as Mr Kane later explained that, in his role as a meteorologist, he would always provide the flood engineer with inflow volumes calculated from rainfall forecasts and an appropriate explanation, and leave the determination of release decisions to them as he was not qualified to make them.[336]

251 In summary, the relevant effect of Mr Kane's evidence was that under the Manual the flood engineer should, in making release decisions, consider a (quantitative) assessment of the volume of inflows calculated by reference to rainfall forecasts but how that was required to be translated into a release decision was beyond his expertise.

Release Decisions Must "Use" Forecasts

252 The net result of the evidence is that both Dr Christensen and, within the limits of his expertise, Mr Kane construed the Manual as requiring the use of forecast rainfall in the making of release decisions. Mr Malone's evidence was to the contrary, as was Mr Fagot's. Mr Pokarier could not overcome his objection to the use of forecasts in selecting strategies. Mr Tibaldi admitted some limited use for forecasts. However, all of the defendants' witnesses have their difficulties, especially given their adherence to constructions of the Manual that I have rejected as unreasonable (see section 3.3.6).

253 Ultimately the conclusion that the Manual requires that rainfall forecasts be considered in making decisions on dam releases follows inexorably from the statement in section 8.4 that "[w]ithin any strategy, consideration is always given to [the flood] objectives in [their] order [of priority], when making decisions on dam releases" and from the above conclusion that strategies are determined by predictions that incorporate rainfall forecasts.

254 I have discussed the flood objectives and their order of priority already. By its twelve references to rainfall forecasts, the Manual makes it clear that the risk management approach embodied in the Manual, especially its prioritised flood

[336] T 3276.10 to T 3277.34.

objectives, is given effect to by erring on the side of caution so far as rainfall forecasts are concerned. In considering flood operations, a cautious risk orientated approach is one that proceeds on the basis, or at least a probability, that depending on the nature of the forecast, forecast rain will fall. By requiring the use of forecasts, notwithstanding the uncertainties, the Manual ensures that dam safety and optimising protection against urban inundation etc, are prioritised in all strategies. Thus, in directing that "within any strategy" consideration be given to the flood objectives and their priorities in making decisions on dam releases, the Manual is directing the use of rainfall forecasts in making decisions on dam releases. The objectives and their prioritisation cannot be given effect to within every strategy or indeed any strategy unless rainfall forecasts are taken into account "when making decisions on dam releases".

255 If the Manual compelled a flood engineer to consider forecasts in determining the strategy in which to operate the dam but also required or permitted the flood engineer to ignore rainfall forecasts when making release decisions within any strategy, then that would result in decisions about strategies being made over a different time frame from decisions about releases and on different assumptions as to the amount of inflow into Wivenhoe Dam. It would inevitably result in release decisions not addressing the objectives of the relevant strategy they were being made within and failing to address the flood objectives overall.

256 As noted, Seqwater contended that there was nothing in the Manual which mandated the use of rainfall forecasts in a "quantitative" manner, that is, it does not "require [the flood engineer] to decide on gate operations that will release a volume of water calculated by reference to estimated inflows from the rain that is forecast to fall above the dams".[337] In so submitting, Seqwater mischaracterised the plaintiff's contention and Dr Christensen's evidence. Neither of them suggested that the Manual mandated the *release* of such a volume of water in all circumstances. Instead, they only contended that the Manuals required the flood engineers to treat estimated inflows derived from

[337] Seqwater subs at [715(b)].

rainfall forecasts as an integer in the decision-making process that yields a release decision.[338] In all of Dr Christensen's simulations, to varying degrees, other factors influenced the release decision. It was only on some days of some of his simulations that Dr Christensen selected a "target volume" to release calculated by reference to an inflow estimate derived from the four-day PME forecast. The "targeted approach" aspect of his methodology and its use in his simulations is addressed in Chapter 10.[339]

257 To similar effect Seqwater contended that, on the plaintiff's construction, if heavy rain was forecast above the dam and heavier rain was forecast to fall below the dam then the plaintiff's construction of the Manual would require the release of the forecast inflows regardless of the impact on urban areas when those releases combined with downstream flows.[340] The plaintiff never urged such a construction of the Manual and that approach was expressly rejected by Dr Christensen.[341] Otherwise, the balance of Seqwater's submissions on this topic repeated the overstatement of what the plaintiff contended for[342] or were predicated on a construction of the Manual that I reject.[343] Similarly, SunWater's submissions on those topics invoked parts of Mr Fagot's evidence in which he construed the Manual in a manner that I reject.[344]

258 It can be accepted that the Manual leaves room for the exercise of engineering judgment in determining how forecasts are to be used in making release decisions. Nevertheless, the strong indications are that it must be some form of quantitative use even if it is not the form of quantitative use described by Seqwater. The ultimate objective of flood operations is to return the dam to, or close to, FSL in accordance with sections 8.5 and 9.4 while respecting the flood objectives and their order of priorities in the meantime.

338 See Chapters 8 and 10.
339 See for example Chapter 10 at [3], [5], [68].
340 Seqwater subs at [750(e)].
341 See plaintiff subs at [479] and Chapter 8, section 8.5.
342 Eg, Seqwater subs at [751(c)], [751(e)].
343 Eg, Seqwater subs at [750(a)] and [751(a)], [751(b)], [751(d)].
344 SunWater subs at [304], [306] to [307].

259 At any instant, the starting point for the flood engineer in determining releases is the relevant strategy and that will have been determined by a predicted maximum height, and in some cases a prediction of downstream flows, both of which were arrived at by a calculation that utilised rainfall forecasts, ie, a form of "quantitative" use of forecasts. The strategy chosen directs attention to the relevant objective(s) and specifies the maximum flow rate. A consideration of that strategy, the forecast(s), the predicted height (and associated inflow volume) and the other parts of the Manual will provide the flood engineer with at least initial guidance as to the amount of water to be evacuated to return the dam to FSL, or possibly below, and at least the maximum time frame over which that should occur. Depending on the forecast, in many cases that will yield a different amount of water to be evacuated than an approach which derived a predicted maximum height from a rain on the ground assessment (or an approach which aims to evacuate the current amount of water above FSL and an estimate of inflow derived from a rain on the ground assessment).

260 The end point is that the flood engineer will make a decision to open a certain number of gates and release a specified volume of water at specified times. Between obtaining that initial guidance and making that release decision, there are a number of other factors that must be considered, including lower level objectives, the state of downstream flows and the current height of the dam. The weighing up of these matters will involve an exercise of engineering judgment. A consideration of those factors may or may not result in a release decision that meets Seqwater's definition of a quantitative use, namely the release of "a volume of water calculated by reference to estimated inflows from the rain that is forecast to fall above the dams".[345] However, given at least the initial role that must be played by forecasts, it is difficult to see how any such "use" of forecasts could be described as anything other than "quantitative" (even if not "quantitative" in the sense described by Seqwater).

261 Ultimately, it is not necessary to descend to the point of identifying each and every potential "use" of forecasts that might conform with the Manual and then

[345] Seqwater subs at [715(b)].

identify one or other as qualitative or quantitative according to Seqwater's definition or anyone else's. In this case, the relevant questions are whether the flood engineers' "use" of forecasts was consistent with the Manual (and ultimately led to the release of too little water early in the flood event) and whether the plaintiff has demonstrated a form of "use" of forecasts that at a minimum was required (and should have ultimately led to the release of more water early in the flood event). At least so far as the former question is concerned, to the extent that there was any "use" of upstream rainfall forecasts by the flood engineers, it was not a use that conformed with the Manual's requirement to give effect to the flood objectives in their specified order.[346] The latter question is addressed in Chapters 8 to 10.

3.3.9: Peak Outflow Should Generally Not Exceed Peak Inflow

262 As noted, one issue between the parties concerns the nature of the constraint, if any, imposed by the statement at the bottom of page 23 of the Manual and before the flow chart namely that "[w]hen determining dam outflows within all strategies, peak outflow should generally not exceed peak inflow."

263 The plaintiff contended that the reference to "peak inflow" was a reference to predicted peak inflow over the entirety of the flood event determined by reference to rainfall forecasts. Seqwater submitted that it was at least a reasonable interpretation of the Manual that peak inflow was restricted to peak inflow experienced to date or the higher of that peak and a prediction based on rain on the ground.[347] Seqwater contended that, if the peak inflow was determined by reference to rainfall forecasts, then the uncertainty inherent in that assessment would mean that the flood engineer could not be satisfied that they will not "violate the constraint"[348] and make the flood event worse overall than if the dam was not there.[349] SunWater submitted that the statement embodied a "fundamental principle" followed by flood operations engineers and, while there "might be nuances" about its interpretation, it is the

[346] See Chapter 7, sections 7.17 and 7.18
[347] Seqwater subs at [803].
[348] Seqwater subs at [807].
[349] Seqwater subs at [795], [807].

"antithesis of using rainfall forecasts for the purposes of making pre-releases".[350] Based on Mr Fagot's evidence, the State submitted that the statement limits outflows to the peak inflows experienced to date.[351]

264 In support of its construction, the plaintiff noted that the concept of "peak" appears in two other places in section 8.4, namely the references to "peak flow rate" at the Lowood gauge and Moggill gauge. The plaintiff contended that since they are clearly referencing predicted peaks then the reference to "peak inflow" should also refer to predicted peaks. However, I do not afford much weight to those words *per se*. Unlike the reference to "peak inflow", section 8.4 expressly provides that the reference to "peak flow rate" at Lowood and Moggill are predictions.

265 The concept of "peak inflow" is referred to in two other parts of the Manual. First, in section 8.5 concerning gate closing, the Manual states that "the maximum discharge from the dam during closure should generally be less than *the peak inflow* into Wivenhoe Dam experienced during the event". Thus, this part of the Manual expressly refers to a peak inflow that has already been experienced, albeit in a context where it has been determined that the peak has passed. Second, as noted above, "peak inflow" is referred to in the discussion of Strategies S1 and S2. Thus, in describing Strategy S1 the Manual provides "that the release rate from Somerset Dam is not to exceed *the* peak inflow into the dam". Further, three of the four boxes for Strategy S2 state that "the release rate from Somerset Dam is *generally* not to exceed *the* peak inflow into the dam".

266 Other parts of the Manual refer to "the flood event peak" or "the flood peak". Thus, both sections 1.1 and 3.1 state that "normal procedures require stored floodwaters to be emptied from the dam within seven days *of the* flood event peak passing through the dams". Section 3.2 has a statement to similar effect, although it twice refers to "the flood peak". Like section 8.5, these

[350] SunWater subs at [960].
[351] State subs at [44(f)] and [507] to [514].

passages are addressed to the circumstance that “the” flood peak has passed and water is being released.

267 These provisions provide some support for the plaintiff’s proposed construction in two respects. First, because the Manual expressly refers to past peaks in a number of places. Second, because all of these provisions appear to contemplate there being only one “peak inflow”, “flood peak” or “flood event peak” for each flood event. Thus, they suggest that the reference to “peak inflow” in section 8.4 should also be to *the* peak for the flood event and not just the peak inflow experienced to date.

268 In support of their submissions, the defendants invoked the evidence of a number of their witnesses which is outlined below. Generally, the resistance of various witnesses to the plaintiff’s construction was almost entirely bound up with their resistance to the use of forecasts in making the predictions required of the Manual.

269 As noted by Seqwater, effectively three views on this part of the Manual were proffered by the various witnesses.[352]

270 The first view was adhered to by both Mr Malone and Mr Fagot. They construed the Manual as precluding releases that exceeded the rate of inflows into Wivenhoe Dam to that point in time.[353] Mr Fagot’s evidence is addressed in section 3.4. Mr Malone asserted that, despite the inclusion of the word “generally”, the requirement that peak outflow not exceed peak inflow experienced to that point in time was an overarching principle to be applied in all circumstances until after the dams have peaked.[354] He described it as an incident of what he thought was the first principle of a flood mitigation dam, being not to make things worse than one necessarily has to.[355] Mr Swain also stated that in his experience it was “general practice” that outflows should not

[352] Seqwater subs at [801].
[353] T 4756.40, T 5240.38 (Malone); T 9031.39 (Fagot).
[354] T 4757.21, T 4804.45, T 4905.43, (Malone); T 7538.39 (Ayre).
[355] T 5241.23.

exceed the peak of actual inflows to date, although this was not tied to any attempt to construe the Manual.[356]

271 Two matters should be noted about Mr Malone's evidence on this topic (both of which are equally applicable to Mr Fagot's evidence). First, he maintained his view that outflow could not exceed experienced inflow even in circumstances where there was a high degree of confidence based on, say, rain on the ground, that higher inflows would be received even at a level that caused urban inundation.[357] To act in that way could only operate to undermine the Manual's objectives and strongly suggests that the proposed construction is incorrect.

272 Secondly, Mr Malone agreed that his view was the product of his belief that forecasts were not to be used to determine gate releases under the Manual[358] because, if one is not operating based on forecast rain, the dam is operated so that outflows do not exceed the peak rate at which water has flowed in to date.[359] I have already rejected the suggestion that forecasts were not to be used in determining gate releases.

273 The resistance to the use of forecasts also informed the second view of this statement, which was that the reference to peak inflow was a reference to the higher of the peak inflow experienced to date or a predicted inflow based on rain on the ground. Most of the adherents to this view were only recent converts. Initially in his evidence Mr Ayre was of the same view as Mr Malone[360] but he later explained the constraint as referable to a future peak predicted by reference to rain on the ground.[361] Similarly, Mr Ickert initially insisted that "peak inflow" meant peak inflow to date, rather than predicted peak flow, but later agreed that it was a reference to predicted peak inflow,

[356] Swain I, EXP.SEQ.008.0065 at 0071, 0082; Swain III, EXP.SEQ.019.0006 at 0013.
[357] T 4757.25, T 4905.47 (Malone).
[358] T 5241.14 - .25.
[359] T 5241.27.
[360] T 7538.39 to T 7539.11; T 7693.25.
[361] T 7811.26 to T 7813.33.

although it was a prediction only determined by reference to rain on ground and not forecast rain.[362]

274 Although unclear, it appears that Mr Pokarier also interpreted the reference to peak inflow as the higher of peak inflow to date or peak inflow based on a rain on the ground prediction. His attitude to this part of the Manual emerged during cross-examination over his resistance to the use of forecasts. He said this part of the Manual embodied “a fundamental principle of a flood mitigation dam in that the dam does not make - the construction of the dam and the operation of the dam does not exacerbate the peak flood that would have occurred if the dam wasn't there.” He contended that this principle could be violated with the use of forecasts, because “it is not possible to predict with any certainty what that peak inflow would look like”.[363] However, he contended that the principle could be accommodated if the predicted inflow against which peak outflow was to be compared was derived using modelling based on “rain on ground”.[364]

275 It follows that Mr Pokarier’s attitude to this aspect of the Manual was governed by his attitude towards forecasts generally. On that Mr Pokarier accepted that the Manual made numerous references to predicted peak flow but did not accept that any of them were to be made using forecast rainfall, notwithstanding the express direction to that effect in section 8.4 (“…. although the manual says, “use best forecast rainfall and stream flow”, you interpret that to mean rain on ground? A. It's consistent, yes.”)[365]

276 The third view identified by Seqwater was articulated (and applied) by Dr Christensen. He said that the reference to “peak” was to the peak over the entire flood event[366] and that was a peak determined from forecasts.[367]

[362] T 8319.18.
[363] T 6853.11.
[364] T 6856.9.
[365] T 6980.17.
[366] Reply Report, EXP.ROD.004.0005 at [78].
[367] Ibid at [79]; T 1966.3 - .8.

277 In its critique of Dr Christensen's operations, SunWater (and the other defendants) repeatedly asserted that his making of precautionary releases in advance of forecast rain falling breached the statement in the Manual that "peak outflow should generally not exceed peak inflow".[368] SunWater placed particular emphasis on the following passage from the cross-examination of Dr Christensen:[369]

> "HIS HONOUR: Q. You couldn't have precautionary releases if you were restricted to inflow to that time, could you?
> A. No, and that's – so if you're going to operate off a forecast, you have to relax that to where you use forecasts.
>
> MR WILLIAMS: Q. What I want to suggest to you is that your fundamental proposition that there should be precautionary releases conflicts with the proper understanding of the peak inflow/peak outflow **guiding principle**; that's right, isn't it?
> A. That guiding principle is just that, a **guiding principle**. When you operate from forecasts, you have to relax that. The Corps of Engineers did it for Folsom Dam and that would apply here because you're supposed to use forecasts.
>
> Q. So is the proposition for which you contend that precautionary releases are some sort of exception to the guiding principle?
> A. No.
>
> Q. Well, they don't fit within it, do they?
> A. That's because the **guiding principle** fits rain on the ground operations, if you're going to use forecasts, you have to have a different guiding principle and you –
>
> Q. What I want to suggest to you is that the **guiding principle** that peak outflow should not exceed peak inflow is based upon actual rather than forecast inflows; it's the whole basis of the principle, isn't it?
> A. That's correct, and if you follow that, your dams could fill too soon." (underlined emphasis in SunWater submissions; bold emphasis added)

278 SunWater contended that Dr Christensen uses an 'objectives' based approach to "ignore or by-pass the peak inflow/peak outflow constraint" and asserted that "[e]xperienced flood operations engineers do not overlook the

[368] SunWater subs at [960] to [985].
[369] T 1960.35 to T 1961.20; SunWater subs at [967].

constraints by reference to *motherhood-type principles* in a manual".[370] Seqwater made a similar submission.[371]

279 Both Seqwater and SunWater submitted that, in the above passage, Dr Christensen accepted that the statement in the Manual is a "constraint" and that it was based on actual rather than forecast inflows.[372] I do not agree that Dr Christensen made that concession.[373] It is noteworthy that in the above passage the cross-examiner adopted the characterisation of a "guiding principle", a characterisation that Dr Christensen accepted. A "guiding principle" is not a rule and it is not a "constraint". As noted by Dr Christensen later in his evidence,[374] the grammatical embodiment of that "guiding principle" in the Manual is not expressed as a rule or as a constraint ("generally not exceed"). Otherwise, according to SunWater's submissions, flood engineers must strictly observe "guiding principles" but principles associated with "motherhood" are of no consequence. Apparently flood operations engineers do not listen to their mothers.

280 Contrary to Seqwater and SunWater's submissions, the effect of what Dr Christensen was conveying in the above passage is that a determination of the scope of the statement in the Manual that peak outflow should generally not exceed peak inflow involves a consideration of the Manual as a whole. If, as Dr Christensen contends, the Manual is construed as requiring the use of forecasts in the selection of strategies and releases, then he considered this to be a strong reason why the reference to peak inflow is not restricted to past peaks but includes future peaks during the flood event determined by forecasts,[375] and why the statement is not expressed in proscriptive terms.[376] Mr Ayre agreed that if forecasts were used to "carry out flood operations

[370] SunWater subs at [968] to [969].
[371] Seqwater subs at [841].
[372] Seqwater subs at [839] and [841]; SunWater: T 9810.13; T 9875.47 to T 9876.19.
[373] See T 1903.23.
[374] T 1966.8.
[375] T 1901.25 - .40; T 1932.29 -.33; T 1960.23.
[376] T 1963.28; T 1966.8.

under section 8.4" then forecast rain would be considered to make decisions about peak inflows for the purpose of limiting peak outflows.[377]

281 Otherwise, I note that Mr Tibaldi adopted all three views in his evidence. Initially, he agreed with Mr Malone and Mr Ayre's construction.[378] However, he later accepted that the reference to "peak" outflow and inflow referred to a predicted inflow and outflow that is "likely to occur",[379] which he nominated as being based on rain on the ground,[380] although he accepted it could also be based on a forecast product that one had a "very, very high level of confidence in".[381]

282 Overall, I do not accept that there is some general principle of flood mitigation that peak outflow should never exceed peak inflow to date. Included amongst the materials that Mr Pokarier has prepared to train flood engineers[382] is a slide that shows the benefits of pre-releasing ahead of inflows in order to mitigate the flood that would otherwise occur.[383] A bulletin issued by the International Committee on Large Dams ("ICOLD") in 2003 specifies a number of "general methods" for operating dams, one of which is described as the "Advanced Discharge Method".[384] An accompanying diagram explaining that method depicts discharges made in advance of inflows; ie, outflows that exceed peak inflow experienced to date.[385] Clearly that method contemplates operating on forecast inflows. All operations based on forecast inflows, whether based on forecast rainfall or only rain on the ground, must contemplate the possibility that the forecast will prove wrong and thus the possibility that, judged with hindsight, peak outflow exceeded peak inflow. That is exactly the type of operation contemplated by Dr Christensen. Such an operation seeks to provide a higher level of protection against more serious floods at the risk of providing lower levels of protection against, and potentially

[377] T 7815.37.
[378] T 5627.34.
[379] T 5631.2.
[380] T 5630.17 - .20.
[381] T 5629.1 to T 5629.8.
[382] T 6981.14.
[383] Flood Engineers Training Day 2 Module 4.5 Flood Modelling, SEQ.095.001.0971 at .0981.
[384] SEQ.093.001.0001 at .0186.
[385] SEQ.093.001.0001 at .0187.

worsening, less serious floods. At its highest, the evidence established no more than a general objective similar to that stated by Seqwater, namely that flood operations should not, but not necessarily will not, result in an outcome downstream worse than what could have occurred had the dam not existed.[386]

283 Ultimately the determination of the meaning and scope of this statement returns to a consideration of the Manual as a whole. Some textual aspects have already been noted above. At the risk of repetition, it is necessary to note its emphasis on objectives and their priorities as well as its acknowledgement of the uncertainty of forecasts while mandating their use. The acknowledgment of the uncertainty of forecasts within the Manual and the less than strictly proscriptive wording of the peak outflow less than peak inflow statement addresses Seqwater's concern that the use of forecasts may result in peak outflow being higher than peak inflow over the course of the event if forecast rain does not fall; ie, the Manual acknowledges that possibility and accepts it as the cost of giving effect to the Manual's priorities. I have already noted that the effect of the Manual's priorities is that a possible cost of optimising protection against urban inundation is the potentially unnecessary inundation of rural bridges; that is a circumstance where over the course of the flood event the peak outflow might be greater than the peak inflow. Another such example maybe when Strategy W4 is engaged above EL 74.0m AHD and gates are opened to address the rising storage level (see below).

284 Thus, whatever the scope of the "guiding principle" or the "tenet",[387] the Manual has relaxed it by requiring the use of forecasts and by expressing the relevant principle in terms that are inconsistent with it being an inviolable constraint ("generally not exceed"). This is not an instance of an objective trumping a constraint but instead it is an instance of construing the Manual as a whole, including its emphasis on objectives and forecasts, to ascertain whether the statement on the bottom of page 23 is a constraint and determining its scope. The outcome of the latter inquiry is that it is a reference

[386] Seqwater subs at [795].
[387] Id.

to a predicted peak inflow formed by reference to rainfall forecasts (and rain on the ground). The answer to the former question is that it is not an inviolable constraint but a “general” or “guiding principle” (“generally”). By expressing it in those terms, the Manual contemplates that the cost of prioritising higher objectives over lower objectives may be that, after the peak of the flood event has passed, it can be ascertained that at some point peak outflow exceeded peak inflow. As stated, such circumstances could include the result of dam operations being conducted in accordance with Strategy W4 above EL 74.0m AHD or it may be a result of acting on the basis of forecast rainfall that did not fall or did not yield the predicted inflows.

285 Accordingly, I am satisfied that the reference to “peak inflow” in the concluding words on page 23 of the Manual is to the “peak inflow” across the relevant flood event, the determination of which will require consideration of predicted peaks using rainfall forecasts and not just the peak inflows already experienced. As I do not accept that a flood engineer could reasonably construe the Manual as not mandating the use of forecasts and could otherwise overlook the significance of the order of priority of the objectives in the Manual, I do not accept the contrary view was reasonably open to a flood engineer.

3.3.10: Strategies W1 to W3

286 It follows from the above that the selection of strategies (and sub-strategies in W1) are made by reference to predicted lake levels, being predictions made that use, inter alia, rainfall forecasts and which adopt a no release assumption.

287 Two issues remain with W2 and W3.

288 The first concerns the reference to “upper limit of non-damaging floods” of 3500m^3/s at Lowood in the case of W2, of 4000m^3/s in the case of Moggill in the case of W3, and the reference to “optimum” protection in the “primary objectives” of section 1.1. SunWater contended that it was open to a flood engineer to treat operations that did not result in any damage to urban areas

as the provision of optimum protection. It pointed to a Flood Damage curve sheet that indicated that some urban damage is occasioned by flows of 2000m^3/s at Moggill with exponential increases thereafter, namely \$1.8 million at 2000m^3/s, \$5.6 million at 3000m^3/s, \$47.2 million at 4000m^3/s, \$250.8 million at 5000m^3/s and so on.[388]

289 It can be accepted that the flood engineers were entitled to treat the avoidance of any urban inundation as the (ultimate) optimum outcome[389] (although trading away the prospect of saving a large number of properties to save a small number is a different matter). However, they were not entitled to effectively override the Manual and take some other source of information as specifying what flow rate definitely secured an avoidance of any urban inundation altogether. To accept SunWater's submission requires, or at least permits, the flood engineers to treat 2000m^3/s as the upper limit of non-damaging flows and treat, say, 3000m^3/s as constituting damaging flows. The Manual did not permit that. It left many things to the judgment of the flood engineers but not that. The flood engineers were entitled to, and in fact required to, treat this aspect of the Manual as authoritative. Were it otherwise then they might be entitled, or even required, to start making inquiries about further building development undertaken since the Manual was approved each time there was a flood event. The various compromises and approach embodied in the Manual was predicated on the authoritative nature of the statement of the level of non-damaging flows. To the extent it may be relevant, the events of the review process described in Chapter 4 confirm this.

290 The second issue concerns so much of the table in W3 that provides that the "flow at Moggill is to be minimised" when operating "prior to the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases)". As noted, the plaintiff contended that this statement was confined to the circumstance when flows at Moggill are above 4000m^3/s.

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[388] SunWater subs at [246]; citing SEQ.004.045.0662.
[389] T 9830.27 to T 9831.34.

291 In contrast, and at least partly based on Mr Fagot's evidence, the State, Seqwater and SunWater submitted that this statement concerned all flood operations in W3.[390] Mr Fagot's evidence is addressed below. In addition, the State noted that the table is not introduced by that statement but by the statement that "[t]he combined peak river flow targets for Strategy W3 are shown in the following table", which it contends is concerned with the entirety of operations in W3.[391]

292 Unfortunately to resolve these debates it is best to again set out the relevant part of W3:

> "The intent of Strategy W3 is to limit the flow in the Brisbane River at Moggill to less than 4000 m^3/s, noting that 4000 m^3/s at Moggill is the upper limit of non-damaging floods downstream. The combined peak river flow targets for Strategy W3 are shown in the following table. In relation to these targets, it should be noted that depending on natural flows from the Lockyer and Bremer catchments, it may not be possible to limit the flow at Moggill to below 4000 m^3/s. In these instances, the flow at Moggill is to be kept as low as possible.

TIMING	TARGET MAXIMUM FLOW IN THE BRISBANE RIVER
Prior to the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases)	The flow at Moggill is to be minimised.
After the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases)	The flow at Moggill is to be lowered to 4,000m^3/s as soon as possible.

293 The second column of the box is concerned with identifying the "target <u>maximum</u>" flow in the Brisbane River while in Strategy W3; ie, the upper limit of the downstream flow rate (as opposed to the maximum release rate). The first sentence of the text above the box makes it clear that the target maximum flow for Strategy W3 is 4000m^3/s, being the "upper limit of non-damaging floods". The balance of the text before the box is directed to the

[390] State subs at [520]; Seqwater subs at [751(d)], SunWater subs at [224(b)], [1164] and [1264].
[391] State subs at [520].

circumstances in which that target cannot be met. In those circumstances both the text and then the box make it clear that the (revised) target maximum is, prior to the naturally occurring peak at Moggill, the minimum possible flow above 4000m^3/s and, after that peak, that target maximum should be brought down to 4000m^3/s as soon as possible (ie, "is to be lowered"). Any doubt about that is removed by the statement immediately preceding the box which specifies that, if the flow at Moggill is above 4000m^3/s, then the "flow at Moggill is to be kept as low as possible". Thus, the first row in the box is merely repeating that statement. If the first row of the box was directed to the entirety of operations in W3 then its statement that the "target maximum" downstream flow was to be minimised would be inconsistent with the opening statement in the text that 4000m^3/s is the intended limit (ie, maximum) of the strategy being the designated or deemed point at which non-damaging flows cease. It follows that I accept that the first row of the box is directed to the circumstance where the flow rate at Moggill is above 4000m^3/s.

3.3.11: Strategy W4

294 Like the other strategies, the parties were in dispute about whether Strategy W4 could be invoked by a predicted storage level above EL 74.0m AHD formed by reference to rainfall forecasts. For example, by reference to Mr Fagot's evidence, the State contended that W4 "should not be implemented until there is certainty that the lake level at Wivenhoe Dam will reach EL 74m",[392] with that "certainty" being derived from modelling rain on the ground.[393] Mr Fagot's evidence is addressed in section 3.4. I have already concluded that the rainfall forecasts must be used in determining predicted storage levels for the selection of strategies.

295 The principal dispute about Strategy W4 concerned what action Strategy W4A required the flood engineers to take within W4, once the actual storage level in Wivenhoe Dam exceeded EL 74.0m AHD.

[392] Ibid at [48].
[393] T 9075.7.

296 This issue is not *directly* relevant to any critique of the flood engineers' conduct. The only time the flood engineers purported to operate above an actual storage level of EL 74.0m AHD was on 11 January 2011. There is no particular of negligence alleging any failure on their part on that day. Further, the gate openings undertaken by the flood engineers on 11 January 2011 are set out in Chapter 7 (at [378]).[394] While they undoubtedly sought to arrest the rise in storage levels, they did not open gates in a manner consistent with Seqwater's proposed construction; ie while the rate of outflows was less than $4000m^3/s$ they did not open gates at the rate of six increments per hour (see below). Instead, this issue is relevant to a consideration of the flood engineers' actions prior to the actual dam level exceeding EL 74.0m AHD because of the possible restrictions that are imposed on them from that time. It is also relevant to a consideration of that part of the plaintiff's causation case which contends that a reasonably competent flood engineer would have operated the dams in accordance with Dr Christensen's simulations B, D, F, G, and H. In each of those simulations the storage level of Wivenhoe Dam would have exceeded EL 74.0m AHD. In those simulations, Dr Christensen suspended further gate openings for various periods while the storage level of Wivenhoe Dam was above EL 74.0m AHD.

297 The critical passages from the Manual relevant to the resolution of this dispute are as follows:

> "The strategy normally comes into effect when the water level in Wivenhoe Dam reaches 74.0m AHD ...
>
> Under Strategy W4 the release rate is increased as the safety of the dam becomes the priority. **Opening of the gates is to occur generally** *in accordance with the requirements of Section 8.6*, **until the storage level of Wivenhoe Dam begins to fall**.
>
> There are no restrictions on gate opening increments or gate operating frequency once the storage level exceeds 74.0 AHD, as the safety of the dam is of primary concern at these storage levels. …
>
> …

[394] Table 7-4.

> **Gate openings are generally to occur** *at the minimum intervals and sequences as specified in Section 8.6* until the storage level of Wivenhoe Dam begins to fall. However, to protect the safety of the dam, minimum opening intervals can be reduced and gate opening sequences can be modified." (emphasis in bold and italics added)

298 As noted, the plaintiff contended that there is not a strict requirement to open Wivenhoe gates until the dam level begins to stabilise above EL 74.0m AHD.[395] The plaintiff pointed to the phrase "generally" in the above passages, the statement that the release rates is increased as the safety of the dam becomes a priority and the fact that, if an increase in releases was mandated, that would be inconsistent with the requirement to consider lower level objectives within the strategy.[396]

299 Both SunWater and the State contended that once the storage level exceeds EL 74.0m AHD, Strategy W4 requires an opening in the gates with a consequential increase in releases until the lake level at Wivenhoe Dam begins to fall.[397] Seqwater made the same submission[398] but took it further and contended that where the rate of release was below 4000m^3/s then the gates had to be opened at the rate of six increments per hour.[399]

300 Thus, as between the plaintiff on the one hand and SunWater and the State on the other, the difference between them concerns the scope for the exercise of judgment left by the Manual to the flood engineer once the actual level exceeds EL 74.0m AHD. On the plaintiff's approach, there is scope for judgment as to whether to address the rises at all and, in particular, gate openings could be maintained if the rate of inflows were beginning to fall and the weather outlook was positive. According to SunWater and the State, there is only scope for the exercise of judgment as to the rate at which the rising levels are addressed. Unlike Seqwater's proposed construction, both approaches allow for the possibility that gate openings could be suspended for a period, although they would differ about the period, and the reasoning in

[395] Plaintiff subs at [540].
[396] Ibid at [540] to [541].
[397] State subs at [49]; SunWater subs at [747] to [849].
[398] Seqwater subs at [868].
[399] Ibid at [2207]; T 9757.35 - .42.

support, of any suspension of further openings. In recognition of the difference between SunWater and Seqwater, SunWater submitted that in each of Dr Christensen's simulations B, D, F, G, H and J "the only reasonable thing for the Flood Engineers" to have done if the storage level exceeded EL 74.0m AHD was to open at the rate of four increments an hour until the level began to fall.[400] Seqwater contended that was impermissible.[401]

301 The first matter to address is Seqwater's proposed construction. Other than possibly Mr Malone,[402] no witness contended that Strategy W4 required gate openings of six increments per hour when the storage level exceeded EL 74.0m AHD and outflows were less than 4000m^3/s.[403] In any event, this aspect of Seqwater's submission involves a misreading of the phrase "the requirements of section 8.6". Section 8.6 is addressed at [65]. There are two "relevant requirements of section 8.6", being the minimum interval period of 10 minutes between gate opening increments of 0.5m where inflows are less than 4000m^3/s and the sequence in which gates must be opened. The former requirement is relaxed if outflows exceed 4000m^3/s or if it is otherwise considered necessary to protect the safety of the dam. Thus, while section 8.6 specifies a minimum interval period between increments, it does not specify a minimum number of increments that must be opened while the outflow rate is below 4000m^3/s. It follows that to state the gates must be opened in "*accordance with the requirements of Section 8.6"*[404] does not mean that they must be opened at a specified rate. The same position applies to the statement that *"gate openings are generally to occur at the minimum intervals and sequences as specified in Section 8.6"*.[405] Leaving aside the effect of the word "generally", to make gate openings "at" the "minimum intervals" is not the same as stating that a gate must be opened by one increment at *every* minimum interval.

400 SunWater subs at [847] to [849].
401 Seqwater subs at [2207].
402 T 4974.29 to T 4975.2.
403 See the summary of the evidence on this topic in Seqwater's submissions at [898] to [956].
404 Manual at 30; QLD.001.0001.0146 at .0180.
405 Id.

302 Once it is appreciated that section 8.6 does not specify a minimum number of gate openings then it follows that the above statements do no impose any requirement to open at six increments an hour when storage levels exceed EL 74.0m AHD and outflows are less than 4000m^3/s. Accordingly, I reject Seqwater's submission to the contrary.

303 Before addressing the dispute between the plaintiff, SunWater and the State, it is necessary to note the evidence concerning the meaning and application of Strategy W4. With the possible exception of Mr Malone, the defendants' witnesses generally accepted that there was scope for judgment as to the rate at which the rise in levels above EL 74.0m AHD was addressed, but they did not accept that the scope to suspend openings was as wide as contended for by the plaintiff.

304 Mr Malone stated that W4 was engaged by actual lake levels[406] and that gates were to be opened at minimum intervals until the lake level dropped and during that rise there was to be no regard to lower strategies.[407] In fact, he regarded both the inclusion of the reference to considering lower level strategies and considering the effect on downstream reaches as erroneous.[408] I found this aspect of Mr Malone's evidence unconvincing.[409]

305 Mr Ayre said that his "interpretation of Strategy W4 was that you had to open gates to ensure that you could arrest the rate of rise of that lake level"[410] but did not consider that the flood engineer had to "simply continuously open the gates". He did not "believe that [this] would necessarily achieve the best outcome for downstream communities".[411] Instead, he considered the flood engineer to be required to "progressively target the releases equalising the inflow".[412] He agreed that there was some scope to slow down increases,

[406] T 4971.16 (Malone).
[407] T 4974.3; T 4975.26.
[408] T 4974.3 - .15; T 4975.26 - .32.
[409] Footnote 927 of Seqwater's submissions asserts that Mr Malone said in his statement that "once the dam level stabilised" then lower level objectives could be considered, citing LAY.SEQ.007.0001_2 at .0074. He did not address that aspect of W4 in the passage cited.
[410] T 7520.15.
[411] T 7521.12.
[412] T 7521.13.

that is, an engineer would not necessarily “keep chasing the inflows up” by opening gates.[413]

306 Mr Tibaldi stated that once W4 was triggered, the engineers were generally required to operate the Wivenhoe Dam gates to arrest the rise in water levels in the dam, but once that was achieved, the gates could be closed if doing so would achieve the lower level objectives in the Manual.[414] He agreed that the inclusion of the word “generally” meant that there was scope to exercise judgment to arrest the rise in storage levels above EL 74.0m AHD in W4.[415] He contended that downstream flows could not be considered while the rise in storage levels was being considered, but could be once storage levels had stabilised.[416]

307 Initially Mr Pokarier stated that, once the water level exceeds EL 74m AHD, the Manual requires the engineer to increase releases until the water level stabilises and starts to fall.[417] He said that the only scope for judgment was whether to open at the minimum intervals or reduce the interval period.[418] He also stated that the same position applies when the water level was predicted to exceed EL 74.0m AHD, although at that time there was scope to consider lower objectives.[419] However, he later accepted that the Manual permits the exercise of discretion to open the gates more slowly and to consider downstream impacts, although he had difficulty conceiving how that would occur in practice.[420]

308 Mr Fagot characterised the flood engineers’ conduct on 11 January 2011 as utilising storage so as to crest Wivenhoe near EL 75m AHD, in an attempt to release on the recession limb of downstream hydrograph. He said this was an acceptable operational practice.[421] In his oral evidence Mr Fagot stated that

[413] T 7521.40.
[414] T 5640.16 to T 5641.25.
[415] T 5832.8 - .26.
[416] T 5641.17 - .25.
[417] T 7007.10.
[418] T 7012.39.
[419] T 7022.3.
[420] T 7019.18-38; T 7026.6 to T 7028.14.
[421] EXP.QLD.001.0232_3, [269] and [293].

"once you get to elevation 74 you have to start making releases in order to stop the rise of the pool".[422]

309 Mr Ickert agreed that there is a discretion on the part of the engineer to raise the gates more slowly, depending on consideration of multiple factors, including the rate of rise, current release rate, predicted inflows and current storage level.[423] Mr Ickert agreed that an engineer could reasonably have opened gates at less than four increments an hour, which was the rate that he adopted in proposing alternative W4 operations for some of Dr Christensen's simulations.[424]

310 Leaving aside Mr Malone and possibly Mr Pokarier, all of these witnesses appeared to accept that W4 allowed for some discretion as to the rate of gate openings when the Wivenhoe Dam storage level was above EL 74.0m AHD, including some scope to not make further openings while the flood engineers took stock of the rate of rise of water levels. However, none of them appeared to countenance closing gates or even maintaining existing gate increments for an extended period while Wivenhoe Dam was above EL 74.0m AHD, much less doing so while Wivenhoe Dam rose close to or above EL 75.0m AHD.

311 In his February 2015 report, Dr Christensen described the operation of Wivenhoe Dam and Strategy W4 in similar terms to that suggested by Seqwater and SunWater except that he stated that W4 could be invoked by a predicted level based on a rainfall forecast.[425] Thus, Dr Christensen stated that when Wivenhoe Dam was predicted to exceed EL 74.0m AHD but prior to the actual storage level reaching that point:[426]

> "Releases could then be made at lower water levels for dam protection, if possible, based on forecasts, within the flow limits of urban flood mitigation or lower priorities. The releases made prior to reaching the 74.0 m level would then both better protect the dam and reduce the magnitude and severity of necessary spillway releases when the water level actually did reach the 74.0m level as predicted."

[422] T 9075.2.
[423] T 8325.3 to T 8327.47; T 8334.23 to T 8335.22 (Ickert).
[424] T 8361.11 - .22, see Chapter 9, section 9.7.
[425] February 2015 Report, EXP.ROD.001.0016, [323] to [327].
[426] Ibid at [324].

312 Dr Christensen then addressed the position when the storage level exceeded EL 74.0m AHD stating:[427]

> "Then, once 74.0m was reached, flood mitigation storage had been filled and it would become time to open the spillway gates as needed to protect the dam by making *whatever spillway releases were necessary*. Accordingly, the W4 Strategy placed "No limit on the Maximum Release rate" and the gates were to be opened as much and as rapidly as needed "until the storage level of Wivenhoe Dam begins to fall." (emphasis added)

313 Similar statements were made elsewhere in that report and his other reports.[428]

314 Dr Christensen's methodology and his simulations are addressed in Chapters 8 to 10. At this point it suffices to state that under a number of Dr Christensen's simulations the storage level of Wivenhoe Dam would have exceeded EL 74.0m AHD but, during the period when the water level would have been above that height, he would not have increased gate openings for many hours in order to minimise downstream effects.[429] In cross-examination it was suggested to Dr Christensen that this aspect of those simulations departed from his statements in his report as to how W4 operates.[430] Dr Christensen denied that stating this reference to "making whatever spillway releases were necessary" in the above passage, included the necessity to address downstream impacts while being satisfied that there was no risk to dam safety.[431] He otherwise justified the approach on the basis of the need to consider lower level flood objectives.[432] Those simulations are hard to reconcile with the approach to W4 stated in his reports,[433] although I am not persuaded that Dr Christensen consciously departed from his own stated approach to W4 to achieve a better result. Equally, however, I consider that the above extracts from his report accord more with the natural meaning of the disputed parts of W4 especially when read with the balance of the Manual.

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427 Ibid at [325].
428 Ibid at [157] and [354]; Response Report, EXP.ROD.015.0005 at [278(3)].
429 See Chapter 9, section 9.7.
430 See T 1167 to 1168; T 1182.9 to T 1184.7; see also T 1684.20 to T 1685.41 and T 2485.7 to T 2491.14.
431 T 1182.390.
432 T 1183.14 to T 1184.7.
433 See Chapter 9, section 9.7.

315 Overall, the wording and structure of the Manual (mostly) supports SunWater and the State's construction. Both of the relevant statements set out at [297] suggest that gate openings must address the rise in storage levels above EL 74.0m AHD. The placement of the word "generally" suggests there is scope for judgment as to the rate at which they are opened but the necessity to address the rising water level remains. This conclusion is only reinforced by bearing in mind the priorities of the Manual and their hierarchy. By the time the storage level exceeds EL 74.0m AHD, dam safety is the priority, and it predominates over other flood objectives. Further, the increase in inflows from raising gates may yield an outflow that exceeds peak inflow to date (and predicted peak inflow) but as explained, the statement on the bottom of page 23 of the Manual addressed in section 3.3.8 does not prevent that occurring.

316 Two further matters should be noted about Strategy W4 as a consequence of the above.

317 First, it follows from the above that, once the actual level of Wivenhoe Dam exceeds EL 74.0m AHD, there is only very limited scope for a consideration of lower level objectives in the Manual. I accept that a flood engineer has some discretion as to whether to open gates, and at what rate, when in W4A and the storage level is above EL 74.0m AHD, however their overall objective must be to address the rising level (and presumably do so quickly). Contrary to SunWater and the State's submissions, and most of its witnesses, I do not accept that in exercising that judgment as to whether to open the gates, and at what rate, the flood engineer has no scope whatsoever to consider lower level objectives, including protecting urban areas against inundation, but it is very limited. An important consequence of this is that in conducting flood operations below EL 74.0m AHD the flood engineers must be cognisant of the consequences of exceeding EL 74.0m AHD, namely, that if that level is exceeded then generally a large increase in releases will have to be made and there will then be little scope, if any, to consider downstream effects. Once the storage level of Wivenhoe Dam has stabilised above EL 74.0m AHD then lower level objectives can be considered more fully.

318 Second, it also follows from the above that Strategy W4 is engaged by a predicted storage level above EL 74.0m AHD and not an actual storage level. This follows from the statement in the conditions box and the flowchart. The reference to the “strategy normally com[ing] into effect when the water level in Wivenhoe Dam reaches 74.0m” is a reference to that part of the strategy that effectively mandates large releases to arrest rising water levels that threaten dam safety. It further follows that when Strategy W4 is only engaged by a predicted height above EL 74.0m AHD, there is no requirement to keep opening gates to address the rising water levels and the requirement to consider lower level objectives in their order of importance, in addition to dam safety, is fully engaged although the flood engineer is no longer limited to maximum releases of 4000m^3/s. As discussed in Chapter 7,[434] that may mean that a transition from W3 to W4 based on a prediction does not necessarily lead to an immediate increase in releases.

3.3.12: The Overall Strategy Set by the Senior Flood Engineer

319 As noted above, there was debate, principally amongst the defendants, about the respective roles of the SFOE and DFOE as stated in sections 2.3 and 2.4 and, in particular, what the meaning of the phrases the “overall strategy” and the “general strategy” was in those provisions and what obligations any such strategies impose on the DFOE. The debate arises in the context of submissions made on behalf of Messrs Malone, Tibaldi and Ruffini to the effect that they could deflect any or some responsibility they may have for their conduct of flood operations by asserting that they were acting in accordance with Mr Ayre’s direction. The evidence relevant to those submissions is addressed in Chapters 6 and 7.

320 The plaintiff contended that the reference to “general strategy” was effectively a “campaign plan for the whole event” but, in any event, the setting of such a strategy did not obviate the obligation of any of the engineers to comply with the Manual. For example, the plaintiff contended the setting of a “general

[434] At [108] to [109].

strategy” by the SFOE would not enable them, for example, to select strategies based on actual levels.[435]

321 By reference to some evidence given by Mr Tibaldi, Seqwater contended that it was reasonable for a DFOE to operate on the basis that they were required to operate the dam in accordance with the “instructions” or “guidelines” set by the SFOE flood operations engineer and not “go outside those guidelines” without reporting back to the SFOE first.[436] That said, Mr Tibaldi also agreed that he was obliged to exercise an “independent judgment” about releases “in accordance with the Manual and in accordance with the instructions set by the senior flood engineer”.[437] Seqwater contended that a general strategy could be set for only part of an event and could include the specification of a particular strategy such as W1 etc.[438] The State’s submissions were similar to Seqwater’s.[439]

322 SunWater contended that the references to “general strategy” and “overall strategy” are only references to the various strategies for Wivenhoe Dam and Somerset Dam described in the Manual (ie, W1 to W4 and S1 to S3). Otherwise, SunWater submitted they did not include setting gate openings and release decisions[440] and did not excuse flood engineers from complying with their obligations under the Manual.[441]

Approach

323 While a precise consideration of the delineation between the SFOE and the DFOE is best undertaking when considering the detail of what happened during the January 2011 Flood Event, three matters should be noted.

324 First, the phrases “overall strategy” and “general strategy” denote the same concept, specifically, some form of overall direction or guideline that is a level

[435] T 9305.29.
[436] Seqwater subs at [1082]; T 5477.2.
[437] T 5477.21 - .46.
[438] T 9620.16.
[439] T 10017.29 to T 10018.16; State subs at [112] to [117].
[440] T 9962.35.
[441] T 9963.10.

of generality above any specific Wivenhoe or Somerset strategy or release decisions. This follows from the adjective “overall” and “general”. It is also clear from the Manual that the selection of Wivenhoe and Somerset strategies change with prevailing conditions, especially rainfall forecasts. It would be inconsistent with the balance of the Manual for sections 2.2 and 2.3 to confer on the SFOE definitive authority to set those strategies in advance of the relevant data being received and in respect of periods when he or she may not be on duty.

325 Second, there is no reason why the relevant “overall strategy” and “general strategy” need be set for the whole of a flood event, especially given the various uncertainties involved.

326 Third, it follows that, notwithstanding the setting of some overall strategy or general strategy by the SFOE, responsibility for applying the Manual to select the relevant Wivenhoe and Somerset strategy and make releases rests with the duty flood engineer who is confronted with the unfolding flood event, including the best forecast rainfall and stream flow information (see section 8.4). Any “overall strategy” or “general strategy” set prior to a particular shift must give way to the application of the Manual to the situation that unfolds. Section 2.4 confirms that, unless otherwise directed by a SFOE applying section 2.8, the DFOE is obliged to follow the Manual during the flood event.

327 A simple example of the type of decision that may constitute the setting of an “overall strategy” or a “general strategy” may be the specification of the drain down period for releasing water after the flood peak has passed and in circumstances where the forecasts are clear. The Manual provides that the floodwaters should normally be drained down within a seven-day period, although that may be extended (section 3.2). It would be open to the SFOE to specify an intended drain down period that was to be aimed at by flood operations which might be set having regard to past and anticipated future downstream conditions and long-term weather outlooks. The setting of a guideline drain down period would not obviate the obligation of each flood

engineer who was subsequently on duty from applying the Manual according to its terms in case, say, further rain was forecast or fell.

3.3.13: Are Pre-releases Permissible?

328 In its written submissions, Seqwater contended that the effect of its construction of the Manual was that pre-releases of the kind made by Dr Christensen, namely releasing a volume of water, below FSL if necessary, to accommodate inflows from forecast rainfall, was not permissible under the Manual and, even if it was, the contrary represented a reasonable interpretation of the Manual.[442] The particular aspects of the Manual that it identified was the supposed prohibition on making releases below FSL for flood mitigation purposes and the "constraint" that peak outflow had to be less than peak inflow to date (or predicted peak inflow based on rain on the ground).[443] The submissions referred to the evidence of Mr Fagot and Messrs Ayre, Tibaldi and Malone.[444]

329 The issue of whether pre-releases are permitted based on forecasts can only be addressed once the various disputed aspects of the Manual's construction are resolved. In that regard, the combined effect of the various findings I have made in this Chapter and in Chapter 5 concerning FSL is that, at the commencement of a flood event, and while Wivenhoe Dam is at or below EL 67.25m AHD, "pre-releases" based on forecasts (or anything else) are not permitted. However, once that threshold is exceeded, "pre-releases" to create storage space in advance of forecast rain are permitted and required if necessary to give effect to the flood objectives and their order of priority. Such releases are permitted in the case of Somerset Dam in S1, as that has no similar constraint to that stated in section 8.3, and otherwise might be allowed in S2 depending on the predicted levels of Wivenhoe Dam and the predicted and actual levels of Somerset Dam.

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442 Seqwater subs at [849] to [850].
443 Ibid at [851].
444 Ibid at [853] to [856].

330 As for Mr Fagot's evidence, that is addressed below. In relation to the flood engineers' supposed belief on this topic, it follows from the findings earlier in this Chapter, Chapter 4 and Chapter 5 that I do not accept their evidence to the extent that they asserted that in January 2011 they had a specific belief that, other than via the operation of EL 67.25m initial threshold, pre-releases based on forecast rainfall were precluded by the Manual (or some operative legislation or instrument). As the next Chapter demonstrates, the flood engineers made pre-releases from Somerset Dam below FSL in advance of forecast rain in May 2009 under Version 6 of the Manual and, to an extent, in March 2010.[445]

3.4: Mr Fagot's Evidence

331 Reference has already been made to some of the evidence of Mr Fagot. As noted, Mr Fagot stated that the Manual should be interpreted by first seeking to identify the constraints imposed by the Manual and then "within those constraints you can then apply the objectives".[446] That approach has already been addressed but given the significance placed on Mr Fagot's evidence by the defendants, it is necessary to address his evidence including his approach to the Manual in more detail.

332 Mr Fagot is a licensed professional engineer in the states of Colorado and Washington, USA. He obtained a Bachelor of Science (Civil Engineering) in December 1993 followed by a Master of Science (Civil Engineering) in December 1997 from the University of New Orleans. From 1993 to 1998, he was a Hydraulic Engineer at the United States Army Corps of Engineers ("USACE") in the New Orleans District. He then worked as a Hydraulic Engineer at the Bureau of Reclamation in the Lower Colorado region from 1998 to 2003. In 2003, he became a Hydraulic Engineer with the Corps of Engineers in the Little Rock District. He commenced his current position at WEST Consultants in 2010 and is employed as a Project Manager. In this role, he undertakes reservoir operations modelling, hydrological and hydraulic

[445] See Chapter 4 at [197].
[446] T 9028.41.

engineering projects in addition to updating and reviewing water control manuals.

333 In his first report,[447] Mr Fagot outlined his interpretation of the Manual[448] and then critiqued the flood engineers' conduct of flood operations during the January Flood Event[449] and Dr Christensen's simulations.[450] Some of these topics were revisited in his four subsequent reports[451] which also responded to the reports of a number of the plaintiff's experts.

334 In their written submissions, the defendants placed great emphasis on Mr Fagot's opinions. Thus, the State described him as the "most experienced expert flood operations engineer to give evidence".[452] It contended that the cross-examination of him was limited, did not seek to challenge most of his opinions and that overall his evidence as to reasonably competent dam operations, including the interpretation of the Manual, should be accepted over Dr Christensen's evidence.[453] SunWater and Seqwater's submissions were to similar effect.[454]

335 In contrast, the plaintiff contended that Mr Fagot's interpretation of the Manual and critique of the flood engineers and Dr Christensen suffered from two interrelated flaws. The first was that Mr Fagot directly transposed his experience from United States dams which use highly prescriptive flood procedures manuals to the completely different context of Wivenhoe and Somerset Dams which were governed by a very differently worded manual, specifically a manual that emphasised objectives and strategies. Second, the plaintiff contended that Mr Fagot either ignored or substantially misread parts of the Manual. The plaintiff submitted that these flaws (fatally) undermined any attempt to rely on his opinions concerning the proper interpretation of the

447 EXP.QLD.001.0232_2.
448 Ibid at Chapter 3, .0270.
449 Ibid at Chapter 5, .0329.
450 Ibid at Chapter 6, .0380.
451 EXP.QLD.001.0524_2; EXP.QLD.001.1305; EXP.QLD.001.0505; EXP.QLD.001.1311.
452 State subs at [10]; see also [16] to [18].
453 Ibid at [640].
454 SunWater subs at [9] and [661] to [669] and [1474] to [1484]; Seqwater subs at [195] and [738] to [741] and [2374] to [2381].

Manual, the conduct of the flood engineers during the January 2011 Flood Event and his critique of Dr Christensen. For the reasons that follow, I accept those contentions.

3.4.1: USACE Experience

336 To address the plaintiff's contentions, it is necessary to further describe Mr Fagot's experience with the USACE. With one exception, all of his practical experience in dam operations was at dam infrastructure operated by the USACE.[455] The USACE is divided in to seven geographic divisions which in turn are divided into multiple districts.[456] Mr Fagot has considerable experience working in the White River Basin which is in the Little Rock District and which in turn forms part of the Southwestern Division of the USACE.[457] There is a corresponding hierarchy of controlling documents for those dams. Thus, the USACE headquarters has published a high-level manual, "Management of Water Control Systems", which provides "guidance to field offices for the management of water control projects or systems".[458] Within each catchment or basin there is a master control manual with each project or dam having its own water control manual.[459] Appendix (vii) to the water control manual for the White River Basin is the water control manual for the Bull Shoals Dam and Norfork Dam which are on the White River and North Fork River respectively in Arkansas.

337 The "Management of Water Control Systems" document includes a classification of "Flood Regulation Methods".[460] According to that manual, a reservoir operated according to Method A "disregard[s] the possibility of having an appreciable portion of the flood control storage capacity filled upon the occurrence of a large subsequent flood".[461] Thus, Mr Fagot described a Method A reservoir as "try[ing] to protect" against minor and moderate

[455] T 8966.9.
[456] T 8967.14.
[457] T 8970.12 - .27
[458] T 8969.1; SEQ.092.001.4293.
[459] T 8968.20.
[460] SEQ.092.001.4293 at .4358.
[461] SEQ.092.001.4293 at .4359.

flooding until that level of protection is no longer available.[462] In contrast, Method B was described as "based on control of the project design flood". It is said to "provide ... considerable assurance of satisfactory regulation of major floods [but] less satisfactory regulation of lesser floods".[463] Mr Fagot described a "Method B reservoir" as one that assumes that it is always providing protection "against a very high-level flood".[464] Method C is a combination of Method A and Method B.[465] Mr Fagot said that the White River dams were Method A reservoirs.[466]

338 The water control manual for the Bull Shoals and Norfork Dams is almost 500 pages long. It is highly prescriptive. Three particular aspects should be noted. First, neither the water control manuals for Bull Shoals and Norfolk Dams or any other manuals that Mr Fagot had worked with contained any detailed statement of objectives like the Manual.[467]

339 Second, the water control manual for the Bull Shoals and Norfork Dams include an express prohibition on the use of forecasts for operational decisions ("QPF forecasts are not used for daily operational decisions").[468] Mr Fagot explained that the origin of this prohibition was a policy decision made by the USACE headquarters.[469] He was shown a USACE after event flood report for a flood in 2010 in the Great Lakes and Ohio Division[470] which he agreed suggested that reservoir lake levels had been reduced based on a forecast of heavy rain.[471] He added that he would expect that such an operation was expressly referred to in the relevant water control manual.[472] That said, Mr Fagot said that he had never worked with a USACE manual or

[462] SEQ.092.001.4293 at .4359; T 9010.43.
[463] SEQ.092.001.4293 at .4359.
[464] T 9011.1.
[465] SEQ.092.001.4293 at .4360.
[466] T 9011.3.
[467] T 9016.1.
[468] SUN.300.001.4297 at .4375; T 8973.11.
[469] T 8974.3.
[470] MSC.010.544.0001.
[471] MSC.010.544.0001 at .0051; T 8980.37.
[472] T 8980.44; see also T 8974.10.

any other manual that specifically referred to the use of forecast rain in the making of operational decisions.[473]

340 Third, the water control manuals for Bull Shoals and Norfork Dams do not confer on the flood engineers any, or only very little, scope for the exercise of discretion or judgment as to the release rates from the dams. Instead, releases may only be made from the dams above the “flood pool”[474] with the rate of release dictated by a rain on the ground assessment[475] of the river level at a point two days downstream of the dams.[476] When the dam levels exceed the flood pool, or is predicted by a rain on the ground calculation to exceed the flood pool,[477] then the constraint imposed by the downstream flow is removed and so called “induced surcharge” operations commence,[478] whereby releases are dictated by a chart that matches minimum required releases and dam levels.[479] As releases from the flood pool are not governed by the rate of inflow to the dams, it follows that this approach means that if the calculated rate of outflows cannot address the inflows then the dam levels will rise until induced surcharge operations are required,[480] this being consistent with a Method A reservoir. Mr Fagot accepted that this approach involves letting the dams fill and not making releases against the risk that the flood pool will be filled but instead only making such releases when it was certain that the flood pool will fill.[481]

341 The essence of the difference between these water control manuals (and other USACE manuals with which Mr Fagot is familiar) on the one hand and the Manual on the other is encapsulated by the following passage from Mr Fagot’s evidence:[482]

[473] T 9021.43.
[474] SUN.300.001.4297 at .4399; T 8992.30.
[475] T 8988.24.
[476] T 8990.37; T 8993.12 - .18; T 8987.29 - .38.
[477] T 8999.16.
[478] T 8998.22.
[479] T 8998.29; T 8987.42.
[480] T 9000.17 to T 9000.28.
[481] T 9058.25 to T 9058.37.
[482] T 9066.

"Q. And the approach in USACE dams, unless a manual expressly says otherwise, is not to evaluate the risk benefit of making releases on the rising limb of the hydrograph, but simply never to do so; is that correct?

A. So the risk that is associated with reservoir operations is developed during the development of the water control manual, *so as a real-time reservoir engineer, I'm not calculating risk into my real-time reservoir operations*.

Q. That's because the manual does it for you; correct?

A. It's because it's - the determination of how they want me to operate in an uncertain environment is provided to me through the constraints that are found within the manual." (emphasis added)

342 In contrast, the Manual clearly did require the flood engineers to evaluate risk while conducting flood operations.

3.4.2: Downstream and Upstream Peak Flows

343 The difficulties with Mr Fagot's evidence are evident by considering that part of his evidence where he sought to identify what he regarded as the all-important "constraints" that governed flood operations under the Manual.[483]

344 One of the sources of those "constraints" identified by Mr Fagot has already been adverted to, namely section 3.2. As noted, Mr Fagot interpreted the emphasised passages in section 3.2, which are set out at [22], as imposing a "constraint" operating throughout a flood event which precludes dam releases that would result in a flow downstream greater than had been experienced downstream to that time.[484]

345 Another "constraint" identified by Mr Fagot was said to flow from the statement in section 8.4 that "peak outflow should generally not exceed peak inflow". As already noted, Mr Fagot interpreted those words as precluding peak outflow from Wivenhoe Dam from ever exceeding peak inflow experienced to date.[485]

[483] Cf State subs at [507] to [514].
[484] T 9031.18; EXP.QLD.001.0232 at [98], [250], [277] and [289].
[485] T 9031.39.

346 The manner in which these constraints were said to relate to one another was illustrated by an example that was posed to Mr Fagot in his oral evidence which illustrated that which of these constraints governed flood operations depended on whether flooding originated downstream or upstream.[486] The example posited a previous peak flow of 200m^3/s downstream of Wivenhoe Dam, a current inflow of 800m^3/s into Wivenhoe Dam with a greater predicted inflow into the Dam. Mr Fagot stated that, as the rainfall originated upstream of the Dam, the second constraint was operative and thus the maximum discharge rate from Wivenhoe Dam was 800m^3/s even though an outflow of 1000m^3/s would make no difference to the closing of bridges.[487] According to Mr Fagot, if, however, rainfall was experienced below Wivenhoe Dam then the first constraint would be operative, that is, releases could not exceed 200m^3/s.

347 No other witness identified section 3.2 of the Manual as the source of a constraint on downstream releases in the manner that Mr Fagot did. His interpretation misconstrues the provision entirely. Nothing in section 3.2 expressly refers to any "peak" flow downstream. Instead, the second paragraph refers to the "flood peak [that] has passed through the dams". The last paragraph then states that the "level of flooding as a result of emptying stored floodwaters after the peak has passed is to be less than the flood peak, unless accelerated release is necessary to reduce the risk of overtopping". Mr Fagot accepted that he treated the reference in the second-last line to "flood peak", and third-last line to "the peak", as a reference to the flood peak downstream of the dam experienced to date[488] while accepting that the reference to "flood peak" in the second paragraph of the extract to the flood peak through the dam.[489] The passages are clearly referring to the one peak that has passed through the dam. It is simply stating that the evacuation of stored flood waters after that peak has passed should not cause greater flooding than the peak itself, unless accelerated evacuation is warranted because of another impending flood.

[486] T 9047.44 to T 9049.20.
[487] T 9049.26.
[488] T 9034.18.
[489] T 9034.32.

348 I have already addressed the proper interpretation of that part of section 8.4 which requires that "peak outflow should generally not exceed peak inflow". As noted, Mr Fagot treated that statement as "never" permitting releases greater than peak inflow to date,[490] notwithstanding the presence of the word "generally". In cross-examination, Mr Fagot agreed that his approach to this "constraint" (and section 3.2) meant that, prior to the peak of a flood event, no releases from Wivenhoe Dam could increase storage capacity in the dam, even if the storage of flood waters meant that dam reached critical levels and the water had to be released and combined with downstream flows ("that's the accepted method of operating a Method A reservoir"[491]). In explaining this answer, Mr Fagot said he treated Wivenhoe Dam as a "Method A reservoir".[492] He was then asked:[493]

> "Q. But that type of reservoir is one where either hydropower or other water conservation purposes are regarded as of paramount importance; that's right, isn't it?
> A. *No, a Method A reservoir means that you're trying to provide lower level protection.* You're not just moving out all of the inflow that comes in because you have an expectation that a severe flood event would occur. They say that we want to you mitigate against the flood, you know, that could be minor to moderate, and there's an acknowledgment that if the flood does turn out to be a major flood, then you have used up some of your flood storage, providing this lower level protection
>
> Q. But that's preferring the lower level protection to the protection that's required to achieve the object of a higher level protection in a major flood event, isn't it?
> A. *Again, that's acknowledged in these types of reservoirs.*
>
> Q. But it is entirely contrary to the objectives in this manual, isn't it?
> A. Again, I read the objectives where you have got to make sure that the decisions that you're making based on those objectives fit within the constraints that are applied in the manual, or that are given to you in the manual." (emphasis added)

349 As stated above, a "Method A" reservoir is a dam that applies a flood operations methodology which seeks to protect against minor and moderate flooding until that level of protection is no longer available.[494] This passage

[490] T 9032.17.
[491] T 9041.8.
[492] T 9041.14.
[493] T 9041.11 - .37.
[494] SEQ.092.001.4293 at .4359; T 9010.44.

illustrates the difficulties with Mr Fagot's evidence. Mr Fagot construes the Manual consistent with his USACE experience of Method A reservoirs, so that the dams are allowed to fill such that releases are not made against the risk that the flood pool will be filled, but only when it is certain that it will do so. He acknowledges that Method A reservoirs involve preferring lower level objectives to higher level objectives even though that is entirely inconsistent with the priority of objectives in the Manual. In fact, the description of the various flood events in the Manual and the statement of the flood objectives and their order of importance themselves demonstrate beyond any doubt that, even assuming the USACE classifications are appropriate, Wivenhoe Dam is certainly not a Method A reservoir.[495] As noted, the "prime purpose"[496] of incorporating flood mitigation measures into the Manual governing their operations was to reduce flooding in urban areas and that is occasioned by moderate to extreme floods. The thrice stated objectives in the Manual make it clear that disruption to rural areas is subordinated to that objective.

350 It is one thing to read the plain words in the Manual and identify the various constraints that it imposes. As stated, where the Manual clearly identifies a constraint then, subject to section 2.8, the constraint must be observed, irrespective of the priorities afforded to the flood objectives. In that sense, the constraints "trump" the objectives. However, it is another thing to adopt some preconception as to what type of reservoir Wivenhoe Dam is, then interpret the Manual having regard to that preconception and ignore the emphasis placed on the objectives in the Manual when construing the Manual and ascertaining its constraints. Mr Fagot took the latter course. His answers demonstrate that he effectively ignored the Manual and instead wrongly classified Wivenhoe Dam as a "Method A" reservoir like the dam in the White River basin. No sensible reading of the three times repeated flood objectives for Wivenhoe Dam set out in the Manual could lead to the conclusion that it authorises higher level objectives to be sacrificed to satisfy the lower flood objectives as Mr Fagot suggested it did.

[495] Cf Seqwater subs at [2376].
[496] Manual at 10 (QLD.001.001.0146 at .0160).

351 Similarly, it is difficult to understand how Mr Fagot interpreted section 3.2 in the manner he did unless he was searching for a downstream constraint similar to that imposed by the Newport gauge on the White River system. Otherwise I note that the constraint he identifies as flowing from section 3.2 was violated during the January Flood Event from the morning of 8 January 2011 onwards.[497]

3.4.3: Mr Fagot and Strategy W3

352 Another supposed "constraint" identified by Mr Fagot concerns Strategy W3.[498] In that part of his first report which responds to Dr Christensen's commentary on the flood engineers' conduct, Mr Fagot stated:[499]

> "In the first row in the table describing W3 timing, it clearly states that prior to the naturally occurring peak at Moggill, the flow at Moggill is to be minimised. It is my opinion that this statement intends for the reservoir engineer to adhere to the lower level strategies and to empty the stored flood waters, however, *the flow in the downstream channel should not rise above the naturally occurring peak*." (emphasis added)

353 In cross-examination, Mr Fagot confirmed that he read the first row of the table in [292] as applying throughout the flood event and, in particular, preventing releases in W3 causing downstream flows to rise "above the[ir] naturally occurring peak".[500]

354 No other witness construed W3 in this manner and it is clearly wrong. I have already concluded that the first row of the table is directed to that circumstance and only directs the flood engineer to minimise flows when above 4000m^3/s. Even if the first row of the table was specifying a condition that always applied during W3, Mr Fagot would still be wrong. All that would then be required is that the flow be minimised but not that it be kept below the naturally occurring peak. Mr Fagot construed W3 as though it was W2 which does require that flows at Moggill be kept below the naturally occurring peak

497 EXP.QLD.001.1285 at 1296, fig 3-2.
498 T 9041.42.
499 EXP.QLD.001.0232 at .0401, [348].
500 T 9041.44 to T 9043.46.

(or at least the lesser of that and 4000m^3/s). This is another example of Mr Fagot identifying a supposed constraint that is not found in the Manual which appears to be based on his professional experience in the highly regulated (ie, constrained) USACE operating environments.

3.4.4: Mr Fagot, Forecasts and Predicted Lake Levels

355 In section 3.7 of his first report, Mr Fagot addressed various questions concerning the proper interpretation of the Manual. In section 3.7.4, he addressed separately a question as to whether firstly the flowchart on page 23 of the Manual required the use of forecast rainfall and then as to whether section 8.4 of the Manual required "pre-releases to be made based on ... forecast rainfall".[501]

356 In relation to the former Mr Fagot stated that it was "not possible to use forecast rainfall to make the determination of whether or not a particular pool elevation will be 'likely exceeded'" for the purposes of applying the flowchart on page 24 of the Manual for strategy selection.[502] He stated that "[i]n my interpretation of the Manual, the words 'likely to exceed' [and] 'forecasted pool elevation' refer to the use of forecasted pool elevation based on rainfall observed data".[503]

357 When he addressed section 8.4, Mr Fagot extracted that part of the text that begins "[t]he strategy chosen" and concludes "should generally not exceed peak inflow". He then stated "[a]s was discussed in the paragraphs explaining the Wivenhoe flow chart, making these predictions requires the parameters of current pool elevation, inflow into the dam, and conditions below the dam", ie not rainfall forecasts. In the balance of the discussion, Mr Fagot only contemplated rainfall forecasts of areas downstream of Wivenhoe Dam being used as a basis to *not* make releases on the basis that flood engineers "are trained to delay increasing releases prior to forecasted rainfall if there is

[501] EXP.QLD.001.0232 at .0283.
[502] Ibid at .0286; [101].
[503] Ibid at .0286, [103].

storage remaining in the flood pool"[504] or, as he put in his second report, "delaying large releases until it is no longer an option due to downstream conditions is a common method of operating reservoirs with a flood control purpose".[505] Mr Fagot then stated:[506]

> "In real-time operations of multi-purpose reservoirs, pre-releasing based on a forecast is not the *typical* method of operations. *In the two systems that I operated for the Corps*, *the Little River System and the White River System, project personnel were provided with instructions* on reducing releases *dependent on the amount of rainfall received*. In addition, forecasted pool elevations were developed based on forecasted rainfall for situational awareness and for the development of potential what-if scenarios. Operational actions, however, were not implemented based on forecasted rainfall and pre-releases based on forecasted rainfall were not performed." (emphasis added)

358 At no point in this discussion in his first report does Mr Fagot even attempt to engage with the phrase "best forecast rainfall" and the absolutely clear statement that it had to be considered in determining maximum storage levels. In addition, the order in which Mr Fagot addressed the questions posed of him distorted the structure of the Manual. The flowchart that he analysed first follows immediately after the statement in section 8.4 about using best forecast rainfall information to determine maximum storage levels. The text of section 8.4 is clearly providing guidance, if not direction, as to how to interpret the flowchart (or vice-versa). The manner in which Mr Fagot addressed these provisions meant that he both failed to address the entirety of the Manual and consider its express words.[507] Instead, he drew on some "typical method" employed in the White River dam systems with which he is familiar, that has explicit instructions on operations by reference to the amount of rainfall received.[508] Those explicit instructions are described above. They prohibit the use of rainfall forecasts in the making of operational decisions.

359 In his second report, Mr Fagot attempted to address section 8.4 by pointing out that it does not specify how a rainfall forecast is to be used. He then

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[504] Ibid at .0381; [298].
[505] EXP.QLD.001.0524_2 at [30].
[506] EXP.QLD.001.0232, [112].
[507] Ibid at .0290, [109].
[508] See [340].

rejects the use of forecasts by considering the terms of each strategy.[509] He notes that with the W1 sub-strategies, the words "predicted or forecasted" are not used in their descriptions (thus suggesting that they are not based on any form of predictions at all).[510] However, he does not address the word "predicted" in the operative conditions for W1. With W3, he interprets its provisions concerning flow as (implicitly) excluding the use of rainfall forecasts.[511] With W4, he interprets the statement that the strategy normally comes into "effect when the water level in Wivenhoe Dam reaches 74.0m AHD" as also excluding the use of rainfall predictions.[512] The possibility that rainfall forecasts are utilised for those circumstances when W4 is engaged prior to the lake level exceeding 74.0m AHD is not addressed in that report. In re-examination, he adverted to the possibility that W4 would be invoked by a predicted level but only a prediction formed by modelling rain on the ground.[513] Otherwise, section 8.4, the flowchart and the references to predicted lake levels in the strategies are put aside because Mr Fagot could not find the level of specific detail he required to implement them.[514]

360 When Mr Fagot was cross-examined on whether section 8.4 requires the use of forecasts in the selection of strategies, he repeatedly asserted that "within the [M]anual there is some ambiguity"[515] but added:[516]

> "Q. Don't you say in your reports that a reasonably competent flood engineer applying this manual to these dams would make release decisions based only on observed rain, that is, rain on the ground?
>
> A. *That is the way that I operated the dams for the White River system, and in order to not violate the constraints that are found within the manual*, you can consider the forecasted rainfall, but any decisions that you make based on forecasted rainfall have to ensure that you're not going to violate constraint that's found within the manual." (emphasis added)

509 EXP.QLD.001.0524, [178] to [187].
510 Ibid at [178].
511 Ibid at [182] to [183].
512 Ibid at [187].
513 T 9074.28 to T 9075.7.
514 See EXP.QLD.002.0524 at .0596, [175].
515 T 9018.19; T 9019.35; T 9023.32.
516 T 9018.24.

361 Thus, again Mr Fagot resorts to his specific experience with the USACE to justify rain on the ground modelling, even though section 8.4 is emphatic in its requirement to use rainfall forecasts and no relevant part of the Manual expressly refers to predictions being based (solely) on rain on the ground modelling. As noted, his USACE experience predominantly concerns the White River Basin where the relevant manually specifically prohibits the use of rainfall forecasts in making operational decisions and he has never worked with a Manual that specifically required the use forecasts.[517]

362 Overall, I found Mr Fagot's attempts to address the clear wording of section 8.4 entirely unconvincing. Mr Fagot ultimately accepted that the Manual does not contain any strategy that contemplates closing "up all the outlets from the dam and storing all the inflows and waiting to see whether there's enough storage to accommodate the flood before making releases"[518] which is the effect of his approach to a Method A reservoir.

3.4.5: Mr Fagot and FSL

363 This is addressed in Chapter 5.

3.4.6: Mr Fagot and the Operating Target Line

364 In his first report, Mr Fagot referred to a statement by Dr Christensen in his first report[519] that the Manual did not intend the S2 chart to control and specify operations but to guide operations with a general target to minimise flood peaks "in relation to their associated dam failure levels".[520] Mr Fagot rejected this approach stating that "having operated the White River system, which requires balancing of projects, … the balancing is not guidance" but a "specific requirement"[521] and that the "reservoir engineers have *observed data* and can make decisions to bring or keep the reservoirs in balance".[522] This approach appears to be derived from his USACE experience. It is not

[517] T 9021.43.
[518] T 9039.44.
[519] February 2015 Report, EXP.ROD.001.0016 at [343].
[520] EXP.QLD.001.0232 at [318].
[521] Ibid at [318]; see also at [116].
[522] Ibid at [319].

reconcilable with the wording of the Manual which refers to "generally" following the line as the event progresses and the setting of a target point by reference to forecasts.

365 Otherwise, I note that Mr Fagot discussed the operating target line extensively in his reports.[523] However, at no point in those reports did he address the role of forecasts in S2 operations and, in particular, did not explain how his approach could be reconciled to the interpretation of the first two dot points on page 42 of the Manual which refer to forecasts and the establishment of the duty point. When the Court directed his attention to those points[524] he stated that there was an apparent inconsistency between those points and the necessity for the operating target line to "generally be followed".[525] However, he stated that in S2 forecasts for Wivenhoe Dam and Somerset Dam are used to determine how aggressively a flood engineer moves from the current height of both dams towards the operating target line.[526] He otherwise expressed a preference to bringing the dams into balance relatively early during the flood event and "maintaining that balance all the way to the peak elevation".[527]

366 Given that this discussion of the role of forecasts in S2 only emerged in his evidence in reply and was not expanded upon, I did not attribute much weight to it in light of my assessment of the balance of Mr Fagot's evidence. However, I note three matters. First, Mr Fagot appeared to treat the statement that the operating target line should "generally" be followed as a strict requirement. Second, Mr Fagot's approach does not appear to be reconcilable with the statement in the Manual that the intent of S2 operations is to seek to protect the structural safety of the dam and maximise the benefits of the flood storage capabilities of the dams.[528] Third, Mr Fagot's approach does not appear to be reconcilable with the statement that movement towards the target line will be in a "progressive manner", that it will "not necessarily be

[523] EXP.QLD.001.0524 at [191ff]; EXP.QLD.001.1311.
[524] T 9070.20; T 9070.46.
[525] T 9070.31.
[526] T 9069 to T 9071.
[527] T 9070.10.
[528] Manual at 40.

possible to adjust the duty point directly towards the target line in a single gate operation" and involves the utilisation of rainfall forecasts for both dams.[529]

3.4.7: Mr Fagot's Critique of Flood Operations

367 As noted, Mr Fagot's report contains an extensive critique and ultimate endorsement of the flood engineers' conduct throughout the January 2011 Flood Event. The defendants relied heavily on that critique and repeatedly emphasised that he had not been "challenged" on the views he expressed about the flood engineers' conduct or Dr Christensen.[530]

368 Chapter 5 of Mr Fagot's first report is entitled "Analysis of Actual Operations at Wivenhoe and Somerset – Dec 2010 and Jan 2011". It commences with the following statement:[531]

> "The objective of this chapter is to provide commentary on the actual operations at Wivenhoe Dam and Somerset Dam during the December 2010 and January 2011 event. In particular, I was asked to:
>
> a. Assume the accuracy of the facts contained in the statement of Mr. John Ruffini and the documents referred to in *the Chronology attached to the statement of Mr Ruffini*.
>
> b. Use *my interpretation* of the Flood Mitigation Manual.
>
> c. Draw upon my own experience as a real time flood reservoir engineer.
>
> d. Give particular attention to the conduct of Mr. Ruffini during the times he was on duty in the Flood Operations Centre (FOC)." (emphasis added)

369 This extract reveals why little weight should be, and has been, afforded to this part of Mr Fagot's report. The statement of Mr John Ruffini referred to in this extract was not tendered. The "Chronology" was not tendered although presumably it was a reference to the contemporaneous documents created during the course of the flood event. I have already addressed, and in substantial part rejected, Mr Fagot's interpretation of the Manual. I have also addressed and in substantial part accepted the plaintiff's submissions that, in

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[529] Manual at 42.
[530] State subs at [640]; SunWater subs at [9].
[531] EXP.QLD.001.232 at .0329, [153].

this case, Mr Fagot has inappropriately translated his specific experience as a real time flood reservoir engineer in the White River Basin to the very different circumstances (and Manual) of Wivenhoe and Somerset Dams.

370 A consideration of the balance of Chapter 5 of Mr Fagot's first report only confirms that his analysis was based on a combination of an incorrect construction of the Manual, an attempt to directly translate the operational approach in the White River Basin to Wivenhoe and Somerset Dams and Mr Ruffini's untendered statement. Thus, Mr Fagot's review of the flood event included an analysis of the flood engineers' conduct that endorsed the use of actual lake levels for strategy selection,[532] his interpretation of W3,[533] his interpretation of section 3.2[534] and the use of rain on ground modelling to base releases[535] with forecasts only used to moderate releases because of downstream effects but not as a basis to increase releases.[536] He specifically endorsed the flood engineers' approach on the morning of 10 January 2011 as being in accordance with the approach of the White River system of using flood storage "until it was necessary to perform induced surcharge operations due to lack of capacity in the flood pool"[537] and there is otherwise no suggestion by Mr Fagot that the selection of strategies should be based on predictions, much less predictions based on forecasts. His review concludes with a finding that the conduct of the flood engineers was consistent with the Manual because it "requires the reservoir engineers *to adhere to the rural strategy of keeping the transportation routes open* and to continue to consider that objective during high level strategies".[538] I agree that that is a reasonably accurate assessment of the flood engineers' approach during the January 2011 Flood Event, however it involves a complete misunderstanding of what the Manual requires. Further, in commenting on Mr Ruffini's actions in

[532] Ibid at [226], [232], [234], [235] and [242].
[533] Ibid at [250].
[534] Ibid at [280].
[535] Ibid at [252].
[536] Ibid at [260] and [279].
[537] Ibid at [260].
[538] Ibid at [283].

section 5.6 of his report, Mr Fagot generally endorsed what Mr Ruffini is said to have "stated" was his approach at various times.[539]

371 In Chapter 6 of his first report, Mr Fagot responded to Dr Christensen's analysis of the flood engineers' conduct[540] and in Chapter 7 Mr Fagot critiques Dr Christensen's simulations.[541] Particular aspects of these chapters are addressed later in considering Dr Christensen's evidence and his simulations. It suffices to state that these chapters are also relevantly affected by the two interrelated flaws noted above.

372 Thus, in Chapter 6 of his first report, Mr Fagot rejected Dr Christensen's use of rainfall forecasts in both selecting strategy and making releases[542] and did so in part because it was said to be impermissible under the Manual.[543] He criticised Dr Christensen for not observing: the "requirement" to adhere to the "rural and bridges strateg[y]",[544] the necessity to use rain on ground modelling,[545] the "specific requirement" of the operating target line[546] and Mr Fagot's interpretation of W3.[547] Mr Fagot stated that the flood engineers were "not authorised to lower the pool below FSL".[548] Critically, Mr Fagot criticised Dr Christensen for "contend[ing] that once flood operations commenced, 'optimising' urban flood protection should have been the overriding priority over minimising rural bridge inundation and water supply". Mr Fagot stated that "this misses the objectives of the flood mitigation manual".[549] To the contrary, and as noted above, section 8.4 states that within all strategies, including W1, priority is given to all objectives in their stated order of

[539] Ibid at [290].
[540] Ibid at [297].
[541] Ibid at [374].
[542] Ibid at [298] to [311].
[543] Ibid at [308].
[544] Ibid at [314].
[545] Ibid at [338] to [339].
[546] Ibid at [318].
[547] Ibid at [348].
[548] Ibid at [313].
[549] Ibid at [337].

importance. Similar conclusions affect Chapter 7[550] and the equivalent parts of Mr Fagot's second report.[551]

373 As noted, the defendants' submissions repeatedly referred to the supposedly unchallenged status of Mr Fagot's evidence. To the extent that Mr Fagot describes the January 2011 Flood Event, he is in effect recounting an assumption that was given to him, the evidentiary status of which is dubious given that Mr Ruffini did not give evidence and the "Chronology" was not tendered. His recitation of those events did not have to be challenged by the plaintiff, it had to be independently proved by the defendants. Otherwise, I am satisfied that the two flaws identified in [335] have been demonstrated and that they substantially, if not completely, undermine Mr Fagot's endorsement of the flood engineers' conduct during the January 2011 Flood Event and his critique of Dr Christensen's evidence and simulations. Both of those flaws were the focus of his cross-examination. The connection between them and most, if not all, of the relevant opinions in his reports was self-evident. In the end result the defendants needed to persuade me that I should act on Mr Fagot's evidence and they did not. I derived little assistance from his evidence.[552]

3.4.8: Mr Fagot and "Generally Recognised Flood Mitigation Practices"

374 Although some of Mr Fagot's particular criticisms of Dr Christensen and opinions concerning the flood engineers are addressed below, it is necessary to address one part of SunWater's submissions that relied on Mr Fagot's evidence. SunWater invoked Mr Fagot's evidence as supporting its contention that there were (at least) four "principles and practices" of flood mitigation which it submitted either governed or informed the construction of the Manual and the conduct of flood operations. The first principle was that multi-design dams are to be operated according to their design and purpose wherein, according to SunWater, this case accords with a Method A reservoir.[553] The

[550] See for example EXP.QLD.001.232, [375] to [383].
[551] EXP.QLD.001.0524.
[552] Cf SunWater subs at [669].
[553] SunWater subs at [83] to [91].

second was that “flood operations engineers ordinarily use ... rain on the ground ... to make operational decisions in times of flood events”.[554] The third was that “reservoir engineers do not make pre-releases based on forecast rainfall”.[555] The fourth was that dams are not to be operated in a manner that “may make downstream conditions worse than the natural flow,[556] an aspect of which is said to be that peak outflow should not exceed peak inflow to date.[557]

375 The first of these principles can be accepted but, for the reasons already stated, Mr Fagot wrongly characterised Wivenhoe and Somerset Dams as Method A reservoirs. His characterisation was inconsistent with the order of objectives in the Manual. The same problem affects the fourth principle. As noted, the structure and text of the Manual demonstrates that the dams are to be operated on the basis that, if the cost of optimising protection against urban inundation is that, viewed with hindsight, rural bridges were unnecessarily inundated, then so be it.

376 In relation to the second and third principles, any suggestion that Mr Fagot was in principle opposed to the use of rainfall forecasts in making release decisions dissipated in cross-examination. Mr Fagot agreed that he did not “have a problem” with making releases, including pre-releases based on rainfall forecasts, provided it was documented in the relevant manual and did not otherwise violate the constraints of the relevant manual.[558] He articulated the same view in relation to releasing below fully supply level[559] and allowing peak outflow to exceed peak inflow to that point in time.[560] Thus, all these supposed issues of principle simply devolved to a consideration of Mr Fagot’s construction of the constraints in the Manual and his view that, despite its repeated references to forecasts, the Manual was not sufficiently prescriptive in relation to their use. For the reasons already stated, Mr Fagot misconstrued

554 SunWater subs at [92].
555 SunWater subs at [99(a)] citing Mr Fagot’s first statement, EXP.QLD.001.0232_3, [44(d)]; Later elaborated upon in SunWater subs at [519].
556 SunWater subs at [106] to [110].
557 Ibid at [515].
558 T 9022.31; T 9023.12; cf State subs at [228(a)], [228(g)], [639(b)], and [639(g)].
559 T 9035.31; cf State subs at [211], [228(e)] and [228(g)] and [639(a)]; see Chapter 5.
560 T 9008.19.

the Manual and was otherwise the prisoner of his own experience with the highly prescriptive manuals deployed by the USACE.

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CHAPTER 4: FLOOD PROCEDURES, POLICIES AND OPERATIONS UNTIL THE END OF 2010

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CHAPTER 4: FLOOD PROCEDURES, POLICIES AND OPERATIONS UNTIL THE END OF 2010

1 In various ways, both the plaintiff and the defendants sought to draw support from the conduct of flood operations prior to the January 2011 Flood Event, as well as the review of the Manual in 2009. In particular, the defendants asserted that the plaintiff's construction of the Manual, which required the use of predicted levels and rainfall forecasts as well as permitting releases from below Full Supply Level ("FSL") during a flood event, was completely contrary to the past practice of flood operations and the revision of the Manual in 2009 would only have reinforced the reasonableness of any beliefs held by the flood engineers on those matters.[1] All of the various points are best considered by addressing the events chronologically, although there is other evidence concerning the conduct of flood operations below FSL. That topic is addressed in Chapter 5.

2 In summary, the revision process in 2009 that lead to the gazettal of the Manual only reinforces the findings in Chapter 3. Further, the conduct of flood operations at Somerset Dam in May 2009 and March 2010 involved the making of precautionary releases based on rainfall forecasts and releases from below FSL for the purposes of flood mitigation.

4.1: Old Manuals and 2001 Pre-Release Report

3 The version of the Manual discussed in Chapter 3 is Version 7. Chapter 5 of the plaintiff's submissions traces the development of Versions 1 to 5 of the Manual from 1992 to December 2004. The only provision of present relevance is a change introduced by Version 2 in October 1997 which expressly permitted "[p]re release or accelerated release of storage at damaging flood levels" but "only after careful consideration of the reliability of precipitation forecasts and of perceived antecedent conditions".[2] The plaintiff contended that this was significant because it amounted to express permission to make such releases bearing in mind rainfall forecasts. It contended that this

[1] See for example Seqwater subs at [671] and SunWater subs at [123] and [213].
[2] QLD.005.001.0283 at .0305.

undermined a suggestion made by Mr Fagot that, if pre-releases were permitted, then ordinarily one would expect "a detailed operation specifying that intent".[3] I have already addressed the extent to which pre-releases based on forecasts are permitted by the Manual.[4] In addressing that issue, I did not derive any support from the approach adopted by an old version of the Manual.

4 In 2001, Mr Ayre prepared a report for Seqwater's predecessor, titled *"Feasibility of Making Pre-Releases from SEQWC Reservoirs"* (the "2001 Pre-Release Report").[5] The 2001 Pre-Release Report assessed the reliability of QPF and SILO Meteogram forecast products by comparing forecasted estimates with recorded rainfall totals for three periods: September 1997 to February 1998; October 1998 to July 1999; and October 2000 to July 2001.[6] This was undertaken as part of an investigation into the effect of making pre-releases from Somerset Dam, Wivenhoe Dam and North Pine Dam.

5 The report found that, at that time, "QPF generally under estimates significant rainfall events that are of most relevance to the flood operations of the dams" and "the relationships derived from the various periods of available records indicate[d] that there is a wide scatter in the correlation between forecasted and recorded catchment rainfalls".[7] It concluded that "whilst the QPF provides awareness that flood activity is likely, the forecasts themselves do not provide a definitive basis on which to quantify likely runoff amounts and hence release strategies."

6 The report noted that there were a "number of practical constraints concerning the use of pre-releases"[8] including the potential downstream effect of such releases and the effect on the water supply if the forecast rain does not fall. It noted that a pre-release strategy "appears to be most suited to large or rare flood events" but their effectiveness was undermined because with such a

[3] Plaintiff subs at [607] to [609]; Fagot 1, EXP.QLD.001.0232_3 at [280].
[4] Chapter 3, section 3.3.13.
[5] SUN.001.002.6314.
[6] Ibid at .6317 and .6340; sections [2.2.2] and [2.3].
[7] Ibid at .6316, section [1.0].
[8] Id.

forecast “it is likely that there will not be sufficient lead-time for a pre-release strategy to make any real impact on such an event, as the volume of pre-release is likely to be made is only a relatively small proportion of the associated inflow.” Accordingly, the use of pre-releases was not recommended.

7 The form of pre-releases being considered by the report was releases of water prior to the onset of a flood event.[9] The report did not address whether forecasts were sufficiently reliable to make pre-releases during a flood event.[10]

8 The directors of the predecessor to Seqwater (the “Board”) met on 24 September 2001 to discuss the 2001 Pre-Release Report. Page 1 of the note prepared for the meeting of the Board provided the following written recommendation:[11]

> “That the pre-release of water from Wivenhoe Dam for flood mitigation purposes not be considered, with the Dam continuing to be operated in accordance with the Manual of Operational Procedures for Flood Mitigation.”

The note also provided on page 3 as follows:[12]

> “Flood Releases are undertaken to return the dam to Full Supply Level for water supply.”

9 This recommendation was ultimately accepted by the Board and they so resolved.[13]

10 SunWater submitted that nothing turned on the fact that the report was directed to pre-releases prior to a flood event as opposed to during a flood event. It noted Mr Ayre’s evidence to the effect that the performance of the QPF and SILO meteogram forecast products did not change from the time of

[9] Ibid at .6343 to .6344; T 5983.14 and T 5989.40 (Tibaldi).
[10] T 7846.40 (Ayre).
[11] SEQ.004.030.2564 at .2564.
[12] Ibid at .2566.
[13] SEQ.018.004.0066 at .0081 to .0082.

that report[14] (although his evidence concerned their capacity to predict "heavy rain events").[15]

11 Two matters should be noted about that contention. First, the Board accepted the recommendation which included continuing to operate in accordance with the then current version of the Manual. At that time, Version 3 of the Manual was in force, which maintained the provisions of Version 2 noted above. Version 2 explicitly made provision for pre-releases during flood operations.[16] Those provisions were also maintained in Version 4 dated 6 December 2002, ie, the next revision that was implemented after the Board's recommendation.[17] The reference to pre-releases was not removed until Version 5 was introduced in October 2004.[18] The plaintiff contended that this coincided with the construction of the auxiliary spillway and fuse plugs because they addressed the risk of overtopping Wivenhoe Dam and obviated the need for pre-releases to avoid those outcomes.[19] It is not necessary to determine that. It suffices to state that the express but limited permission in the Manual for the making of pre-releases survived the Board's acceptance of the recommendation.

12 Second, whatever the Board's collective or individual views on forecasts were in 2001, they were introduced with apparent enthusiasm by the flood engineers during the revision of Version 6 of the Manual in 2009 (see below).

4.2: Version 6 of the Manual

13 Version 6 of the Manual was produced two months after Revision 5 and was operative until late 2009 ("Version 6").[20] The differences between it and Version 5 are immaterial. The years of its operation mostly coincided with a sustained drought and it was not until 2009 that Version 6 was engaged for flood operations.

[14] T 7476.33 to T 7477.20 (Ayre); SunWater subs at [610].
[15] T 7476.46.
[16] SUN.001.003.1607 at .1622.
[17] QLD.005.001.0359 at .0374 to .0375.
[18] QLD.005.001.0480 at .0482.
[19] Plaintiff subs at [614] to [619].
[20] QLD.005.001.0554.

14 As with the Manual (ie, Version 7), section 3.1 of Version 6 identified the flood objectives, which, "listed in descending order of importance", were:[21]

> "(a) Ensur[ing] the structural safety of the dams;
>
> (b) Provid[ing] optimum protection of urbanised areas from inundation;
>
> (c) Minimis[ing] disruption to rural life in the valleys of the Brisbane and Stanley Rivers;
>
> (d) Minimis[ing] disruption and impact upon Wivenhoe Power Station;
>
> (e) Minimis[ing] disruption to navigation in the Brisbane River."

15 Unlike the Manual, Version 6 did not include the retention of storage at FSL at the conclusion of the flood event, as a flood objective.

16 The commencement of flood control action at Wivenhoe Dam under Version 6 was addressed by clause 8.3 and at Somerset Dam by clause 9.2. Clause 8.3 was engaged when "indications are received of an imminent flood". In that event, Version 6 required that all inflow be stored in Wivenhoe Dam while an assessment was made of the "origin and magnitude of the flood". The spillway gates could not be opened prior to EL 67.25m AHD.[22]

17 In relation to Somerset Dam, clause 9.2 provided:[23]

> "Upon indications being received of a significant inflow, the flood control operation of the dam shall commence with the raising of any closed gates and the closure of all low level regulators and sluices, whilst an assessment is made of the origin and magnitude of the flood."

18 Version 6 provided for four flood procedures at Wivenhoe Dam, which roughly correspond to W1 to W4. Under Procedure 1, water was to be released from Wivenhoe Dam "with care being taken not to prematurely submerge the downstream bridges".[24] Releases were to be made to limit downstream

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[21] Ibid at .0568.
[22] Ibid at .0580.
[23] Ibid at .0592.
[24] Ibid at .0583.

flooding and, except in the “drainage phase”, releases were not to exceed the values in the following table:[25]

Lake Level in Wivenhoe Dam	Maximum Release Rate (m^3/sec)
67.00 – 67.25	0
67.25 – 67.50	110
67.50 – 67.75	380
67.75 - 68.00	500
68.00 – 68.25	900
68.25 – 68.50	1900

Table 4-1: Maximum release rates in Version 6 of the Manual

19 The balance of the discussion in Version 6 in relation to Procedure 1 addressed sub procedures 1A to 1E which related to each of the individual bridges and were engaged when the “lake level [was] between” certain heights. Each of the sub procedures specified a maximum discharge rate consistent with the above table. The concluding part of Procedure 1 stated:[26]

> “**If the level reaches EL 68.5m AHD in Wivenhoe Dam, operations switch to Procedure 2 or 3 as appropriate**.” (bold emphasis in original)

20 Version 6 did not specify that Procedures 2 and 3 had any particular objective but they did specify maximum discharge rates and limitations in similar terms to W2 and W3.[27] In relation to Procedure 4, Version 6 provided:[28]

> “This procedure normally comes into effect when the water level in Wivenhoe Dam reaches EL 74. However the Senior Flood Operations Engineer may seek to invoke the discretionary powers of section 2.8 if earlier commencement is able to prevent triggering of a fuse plug.”

21 The balance of Procedure 4 for Wivenhoe Dam addressed operations above EL 74.0m AHD and the avoidance of a fuse plug breach.

22 Table 8.5 of Version 6 summarised all the procedures as follows:[29]

[25] Ibid at .0583 to .0584.
[26] Ibid at .0585.
[27] Ibid at .0585 to .0586.
[28] Ibid at .0586.

Procedure	Reservoir Level	Applicable Limits		
0	EL <67.25	$Q_{wivenhoe}$[30] = 0m^3/sec … ie No releases		
1A	67.25 <EL<67.50	$Q_{wivenhoe} <$ 110m^3/sec	$Q_{Colleges\ Crossing}$ < 175m^3/sec with care taken not to submerge Twin Bridges prematurely	
1B	67.25 <EL<67.50[31]	$Q_{wivenhoe} <$ 380m^3/sec	$Q_{Burtons/Noogoorah}$ < 430m^3/sec with care taken not to submerge Colleges Crossing prematurely	
1C	67.75 < EL < 68.00	$Q_{wivenhoe} <$ 500m^3/sec	Q_{Kholo} < 550m^3/sec with care taken not to submerge Burtons/Noogoorah prematurely	
1D	68.00 < EL < 68.25	$Q_{wivenhoe} <$ 900m^3/sec	$Q_{MtCrosby}$ < 1900m^3/sec with care taken not to submerge Kholo prematurely	
1E	68.25< EL < 68.50	$Q_{wivenhoe} <$ 1500m^3/sec	$Q_{MtCrosby}$ < 1900m^3/sec with care taken not to submerge Kholo prematurely	
2	68.50 < EL <74.00	$Q_{Lowood} <$ 3500m^3/sec	Q_{Lowood} < peak of Lockyer <u>and</u> Q_{Lowood} < peak of Bremer	Gates are <u>NOT</u> to be overtopped
3	68.50 < EL < 74.00	$Q_{Lowood} <$ 3500m^3/sec	Q_{Moggil}l< 4000m^3/sec	
4	EL > 74.00	Gates are to be opened until reservoir level begins to fall		

Table 4-2: Strategy chart from Version 6 of the Manual

23 A footnote to the reference to Procedure 4 in Table 8.5, states that "[o]nce water level exceeds EL 74.0, operating procedures are dependent on the predicted peak water level".[32]

24 Section 8.6 of Version 6 dealt with gate closing procedures. Unlike Version 7, there was no reference to closing gates below FSL to allow for baseflow. Instead, it states that "[g]ate closing procedures should be initiated having

[29] Ibid at .0588.
[30] "Q" is a reference to flow rate. $Q_{wivenhoe}$ means flow rate at Wivenhoe Dam.
[31] This appears to be a typographical error.
[32] QLD.005.001.0554 at .0588.

regard to the following requirements" which include "[e]stablishment of storage at FSL at completion of flood events".[33]

25 In relation to Somerset Dam, section 9.4 stated that the normal operating procedure during flood operations was that the crest gates were to be raised to enable uncontrolled discharge and the regulators and sluices gates were to be kept closed until either "(i) the lake level in Wivenhoe begins to drop" or "(ii) the level in Somerset Dam exceeds EL 102.25".[34] In the case of (i), the opening of regulators or sluices could not increase inflow to Wivenhoe Dam "above the peak inflow from the Brisbane River just passed or, if possible not to cause the Wivenhoe Dam lake level to exceed EL 74".[35] In the case of (ii), there were various constraints on the operator, including the targeting of a correlation in the dam heights according to a particular table.

26 There was nothing in section 9 of the Manual which appears to preclude releases from below FSL in Somerset Dam. There was no table for Somerset Dam equivalent to the above tables for Wivenhoe Dam.

27 There was only one reference to forecast rainfall or the like in Version 6, namely, section 2.7 which provided:[36]

> "The Flood Operations Engineer must apply the operational procedures in accordance with this manual and the direction set for flood operations. In so doing, account must be taken of prevailing weather conditions, the probability of follow up storms and the ability of the dams to discharge excess flood waters in the period between rainfall events or in the period from the time of detection of conditions associated with the development storm cells, to the likely time of occurrence of the rainfall."

28 With the possible exception of Procedure 4 for Wivenhoe Dam, it is self-evident that the flood strategies provided for in Version 6 were dependent on the observed storage levels in the dams and not upon predictions as to storage levels, whether based on rain on the ground, forecast rainfall or both. Further, notwithstanding section 2.7, Version 6 did not provide any indication

[33] Ibid at .0589.
[34] Ibid at .0593.
[35] Id.
[36] Ibid at .0566.

of what role rainfall forecasts might play in the flood operations. Equally, they did not preclude their use in making some decisions, including as to whether there were "indications of significant inflow" for the purposes of clause 9.2 (or an "imminent flood" for clause 8.3). Otherwise, leaving aside drain down, Table 8.5 appeared to preclude any releases from Wivenhoe Dam below EL 67.25m AHD. However, there was no express prohibition in Version 6 on making releases below FSL at Somerset Dam.

4.3: 2006 – The Connell Wagner Report and the BoM Report

29 By 2006, Queensland was in a sustained drought. A firm of consultants, Connell Wagner, were retained to investigate a proposal to utilise one metre of water storage capacity above the existing level of FSL in Wivenhoe Dam. In December 2006 they produced a draft paper, 'Discussion Paper – Change in Operation of Wivenhoe Dam'[37] (**the Connell Wagner Paper**). They described the proposal under consideration as follows:[38]

> "The proposal discussed in this paper is to flood harvest additional water by closing the gates on the receding limb of a flood when the water level drops to EL68m (1m above FSL). This would only be done if there were no forecast of significant follow-up rain in the foreseeable future (ie no rain forecast in the following 3 day period)"
>
> Whilst the water level remained above the nominated FSL of EL67m, operational rules for the dam gates would be implemented with the objective of reducing the dam water level to FSL before the collection of any significant rainfall. This proposed rule change requires the critical monitoring of rainfall forecasts looking out at least 2-3 days in order to give sufficient time to discharge excess stored water and reduce the dam water level to FSL.
>
> The process therefore relies upon some advanced warning time in order to take action. Currently the Bureau of Meteorology provides the Operator with quantitative rainfall forecasts with an 18-hour time scale."

30 The Connell Wagner Paper discussed the various issues relating to this proposal, including the existing forecasting capacity and whether it was

[37] ROD.901.001.1115.
[38] Ibid at .1118.

adequate to enable it to be implemented. On that topic, the Connell Wagner Paper stated:[39]

> "Discussions with the Bureau of Meteorology (Messrs Mike Bergin and Peter Baddiley) have been held regarding the state of rainfall forecasting and its ability to assist in managing risk associated with the raised dam water level. The advice from the Bureau is that quantitative rainfall forecasting is still very much a developing science, with a large degree of uncertainty. *Therefore any proposed management system would need to accept that accurate quantitative forecasts of rainfall for 2-3 days and beyond are not likely to be available in the foreseeable future*. The Bureau already provides Quantitative Precipitation Forecasts ("QPF"s) to SEQ Water with an 18 hour forward outlook, but this is about the limit of current quantitative forecasts.
>
> Therefore for the proposal to be feasible, the focus with forecasting is, not on knowing how much rain is likely to fall 2-3 days out, but rather, *"is a significant rainfall event potentially going to occur in the next 2-3 days and what operating rules should be in place if this is likely*?"
>
> While the Bureau of Meteorology is not able to provide 2 to 3 days' notice it must be noted that Seqwater has developed and maintains an extensive flood alert system complete with predicative models to provide flood operations with advanced knowledge of flood events. These systems would provide up to 24 hours' notice of a flood event along with accurate prediction of flood levels and the gate operations required. This would assist in minimising the risk associated with the temporary raising of the storage in Wivenhoe." (emphasis added)

31 Three matters should be noted about this proposal and its description of discussions with the BoM about the use of forecasts.

32 First, this proposal involved a potential compromising of the flood mitigation capacity of Wivenhoe Dam in that it involved water being retained at one metre above FSL and then evacuated (quickly) if significant rainfall was forecast. This created a particular risk for flood operations if the forecast failed to detect significant rain because one metre of flood storage capacity would be lost as that rain flowed into the dam. A cautious approach to avoiding flood damage warranted circumspection in adopting the proposal unless there was a high degree of confidence that significant rainfall events would be detected. Thus, this proposal fell to be considered in a completely different context to the situation faced by a flood engineer considering whether to avoid the potential for flood damage by conducting modelling using forecast rainfall, as

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[39] Ibid at .1122.

opposed to only modelling rain on the ground. In that circumstance, if the forecast fails to predict rain that falls, then the loss of flood storage capacity will be no worse than that which will result from rain on the ground modelling. On the other hand, if the forecast wrongly predicts rain and releases are made, then there will be no compromising of flood storage capacity.

33 Second, in light of the limitations that the BoM advised Connell Wagner about its capacity to provide an accurate quantitative forecast two to three days in advance, Connell Wagner formulated the proposal so that a quantitative forecast was not necessary to trigger the evacuation of the extra water. Instead, they proposed that a forecast that merely suggested a likelihood of sufficient rainfall was enough to trigger an evacuation of water. They proposed operating rules to that effect.[40] Although the proposal does not have to have been formally rejected, it was not taken up.[41]

34 Third, in its written submissions, SunWater noted that Connell Wagner had Version 6 of the Manual available to them. It described existing flood operations as involving closing the gates once the level of Wivenhoe Dam had dropped to FSL and noted that there was no suggestion that Connell Wagner erred in interpreting Version 6 or that they misunderstood dam operations.[42] Given the nature of the proposal that Connell Wagner was addressing I do not consider much turns on their understanding of the potential for flood operations below FSL. In any event, I accept that by its reference to actual levels, Version 6 did not contemplate releases below FSL during flood operations at Wivenhoe Dam.

35 The discussions with the BoM referred to in the above extract were reduced to written form by a BoM representative in a note that described a meeting on 6 July 2006 (the "2006 BoM Report").[43] As explained below, this note was reviewed by the flood engineers around the time it was made and it was

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[40] Ibid at .1124.
[41] See SEQ.045.004.0057 at .0058.
[42] SunWater subs at [617] to [626].
[43] SEQ.001.018.9373.

resent to the flood engineers in early December 2010. In light of the references to it by various witnesses it is necessary to set out parts of it in full:

> "3. As discussed at the meeting [between Connell Wagner and BoM representatives], the experience of Meteorologists and Hydrologists in the Brisbane office of the Bureau is that the short to medium term (0 to 48 hour) prediction of rainfall for the purpose of objective use in flood forecasting models is a difficult task. Quantitative Precipitation Forecasts (QPF) are available from the Australian and international Numerical Weather Prediction (NWP) models and have been used subjectively in the Brisbane office for many years. *Whilst the NWP models have shown improvement in the accuracy of QPF over the past decade or so, there is still at times considerable error or uncertainty, in the prediction of the location, amount and timing of rainfall events at the catchment scale.*
>
> 4. The improved skill of NWP models in recent years has particularly been in forecasting the development and movement of broad-scale synoptic features that would be likely to produce the threshold rainfall amounts in question. These large-scale features include decaying tropical cyclones, east coast low pressure systems and significant upper level troughs. However, while these systems maybe well forecast on a time scale of 2 to 3 days the very heavy rainfall concentrations are dependent on finer scale (mesoscale) and convective features. Whilst there is often the ability to forecast the potential for a significant rain event to occur in the southeast Qld-northern NSW region, it is difficult (if not impossible) to predict the actual location of the heaviest rain, even with only a few hours' notice.
>
> 5. Examples of high rainfall events that have occurred in the past 10 to 15 years in this region, some of which had little to no advance prediction of the "precise" location and/or magnitude of resulting rainfall, …. While one could reasonably expect that most really significant rainfall events are most likely through the warmer months, winter extreme events are by no means rare.
>
> 6. Considerable effort is being applied to derive improved deterministic and probabilistic QPFs from NWP models. In the near future, the Bureau will be providing a publicly available rainfall forecasting service via a website. The rainfall predictions will be generated automatically by combining the outlooks from a suite of Australian and International [Forecasts]. Forecast rainfall amounts for 24 hour periods will be given for 4 days ahead, together with the chance of exceeding various amounts from 1mm to 50mm. The latter is a "pseudo" measure of probability based on the consistency in the forecast rain amounts given by up to eight NWP models used in deriving the rainfall forecast. Whilst it is not considered that this will provide a sufficiently accurate method for objective decision making for pre-releases from Wivenhoe Dam, the probabilistic rain forecasts may provide a basis for a risk management approach. There may need to be further studies on risk quantification for prediction of high to extreme rainfall events to support this approach. Given that there are large levels of uncertainty in rainfall forecasts, the forecasting of hydrological response may

require an ensemble of future rain scenarios to be considered for the Wivenhoe Dam application.

…

8. Currently the Bureau provides a QPF service for the dams in Southeast Queensland. This twice-daily service predicts the average rainfall across the catchments in the following 24-hour period. We have not undertaken any verification of the service. *However it is likely that verification would show reasonable skill in identifying rainfall events but quite poor skill in predicting extreme events*. ……

Summary

9. In light of the demand for water in southeast Queensland and the highly variable nature of rainfall in the area the project has many obvious attractions. However the capability of the science to provide sufficiently reliable 24 to 48 hour advance predictions of high catchment average rainfalls is limited. The Bureau would be willing to participate in future discussions on the subject and maybe able to assist with some service that would assist." (emphasis added)

36 Paragraph 6 of this note is adverting to the introduction of PME forecasts which are discussed elsewhere. Otherwise, the note confirms that the BoM advised that there had been improvement in the accuracy of QPF forecasts but that there was still "*considerable error or uncertainty in the prediction of the location, amount and timing of rainfall events at the catchment scale"* with the overall expectation that they showed *"reasonable skill in identifying rainfall events but quite poor skill in predicting extreme events".* This concern about the precise location and timing of rainfall events and the poor skill in predicting extreme events, was of particular significance to the Connell Wagner proposal because, as I have explained, that proposal created a risk of significantly compromising flood storage capacity and that risk would materialise if significant rainfall events occurred which were not forecast. Hence, in paragraph 5 of this note, the author refers to instances of "high rainfall events" which were not predicted. However, those shortcomings in the QPF forecasts are either not material, or of far less materiality, to any assessment of the relative merits of conducting flood operations based on QPF forecasts, compared with assessments confined to modelling rain on the ground.

37 On or about 1 December 2010, Mr Baddiley located this note and emailed it to Mr Drury.[44] In his covering email, he stated that "whilst weather prediction models are steadily improving, the forecast of rainfall amounts over catchment time/space scales is recognised as one of the most challenging/difficult tasks" and that "[d]etailed rainfall forecasting is not deterministic - the uncertainties involved are often expressed in probabilistic forecasts".

38 At this point, it is appropriate to address what the defendants and some of their witnesses contend is the significance of the 2006 BoM Report and Mr Baddiley's email. Seqwater pleaded that the documents suggested that rainfall forecasts are "uncertain",[45] and the State pleaded that in providing this advice, the BoM had qualified reliance upon forecasts in making dam operation decisions.[46] Both assertions are generally uncontroversial but they do not advance the defendants' case. SunWater pleaded the terms of the advice and that its effect was that there was "*no sufficiently accurate method for objective decision making for pre-releases from Wivenhoe Dam*".[47] I have explained the context and effect of the BoM's advice. I do not accept it had that effect.

39 In his first affidavit, Mr Ayre referred to the 2006 BoM Report and Mr Baddiley's email as suggesting that "there was a high degree of unpredictability even in the 24-hour QPFs".[48] Three points should be noted about that assertion.

40 First, the only "high" degree of unpredictability suggested by the BoM advice was in relation to the use of QPFs to quantify "high rainfall events".

41 Second, Mr Ayre was aware of the context in which the BoM was advising. In cross-examination, Mr Ayre agreed that the "specific question" being asked of the BoM during this process was "whether forecasts were sufficiently reliable to make operational decisions if those operational decisions required either

[44] SEQ.220.001.2868.
[45] PLE.020.012.0001, particulars (ii) and (iii) to [203(b)].
[46] PLE.040.007.0001, [113(k)].
[47] SunWater Defence, PLE.030.008.0001, [139A(e)(v)].
[48] Ayre 1, LAY.SUN.001.0001_OBJ; T 7685.11.

certainty or a very high percentage accuracy before a particular risk could be taken".[49]

42 Third, the relevant statement in Mr Ayre's affidavit was expressed to be part of the reason for his conclusion that "it was inappropriate to choose strategy during flood events on predictions using forecast rainfall."[50] Ultimately, he did not understand clause 8.4 of the Manual to require the use of forecasts "as the basis for predicting lake levels for the purpose of selecting operational strategy".[51] I have already found that to be a completely untenable construction of the Manual. Further, as the discussion below makes clear, throughout the process of revision of Version 6 in 2009, the role of forecasts in selecting strategies was made clear to Mr Ayre.

43 Mr Malone was employed by the BoM at the time the 2006 BoM report was prepared[52] and spoke to Mr Baddiley about its contents around that time and then subsequently read it.[53] In his first affidavit, he stated that he understood the "substance of the advice was that the BoM could not produce sufficiently reliable rainfall forecasts which could be used for the purpose of operating the dams".[54] However, like Mr Ayre, he understood the context in which the advice was given, namely, as addressing the risk of under-predicting rainfall in the context of undertaking pre-releases to free up storage space above FSL.[55] Mr Malone asserted that the context was irrelevant because the forecast is "independent of the state of the dam".[56] However, the use and utility of a forecast in flood operations is not independent of the state of the dam. As he conceded, the smaller the flood storage available above FSL, the greater the required level of confidence in forecasting significant rain to begin evacuating water.[57] Otherwise, Mr Malone's concept of "operating the dams" must be a

[49] T 7683.24.
[50] Ayre 1, LAY.SUN.001.0001_OBJ at [628].
[51] Ibid at [630].
[52] T 4729.24.
[53] T 4729.35 - .40.
[54] Malone 1, LAY.SEQ.007.0001_OBJ, [196] - [197]; Malone 5, LAY.SEQ.016.0001 at [5(g)].
[55] T 4838.8 (Malone).
[56] T 4844.22 - .30.
[57] T 4842.215 - .25.

reference to release decisions, because he accepted that the Manual required the use of forecasts in the selection of strategy.[58]

44 In his first affidavit, Mr Tibaldi stated that he believed Mr Drury shared Mr Baddiley's email with him in December 2010. He stated that he concluded from the 2006 BoM report that "even improved rainfall predictions would not provide a sufficiently accurate method for objective decision making for pre-releases from Wivenhoe Dam".[59] He did not agree that the 2006 BoM Report was to be limited to its context.[60] He maintained that it supported the view that the BoM could not produce sufficiently reliable forecasts for use in the operation of dams.[61]

45 Ultimately, the true scope of the 2006 BoM Report so far as the use of forecasts in flood operations was concerned is set out in the following answers given by Mr Malone:[62]

> "Q. It [the 2006 BoM report] doesn't say that if there is a forecast for a rainfall event, then you shouldn't act on it, does it?
> A. No. It doesn't say we should, either."

46 The 2006 BoM Report simply did not address itself to the circumstances that would arise in late 2010 and early 2011 in applying Version 7 of the Manual. As already outlined in Chapter 3, Version 7 of the Manual (and the FPM) was far from silent on the use of forecasts in flood operations. The drafting of Version 7, with its numerous references to rainfall forecasts, was a process that all of the flood engineers participated in.

4.4: The May 2009 Flood Event

47 As noted in Chapter 2, in 2008, various amendments were made to the relevant legislation which effected structural changes to the instrumentalities responsible for the operation of the dams. As part of that process, the

[58] See Chapter 3.
[59] Tibaldi 1, LAY.SEQ.004.0001_OBJ, at [116(d)].
[60] T 6061.11 - .27.
[61] T 6062.36.
[62] T 4846.3 - .5.

employer of Mr Malone and Mr Tibaldi changed from SunWater to Seqwater.[63]

48 On 15 May 2009, Mr Drury circulated an email within Seqwater advising that "[a]s Somerset Dam ha[d] slowly crept up to 93.32%, we intend to release water from the cone valves from Monday [18 May 2009]". He added that "[r]ain is predicted for Tuesday onwards with falls of 50mm or more possible, although this could change over the next few days".[64]

49 Just after 8.00am on 18 May 2009, Mr Tibaldi sent an email to the dam operators stating as follows[65]:

> "As discussed, please fully open one cone valve at Somerset Dam this morning at 8:00am and please continue with this water release until further instructed. At this stage, if no further inflow occurs, this release is expected to cease on Wednesday 20 May 2009. Somerset should be storing around 90% of its Full Supply Capacity at that time."

50 At 10.19am on that day, Mr Ayre circulated an email[66] stating as follows:

> "Please be aware of the following developing situation. Attached is the SILO Meteogram for Somerset Dam catchment.
>
> A cut-off low is developing over South-East Queensland and this should result in some rain periods from Tuesday through to Friday of this week.
>
> A cone value was fully opened this morning at Somerset Dam to assist in bringing the lake level down to 90% capacity (or EL98.06 m AHD). This operation will continue until at least Wednesday afternoon depending upon the forecast rainfall.
>
> Any problems in performing your rostered duty this week should be reported to John Ruffini at handover today."

51 When cross-examined about Mr Ayre's email, Mr Malone suggested that the reason for the reduction in Somerset Dam could have been to "collect ... exotic weeds" or make "areas available for campers" but accepted it was "most likely" in anticipation of forecast rainfall.[67] Both SunWater and Seqwater

[63] Ayre 1, LAY.SUN.001.0001_OBJ at [239].
[64] SEQ.243.003.2465.
[65] SEQ.083.001.0503.
[66] SEQ.215.016.3072.
[67] T 5008.12 - .36 (Malone).

submitted that this acceptance was based on misconceptions inadvertently introduced by the cross-examiner.[68] It is not necessary to decide whether that is so. Mr Malone agreed that a (different) email sent by Mr Tibaldi on 19 May 2009 directing the opening of a further cone valve at Somerset Dam while it was below FSL[69] was "not to do with water supply".[70]

52 At 10.21pm on 18 May 2009, Mr Drury circulated an email which was copied to Messrs Tibaldi and Malone noting that the BoM was predicting rainfall of between 50 and 100mm in the following four days and that "we initiated releases from Somerset Dam to drop the level from 93% to 90% … to provide a buffer in case there are inflows".[71]

53 By 7.00am on 19 May 2009, the target level of 90% had been reached but rain had commenced to fall[72] and continued to fall through most of the day.[73] At 3.42pm on 19 May 2009, Mr Tibaldi directed that a second cone valve be opened at Somerset Dam.[74]

54 At 6.38am on 20 May 2009, Somerset Dam was at EL 98.63m AHD.[75] Just after 9.30am, Mr Ruffini advised the dam operators that the Flood Operations Centre ("FOC") would mobilise at 10.00am.[76] Mr Ruffini was the SFOE for this event. Mr Ayre was the relief SFOE. Mr Ruffini stated that flood operations would commence later that day but that it was not anticipated that Wivenhoe Dam would be involved. At midday, "Flood Event Operations Advice No 1" was sent to Mr Drury advising that Somerset Dam was at EL 99.00m AHD. It stated that predicted event inflow "based on 100mm of additional rain in the next 24 hours" was 162,000ML and that the anticipated peak level of Somerset Dam was 101.20m AHD (and Wivenhoe Dam was

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68 Seqwater subs at Annexure A, [7]; SunWater subs at [1687].
69 SEQ.211.001.2251.
70 T 5020.19.
71 SEQ.215.016.4603.
72 SEQ.211.004.7599.
73 SEQ.215.019.2641.
74 SEQ.211.001.2251.
75 SEQ.211.001.2323.
76 SEQ.083.001.0592.

EL 64.80m AHD).[77] Releases continued to be made through two cone valves[78] until 9.00pm that night when a sluice gate was opened at Mr Ruffini's direction.[79] There were further cone valve openings at Somerset Dam throughout 21 May 2009.

55 Flood Event Operations Advice No 8, issued at midnight on 22 May 2009, stated that Somerset Dam was at EL 99.13m AHD and falling, with four cone valves and three sluice gates open and discharging 875m^3/s. Somerset Dam peaked at EL 99.68m AHD at 8.00am on 21 May 2009.[80] The Advice stated:[81]

> "The drainage strategy will attempt to return Somerset Dam to below FSL (EL99.0 m AHD) within the next day. It is expected that with the current rate of drainage FSL will be reached by around 02:00am on Friday morning 22 May 2009. Releases will continue in order to drain the lake to pre event levels of between 90 and 95% capacity."

56 Flood Event Operations Advice No 9 was issued at 6.00am on 22 May 2009.[82] It noted that the height of Somerset Dam was EL 98.8m AHD and falling. It stated that:[83]

> "The drainage strategy will attempt to return Somerset Dam to below FSL by later this afternoon. Releases will continue in order to drain the lake to pre-event levels of between 90 and 95% capacity."

57 The sluice gates were closed during 22 May 2009. The final flood event operations advice was issued at 4.00pm on 22 May 2009.[84] At that time, Somerset Dam was at EL 98.46m AHD with three regulators open. The advice stated that all regulators would be closed when Somerset Dam lake level "reaches 98.06m AHD". The flood event was said to be over and Mr Ruffini was the duty flood engineer. The valves were closed at Somerset Dam

[77] SEQ.083.001.0588 at .0589.
[78] SEQ.002.581.6612 at .6613.
[79] SEQ.083.001.0424.
[80] SEQ.083.001.0573 at .0574.
[81] Id.
[82] SEQ.083.001.0571.
[83] Ibid at .0572.
[84] SEQ.083.001.0569.

at 6.30pm on 24 May 2009 "with the dam at EL 90.11 or approximately 90% capacity".[85]

58 According to the flood event report for this (and other 2009 events) that was published in August 2009 (the "2009 FER"), this flood event was declared over at 17.30 on 22 May 2009.[86] In a section entitled "Flood Management Strategies", the report described the release strategy as follows:[87]

> "This event was treated as a formal mobilization flood event at both Somerset Dam and North Pine Dam. No gate operations were required at Wivenhoe Dam due the prevailing depressed level (EL 59.02m or 45% capacity).
>
> *At Somerset Dam, the release strategy devised was aimed at emptying the flood storage component as quickly as possible. All crest gates were lifted clear before the storage reached Full Supply Level. Releases using the regulators commenced prior to the lake level reaching Full Supply Level*. Forecasted inflows suggested that the dam would fill regardless of the initial regulator discharges. The magnitude of the flood release was determined after consideration of the drainage time once the overall estimated inflow volume was defined with some confidence.
>
> The closure sequence was determined with consideration to public safety over the weekend [23 – 24 May 2009]. All regulators were shut down on the Friday evening [22 May 2009] to ensure that sight seers [sic] would not be encouraged by continuing releases." (emphasis added)

59 Immediately after this passage is a table of the sluice and regulator operations. It commences on 18 May 2009.

60 The report also noted that the actions of the flood engineers, in releasing water from Somerset Dam via the regulators and the sluice gates before Somerset Dam reached EL 102.25m AHD, was inconsistent with Version 6, which required that water at Somerset Dam be stored until the "Wivenhoe Dam lake level begins to drop" which did not occur. Thus, the 2009 FER stated:[88]

> "In general, the flood operation procedures were followed, however, given the circumstances some extra guidance is considered warranted in the case of the Somerset - Wivenhoe system.

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[85] SEQ.215.018.0384.
[86] SEQ.084.003.0365 at .0372.
[87] Ibid at .0395.
[88] Ibid at .0408.

> It is recommended that some specific guidelines be developed for the situation whereby Somerset Dam is close to full (ie over 90% capacity) and Wivenhoe Dam is less than 75% capacity. Under the current interpretation of the Manual, it is expected that Somerset Dam will store all floodwaters and the low-level regulators and sluices be kept closed until either:
>
> - Wivenhoe Dam lake level begins to drop.
> - The level in Somerset Dam exceeds EL 102.25 m AHD.
>
> In the events experienced this year, the situation arose on several occasions whereby, neither of these criteria would be attained. The lake level in Wivenhoe Dam simply did not peak (and thus begin to drop), but it seemed impractical to simply store flood water in Somerset Dam until it reached EL 102.25 m AHD. The decision was made to release floodwaters using the low level regulators and sluices prior to the level in Somerset Dam reaching EL 102.25 m AHD. This action was taken with the intention of equalizing the storages of Somerset Dam and Wivenhoe Dam."

61 The report recommended the adoption of some interaction diagram allowing for the equalisation of storages when the dams are below FSL.

62 Mr Ayre accepted that the releases via sluice gates were not consistent with Version 6 but said they reflected the adoption of a "practical approach".[89] Mr Tibaldi contended that Version 6 had accommodated the releases.[90] Mr Malone accepted that the releases in the May 2009 Flood Event were not in strict compliance with "section 9.3" of Revision 6 of the Manual[91] (although it was section 9.4 that required that low level regulators and sluices to be kept closed). Mr Malone agreed that releases were made during the flood event from below FSL at Somerset Dam for "*sensible and reasonable reasons*".[92] He stated that "*[t]here was no implications for water supply security*" in making releases from Somerset Dam into Wivenhoe Dam.[93]

63 The plaintiff submitted that the May 2009 Flood Event involved the making of releases from Somerset Dam below FSL during a flood event and in anticipation of a flood event. It also contended that it involved releases being

89 T 7795.20; T 7794.25 (Ayre).
90 T 6199.32.
91 T 5024.25 (Malone).
92 T 5028.45 to 5029.5.
93 T 5029.16.

made below FSL in advance of forecast rainfall[94] and that the flood engineers had no apparent difficulty in modelling event inflows based on forecast rainfall.[95] It submitted that these releases contradicted the flood engineers' and the defendants' repeated assertions that precautionary releases were not made in reliance on forecasts[96] and water was not released from the water storage compartment of any of the dams for flood mitigation purposes.[97]

64 The submissions of SunWater and Seqwater draw attention to the difference, if any, between so called operational and "flood releases".[98] Mr Drury, Seqwater's Manager of Water Source Services, described himself as the person responsible for water releases during "non-flood event periods".[99] To that end, he described "operational releases" as water releases "other than when there's a declared flood event".[100] Both SunWater and Seqwater submitted that the releases in 2009 made prior to the declaration of a flood event were "operational releases" and were giving effect to an operational policy or approach to equalise storage between the dams by retaining Somerset Dam at around 90% of FSL when Wivenhoe Dam was below FSL.[101] Seqwater submitted that this was part of the process of managing downstream demand.[102] Both submitted that those releases were not made in anticipation of forecast rainfall but in giving effect to that approach.[103] In respect of the releases made below FSL when the flood event was declared, Seqwater contended that it was merely the consequence of the flood engineers misjudging the conclusion of the event and then complying with the minimum gate closing sequences.[104] Citing Mr Ayre's evidence, SunWater

94 Plaintiff subs at [911] to [922].
95 Ibid at [757].
96 Plaintiff subs at [915] referring to Seqwater defence PLE.020.012.0001 at [87A], [299(da)(i)].
97 Plaintiff subs at [919] referring to Seqwater defence, PLE.020.012.0001 at [299(b)(iii)].
98 Seqwater subs at Annexure A, [2].
99 LAY.SEQ.006.0001 at [10].
100 T 6650.29 (Drury).
101 Seqwater subs at Annexure A, [10]; SunWater subs at [1673] to [1692].
102 Seqwater subs at Annexure A, [10].
103 SunWater subs at [1687]; Seqwater subs, Annexure A at [7].
104 Seqwater subs at Annexure A, [11].

submitted that these were "operational releases" which "commenced prior to the Flood Engineers formally declaring that the event was over".[105]

65 The releases that were made between 18 May 2010 and 20 May 2010 were made prior to the declaration of a flood event. Adopting Mr Drury's definition, they were "operational releases". However, the significance of the distinction drawn between "operational releases" and releases during a flood event by Mr Drury is hard to evaluate, especially as the Moreton ROP did not come into effect until 7 December 2009. The legislative arrangements governing the release of water during that period were not addressed by the parties. Thus, for example, it is not known whether the making of releases from water below FSL in each dam was restricted to meeting downstream demand or could include flood mitigation purposes. The evidence does not rise any higher than establishing that at this time the concept of "operational releases" was internal to Seqwater.

66 It suffices to state that I am overwhelmingly satisfied that the releases undertaken in the period 18 to 20 May 2009 were made predominantly because of, and in advance of, forecast rainfall and as part of a process and for the purpose of flood mitigation. Mr Malone's (disputed) "concession" about the connection between the releases and forecast rain merely reflected the effect of the contemporaneous documents. Forecast rainfall was referred to in all of the correspondence surrounding those releases. The 2009 FER correctly described these releases as "[r]eleases using the regulators [that] commenced prior to the lake level reaching Full Supply Level".[106] Most importantly, the relevant flood report describes them as being part of the "release strategy". As that description is set out in the flood management strategies discussion in a 2009 FER, it follows that is clearly a reference to a flood "release strategy".[107] That report also makes it clear that the releases that were made from Somerset Dam prior to it reaching FSL were undertaken to "aim" or assist in "emptying the flood storage component [of Somerset

[105] SunWater subs at [1681].
[106] SEQ.084.003.0365 at .0395.
[107] Id.

Dam] as quickly as possible".[108] The releases could have only had that character if there was a concern, based on forecast rainfall, that the flood storage component would fill.

67 There was evidence, including the Flood Advices themselves, which suggested that Seqwater had decided to keep Somerset Dam approximately 10% below FSL when Wivenhoe Dam was also below FSL.[109] However, the making of releases below FSL in advance of forecast rain for the purpose stated in the above extract from the 2009 FER, is not inconsistent with that approach. As a matter of substance, the releases that were made in the period between 18 and 20 May 2009 were clearly undertaken for flood mitigation purposes, ie, they were precautionary releases involving releases from Somerset Dam below FSL and they were made predominantly because of, and in advance of, forecast rain. SunWater contended that, if they were precautionary releases, forecasts were not used quantitatively "in the … fashion advocated by Dr Christensen".[110] That may be so, but quantitative inflow estimates based on forecast rainfall were prepared.

68 In relation to the releases made below FSL towards the end of the flood event then, according to Mr Drury's definition, they were not "operational releases" in that they were clearly releases made below FSL from Somerset Dam during the course of a flood event. In cross-examination, Mr Ayre was taken to Flood Event Operations Advice No 8, which he authored and which is set out above. Mr Ayre agreed that that directive contemplated releases below FSL in Somerset Dam. He said that this was consistent with the "operational decisions" made by Seqwater "earlier in the week", that is, the releases from Somerset Dam prior to the declaration of the flood event. When it was suggested that this approach was inconsistent with a statement that he previously had made, that releases could never be made from below FSL at

[108] Id.
[109] T 7790.20 - .26 (Ayre).
[110] SunWater subs at [1690].

Somerset Dam during a flood event,[111] Mr Ayre stated that, by definition, flood releases ceased at FSL and operation releases continued after that:[112]

> "Q. But so far as the regulators were concerned, they'd been releasing water when the level was above 99 and they continued to release water when the level was below 99?
> A. Yes.
>
> Q. So that it was a characterisation that changed, from that water being released as part of flood operations to that water being released as part of normal operations?
> A. Yes"

69 If one accepts the premise that all releases below FSL are "operational releases" and not "flood releases", then it will follow that flood releases are never made below FSL. This and similar attempts[113] involving circular reasoning to defend the releases made below FSL during a flood event were unpersuasive. Ultimately, Mr Ayre agreed that "there were releases being made as part of flood operations which reduced Somerset Dam level below FSL".[114] Similarly, Mr Tibaldi also said that in effect and by definition, once Somerset Dam was below FSL, releases were "operational"[115]. He also said that, though the "the flood event effectively finish[ed] once Somerset attains full supply", they "took advantage of the situation to exercise our procedures and let all the flood officers have a turn at being flood officers and undertaking those duties".[116] I also found that unpersuasive.

70 Mr Ayre also stated that the releases made below FSL might have been occasioned by the necessity to comply with minimum gate closing intervals.[117] Even if that is so, the fact that releases below FSL were made during a declared flood event cuts across the emphatic assertions of the defendants and the flood engineers that such releases could not be countenanced. It is noteworthy that there is no reference in the relevant 2009 FER to the fact that releases from below FSL at Somerset Dam were made during the flood event

[111] See T 7776.14.
[112] T 7796.40 to T 7797.1.
[113] See T 7802.26.
[114] T 7802.23.
[115] T 6167.42; T 6168.34.
[116] T 6195.7 - .13.
[117] T 7802.28 - .34.

by the flood engineers, much less any explanation for them. This is something one would expect if the practice not to make such releases was so emphatic and important as was asserted.

71 If the making of releases below FSL for flood mitigation purposes is assessed as a matter of substance then the releases made in the period 18 to 20 May 2009 prior to the declaration of a flood event answer that description. If the making of releases below FSL for flood mitigation purposes is assessed as a matter of form, then the releases made below FSL during the May 2009 Flood Event answer that description. Either way, the circumstances of the May 2009 Flood Event are inconsistent with the contention that, as the time of the January 2011 Flood Event, it was the practice to never make releases for flood mitigation purposes below FSL from Somerset Dam.

72 At the time the 2009 FER was published, the flood engineers had commenced, or were about to embark upon, the revision of Version 6. The circumstances that arose in May 2009 and aspects of the response were ultimately addressed by Strategy S1 in the Manual which allowed releases from the valves and sluice gates when it was expected that Somerset Dam would exceed its FSL but Wivenhoe Dam would not during the course of a flood event.

4.5: The Revision of Version 6 of the Manual

73 The relevant provisions of Version 6 are summarised above. As required by ss 372(4)(b) and 373 of the *Safety and Reliability Act*, the Manual had to be reviewed every five years and that review had to be completed by December 2009. As noted, it was Seqwater and SunWater's contention that the process of revision of Version 6 to the Manual that occurred in 2009 provides support for both their suggested constructions of the Manual and the reasonableness of any belief held by the flood engineers as to its interpretation.[118]

[118] SunWater subs at [123] to [128].

74 The material below demonstrates that Mr Tibaldi assumed responsibility for preparing the drafting revisions to Version 6. He was correctly described in a submission made by Seqwater to the Queensland Water Commission as having "drafted the updated Manual".[119] Mr Ayre described his participation in the review as being part of a "technical review panel" that included Mr Tibaldi, Mr Ruffini, Mr Drury, Mr Barton Maher, Mr Peter Allen and Mr Ron Guppy from DERM, Mr Peter Baddiley from BoM and representatives of local councils.[120]

Draft 1

75 On 30 July 2009, Mr Tibaldi sent a calendar invite to the other flood engineers, Mr Drury and Mr Allen, inviting them to a "Flood Manual Review" meeting on 13 August 2009.[121] The date of the meeting was subsequently changed to 14 August 2009.[122]

76 On 10 August 2009, Mr Tibaldi sent an email to Messrs Allen, Drury, Malone and Ayre advising them of the meeting and stating that he would send out an agenda but that the main topics would include changes to the flood procedures at Wivenhoe and Somerset Dams.[123] He attached a first draft of the revised manual ("Draft 1").[124] Draft 1 did not contain any changes to the flood objectives set out in Version 6,[125] and no relevant change to the Wivenhoe procedures, which were still determined by reservoir level.[126] There were substantial changes to the Somerset procedures that bear similarity to S1 to S3 in the Manual although all levels were engaged by actual and not predicted lake levels.[127] There was a new definition of "Flood Event" which was defined as "[s]ituations where the water level is [that] either of the Dams

[119] SEQ.018.005.0214 at 0223.
[120] Ayre 1, LAY.SUN.001.0001_OBJ at .0062, [241].
[121] SEQ.001.039.3615.
[122] SEQ.001.039.3614.
[123] SEQ.004.048.0394.
[124] SEQ.004.048.0396; described as the "10 August Draft" in Plaintiff subs at [628].
[125] Ibid at .0402.
[126] Ibid at .0431 - .0442.
[127] Ibid at .0445 - .0448.

exceeds the Full Supply Level".[128] An amendment to the gate closing procedures for Wivenhoe Dam included the statement:[129]

> "There may be a need to take into account base flow when determining final gate closure. This may mean that the lake level temporarily falls below Full Supply Level to provide for a full dam at the end of the Flood Event."

77 The same statement was included in the "Gate Closing Procedures" section for Somerset Dam.[130]

78 The only reference to forecasted or predicted rain in Draft 1 was in section 5.1, which contained a discussion of the RTFM that was not materially different to section 5.1 of the Manual (see Chapter 2 at [101]).[131]

79 A copy of Draft 1 with Mr Ayre's handwritten amendments was admitted into evidence.[132] Against the new definition of "Flood Event" the words "By Duty Engineer" are written.[133] Against the statement of the flood mitigation objectives in section 3.1 the words "Retain FSL" and "Minimise environmental impacts" are written.[134] Against Procedure 4A he wrote "Predicted Levels".[135]

80 On 12 August 2009, Mr Tibaldi circulated an email advising of the meeting due to be held on 14 August 2009 and attaching an agenda for the meeting.[136] The attendees were listed as himself and Messrs Drury, Malone, Maher, Ayre, Allen and Ruffini. The email also said that it was attaching a "resend of the draft updated Manual".[137] The resent draft was no different, at least in substance, to Draft 1.[138]

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[128] Ibid at .0404.
[129] Ibid at .0442.
[130] Ibid at .0448.
[131] Ibid at .0416.
[132] SUN.001.013.0298.
[133] Ibid at .0304.
[134] Ibid at .0311.
[135] SUN.001.013.0298 at .0333.
[136] SEQ.210.001.6810; SEQ.210.001.6873; SUN.054.001.4313; SUN.054.001.4314.
[137] SEQ.210.001.6810.
[138] SUN.054.001.4316.

81 Item 4 of the agenda described the flood objectives as "relatively unchanged".[139] Item 6 referred to "Wivenhoe Procedures (Procedure 1)" as "essentially unchanged". Item 7 referred to the rewriting of "Wivenhoe Procedures (Procedures 2 and 3)" as "[a]n attempt … to clarify the intent of both procedures".[140]

82 On 12 August 2009, Mr Tibaldi sent an email to Mr Borrows (and others) advising that he was "taking this opportunity to update the Manual to reflect current organisational and legislative arrangements and also to correct a number of errors, anomalies and omissions in the current Manual". He also stated that the "Flood Mitigation Objectives are not being changed in any way, but some of the procedures that support these objectives are currently wrong and must be corrected".[141] In its written submissions, SunWater referred to that part of Mr Ayre's statement where he said that his understanding "at around this time" was that the correction was to address certain ambiguities in Version 6.[142] However, Mr Ayre's understanding at that time is ultimately irrelevant given the subsequent changes to the draft.

83 There are no minutes or other documents recording what occurred at any meeting on 14 August 2009. It was not addressed in the affidavits of the flood engineers that were read.

Draft 2

84 On 17 August 2018, Mr Tibaldi emailed Messrs Ayre and Malone to schedule another meeting on 18 August 2009 to discuss the revisions to Version 6.[143]

85 The only direct evidence concerning that meeting was part of Mr Ayre's affidavit, in which he stated that, "[e]ither at this meeting or at a meeting around this time," Mr Tibaldi stated: "[t]he Manual needs to reflect the way in which the dams have been operated and in particular the use of the RTFM in

[139] SEQ.210.001.6873.
[140] Ibid at .6874.
[141] SUN.016.001.0274.
[142] LAY.SUN.001.0001_OBJ at [253]; SunWater subs at [153].
[143] SEQ.215.006.7831.

making predictions"[144] which he explained was a reference to modelling using rain on the ground for the purpose of determining operational procedures.[145]

86 On 24 August 2009, Mr Tibaldi sent an email attaching another version of the redraft ("Draft 2").[146] Mr Tibaldi stated that "[b]ased on recent discussions with Rob [Ayre] and Terry [Malone]", he had "substantially rewritten the Flood Operation Strategies for both dams" but "the intent has not changed". He added that he had edited the "minor Objectives (Section 3)" which he proposed discussing at their next meeting.

87 The relevant changes were as follows.

88 First, the flood mitigation objectives now included "[r]etain the storage at Full Supply Level at the conclusion of the Flood Event" (and the minimisation of impacts on "flora and fauna during the drain down phase").[147]

89 Second, the definition of flood event was amended so that it was engaged when the "Duty Flood Operations Engineer expects" the water level in either dam to exceed FSL.[148] Section 2.2 was amended so that it now obliged the DFOE to review weather forecasts and catchment rainfall and declare a flood event if either dam was expected to exceed FSL "as a result of prevailing or predicted weather conditions".[149]

90 Third, consistent with the numerous references to forecast or predicted rainfall that were included in Draft 2, section 1.3 noted the "...limitations on being able to: [a]ccurately forecast rainfall and associated flood run-off during a flood

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[144] LAY.SUN.001.0001_OBJ at .0065, [253].
[145] Ibid at .0065, [254].
[146] SEQ.004.048.0533; SEQ.004.048.0534; Described in Plaintiff subs at [634] as the "24 August Draft".
[147] SEQ.004.048.0534 at .0538 and .0547.
[148] Ibid at .0539.
[149] Ibid at .0543.

event".[150] In his evidence, Mr Malone agreed that this was included because the concept of rainfall predictions was included at various places in Draft 2.[151]

91 Fourth, section 8.3 was amended to a similar form to that ultimately included in the Manual.[152]

92 Fifth, section 8.4 was amended to read:[153]

> "There are four strategies used when operating Wivenhoe Dam during a flood event as outlined below. These strategies are based on the Flood Objectives of this manual. The strategy chosen at any point in time will depend on predictions of the following factors, made with the best rainfall forecast and streamflow information available at that time:
>
> - The maximum storage levels in Wivenhoe and Somerset Dams.
> - The peak flow rate at the Lowood Gauge excluding Wivenhoe Dam releases.
> - The peak flow rate at the Moggill Gauge excluding Wivenhoe Dam releases.
>
> Strategies are likely to change during a flood event as forecasts change and rain is received in the catchments. It is not possible to predict the range of strategies that will be used during the course of a flood event at the commencement of the event. Strategies are changed in accordance with changing rainfall forecasts and streamflow conditions to maximise the flood mitigation benefits of the dams.
>
> A flowchart showing how best to select the appropriate strategy to use at any point in time is shown below."

93 The principal difference between this version and the equivalent statement set out in Chapter 3 at [39], is that instead of stating "[t]he strategy chosen at any point in time will depend on the *actual levels in the dams* and the following predictions", this version stated that "[t]he strategy chosen at any point in time will depend on predictions of the following factors".[154] (Also, this version does

[150] Ibid at .0541.
[151] T 4902.6 (Malone).
[152] SEQ.004.048.0534 at .0560.
[153] Id.
[154] Ibid at .0560.

not include the statement "[w]hen determining dam outflows within all strategies, peak outflows should generally not exceed peak inflow".[155])

94 Draft 2 also included a flowchart for the Wivenhoe Dam strategies similar to that found in the Manual and set out in Chapter 3 at [39] as follows:[156]

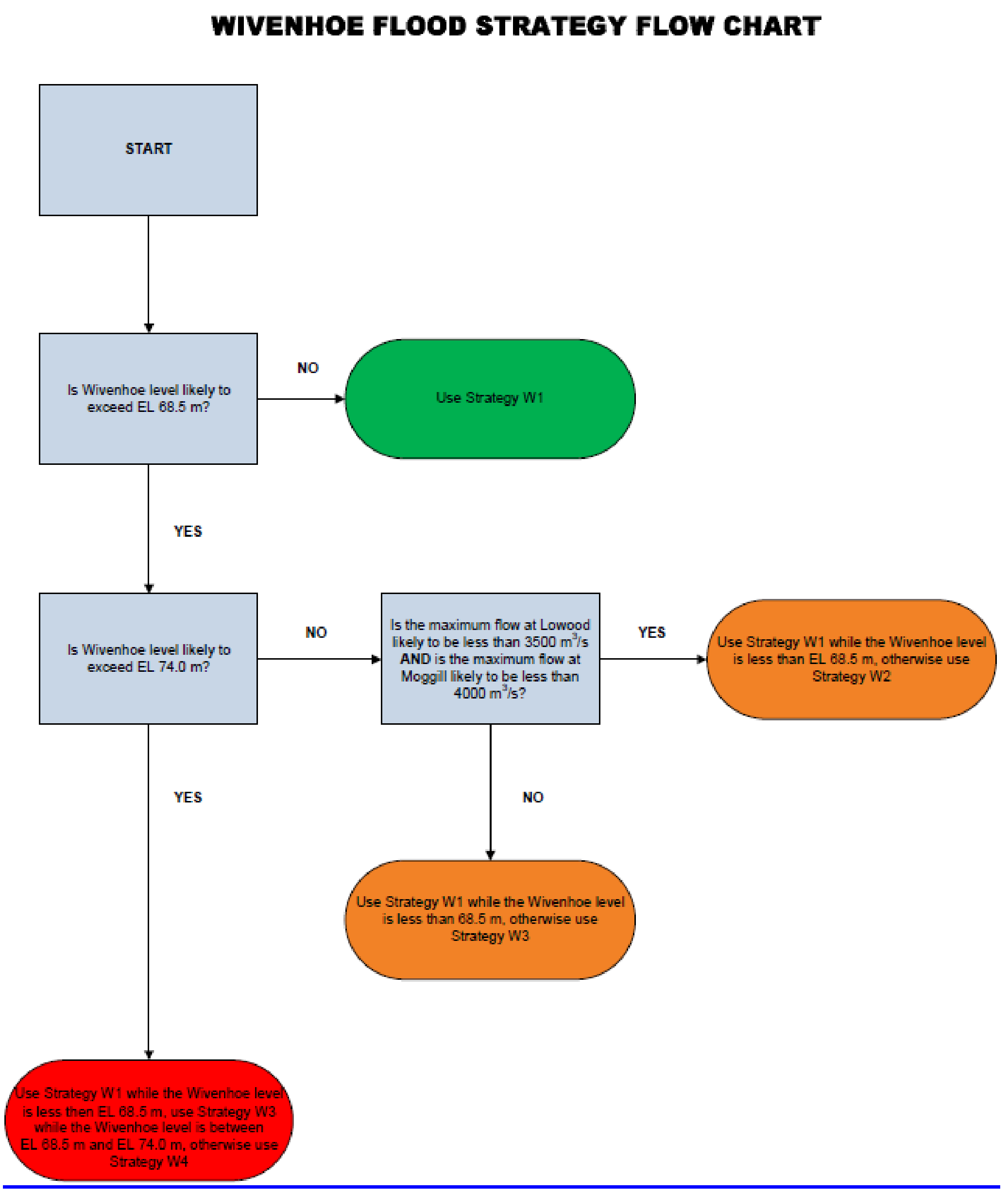

Figure 4-1: Strategy chart from Draft 2 of Version 7 of the Manual

[155] Manual at 23.
[156] SEQ.004.048.0534 at .0561.

95 With this flowchart, the first set of decision boxes require assessments of the "likely" levels of Wivenhoe Dam which, based on the version of section 8.4 noted above, would utilise rainfall forecasts. Unlike the decision circles that state "Use Strategy W2", "Use Strategy W3" and "Use Strategy W4" in the final flowchart included in the Manual, this version of the flowchart advised the flood engineer to "[u]se Strategy W1 while the Wivenhoe level is less than 68.5m, otherwise use Strategy W2", "[u]se Strategy W1 while the Wivenhoe level is less than 68.5m, otherwise use Strategy W3" and "[u]se Strategy W1 while the Wivenhoe level is less then EL 68.5m, use Strategy W3 while the Wivenhoe level is between EL 68.5m and EL 74.0m, otherwise use Strategy W4" respectively.[157] Thus, this part of the flowchart purported to maintain actual lake levels as the ultimate determinant of strategy selection for Wivenhoe Dam.

96 Sixth, the Wivenhoe Dam "procedures" were now replaced by "strategies" W1 to W4 and the draft included condition boxes of the kind noted in Chapter 3 which referred to predicted levels.[158] The discussion of each of the sub-strategies in W1 continued to refer to "[l]ake Level between", and concluded with a similar direction as in the final Manual requiring a transition to higher strategies if "level reaches EL 68.5m AHD".[159]

97 Seventh, the section on flood procedures for Somerset Dam in Draft 2 was rewritten in a manner consistent with the changes made for Wivenhoe Dam and similar to the final version of the Manual. The initial flood control action now required predictions to be "made with the best rainfall forecast and streamflow information available at that time", "procedures" was changed to "strategies", the selection of strategies was made at least partly dependent on predicted lake levels and an operating target line was included for Strategy S2 (although it was different to the final version included in the Manual).[160]

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[157] Ibid at .0561.
[158] Ibid at .0562 to .0567.
[159] Ibid at .0564.
[160] Ibid at .0574 to .0576.

98 It is not clear what Mr Tibaldi meant in his email of 17 August 2009 by his reference to the "intent" of the strategies not changing. The provisions of the flowchart for the Wivenhoe Dam strategies noted above would, if treated as prevailing over other parts of the draft, have had the effect of maintaining lake level as the ultimate determinant of strategy at Wivenhoe Dam. However, those provisions appeared to be in conflict with other parts of Draft 2 which suggested that the strategies were invoked by predicted lake levels.

99 Consistent with his email of 24 August 2009, Mr Tibaldi said that the changes made in Draft 2 were the result of discussions with at least the other Flood Engineers, although he was not sure if that included Mr Borrows or Mr Drury.[161] I infer they were the outcome of such discussions, including at the meeting on or around 14 August 2009, and those discussions included the utilisation of rainfall forecasts.

100 Mr Tibaldi did not accept that the changes were significant and said that the changes were added only to deal with extreme events such as the probable maximum flood.[162] While I accept that the additions to the flowchart to preserve some role for actual lake levels provides some support for that contention, overall, I do not accept that characterisation or that it reflects his understanding at the time. The changes made by Draft 2 introduced rainfall forecasts as a central feature of declaring a flood event and a potentially important feature of conducting flood operations. While they were utilised in the May 2009 Flood Event, they were not expressly addressed in Version 6. Mr Tibaldi's refusal to accept what I regard as obvious is another matter that affected my acceptance of his evidence. Mr Malone initially did not accept that the changes were significant,[163] but later accepted that they were.[164]

101 Mr Ayre agreed that the changes in sections 8.3 and 8.4 of the Manual in the 24 August 2009 draft involved a fundamental conceptual change to flood

[161] T 5710.2 - .28.
[162] T 5711.28; T 5712.39.
[163] T 4904.19.
[164] T 4906.35 -.39.

operations.[165] SunWater's written submissions sought to confine that concession by noting that Mr Ayre was not asked whether he recognised the gravity of this matter at *that* time, as well as referring to Mr Ayre's proposed changes, which were said to tie predicted levels based on rain on the ground modelling.[166] In relation to the former, the significance of the references to rainfall forecasts would have been apparent to a highly intelligent person such as Mr Ayre. The latter is addressed below.

102 On 25 August 2009, Mr Tibaldi sent an email to Messrs Ayre, Allen, Ruffini, Malone, Drury, Maher and another, advising of a meeting on 28 August 2009.[167] No notes or minutes of any such meeting were tendered. However, an agenda[168] for that meeting specified three substantive items would be discussed namely "Section 3 – Changes to flood objectives", "Section 8 – Wivenhoe Flood Operations" and "Section 9 – Somerset Flood Objectives". With the last two items the agenda stated that they had been "substantially rewritten and are to be reviewed".

103 On 1 September 2009, Mr Ayre emailed[169] his comments on Draft 2.[170] They reflected some handwritten notes that he had made on Draft 2.[171] He did not suggest any changes to section 2.2. Otherwise, two of his comments are of present significance.

104 First, in relation to section 8.4, Mr Ayre suggested it be amended as follows:[172]

> "The strategy chosen at any point in time will depend upon predictions at the following *locations which were made with the best actual and forecast rainfall and streamflow* information available at that time.
>
> - Peak storage levels in Wivenhoe and Somerset dams
> - Peak flow rate at Lowood gauge (excluding Wivenhoe dam releases)

[165] T 7573.3.
[166] SunWater subs at [163].
[167] SEQ.004.048.0673.
[168] SEQ.200.024.7013.
[169] SEQ.016.010.5093.
[170] SEQ.016.010.5094.
[171] SUN.001.013.0218.
[172] SEQ.016.010.5094 at .5096.

- Peak flow rate at Moggill gauge (excluding Wivenhoe dam releases)

> Strategies are likely to change during a flood event *as rainfall occurs and forecasts are revised*. It is not possible to predict the range of strategies that will be used during the course of a flood event at the commencement of the event. Strategies are changed in *response with changing rainfall and stream flow conditions* to maximise the flood mitigation benefits of the dams." (emphasis in original)

105 In his affidavit, Mr Ayre said that he "proposed the amendments to seek to capture the manner in which flood operation strategies had been determined in the past, namely by considering actual lake levels and making predictions as to future lake levels and peak flows at various locations from RTFM modelling based on rainfall on the ground".[173] In cross-examination, it was suggested to Mr Ayre that "…*you made changes to what was proposed by including the concept of actual rainfall, but you were not rejecting the concept of best forecast rainfall and stream flow information, were you*?". Mr Ayre rejected that proposition, stating "*No. I believe that was a reference to the fact that the real-time flood model had the predictive capability to consider both rain on ground plus rain on ground and forecast rainfall predictions*" and that, in proposing changes to clause 8.4 he believed "*that* [he] *was trying to make sure that the reference to rain on the ground was front and centre in that particular sentence*."[174]

106 While I accept that, by his amendments, Mr Ayre may have been trying to place greater emphasis on the use of rain on the ground as part of the modelling process, I do not accept that he was seeking to eliminate the use of rainfall forecasts in determining predicted water levels. Mr Ayre was perfectly capable of expressing himself. He understood he was confronted with a draft that clearly required the use of forecasts in determining predicted water levels. If he meant to rule out their use, he could have easily done so. As explained below, Mr Ayre's proposed amendments to this part of section 8.4 were not taken up and he became aware of that. Leaving aside whether he sought to eliminate the use of forecasts, this aspect of the narrative confirms that Mr Ayre was fully cognisant of the proposed role of forecasts in the revisions to

[173] Ayre 1, LAY.SUN.001.0001_OBJ at .0068 [262].
[174] T 7580.45 to T 7581.30 (Ayre).

the Manual and that their role was maintained.[175] Otherwise, his rejection of the obviously correct proposition that was put to him (at [105]) reinforces my doubt about the reliability of so much of his evidence that was uncorroborated.

107 Second, the other change suggested by Mr Ayre concerned the flowchart for selection of Wivenhoe Dam strategies. In his memo, Mr Ayre stated that he thought that the Manual "[does] not need options for W2, W3 and W4" and that Strategy W2 could be annotated to ensure that bridges are not inundated prematurely".[176] Some insight into what he meant by this can be gained from considering his handwritten amendments on a copy of Draft 2.[177] It contains an annotated version of flowchart noted in [94] as follows:[178]

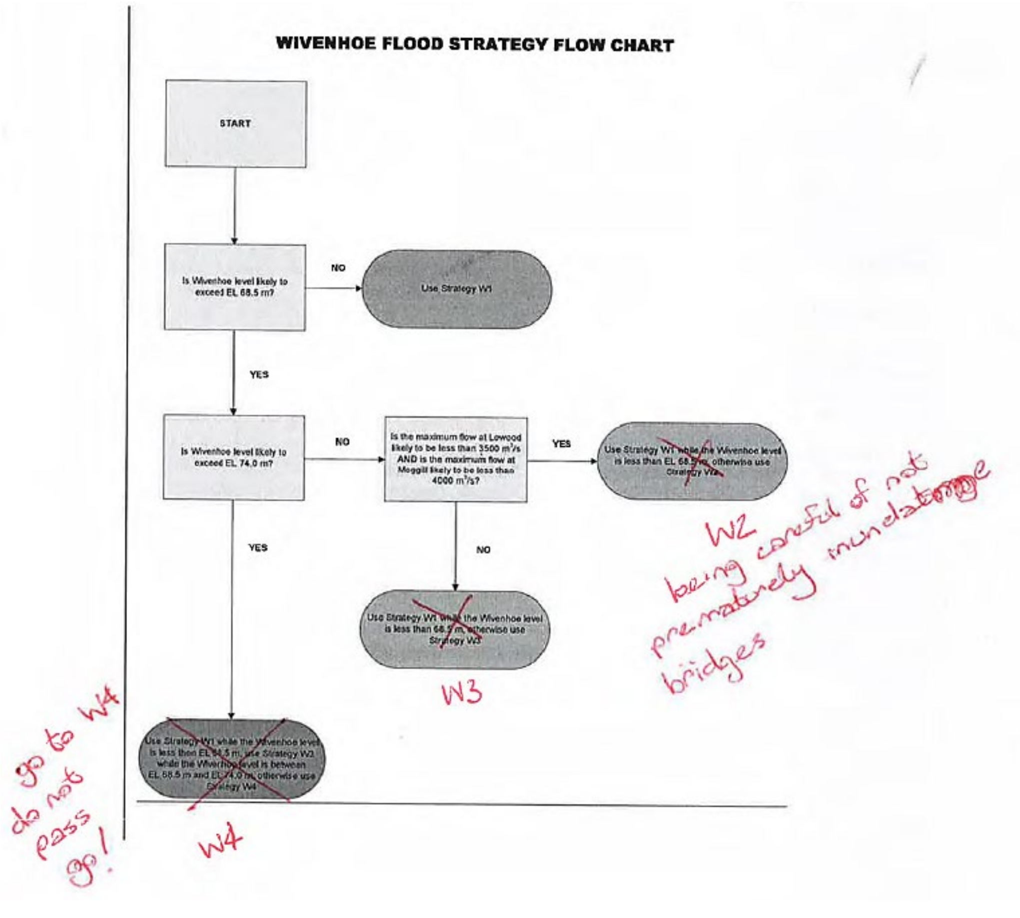

Figure 4-2: Mr Ayre's annotation of the flowchart in Draft 2 of Version 7 of the Manual

[175] T 7580.45.
[176] SEQ.016.010.5094 at .5096.
[177] SUN.001.013.0218.
[178] Ibid at .0245.

108 The handwritten annotations are suggesting the amendment of the action circles that referred to actual lake levels and their replacement by “W4”, “W3” and “W2 being careful of not prematurely inundating bridges”. Against “W4” he has written the words “go to W4 do not pass go!”.[179]

109 Mr Ayre agreed that these changes would have the effect that the selection of all strategies would be determined by reference to predicted lake levels.[180] I am satisfied that Mr Ayre was suggesting the removal of those parts of the flowchart that purported to retain a role for actual lake levels in strategy selection and instead was suggesting the use of predicted levels. The combination of that, and his subsequent knowledge that his amendments to the text of section 8.4 were rejected, confirm, if confirmation is necessary, that he was completely cognisant that Version 7 of the Manual used predicted levels to determine strategies and envisaged those predictions being determined by reference to rainfall forecasts.

Draft 3

110 On 7 September 2009, Mr Tibaldi sent an email attaching a further draft of a revision to Version 6 to Messrs Ayre, Allen, Ruffini, Malone, Maher, Drury and Ms Douglas from DERM[181] (“Draft 3”[182]). Draft 3 incorporated a number of Mr Ayre’s changes, including his suggested discussion about target points underneath the operating target line.[183] However, his suggested changes to section 8.4 and the flowchart for choosing Wivenhoe Dam strategies were not taken up[184] (although the latter was in Draft 4).

111 Three further points should be noted about the changes introduced into Draft 3.

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[179] Id.
[180] T 7583.38 to T 7584.8.
[181] SUN.054.001.4378.
[182] SUN.054.001.4379; described as the “7 September Draft” in Plaintiff subs at [643].
[183] Ibid at .4422.
[184] Ibid at .4404 to .4405.

112 First, the discussion of the "limitations" in section 1.3 was amended to reflect the fact that the flood engineers obtain rainfall forecasts from elsewhere but make their own estimates of runoff.[185]

113 Second, there were only two changes to section 8.4 from Draft 2. The sentence "[t]he strategy chosen at any point in time will depend on predictions of the following factors, made with the best rainfall forecast and streamflow information available at the time" was changed to "[t]he strategy chosen at any point in time will depend on the following predictions which are to be made using the best forecast rainfall and stream flow information", a change that appears immaterial. Also, section 8.4 of Draft 3 included the following statement:[186]

> "When calculating the impacts of flood releases from Wivenhoe Dam, the gate opening sequences outlined in Section 8.6 should be used to determine likely outflow rates from the dam."

114 Third, the discussion in the second "[a]ction" box for S2 (see Chapter 3 at [83]) was changed from requiring the operating target line to be followed "as closely as possible" to a requirement that it only be "followed".[187]

115 Another attachment to the email of 7 September 2009 was a further version of Mr Ayre's comments that were circulated on 1 September 2009.[188] In the covering email, Mr Tibaldi stated that the "*crossed comments*" contained in the further version of comments had been included in the "*updated document*", though "[s]*ome comments require further discussion*".[189] Mr Ayre's revised version of section 8.4 was crossed through. In his affidavit, Mr Ayre stated that he understood that to mean that Mr Tibaldi had included Mr Ayre's amendments to clause 8.4.[190] He said that he printed off a copy of this draft of the Manual and made a handful of handwritten comments.[191] He said that he did not appreciate, at that stage, however, that his proposed

[185] Ibid at .4386.
[186] Ibid at .4404.
[187] Ibid at .4421.
[188] SUN.054.001.4431.
[189] SUN.054.001.4378.
[190] Ayre 1, LAY.SUN.001.0001_OBJ at [268].
[191] SUN.001.013.0152; LAY.SUN.001.0001_OBJ at [269].

amendments to clause 8.4 had not been taken up.[192] This is difficult to reconcile with his handwritten comments, as he annotated the flowchart which immediately followed the text of section 8.4[193] and detected a minor typographical error in section 1.6.[194] In cross-examination, Mr Ayre agreed that he was "*still closely analysing the whole of the proposed draft*".[195] Regardless, Mr Ayre agreed that (at a later time) he became aware that his suggested changes to section 8.4 had not been incorporated into the draft.[196]

116 One of Mr Ayre's annotations to the flowchart was "[w]ords? JT & RA. Reliability of forecast?".[197] There is no suggestion that Mr Ayre ever had any concerns about the reliability of forecasting lake levels based on rain on the ground. I infer that Mr Ayre understood that, at least so far as the flowchart referred to "likely" levels, it required the use of rainfall forecasts.

117 An agenda for a meeting on 18 September 2009 between Messrs Baddiley, Malone, Ayre and representatives of Brisbane City Council was tendered.[198] Mr Malone and Mr Ayre said the revision of the manual was discussed at that meeting.[199] Mr Ayre said that Mr Malone had a copy of the current draft of Revision 7 with him at that meeting.[200]

118 Mr Ayre said that one of the topics discussed at the 18 September 2009 meeting was the flow rate threshold for damage of urban areas below Moggill. Mr Ayre said that they discussed a 2007 study prepared by the Brisbane City Council on the topic of Flood Damage Minimisation.[201] That study had found that flow rates below 4,000m^3/s caused a minor level of flood damage to residential and non-residential property in Brisbane City and Ipswich however,

[192] Ayre 1, LAY.SUN.001.0001_OBJ at [268].
[193] SUN.001.013.0152 at .0178.
[194] Ibid at .0159.
[195] T 7589.44 – .46 (Ayre).
[196] T 7602.16.
[197] SUN.001.013.0152 at .0178.
[198] SUN.001.013.0124.
[199] T 4916.12 (Malone); T 7591.3 (Ayre).
[200] T 7592.9.
[201] Ayre 1, LAY.SUN.001.0001_OBJ, [273].

the level of damage increased exponentially above that figure.[202] Thus, Table 4.1 of that report in relation to Brisbane City was as follows:

Table 4.1 Residential and Non-Residential Flood Damage Summary Results, Brisbane City

Flood Discharge (m^3/s)	Residential			Non-Residential			Total Damage ($million)
	Total Damage ($million)	No. of Flood Damaged Properties	Average Damage Per Property ($1000)	Total Damage ($million)	No. of Flood Damaged Buildings	Average Damage Per Building ($1000)	
1000	0	0	0	0.002	1	2.06	0.002
2000	0	0	0	0.24	1	241.48	0.24
3000	0.40	29	13.78	0.71	4	177.81	1.11
4000	4.22	138	30.56	1.75	26	67.12	5.97
5000	29.10	831	35.02	13.30	125	106.41	42.40
6000	98.27	2052	47.89	59.07	383	154.23	157.34
7000	225.76	4073	55.43	169.27	803	210.80	395.03
8000	382.63	6280	60.93	288.54	1356	212.78	671.17
10000	718.21	10296	69.76	589.12	2259	260.79	1307.33

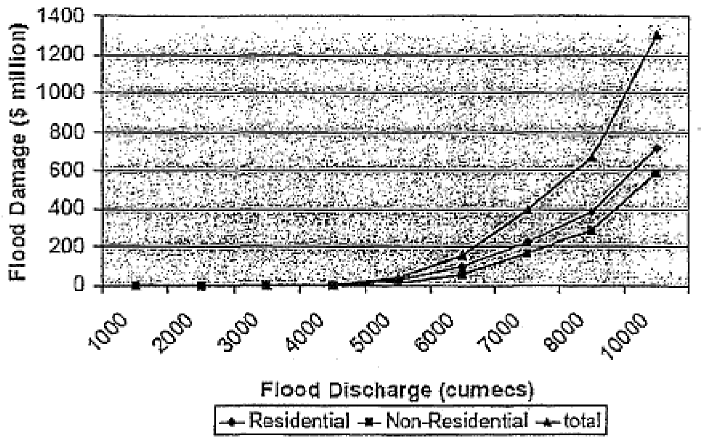

Figure 4-3: Damage Table from Brisbane City Council Report

119 The above figures and table provide more than an adequate basis to conclude that the damage caused by flow rates less than 4000m^3/s at Moggill would be negligible. The relevant table for Ipswich was similar.[203] Mr Ayre said that the study confirmed the 4,000m^3/s figure in the Manual.[204] I am satisfied that, even though there was evidence that some damage to residential and non-residential property might be occasioned by a flow rate of below 4000m^3/s at Moggill, throughout the revision process there was a consensus that that flow rate was the delineation point between downstream flows that did not cause urban damage and those that did. At the time of this meeting, Draft 3 of the Manual referred to 3500m^3/s as the "upper limit of non-damaging floods at

[202] SUN.900.011.5068 at .5078 to .5079.
[203] Ibid at .5079.
[204] T 7592.42.

Lowood" [205] and a flow at Moggill of 4000m^3/s as the "upper limit of non-damaging floods downstream".[206] These figures did not change at any point during the manual revision process and were not the subject of any proposed change.

Draft 4

120 On 24 September 2009, Mr Tibaldi emailed[207] Messrs Allen, Ayre, Malone, Ruffini and others the fourth draft of the revision to Version 6 ("Draft 4").[208] He described the enclosed draft as a "complete updated draft" and stated that Mr Malone would call a meeting the following week to discuss it. He noted that it now included a modified "Operating Target Line" which reflected the "recent modelling results".[209]

121 Draft 4 did not include any change to section 8.4, however the flowchart for choosing Wivenhoe Dam strategies was altered so that those parts of the flowchart that referred to operating as per actual levels were removed and replaced by directions that stated "[u]se Strategies W1 and W2 as appropriate", "[u]se Strategies W1 and W3 as appropriate" and "[u]se Strategies W1, W3 and W4" as appropriate":[210]

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[205] SUN.054.001.4379 at .4409.
[206] Ibid at .4410.
[207] SEQ.016.010.3492.
[208] SEQ.016.010.3493; described in Plaintiff subs at [653] as the "24 September Draft".
[209] Ibid at .3535.
[210] Ibid at .3519.

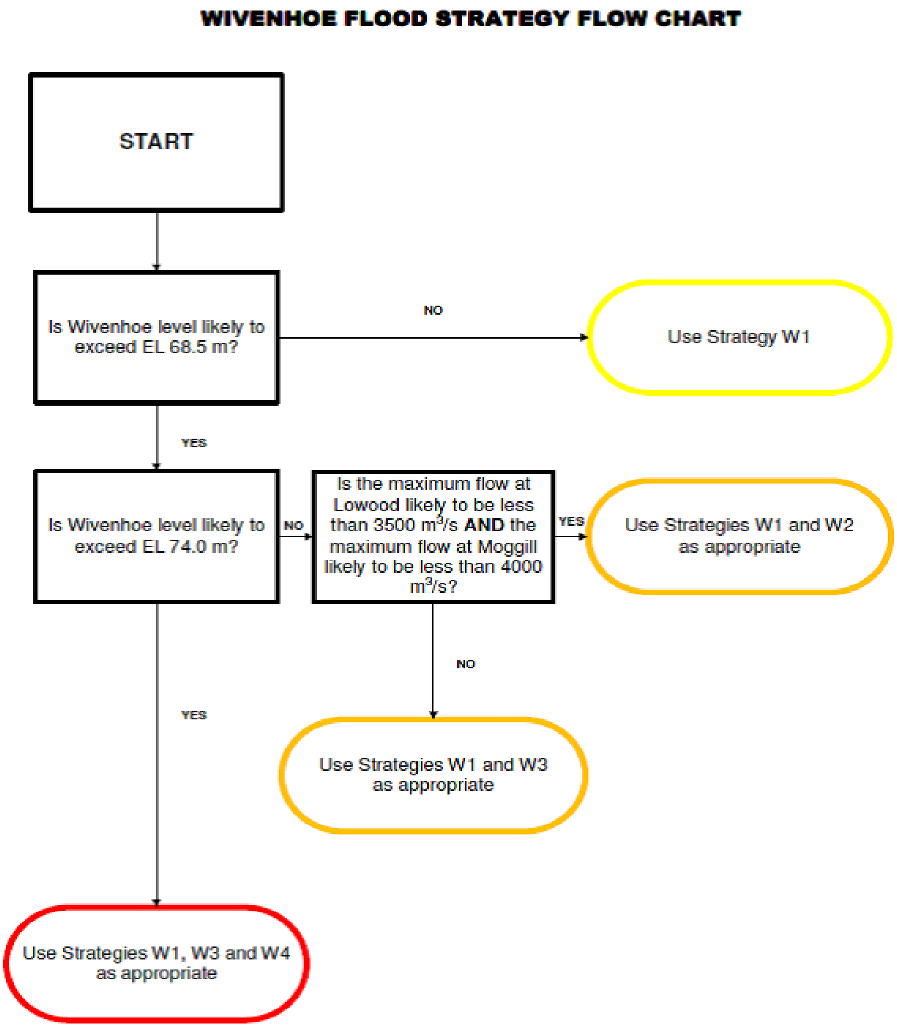

Figure 4-4: Strategy Flow Chart from Draft 4 of Version 7 of the Manual

122 Two points should be noted about this suggested change.

123 First, if implemented, the changes would have meant that the only part of the Manual that potentially suggested that actual lake levels, as opposed to predicted levels, was a determinant of strategy selection, were the words "Lake Level between ..." included in the descriptions of the W1A to W1E sub-strategies.

124 Second, if implemented, it would have meant that the flood engineers would have been conferred with a discretion not just concerning release rates within strategies, but as to the choice of strategies themselves. In

cross-examination, Mr Malone asserted that the "intent" of both drafts was "exactly the same".[211] I disagree. It was a marked shift.

125 Draft 4 also included various amendments to Strategy S2. It now only required the low-level regulators and sluices to "*generally*" be kept closed when the water level in Somerset Dam was below EL 102.25m AHD.[212] Draft 3 required they be kept closed.[213] In cross-examination, Mr Tibaldi agreed that that the introduction of words like "*generally*" into the drafts was intended to permit the engineer to exercise judgment where it was appropriate to make an exception to a stated procedure.[214] Also, Draft 4 now only required the target operating line "to generally be followed".[215] Draft 3 had required it to be "followed" and Draft 2 had required it be "followed as closely as possible".[216]

126 Section 9.3 of Draft 4 specified that the peak level in Somerset Dam "cannot exceed EL 107.5".[217]

Variation on Draft 4 and Draft 5

127 An electronic diary entry records an appointment for a meeting at Mr Allen's office on 7 October 2009 and lists Mr Tibaldi as the "organiser" and Messrs Malone, Ayre, Allen and Tibaldi as "[r]equired attendees".[218] No notes or minutes of that meeting were tendered.

128 In cross-examination, it was put to Mr Tibaldi that his evidence concerning the manual revision process was based "entirely on reconstruction from reading documents".[219] Mr Tibaldi denied that, stating that he did "have one recollection about actual levels".[220] He then asserted that "there is a draft where all levels are removed from strategies" which he distributed to Mr Allen

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211 T 4918.1 - .2.
212 SEQ.016.010.3493 at .3534.
213 SUN.054.001.4379 at .4421.
214 T 5831.24 to T 5832.26.
215 SEQ.016.010.3493 at .3534.
216 SEQ.004.048.0534 at .0575.
217 SEQ.016.010.3493 at .3536.
218 SUN.006.016.2494.
219 T 5714.24.
220 T 5714.26.

but then "Mr Allen called me to his office sometime after that was distributed and told me that he wanted the levels back in W1".[221] Mr Tibaldi said he "thought an opposite outcome had been agreed", but Mr Allen said words to the effect of "I have to take responsibility for this, for government. You need to do what I tell you. If there's a problem, it will come to me, it will never come to you".[222] Senior Counsel for the plaintiff then called for the production of that draft.[223] In response to that call, Senior Counsel for Seqwater identified part of a draft that appeared in a file of documents maintained by Mr Ayre's file during the revision process.[224] Mr Tibaldi was cross-examined about the document further and maintained that Mr Allen insisted on the retention of actual levels in W1.[225]

129 The document produced was an electronically amended portion of part of a revision to Version 6 that addresses strategies W1 up to section 10.4[226] ("Variation on Draft 4"). It bears Mr Ayre's handwritten annotation "7/10/09".[227] It is clearly a variation of Draft 4 because section 9.3 specifies that the peak level in Somerset Dam "cannot exceed EL 107.5"[228] which was included in Draft 4. Against that, there is a handwritten annotation "109". That change was made in the draft that circulated the next day, that is Draft 5 (see [132]). This suggests that, if there was such a conversation as Mr Tibaldi asserted, then it most likely could have only occurred around 7 October 2009 (and well before Mr Allen's memorandum attached to his email of 13 October 2009 discussed below).

130 The amendments noted in the Variation on Draft 4 to Strategies W1 to W3 removed all references to "lake level between" for each of the sub-strategies W1A to W1E and the concluding sentence in W1 that "[i]f the level reaches EL 68.5m AHD in Wivenhoe Dam, switch to Strategy W2 or W3 as appropriate". It also amended the operative conditions for each of W1, W2

221 T 5714.38.
222 T 5714.40.
223 T 5715.38.
224 T 5716.2; T 7600.21.
225 T 5719.12.
226 SEQ.004.033.2091 at .2175 to .2200.
227 Ibid at .2175.
228 Ibid at .2192.

and W3 so that they were all invoked if the Wivenhoe Dam storage level was predicted to be less than EL 74.0m AHD and abolished the utilisation of EL 68.5m AHD to distinguish between W1 on the one hand and W2 or W3 on the other. Instead, the only distinction between those conditions was maximum flow rate. If implemented, these changes would have conferred a very wide discretion on the flood engineer as to the choice of strategy. Thus, this draft did not effect a change from actual levels to predicted levels and nor did it simply remove all possible references to actual levels in the W1 sub-strategies. Instead, it abandoned the use of lake level distinctions between strategies W1, W2 and W3 altogether, including those based on predictions.[229] Thus, a comparison of the changes suggested by the Variation on Draft 4 with previous and subsequent versions does not support the suggestion that there was any agreement to reintroduce into the revised manual references to actual levels for the W1 sub-strategies. Instead, it suggests there was a rejection of a proposal to confer a broad discretion on the flood engineers to choose strategies.

131 The manner in which Mr Tibaldi's evidence of his meeting with Mr Allen emerged, being his "one recollection",[230] was curious. It was not referred to in his voluminous affidavits[231] which included an affidavit sworn only ten days prior to his giving oral evidence.[232] In any event, it is not necessary to decide whether such a direction was given by Mr Allen because it was not acted upon. As just explained, the real import of the changes sought by the Variation on Draft 4 was the removal of references to any levels, predicted or otherwise, in relation to the choice between W1, W2 and W3 strategies. It was that proposal which was rejected by Draft 5 produced the next day (and later drafts). Further, as explained below, Mr Allen later sought the removal of any reference to predicted levels in all of the strategies and the reintroduction of actual levels and was rebuffed. None of the changes or retentions to the drafts provides support for the suggestion that there was an agreement to keep actual levels as the determinant of W1 or its sub-strategies.

[229] Plaintiff subs at [658].
[230] T 5714.26.
[231] LAY.SEQ.004.0001_2; LAY.SEQ.014.0001.
[232] 4 May 2018; LAY.SEQ.017.0001.

132 On 8 October 2009, Mr Tibaldi circulated[233] another draft[234] ("Draft 5") and stated "I think we are getting close".

133 Draft 5 did not include any changes to section 8.4 or the flowchart for Wivenhoe Dam strategies set out in Draft 4. Thus, it did not include the changes to strategies W1 to W3 in the Variation on Draft 4 described above.[235] It also retained the directions in the flowchart to "[u]se Strategies W1 and W2 as appropriate", "[u]se Strategies W1 and W3 as appropriate" and "[u]se Strategies W1, W3 and W4 as appropriate". There was a change in the action required in W4. Instead of stating that "[o]pening of the gates is to occur until the storage level of Wivenhoe Dam begins to fall", it now provided that "[o]pening of the gates is to occur generally in accordance with the requirements of Section 8.6, until the storage level of Wivenhoe Dam begins to fall",[236] although "generally" was removed from under the heading "W4A".[237] There was still no reference to considering lower level objectives in the headings to W2, W3 or W4. Further, section 9.3 stated that the peak level in Somerset Dam could not exceed "EL 109.0".[238]

134 A copy of Draft 5 with Mr Ayre's handwritten annotations was admitted into evidence.[239] In cross-examination, Mr Ayre agreed that his annotation to section 8.4 reflects his noticing that his suggested changes had not been adopted.[240] The colour version of this document reveals that Mr Ayre highlighted the reference to "predicted" for each of W1, W2 and W3.[241] Mr Ayre said that this was a reminder to raise in discussions with the other flood engineers the issue of whether strategies were invoked on the basis of actual or predicted lake levels.[242] Mr Ayre also annotated the flowchart by placing an "x" next to the W4 box, writing "W4" and underneath writing "[t]he adopted

233 SEQ.016.010.3562.
234 SEQ.016.010.3563; described as the "8 October Draft" in Plaintiff subs [661].
235 And not just those noted in SunWater subs at [184].
236 SEQ.016.010.3563 at .3596.
237 Compare Draft 4, SEQ.016.010.3493 at .3525 with Draft 5, SEQ.016.010.3563 at .3596.
238 SEQ.016.010.3563 at .3608.
239 SUN.001.013.0024.
240 T 7602.16.
241 SUN.001.013.0024 at .0052, .0055, .0056.
242 T 7603.28.

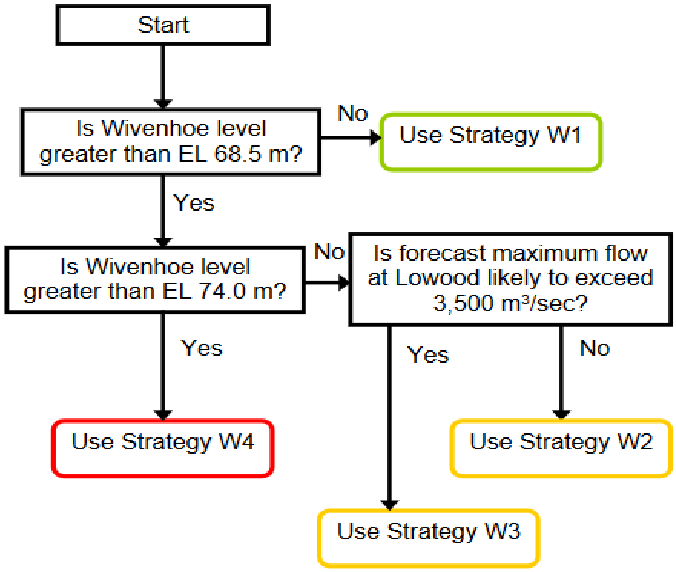
strategy will depend upon actual conditions not predicted".[243] The plaintiff contended that this was only an annotation of W4.[244] In cross-examination, Mr Ayre stated that it "would be certainly a note that would apply to strategies W1 and W4, based on my experience".[245] It was apparent that Mr Ayre had no actual recollection of what the annotation related to. Given the final form of the Manual, I am satisfied it concerns W4.

135 On 13 October 2009, Mr Allen sent an email to Messrs Tibaldi, Malone, Ayre, Ruffini and others. He attached a "collated list of the comments that Ron [Guppy], Ken [Khanh Nguyen] and I have put together on the latest version of the Flood Manual".[246] The memo containing the list of comments noted, inter alia, that the only objective that did not have its own discussion in Chapter 3 of the Manual was the objective of retaining FSL at the conclusion of the flood event.[247] The memo extracted the text of section 8.4 which referred to strategies being chosen by reference to predicted flows and levels based on "best forecast rainfall and stream flow information" and stated as follows:[248]

> "Our understanding is that the actual values are used to select W1 to W4 with some variations allowed for based on forecasts. eg You transition from W1 to W2 or W3 once the water level in Wivenhoe exceeds EL 68.5m. The choice between W2 and W3 is made on the forecast of the peaks depending on whether the Lowood or the Moggill flows control.
>
> 4. From this perspective, it may be better to change the figure on page 27 to something along the following lines.

243 SUN.001.013.0024 at .0051.
244 Plaintiff subs at [663(c)].
245 T 7603.12.
246 SUN.006.014.2030.
247 SUN.006.014.2032 at .2034.
248 Ibid at .2032 to .2033.

Wivenhoe Flood Strategy Flow Chart



5. *All W strategies should refer to actual levels and flows and not the predicted levels and flows*. Then W4A and W4B can be differentiated based on Predicted Maximum Lake Level.

I think there needs to be another criterion under Procedures W2 and W3 of not less than 1900m^3/s given for the target maximum flows. Otherwise if for example the natural peak flow at Lowood excluding Wivenhoe releases was only 1000m3/s that becomes the target maximum flow there,

It may also be useful to specify that the peak outflow should not exceed the peak inflow (ie the total inflow into Wivenhoe including Somerset outflows)." (emphasis added)

136 Thus, Mr Allen recognised that the current draft made all Wivenhoe Dam strategies dependent on predicted levels and suggested their wholesale replacement with references to actual levels. Mr Malone was cross-examined about the fact that Mr Allen made it clear that the current version did not make strategy selection dependent on actual levels but predicted levels and that in Mr Allen's view that should be changed, but that was clearly not done when the Manual was approved.[249] My impression of Mr Malone's evidence on this point was that he was reluctant to concede that Mr Allen was pointing out that the drafts were proposing a significant change which was eventually implemented. Mr Ayre accepted that Mr Allen was suggesting that actual

[249] T 4922.

levels, not predicted levels, should be the basis of the decisions about strategies under the Manual.[250]

137 Electronic diary entries that were tendered suggest that further meetings were held between the flood engineers and Mr Allen and his colleagues on 15 October 2011 and 23 October 2011.[251] No notes or minutes of these meetings were tendered. Mr Ayre said that he had no independent recollection of the meeting on 15 October 2009,[252] although he accepted that it was likely that the distinction between predictions and actual lake levels was a topic of discussion.[253] Given Mr Allen's position and the contents of his memo, I infer that it was raised. Mr Allen's memo suggests he preferred that all the strategies for Wivenhoe Dam be determined by actual lake levels however the flood engineers' preference for predictions was maintained.

138 I do not accept that the fact that the Variations on Draft 4 were not taken up somehow provides comfort for a construction of the Manual pursuant to which any of the strategies or sub-strategies were to be selected based on actual lake levels. As stated, the real significance of the changes proposed in the Variation to Draft 4 is that, if adopted, they would have abolished the relevance of any level, predicted or actual, as a determinant of Strategy W1, W2 or W3. If those changes had been implemented, then the flood engineers would have been left with a wide discretion as to which procedure to adopt when the predicted dam level did not exceed EL 74.0m AHD. Those suggested changes were a logical extension of the flowchart in Draft 4 which made it a matter of judgment whether to use W1 or W2 and W1 or W3, even when the predicted height exceeded EL 68.5m AHD. The significance of Draft 5 is that this attempt was not taken up. Further, as the discussion below indicates, the suggested widening of the flood engineers' scope of judgment in relation to strategy selection suggested by the Wivenhoe Dam strategy flowchart for Draft 4 and Draft 5 was removed by Draft 6, and that change was reflected in the Manual.

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[250] T 7607.3 (Ayre).
[251] SUN.006.016.2500; SEQ.016.010.3643; SEQ.001.039.3623.
[252] T 7608.34.
[253] T 7608.39.

Draft 6 and Draft 7

139 On 30 October 2009, Mr Tibaldi circulated to Mr Allen, Mr Drury and the other flood engineers the updated revision of Version 6 ("Draft 6")[254] and the dam interaction study that was the basis for the operating target line.[255]

140 Following Mr Allen's suggestion, section 3.5 of Draft 6 contained a discussion of the full supply objective that was couched in the same terms as that which was set out in the final version, ie, the Manual.[256] A suggestion by Mr Allen to define the "Flood Operations Centre"[257] was included and his suggested discussion of "Extreme Floods and Closely Spaced Large Floods" was merged with the discussion of dam safety.[258]

141 The discussion of Strategy S2 and S3 in Draft 6 incorporated the effects of the dam interaction study, including a likely failure rate for Somerset Dam of 109.7m AHD.[259] The discussion of Strategy W4A was amended so that instead of stating that "[g]ate openings are to occur at the minimum intervals" it stated "[g]ate openings are generally to occur at the minimum intervals".[260] Thus, over time, the word "generally" was included twice in W4.

142 The changes suggested in Mr Allen's memo to sections 8.4 and the flowchart were not taken up, save for the reference to peak outflow not exceeding peak inflow. Instead, section 8.4 was changed to its final form.[261] Thus, there was included a restatement of the flood objectives, a statement that "within any strategy" consideration is given to the objectives in making decisions on dam releases, references to choosing strategies based on "actual levels" and the inclusion of the requirement that "[w]hen determining dam outflows within all strategies, peak outflow should *generally* no[t] exceed peak inflow". This

[254] SEQ.004.048.0252; described as the "30 October Draft" in Plaintiff subs at [671].
[255] QLD.012.001.0410.
[256] SEQ.004.048.0252 at .0267; cf QLD.001.001.0146 at .0161.
[257] Ibid at .0258.
[258] Ibid at .0266.
[259] Ibid at .0295 to .0297.
[260] Ibid at .0285.
[261] Ibid at .0278; save for a typographical error re "generally no[t] exceed".

reflected Mr Allen's suggestion, although, as accepted by Mr Malone,[262] his proposal did not include the words "generally". The passage referring to gate opening sequences noted in [113] was deleted.

143 It follows that the only change to Draft 5 that made any reference to actual levels was in the substantive part of section 8.4 which was changed from:

> "The strategy chosen at any point in time will depend on the following predictions which are to be made using the best rainfall forecast and streamflow information available at that time…."[263]

to:

> "The strategy chosen at any point in time will depend *on the actual levels in the dams and* the following predictions which are to be made using the best rainfall forecast and streamflow information available at that time…"[264]

144 Another change reflected in Draft 6 was that the flowchart was amended so that the capacity of the flood engineer to choose between Strategies W1, W2 or W3 "as appropriate" was removed and instead the answers to the various questions as to whether the predicted lake level exceeded 68.5m AHD or 74m AHD was to dictate the strategy that was adopted.[265] Although this was a restriction on the flood engineers' discretion, the change needs to be considered with the amendments to the objectives and conditions for each strategy. Thus, the heading to each of the Wivenhoe Dam strategies was amended to emphasise the "*primary*" objective in each case. For example, the heading to Strategy W1 now read "*Strategy W1 - The Primary Consideration is Minimising Disruption to Downstream Rural Life*", whereas it previously read "*Minimising Impact on Rural Life Downstream*".[266] Equivalent changes were made to Strategies W2, W3 and W4. Further, each of the condition's boxes for strategies for W2, W3 and W4 now included the statement "[l]ower level objectives are still considered when making decisions on water releases" and "[o]bjectives are always considered in order of

[262] T 4927.23.
[263] SEQ.016.010.3563 at .3589.
[264] SEQ.004.048.0252 at .0278.
[265] Ibid at .0279.
[266] Ibid at .0280; SEQ.016.010.3563 at .3591.

importance".[267] The insertion of those statements ameliorated the changes to the flowchart which remove the references to the flood engineers having an ability to choose between strategies as appropriate.

145 When the changes made in Draft 6 from Draft 5 are considered in the context of Mr Allen's memo of 13 October 2009, it reveals that Draft 6 represented a complete rejection of his suggestion to move (or return) to determining strategies by reference to actual levels. The only reference to actual levels that was added was in the passage noted above, but this addition is present within a section replete with references to rainfall forecasts including a statement that strategies change with forecasts. The balance of the Manual, especially the flowchart, maintained references to predictions. Some limits were placed on the flood engineers by the inclusion of the statement about peak outflows, albeit one that was qualified by the word "generally", and the modification of the flowchart to remove the scope of the flood engineer to choose which strategy to apply, but even that was qualified by the express statement within each strategy that lower level objectives should be considered.

146 Seqwater's written submissions included the following assertion about the outcome of the interactions with Mr Allen that lead to Draft 6:[268]

> "Both Mr Tibaldi and Mr Ayre gave evidence that they saw the following changes in the drafting of the Manual *as giving effect to Mr Allen's suggestion*:
>
> (a) the words on pp26 – 27 for the application of strategies W1A-W1E, by reference to actual levels [ie the reference to "Lake level between"]
>
> (b) the instruction at the foot of p27 for the transition from W1 to W2/W3 to occur when the actual level reached EL68.5;
>
> (c) the inclusion of "will depend on the actual levels in the dams", in the paragraph regarding choice of strategy in s8.4 (p23).
>
> This evidence was not challenged in cross-examination. The experience of the drafting of the Manual may not be relevant to its true interpretation. But it is submitted it is relevant to whether the interpretation arrived at by the Flood

[267] SEQ.004.048.0252 at .0283, .0284 and .0285.
[268] Seqwater subs at [670].

Engineers was reasonable in the circumstances in which they were placed at the time."

147 It is unclear whether the "suggestion" of Mr Allen being referred to is the alleged direction that Mr Tibaldi states he received from Mr Allen to maintain actual levels for W1, the memo from Mr Allen dated 13 October 2009 or some aspect of the discussion that followed. Ultimately, it does not matter because the first two of these matters were present in Draft 4, which predated any of those actual or alleged communications from Mr Allen.[269] While they were deleted in the Variation to Draft 4, as I have explained, they were only part of a larger pattern of changes that removed the significance of using actual or predicted storage levels to differentiate between W1 and W3. Hence it is incorrect to assert that either of the first two matters came about because of some "suggestion" of Mr Allen to reintroduce actual levels. In any event, none of the transcript references cited in support of the assertion in this paragraph support it.[270]

148 On 4 November 2009, Mr Tibaldi sent an email to Messrs Allen, Ruffini, Drury, Ayre, Malone and Maher. Attached to the email were some explanatory notes concerning the revisions to Version 6.[271] The memo stated that a "comprehensive review" had resulted in a "major rewrite of the Manual". Under the heading "Improved Operational Descriptions" the memo stated that, given the "infinite" number of flood scenarios, it was "obviously not possible for the Manual to contain a specific procedure relating to every possible flood event scenario" and so "a more practical approach" was being adopted. The notes continued:

> "The new approach <u>does not change the original operational intent contained in the previous Manual</u>, *but does allow the optimisation of flood mitigation benefits, depending on the understanding of the magnitude of the flood event*

[269] See SEQ.016.010.3493 at .3522.
[270] Re Mr Ayre: T 7453 - 5 and T 7611.33 – T 7612.5 (did not address any changes giving effect to a direction from Mr Allen), T 7606.33 – .43 (did not tie changes to a direction from Mr Allen); T 7609.19 – .22 (concerns the definition of flood operations centre), T 7613.24 – T 7614.9 (concerns the definition of flood event); Re Mr Tibaldi: T 5713.39 – .46 and T 5728.38 – T 5729.29 (did not relate any of these aspects of the Manual to a direction from Mr Allen); T 5714.26 – .45 and T 5718.41 – T 5719.10 (concerned the alleged instruction given on 7 October 2009 but did not tie any of these parts of the Manual to a direction from Allen).
[271] SEQ.004.048.0082; SEQ.004.048.0083.

at any point in time. The approach provides strategies and objectives to guide flood operational decision making. The strategy chosen at any point in time will depend on the actual levels in the dams and the following predictions, which are to be made using the best forecast rainfall and stream flow information available at the time:…" (underlined emphasis in SunWater submissions; italicised emphasis added)[272]

149 Thereafter the memo explained how strategies were chosen by reference to the balance of the wording of section 8.4. Under the heading "[r]eview of Manual objectives", the memo explained the change in objectives, stating "[n]aturally, *at the end of an event*, a primary objective is to ensure that the dams are at full supply levels".[273]

150 In its submissions, SunWater emphasised the underlined portion of the above passage as somehow reinforcing a belief said to be held by the flood engineers that the Manual did not affect any substantive change to the conduct of flood operations.[274] However, that submission ignores the description of the "new approach" which encapsulates precisely what the plaintiff says was "new" about the Manual. Instead of using actual lake levels to dictate flood operations, the Manual now identified strategies "and *objectives*" as the basis for flood operations. The optimisation of the flood mitigation objectives now depended on an "understanding of the *magnitude* of the flood event". An understanding of the magnitude of the flood event was to be formed, and could only be formed, by making predictions using rainfall forecasts, rather than just relying on observations. The statement that there was no change to the "original operational intent" was made in documents by Mr Tibaldi produced at the beginning and end of the revision process. However, when considered with everything else that was stated in writing, it did not mean anything more than the intent of optimising the flood mitigation benefit of the dams. How that was to done had been transformed.

151 SunWater also submitted that part of the surrounding circumstances confronting the flood engineers was that in the past the Dams had been operated based on rain on the ground modelling; that during the review one of

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[272] SunWater subs at [200].
[273] SEQ.004.048.0083 at .0086.
[274] SunWater subs at [200] and [212].

the flood engineers expressly reiterated the use of rain on the ground modelling; and that no-one (expressly) stated that they would change.[275] In relation to the first point, there were very few flood events in the years preceding the review and in early 2009 releases were made based on forecasts. In relation to the second and third points, the clearest of statements about the use of rainfall forecasts was made in the documents themselves

152 No reasonably competent flood engineer could have concluded anything other than that Version 7 was a significant and, in some respects radical, revision of Version 6 that included the use of predicted levels and rainfall forecasts.

153 It appears that there was a meeting between the flood engineers, Mr Allen and others on 6 November 2009. That night, Mr Tibaldi sent an email to Messrs Borrows, Pruss and Drury[276] referring to the meeting and recording that Mr Allen had "agreed in principle to gazette the current draft of the flood manual". He foreshadowed approving and sending the final draft, covering letter, and Explanatory Notes to Mr Allen and Mr Borrows by 16 November 2009. He then requested Mr Borrows sign the letter, but only "[o]nce you are happy with the documentation".

154 On 26 November 2009, Mr Tibaldi sent Mr Allen an email,[277] copied to the flood engineers, which attached the final draft of the revision to Version 6 ("Draft 7").[278] Draft 7 corrected some typographical errors from Draft 6, including some changes to the gate opening sequences and added a notation to the discussion of the target operating line in section 9.3 that "the failure level of 109.70m AHD for Somerset Dam assumes all radial gates are fully open and this failure level will be reduced if this cannot be achieved".[279]

[275] SunWater subs at [212].
[276] SEQ.004.048.0218.
[277] QLD.012.002.1658.
[278] QLD.012.002.1661; described as the "26 November Draft" in Plaintiff subs at [684].
[279] Ibid at .1705.

155 On 3 December 2009, Mr Borrows wrote to Mr Allen stating that Seqwater had "recently completed a comprehensive review and revision" of the Manual. He sought final approval.[280]

156 As further discussed in Chapter 5, on 7 December 2009 the Moreton ROP came into force. At this point, it suffices to note that, as at that date, Seqwater's flood engineers had secured, in principle, approval to a revised version of the Manual which, on any view, expressly contemplated the reduction of water levels in Somerset Dam and Wivenhoe Dam during flood operations below FSL, namely to accommodate baseflow. Statements to that effect were included in Draft 1 in early August 2009 and remained in all the drafts thereafter. Further, early in 2009 Seqwater had released water from below FSL at Somerset Dam during a flood event.

157 On 22 December 2009, Mr Allen executed a note recording his approval of the Manual for the purposes of s 371 of the *Safety and Reliability Act*.[281] His note asserted that there "are only minor variations in the overall flood operations procedures" and referred to a summary of the amendments as provided by Seqwater, which appears to be a reference to Mr Tibaldi's explanatory notes.[282] The approval was published in the government Gazette on 22 January 2010.[283]

Mr Malone and the Revision of the Manual

158 In his first affidavit, Mr Malone stated that there were several meetings "between various stakeholders to discuss" the revision of the Manual. He recalled that the "meetings were fairly informal and … the changes suggested to the Manual were not all that significant" and that they "were tweaking the document to better understand the process rather than change the whole operating strategy".[284] When cross-examined by Senior Counsel for SunWater, Mr Malone stated that he could not recall the content of any of the

[280] SEQ.016.015.4269.
[281] SEQ.001.002.4959.
[282] Ie, SEQ.004.048.0083.
[283] Queensland *Government Gazette*, No 15, 22 January 2010 (at 127); EXT.700.002.0001 at .0006.
[284] Malone 1, LAY.SEQ.007.0001 at [167].

discussions. He said that he was focussed on the dam optimisation study, the outcome of which became the operating target line.[285] Senior Counsel for the plaintiff took Mr Malone through the above chronology of the revision of the manual. Mr Malone reiterated his lack of recollection of any particular discussion.[286] However, he accepted that the references to forecasts and predictions were introduced into the various drafts following meetings and discussions and certainly not "by accident".[287] He agreed that they were significant changes.[288] The finding made in [152] applies to Mr Malone.

Mr Tibaldi and the Revision of the Manual

159 Mr Tibaldi did not accept that his explanatory notes described above were referring to the shift from operations based on actual levels to operations based on predicted levels. He maintained that he did not *"see a change in terms of the operational descriptions… from revision 6 to revision 7*".[289] This is another example of the unreliability of Mr Tibaldi's evidence. Whatever he actually believed when he gave evidence, I have no doubt in concluding that, as at November 2009, he was very much aware of the significant changes that had been made to the flood procedures by the revision process, specifically the move from a prescriptive approach to an objectives approach based on strategies, the move from strategies dependent on actual levels to predicted levels and the use of rainfall forecasts. Mr Tibaldi had the carriage of the revision process from beginning to the end. Any doubt about the significance of the changes would have been removed when he received Mr Allen's memorandum of 13 October 2009 advocating a return to the use of actual lake levels, a proposal that was not adopted. To the extent that Mr Tibaldi's evidence was to the contrary, then I reject it. Otherwise the finding in [152] applies to Mr Tibaldi.

[285] T 4742.19 - .32; LAY.SEQ.007.0001 at [247] to [254].
[286] See for example T 4892.35; T 4893.29; T 4900.26.
[287] T 4934.38.
[288] T 4906.36.
[289] T 5948.24 - .27.

Mr Ayre and the Revision of the Manual

160 In his first affidavit, Mr Ayre referred to comments that the flood engineers had made during the meetings to revise the Manual in 2009 to the effect that "*base modelling*" would be performed using rain on the ground, and that the references to "*predictions*" in section 8.4 were intended to capture inflow forecasts based on rain on the ground, not rainfall forecasts.[290] In cross-examination, Mr Ayre said that statements to that effect may have been made before the meetings of 15 and 23 October 2009, but he accepted that that approach did not survive those meetings.[291] At one point in his evidence, like Mr Malone, Mr Ayre agreed that the references to forecasts and predictions were not introduced into the various drafts following meetings and discussions "by accident".[292] However, at other times, he maintained that the inclusion of forecast rainfall was "overlooked".[293] I reject Mr Ayre's evidence to the effect that the inclusion of the rainfall forecasts was some sort of mistake. There was not a single draft created at any time after Draft 2 was prepared that supports the suggestion that the flood engineers sought to base predictions on rain on the ground modelling only. Mr Ayre closely monitored the various drafts as they were prepared. His assertions that the references to forecast rainfall were some sort of mistake have caused me to significantly doubt the reliability of his evidence overall. I am satisfied that he had the same understanding as Mr Tibaldi. Otherwise the finding in [152] applies to Mr Ayre.

Mr Ruffini and the Review of the Manual

161 Mr Ruffini did not give evidence. He received copies of the drafts and participated in the meetings that considered them. I am satisfied he had the same understanding as Mr Tibaldi. Otherwise, the finding in [152] applies to Mr Ruffini.

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[290] Ayre 1, LAY.SUN.001.0001_OBJ, [242]-[243].
[291] T 7612.24 - .33.
[292] T 7612.17 -.22.
[293] T 7612.5.

Conclusion

162 A consideration of the documentary evidence of the process of revision provides no support whatsoever for any assertion that (i) under the Manual any of the strategies or sub-strategies were dependent on actual lake levels; (ii) that the Manual somehow respects a distinction between predictions made by reference to rain on the ground as opposed to rainfall forecasts; and, that (iii) otherwise, there were no substantive changes in approach between Version 6 and Version 7.

163 In relation to (i), two points should be noted. First, while there was considerable attention paid to the wording of the text of section 8.4 there was as much and perhaps more attention paid to the various iterations of the flowchart that followed that section. Mr Ayre's annotations to the various versions of flowchart make it clear that he closely reviewed it. The progression of the versions of the flowchart made it clear that strategy selection, including W1, was dependent on predicted levels and not observed levels (save for the usual invocation of W4 and the transition to W2/W3 at EL 68.5m AHD, should the prediction of a maximum height less than that prove incorrect).

164 Second, the documents concerning the changes between Draft 4 and Draft 6 are particularly illuminating. There were at least three meetings in October 2009, being 7 October 2009, 16 October 2009 and 23 October 2009. The material referable to the meeting on 7 October 2009, including the Variation on Draft 4, suggests that the flood engineers were seeking revisions to Version 6 that gave them a very wide scope for the exercise of professional judgment, including as to what strategy to adopt for so long as the predicted level of the dam was below EL 74.0m AHD (and even some when the actual dam level was above that). The attachment to Mr Allen's email of 13 October 2009 suggests that he was seeking to drastically restrict the scope for the exercise of professional judgment, so much that he would have tied the selection of strategies to actual lake levels. Neither of them achieved their objectives. Instead, a compromise emerged that rejected the use of actual lake levels as a determinant of strategy for Wivenhoe Dam and instead used

predicted lake levels and flow but allowed scope for the exercise of judgment within strategies, the exercise of which had to consider the flood objectives in order of importance. The changes to section 8.4, including the restatement of the flood objectives, the requirement that within each strategy consideration be given to the objectives in determining outflows and the specification that peak inflow should generally not exceed peak outflow, were included to limit the wide scope for professional judgment that the revisions were conferring on the flood engineers compared to Version 6. A consideration of the revision process reveals that these changes were included at the expense of the constraints imposed if strategies were to be determined by actual lake levels.

165 In relation to (ii), there is nothing in any of the material that suggests any advertence to some distinction between the use of rainfall on the ground and forecast rainfall in the making of predictions. Draft 2 introduced the numerous references to rainfall forecasts and the proposed amendments to section 8.3 and 9.3 made strategy selection for Wivenhoe Dam and Somerset Dam dependent on predictions that used rainfall forecasts. While the flowcharts for the selection of Wivenhoe Dam strategy in Draft 2 and Draft 3 may have preserved the significance of actual lake levels and thus potentially diminished the role of forecasts that was not the case for Somerset Dam.

166 Seqwater submitted that the flood engineers' involvement in the revision of the manual forms part of any assessment of the "position of the person" for the purposes of applying s 9(1)(c) of the CLA.[294] SunWater's submissions were to similar effect.[295] Even if that is so, it does not assist the defendants.

167 The plaintiff contended that the contemporaneous documents concerning the revisions to Version 6 only serve to confirm that the Manual in its final form was "intended by its drafters at the time to be read in exactly the manner that is conveyed by its ordinary English meaning", in a manner consistent with its submissions as to how the Manual should be construed, most of which I have

[294] Seqwater subs at [671].
[295] SunWater subs at [123] and [213].

already accepted.[296] I accept the plaintiff's submission. I do not accept that the process of revision of Version 6 to Version 7 of the Manual provides any support for any belief held by any of the flood engineers, assuming it was held, that either the selection of strategies or the conduct of gate operations was not based on predicted lake levels formed by reference to actual rainfall and forecast rainfall. To the contrary, their involvement in that process would have made, and did make, that clear. This reinforces my finding that any belief or understanding they held to the effect that the Manual did not make the choice of strategies and gate operations dependent on predictions made by reference to, inter alia, rainfall forecasts was entirely unreasonable.

4.6: Drafting the Flood Procedure Manual

168 The relevant provisions of the Flood Procedure Manual ("FPM") in its final form are set out in Chapter 3 at [102] to [111].

169 Work on preparation of the FPM commenced as the revisions to Version 6 were being finalised. On 23 November 2009, Mr Tibaldi emailed a first draft of the updated FPM to the other flood engineers with copies to Mr Allen, Mr Drury and others.[297] He sought their "comments prior to finalisation". The attached draft included an early draft of the passage set out in Chapter 3 at [104]. It required mobilisation of the FOC if it was "possible" that FSL would be reached. However, this version only required that judgment be formed based on "rainfall occurring in the dam catchments", that is, based "on the available rainfall and streamflow data".[298]

170 These passages were maintained in the next draft sent to Mr Malone by Mr Tibaldi on 12 January 2010.[299] However, sections 3.2 and 3.3 of this draft, which specified mobilisation and normal operations procedures for the FOC respectively, required the preparation of inflow hydrographs for Wivenhoe, Somerset and North Pine Dams, as well as the Lockyer Creek and Bremer River catchments, using actual rainfall, actual rainfall and forecast rainfall,

[296] Plaintiff subs at [688].
[297] QLD.012.001.0273.
[298] QLD.012.001.0274 at .0283.
[299] SEQ.215.009.8048; SEQ.215.009.8049 at .8059.

actual rainfall and 50% of forecast rainfall, and actual rainfall and 200% of forecast rainfall, which were to be inputted into a gate operations spreadsheet to “determine gate operations strategies”.[300] Revisions containing relevantly identical provisions were circulated between Mr Malone and Mr Tibaldi (and others) on 13 January 2010[301] and 14 January 2011.[302]

171 The final version was circulated by Mr Malone to Mr Tibaldi on 18 January 2010.[303] Of present relevance are two substantial changes. First, as noted in Chapter 3, the final version now required, or at least contemplated, the declaration of a flood event “if significant rainfall is forecast or appears possible” and the decision to mobilise was now to be based on “BOM forecasts and available rainfall and stream flow data”,[304] compared to mobilising based only on “available rainfall and streamflow data”.

172 Second, the reference in section 3.3, which concerned the “Normal Operations” of the FOC, had previously required the preparation and use of hydrographs that utilised actual and forecast rainfall. This was deleted. However, its effect was preserved in that the DFOE was required to undertake the actions referred to in section 3.2 “on an hourly basis”[305] (see Chapter 3).

173 Leaving aside the FPM, Mr Malone said that there was no formal training or “training documents” provided to the flood engineers in relation to Version 7 of the Manual.[306]

174 Mr Ayre agreed that he received a copy of the FPM.[307]

175 The events surrounding the preparation of the FPM would only have reinforced the role to be played by forecasts under the Manual to any flood engineer in the position of Messrs Malone, Tibaldi, Ayre and Ruffini.

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300 SEQ.215.009.8049 at .8065 to .8068.
301 SEQ.004.048.0023; SEQ.004.048.0024.
302 SEQ.215.006.8132; SEQ.215.006.8133 at .8145 and .8152.
303 SEQ.215.007.1961.
304 SEQ.004.028.0001 at .0012.
305 Ibid at .0020.
306 T 4790.27 - .32.
307 T 7852.44.

4.7: SunWater's 2009 Review Intention

176 In its defence, SunWater pleaded various events surrounding the revision of the Manual in 2009.[308] In particular, it pleaded that, prior to the revision of the Manual, "predictions as to lake levels and peak flow rates for the purposes of selecting the flood mitigation procedures and strategies had been made by use of the Real Time Flood Model using rain on the ground" and that "it was recognised by the Flood Engineers that the Flood Mitigation Manual needed to better reflect the manner in which the Real Time Flood Model was utilised for the purposes of selecting strategies, then known as 'procedures'".[309] As the above demonstrates, Version 6 of the Manual did not specify procedures that were engaged by predictions that used rain on the ground or forecast rainfall. Instead, the procedures in Version 6 were engaged by observed storage levels. Further, to the extent that the flood engineers had addressed a flood event prior to the revision in 2009, they used forecast rainfall as a basis for making releases from Somerset Dam.[310]

177 SunWater also pleaded that, in fulfilling its obligations to Seqwater, it was required to operate Wivenhoe Dam and Somerset Dam consistently with what it defined as the "2009 Review Intention".[311] The 2009 Review Intention is said to have been shared by the flood engineers and other members of the "Review Panel" and had three components. The first component was that "the Flood Mitigation Manual needed to be updated to reflect the way that the dams had been operated in the past" and, in particular, to utilise the RTFM.[312] The second component was that in the review process it was not suggested that there would be any alteration as to how the dams had been operated in the past and especially no suggestion that "predictions as to lake levels and/or peak flow rates for the purposes of selecting procedures and strategies would be made using rainfall forecasts as opposed to rain on the ground".[313] The third component was that the revised Manual would "reflect then and past

[308] SunWater Defence, PLE.030.008.0001, [106(c) to (i)].
[309] Ibid at [106(d)].
[310] See section 4.4.
[311] SunWater Defence; PLE.030.008.0001, [106(i)(iii)].
[312] Ibid at [106(g)(i)].
[313] Ibid at [106(g)(ii)].

practice, ie, that for the purposes of selecting procedures and strategies, predictions as to lake levels and peak flow rates would be made using the Real Time Flood Model based upon rain on the ground."[314]

178 In its written submissions, SunWater identified the evidence of Messrs Ayre, Borrows, Pruss, Malone and Tibaldi as supposedly demonstrating the existence of the 2009 Review Intention.[315] I have already addressed the evidence of Messrs Ayre, Malone and Tibaldi. In relation to Mr Borrows, in cross-examination by Senior Counsel for SunWater, he was taken to the various covering emails sent by Mr Tibaldi. He confirmed that he understood that while the Manual was being substantially rewritten "the fundamental intent behind it was not changing".[316] However, he clarified this as meaning only that the "outcomes that you're trying to achieve",[317] (ie, the objectives) had not changed.[318] Mr Borrows confirmed that his knowledge of the manual's requirements was based on what he was told by others and that he did not analyse it himself.[319] Mr Borrows' evidence did not assist SunWater in seeking to establish the 2009 Review Intention.

179 Under cross-examination by Senior Counsel for SunWater, Mr Pruss readily agreed that the substance of the discussions he had with the flood engineers during the review process was that it was directed to "improvements [and] clarifications" but there was to be no "changes to the fundamental objectives or way a flood could be managed".[320] He also agreed that it was not suggested to him during the course of the review that there was going to be any changes "in the intention of the operational procedures" and that previously "nobody really operated the dams on forecasts, because of the imprecision in the science.[321] Senior Counsel for the plaintiff cross-examined

[314] Ibid at [106(g)(iii)].
[315] SunWater subs at [2854] to [2870].
[316] T 4010.34.
[317] T 4010.43.
[318] T 4037.6.
[319] T 4034.39.
[320] T 4233.45.
[321] T 4236.46; T 4240.19.

Mr Pruss on the description of the "new approach" set out in Mr Tibaldi's explanatory notes, referred to above, as follows:[322]

"Q. His [Mr Tibaldi's] second point is: Change in approach from procedural based to strategy and objective based ...Do you see that?
A. Yes, I do see that.

Q. That reflects the change from the reactive actual lake level approach to operations to the proactive prediction-based operations, doesn't it?
A. *I can see that you would interpret it that way.*

Q. Well, does it or doesn't it?
A. It could mean a number of things. I'm not Mr Tibaldi. I'm not sure what he intended with that comment.

Q. You were very happy to accept what [Senior Counsel for SunWater] put to you, even though you were not Mr Tibaldi, based on an earlier email from Mr Tibaldi, weren't you?
A. Based on my understanding of what that email said, yes.

Q. What's your understanding of what this email says?
A. That he made some changes to procedure based on objectives.

…

Q. Did you understand that revision 7 of the manual had introduced the concept of using forecasts to make predictions about lake levels?
A. I understand it was written in that they were looking at forecasts, yes.

Q. I'm not asking you about what was written in, Mr Pruss. I'm asking you about whether your understanding of revision 7 of the manual had introduced the concept of using forecasts to making predictions about lake levels. Please answer that question.
A. *And my answer is I don't recall exactly at the time, Mr Sexton, what I assumed or understood to be*." (emphasis added)

180 I formed an adverse view of Mr Pruss as a witness when he gave evidence. In this extract, he did not address himself to the direct import of the question which was drawing his attention to Mr Tibaldi's description of a "new approach". In the end result, I am not satisfied that Mr Pruss had any recollection of his understanding about the course or outcome of the Manual revision process.

181 Based on the findings that I have made, it follows that I am not satisfied that any relevant part of the 2009 Review Intention was established. Prior to the

[322] SEQ.206.006.8743; T 4352.14 to T 4353.16.

revision process, Version 6 employed observed storage levels, not predictions, as the determinants of strategy. In the May 2009 Flood Event, the flood engineers made precautionary releases from Somerset Dam based on rainfall forecasts. The process of the revision to Version 6 made it clear to all concerned that there were significant changes being made to the relevant procedures, including making strategy selection dependent on predicted storage levels with such predictions made by reference to rain on the ground *and* rainfall forecasts.

4.8: The Moreton ROP and the March 2010 Flood Event

182 The first flood event for either of Wivenhoe Dam or Somerset Dam, after the approval of the Manual, was declared on 1 March 2010 (the "March 2010 Flood Event").[323] Since the May 2009 Flood Event, the manual had been revised and the Moreton Resources Operations Plan had commenced on 7 December 2009. This is addressed in Chapter 5 but at this point it suffices to state that, according to Seqwater, it precluded any releases of water from below FSL from either dam for any purpose, including flood mitigation, other than meeting downstream demand.[324]

183 The flood event report for the March 2010 Flood Event was prepared by Mr Ayre[325] although he was not involved in the event due to illness.[326] Under the heading "Flood Management Strategies", the report describes the event as follows:[327]

> "*Seqwater commenced operational releases from Somerset Dam on Wednesday 24th February 2010 at 9:30 as the lake level was just below FSL at EL 98.87m AHD*. These releases were instigated to draw down the storage in Somerset Dam as Wivenhoe Dam was still at a relatively low level (around 61% capacity). Initially the objective of these releases was to draw Somerset Dam down to approximately EL 98.0m AHD or about 90% of capacity.
>
> *However, event rainfalls resulted in operators at Somerset Dam being mobilised for flood operations at 9:00 on Monday 1st March 2010. The lake*

[323] T 7804.17 (Ayre).
[324] See Chapter 5 at [17] and [29] to [33].
[325] SEQ.001.019.6628 at .6629.
[326] T 7805.45.
[327] SEQ.001.019.6628 at .6667 to .6668.

level at this time was EL 98.62m AHD and rising with one cone valve open 100%. The dam was releasing at a rate of 68m^3/s or 5,875 ML/day.

There is no formal record of Somerset Dam being mobilised in the FOC Flood Log and no record of an instruction to open the radial crest gates at this time. As a result, the radial crest gates remained closed at this time.

Initial assessment of the flood magnitude suggested that Somerset Dam was expected to exceed FSL (EL 99.0m AHD) and that Wivenhoe Dam was not expected to reach FSL (EL 67.0m AHD). Therefore, Strategy S1 of the Somerset Dam flood operation procedures was implemented. The objective of this strategy is to return the reservoir to FSL, whilst minimizing the impact on rural life upstream of the dam. The radial crest gates should [have been] raised to enable uncontrolled discharge, whilst regulator valves and sluice gates are to be used to maintain the level in Somerset dam below EL102.0m AHD. The release rate from Somerset Dam is not to exceed the peak inflow into the dam.

Somerset Dam attained FSL at 6:45 on Tuesday 2nd March 2010 and as a consequence, opening of the remaining regulator cone valves commenced. All four regulator cone valves were fully opened by 18:00 that afternoon with the dam releasing 276m^3/s. The lake level was EL99.32m AHD and rising. Opening of sluice gates commenced at 21:00 in an attempt to arrest the rising reservoir level in order to minimize the upstream impacts. Sluices L, M and N were eventually opened. Sluice N was opened in preference to Sluice K because of maintenance preferences.

Somerset Dam peaked at EL 99.45m AHD at around 22:00 on Tuesday 2nd March 2010. The maximum release rate of 885m^3/s occurred at 03:00 on the morning of Wednesday 3rd March 2010. This release was larger than the peak inflow of around 700m^3/s, although at the time of the peak release the estimated inflow was estimated to be 900m^3/s. This estimate was reduced later in the event when there was more confidence in the rainfall on the ground and the volumetric water balance.

Sluice gate releases continued until 17:00 on Wednesday 3rd March 2010. Somerset Dam operators were de-mobilised at 21:00 on Wednesday 3rd March 2010, but operational releases through the regulator cone valves continued until 6:30 on Thursday 18th March 2010." (emphasis added)

184 The following six matters should be noted about this description of the March 2010 Flood Event.

185 First, it is clear from this description that a flood event was declared and the FOC was mobilised prior to Somerset Dam reaching FSL. Mr Tibaldi agreed that the declaration was based on a prediction that Somerset Dam would exceed FSL, although he said it was based on an assessment using rainfall

on the ground.[328] Mr Ayre's evidence was to similar effect,[329] although he could not recall whether or not the prediction was based on forecast rainfall.[330]

186 Second, this description confirms that releases were made from Somerset Dam prior to the dam reaching FSL with the initial objective of drawing the dam down to 90% of FSL. However, in light of further rain, a flood event was declared and releases during a flood event commenced through a cone valve with Somerset Dam still below FSL. Thus, at 6.30am on 2 March 2010, Mr Tibaldi issued "Flood Event Directive No 1", requiring the opening of a further cone valve when the Somerset Dam level was at EL 98.92m AHD.[331] Mr Tibaldi was asked about this release as follows:[332]

> "Q … what you're doing there is making a release when the dam level is below FSL, during a flood event, in circumstances where you're not closing gates, you're opening gates; correct?
> A. Well, that's Somerset Dam under S1, yes. You can't do that at Wivenhoe given the requirements to not open gates until EL67.25, but Somerset, yes, under S1, that's what we're doing, yes."

187 Other than confining the basis for precautionary releases to predictions based on rain on the ground, this answer is consistent with the analysis in section 3.3.13 of Chapter 3.

188 Third, for some reason the crest gates at Somerset Dam were closed at the beginning of the event and not opened until 7 March 2010. This report identifies the relevant strategy invoked as S1, which requires the crest gates to be raised. The report accepts that the failure to open the gates at the commencement of the flood event was contrary to the Manual.[333]

189 Fourth, the maximum release rate from Somerset Dam of 885m^3/s during the event exceeded the maximum inflow rate of 700m^3/s, although the report stated there was an overestimate of that inflow rate during the event

[328] T 6205.9.
[329] T 7804.24.
[330] T 7806.8.
[331] SEQ.083.001.0390.
[332] T 6205.25.
[333] See also Mr Tibaldi's evidence at T 6208.47; SEQ.001.019.6628 at .6668 to .6669.

(900m^3/s). Mr Ayre could not recall whether the estimated peak inflow rate during the event was considered to be the maximum peak experienced to date or the greater of that rate and the highest predicted peak determined by reference to rain on the ground.[334] (However, he ultimately proffered the latter approach as the correct construction of the Manual.[335])

190 Fifth, a graph of the height level at Somerset Dam shows that the dam level increased to around EL 99.5m AHD at midnight on 2 March 2010 but drained down to about EL 98.6m AHD a few days later before filling back to FSL on or around 8 March 2010:[336]

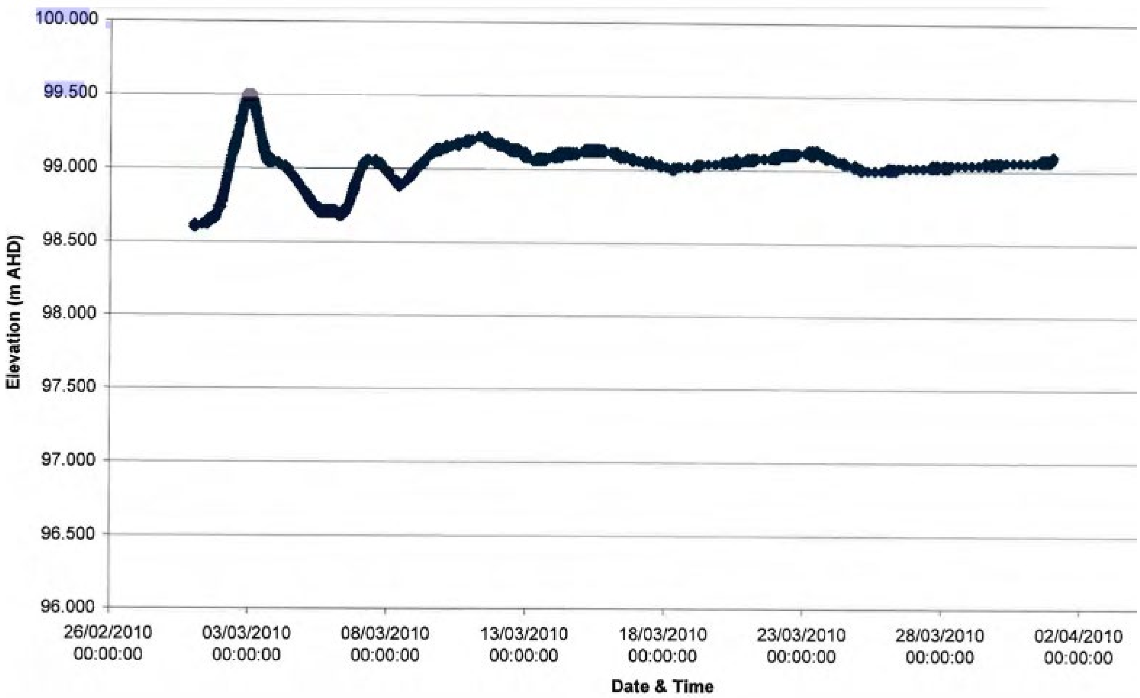

Figure 4-6: Elevation levels of Somerset Dam during March 2010 Flood Event

191 The plaintiff submitted that this demonstrated that, as with the May 2009 Flood Event, "[a]t the end of the event, Somerset Dam was drained down well below FSL".[337] Mr Tibaldi was taken to this graph and agreed that "in the drain down phase, releases were made such that the dam level went well below

334 T 7808.33.
335 T 7813.15 - .38.
336 SEQ.001.019.6628 at .6705.
337 Plaintiff subs at [923].

FSL"[338] before being filled by either further rain or baseflow.[339] However, SunWater submitted that the above graph indicates that, at around the time the flood event ended at 21:00 on 3 March 2010, the level of Somerset Dam was around FSL such that the above graph "is actually representative of operational releases made after the conclusion of the flood event".[340] On the basis that "operational releases" merely mean releases not made during a flood event,[341] SunWater's submissions on this should be accepted. An email from Mr Tibaldi sent at 9.21pm on 3 March 2010 refers to the level of Somerset Dam as EL 99.00 with the event declared over and the sluice gates closed.[342] However, the graph and the material discussed below suggest, and I so find, that these releases below FSL, even if labelled "operational releases", were still undertaken for flood mitigation purposes, specifically to create storage space for baseflow and to minimise the likelihood of further inflows from rainfall triggering another flood event.

192 Sixth, in light of the provisions of the Moreton ROP which was in force in 2010 and the submissions concerning its effect,[343] it is appropriate to consider the nature and purpose of the "operational releases" that "commenced" from 24 February 2010, referred to in the above extract from the relevant flood event report in more detail. Mr Tibaldi suggested that the balancing up of storages "gave more room for camping and just from a safety point of view of recreational management and boating and things".[344] Releases from below FSL to increase recreational amenity would not be consistent with clause 72(3) of the Moreton ROP.[345] Mr Drury noted that any flow that passed from Somerset Dam to Wivenhoe Dam was ultimately for "water supply" but added that in making those releases "*we were merely keeping it down to a lower level rather than risk it getting too high so we could make releases out*

[338] T 6210.17.
[339] T 6210.21.
[340] SunWater subs at [1710].
[341] See [64].
[342] SEQ.001.019.4161.
[343] See Chapter 5.
[344] T 6207.6.
[345] See Chapter 5 at [17].

of Somerset all the time";[346] ie, reducing the level of Somerset Dam to avoid having to make flood releases later.

193 Mr Drury stated that the water yield in the Moreton ROP was calculated on the total storage available in Somerset and Wivenhoe Dams.[347] He stated that releases from Somerset Dam into Wivenhoe Dam were made to "allow Wivenhoe to supply downstream demand because the water from Somerset has to be released into Wivenhoe to supply downstream demand".[348] Ultimately, whether releases made from Somerset Dam into Wivenhoe Dam were, as Mr Drury contended, made to meet downstream demand (and thereby comply with the Moreton ROP) depends on the circumstances of the particular release, the level of downstream demand and the respective levels of each dam. The present issue concerns the characterisation of "operational releases" made from 24 February 2010 onwards. The contemporaneous documents suggest those releases were not made out of any concern to meet downstream demand, but instead were made to create storage space for inflows with a view to avoiding flood releases (or at least minimising them). That characterisation is consistent with Mr Ayre's understanding but it is not consistent with clause 72(3) of the Moreton ROP.

194 Thus, on 18 February 2010, Mr Drury sent an email foreshadowing making releases to return Somerset Dam to 90% of FSL.[349] This was proposed to be done through the cone valves, although there was a concern that it created a risk to staff from the release of hydrogen sulphide.[350] The above extract from the relevant flood event report refers to the operational releases commencing on 24 February 2010. On 25 February 2010, Mr Drury emailed Mr Pruss advising him that one cone valve was open "[m]*ainly to reduce Somerset from 98% to a level that won't require flood releases and resultant impacts if we receive any rain*."[351] The next day, Mr Drury emailed the flood engineers reminding them that Somerset Dam had "got to over 90%" and that "to drop it

[346] T 6665.26.
[347] T 6666.12.
[348] T 6668.44.
[349] SEQ.016.075.2752.
[350] SEQ.016.017.9585; a phenomenon witnessed at the view conducted in February 2018.
[351] SEQ.206.008.4639.

back to around 90% we are releasing through the cone valve as *in previous events*" as that would *"provide some leeway in case we get rainfall over the coming weeks*".[352] The reference to "previous events" appears to be a reference to previous flood events.

195 These emails suggest that, whatever the reasons for reducing Somerset Dam water levels below FSL by making "operational releases" at other times, when a flood event was anticipated, "operational releases" were made in anticipation of inflows in order to avoid or at least minimise flood releases. This is what occurred prior to the May 2009 Flood Event[353] and it is also what occurred in the immediate period after this flood event ended. Thus, as noted, an email from Mr Tibaldi sent at 9.21pm on 3 March 2010 refers to the level of Somerset Dam as EL 99.00 AHD, with the event declared over and the sluice gates closed.[354] On the morning of 5 March 2010, Mr Malone sent Mr Drury and Mr Tibaldi an email advising of rainfall in the "top end" of the Stanley River.[355] On the evening of 6 March 2010, Mr Drury emailed Mr Pruss, Mr Borrows and Ms Moore advising that the FOC was mobilised that evening with the North Pine gates due to open.[356] In relation to Somerset and Wivenhoe Dams, Mr Drury stated:

> "Somerset continues to rise and I instructed the operator to open all four cone valves 100% *to try to keep below 100%.* Wivenhoe is expected to reach over 85% this coming week after good rainfall in the catchment this weekend." (emphasis added)

196 Mr Drury agreed that, as the levels of Somerset Dam were rising, he directed the making of these releases "so that Somerset didn't go over full supply level".[357] He was then asked how these releases were consistent with the necessity to meet downstream demand referred to in the Moreton ROP as follows:[358]

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[352] SEQ.016.010.5189.
[353] See [66].
[354] SEQ.001.019.4161.
[355] SEQ.016.015.9191.
[356] SEQ.206.008.6763.
[357] T 6680.24.
[358] T 6680.27 to T 6681.7.

"Q. My question was that instruction was being given for flood mitigation purposes, not because it was necessary to supply downstream demand; that's correct, isn't it?

A. I can't say it was for flood mitigation - *it was to move water so that we didn't trigger a flood centre mobilisation release out of Somerset*. Wivenhoe was below full supply, so releasing water from Somerset into Wivenhoe made no difference in terms of impacting Wivenhoe. So the same as what we were doing as we said in February, getting it down to 90 per cent, versus the same lowering of the Somerset and moving the water coming in into Wivenhoe.

Q. If that instruction was being given for flood mitigation purposes and not because it was necessary to supply downstream demand, and it was given at a time when Somerset Dam was below FSL, then there would be a non-compliance with the Moreton Resource Operations Plan; correct?

A. I'd have to - could you say that again? If you're making - you're asking if I assumed that it was flood mitigation, which I said

Q. Yes.

A. -- it wasn't, it was for moving water. *So it was what we do regularly and I would consider it is in compliance with the resource operating plan because we always moved water from Somerset into Wivenhoe*. For operational purposes, it has to be moved in regardless." (emphasis added)

197 Generally, I found Mr Drury's evidence unsatisfactory. I formed the view that he was determined to avoid making any concession that the "operational releases" he directed were in any way connected with flood mitigation. Ultimately, he failed because, as a matter of substance, releasing water for the purpose of creating storage space to avoid exceeding FSL, and thereby avoiding making (potentially larger) "flood centre mobilisation releases" at a later time, is a form of flood mitigation. In the end result, Mr Drury's explanation amounted to no more than a contention that, as all releases from Somerset Dam flowed into Wivenhoe Dam, it followed that any release from Somerset Dam below FSL into Wivenhoe Dam was necessarily to meet downstream demand and could not be for flood mitigation.

198 The plaintiff focused on the March 2010 Flood Event (and the May 2009 Flood Event) for the purpose of demonstrating three matters. First, that flood releases were made below FSL from Somerset Dam during a declared flood event. That occurred with both flood events.[359] Second, that, as a matter of

[359] See [56] to [58], [68] and [186].

substance, releases were made below FSL from Somerset Dam in advance of predicted inflows in both events for flood mitigation purposes. The plaintiff also demonstrated that this occurred in both events.[360] Third, the plaintiff sought to demonstrate that with both flood events, releases were made below FSL based on forecast rainfall. That was demonstrated with the May 2009 event.[361] The advance releases from 24 February 2010 were made based against the contingency of rain falling.[362]

199 All that the defendants established in response were two instances of circular reasoning. The first was that if, by definition, "operational releases" and not "flood releases" are made below FSL, then the releases below FSL were not flood releases.[363] The second was, if all releases from below FSL from Somerset Dam flow into Wivenhoe Dam which is the source of drinking water, then those releases necessarily meet downstream demand and satisfy clause 72(3) of the Moreton ROP, and could not be for the purposes of flood mitigation. Neither of those matters deny the plaintiff's points.

200 The question of whether as at the time of the January 2011 Flood Event releases below FSL were permitted is addressed in Chapter 5. However, at this point it suffices to note that, in its defence, Seqwater pleaded that, at all material times, it was the general procedure, or alternatively the policy, in the management of Wivenhoe and Somerset Dams not to make "precautionary releases" of water in reliance on rainfall forecasts.[364] Seqwater also pleaded in relation to the alleged breaches that it had "*long been the practice in the management of the dams not to make pre-releases in reliance on forecasts*".[365]

201 Although there were numerous assertions to this effect in the written and oral evidence of the SunWater's witnesses, neither of them was borne out by the objective evidence concerning flood operations conducted prior to the end of

[360] See [48] to [54] and [66] to [67] and [195].
[361] See [50] and [52]; [66].
[362] See [194].
[363] See [68] to [69] above.
[364] Seqwater Defence, PLE.020.012.0001 at [87A].
[365] Eg, Ibid at [299(da)(i)].

2010. Given the long period of drought, there had been relatively few flood events in the years prior to 2010. However, during both the May 2009 Flood Event and the March 2010 Flood Event, precautionary or pre-releases were made based on rainfall forecasts and they were made below FSL at Somerset Dam.

4.9: Late 2010 Flood Events

202 The warnings about climatic conditions being affected by a La Niña event are noted in Chapter 2. In the months preceding the flooding in January 2011 there were four "flood events" specifically one in October 2010 (the "October Flood Event") and three in December 2010 (the "Early December Flood Event", the "Mid-December Flood Event" and the "Late December Flood Event" respectively). Seqwater published a combined flood event report concerning those four events in May 2011 (the "2010 FER"[366]), that is, some two months after publication of the flood event report for the January 2011 Flood Event ("January FER").[367]

203 The 2010 FER draws a distinction between the designated start date for each event and the time at which the FOC was mobilised, with the former said to account for "antecedent conditions and any rainfall which occurred prior to mobilisation of the Flood Operations Centre".[368] With all four flood events, the mobilisation was said to have occurred "well before gate opening trigger levels were reached at the Dams during each flood event".[369] The reference to "gate opening trigger levels" is to EL 67.25m AHD at Wivenhoe Dam, as referred to in section 8.3 of the Manual.[370] With the flooding in January 2011, the FOC was not mobilised until the day after the trigger level was reached.[371] As noted in Chapter 3, the Manual requires there to be a declaration of a flood event when the duty flood engineer forms the opinion that FSL will be exceeded. The trigger level of EL 67.25m AHD is irrelevant to that process.

[366] ROD.650.003.6506 ("2010 FER").
[367] SUN.016.001.0280 ("January FER").
[368] 2010 FER at .6521.
[369] Ibid at .6514.
[370] See Chapter 3 at [33].
[371] See Chapter 6.

204 Thus, the October 2010 Flood Event had a designated start time of 9.00am on 6 October 2010, the FOC was mobilised at 6.30am on 9 October 2010 and flood releases commenced at 7.00pm on 9 October 2010. Flood operations ceased at 9.15am on 19 October 2010.[372] The event was preceded by above average rainfall in September 2010 such that the 2010 FER described the Dam catchments as "relatively wet" by the time the event started.[373] An indication of the relative saturation of the catchments is derived from considering the estimated initial loss figure set out in the 2010 FER. For the October event, the estimated initial loss figure for the Somerset Dam catchment was 45mm and for the Wivenhoe Dam catchments was 42mm.[374]

205 The total of the average catchment rainfalls for the Somerset Dam catchment for the period 6 October 2010 to 14 October 2010 within the October Flood Event was 260mm and for the Wivenhoe catchments it was 110mm.[375] According to the 2010 FER, the total inflow volume into Somerset Dam during this event was 281,963ML and into Wivenhoe Dam it was 663,818ML. The former reached a maximum height of EL 101.32m AHD and the latter EL 69.65m AHD. The peak outflow from Wivenhoe Dam was 1508m^3/s, which by itself would inundate all downstream bridges other than Fernvale Bridge and Mt Crosby Weir Bridge.[376]

206 The early December Flood Event had a designated start time of 9.00am on 1 December 2010, the FOC was mobilised at 7.00am on 11 December 2010 and flood releases commenced at 12.30pm on 13 December 2010.[377] Flood operations ceased at 10.30am on 16 December 2010.[378] The 2010 FER records the rainfall conditions in November 2010 as being below average, which led to a "slight drying out of the catchments" by early December 2010.[379] This is reflected in the estimated initial loss figure for the Somerset

[372] 2010 FER at .6515, .6521.
[373] Ibid at .6521.
[374] Ibid at .6524.
[375] Ibid at .6542.
[376] Ibid at .6624.
[377] Ibid at .6514, .6521.
[378] Ibid at .6517.
[379] Ibid at .6522.

Dam catchment of 54mm and for the Wivenhoe Dam catchments of 58mm,[380] which are greater than the corresponding figures for the October Flood Event. The rainfall received during the early December Flood Event was described in the 2010 FER as being of "low intensity and scattered throughout the Basin".[381] The cumulative totals for gauges upstream of the Dams for the 15 days from 9.00am on 1 December 2010 varied between 53mm and 272mm.[382] According to the 2010 FER, the total inflow volume into Somerset Dam during this event was just over 98,000ML and the inflow volume into Wivenhoe Dam was just over 111,000 ML. The former reached a maximum height of EL 99.89m AHD and the latter EL 67.35m AHD. The peak outflow from Wivenhoe Dam was 291m^3/s.[383]

207 The mid-December Flood Event had a designated start time of 9.00am on 16 December 2010. The FOC was mobilised at 10.00am on 17 December 2010 and flood releases commenced at 6.00pm on 17 December 2010. Flood operations ceased at around 3.00pm on 24 December 2010.[384] As this event followed soon after the early December Flood Event, the catchments were wet when it commenced. For this event, the 2010 FER stated that estimated initial loss figure for the Somerset Dam catchment was 31mm and for the Wivenhoe Dam catchments was 46mm.[385]

208 The total of the average catchment rainfalls received in the Somerset Dam catchment for the period 17 December 2010 to 24 December 2010 was 115mm and for the Wivenhoe catchments it was 71mm,[386] although there is some doubt over that figure.[387] The bulk of this rain fell on two days being 18 December 2010 and 20 December 2010. According to the 2010 FER, the total inflow volume into Somerset Dam during this event was just over 133,000ML and into Wivenhoe Dam was just over 450,000 ML. The former

[380] Ibid at .6524.
[381] Ibid at .6553.
[382] Ibid at .6554 (excluding one reading of 968mm which is either anomalous or a cumulative reading of other rainfall).
[383] Ibid at .6626.
[384] Ibid at .6514, .6521.
[385] Ibid at .6524.
[386] Ibid at .6570.
[387] See Chapter 9, section 9.3.

reached a maximum height of EL 100.45m AHD and the latter EL 68.24m AHD. The peak outflow from Wivenhoe Dam was 1462m^3/s.[388] All bridges other than Fernvale Bridge and Mt Crosby Weir Bridge were inundated.[389]

209 The Late December Flood Event had a designated start time of 9.00am on 24 December 2010.[390] The FOC was mobilised at 5.30am on 25 December 2010 and flood releases commenced at 09.00am on 26 December 2010.[391] Flood Operations ceased at around 9.45am on 2 January 2011.[392] As explained below, the plaintiff contended that flood operations should not have ended then but instead should have continued throughout January 2011. By the time the Late December Flood Event commenced it can be expected that the catchments were very wet, if not saturated. The 2010 FER stated that the estimated initial loss figure for the Somerset Dam catchment for this event was 14mm and for the Wivenhoe Dam catchments it was 22mm.[393]

210 According to an average catchment rainfall table in the 2010 FER, the average catchment rainfall for the Somerset Dam catchment for the period 25 December 2010 to 1 January 2010 within the Late December Flood Event was 111mm and for the Wivenhoe Dam catchments it was 80mm.[394] The vast bulk of that rain, 90mm and 76mm for Somerset and Wivenhoe catchments respectively, fell within the four days from 25 December 2010 to 28 December 2010. According to the 2010 FER, the total inflow volume into Somerset Dam during this event was just over 127,000ML and into Wivenhoe Dam it was just over 555,000ML. However, as explained in section 9.3 of Chapter 9, there is some uncertainty concerning those rainfall and runoff figures. It suffices to state that the estimates of the proportion of runoff to rain vary between 75% and 86%.[395] Somerset Dam water levels reached a maximum height of EL 99.99m AHD and Wivenhoe Dam water levels reached a maximum height

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388 2010 FER at .6626.
389 See Ayre 1, LAY.SUN.001.0001 at [1011] to [1012].
390 2010 FER at .6521.
391 Ibid at .6514.
392 Ibid at .6519.
393 Ibid at .6524.
394 Ibid at .6598.
395 See Chapter 9 at [186], [187], [191].

of EL 69.36m AHD. The peak outflow from Wivenhoe Dam was 1591m^3/s.[396] This had the effect of inundating all downstream bridges other than Mt Crosby Weir and Fernvale Bridge.[397]

211 In respect of all these December events, the 2010 FER stated that Strategy W1 was used to manage "the event at Wivenhoe Dam until the dam level exceeded 68.5m AHD, then Strategy W3 was used because the conditions for using Strategy W2 could not be satisfied" and that Strategy S2 was used to manage Somerset Dam.[398]

212 During the evening of 1 January 2011, Mr Malone sent Mr Drury and Mr Forster an email that contained a table setting out a comparison of the volume of inflows and outflows in the October and December flood events against earlier flood events, including the severe flooding in 1974. Early the next morning, Mr Drury responded, noting that the table was "[very] interesting" and that in the "last 3 months we have discharged almost the 1974 flood flow", "[w]e have never made releases in Oct[ober], or Dec[ember] before" and "[n]ever made 3 releases in one year before".[399]

213 Based on the evidence of two meteorologists,[400] the plaintiff contended that in early 2011, the cumulative impact of the BoM's advice about the seasonal weather outlook, their knowledge of the recent rain and the recent flood events would have indicated to the reasonably competent flood engineer that there was a high probability of further relatively high rainfall given that it was still early in the wet season.[401] I accept that contention. As Mr Malone stated in evidence, "*the rainfall wasn't about to change in the next three months*".[402] The plaintiff further contended that, in those circumstances, "[a] reasonable flood engineer would not have regarded the water security situation to be so precarious that, in balancing the competing objectives in the Manual, any

[396] 2010 FER at .6627.
[397] See LAY.SUN.001.0001 at [1421].
[398] 2010 FER at .6625 and .6627.
[399] SEQ.016.018.1598.
[400] Kane 1, EXP.ROD.011.0011_OBJ, [126]-[127]; see also Walsh 1, EXP.ROD.014.0034, [3.2].
[401] Plaintiff subs at [983] to [984].
[402] T 5067.16.

significant extra weight would have been attached to ensuring that the dams were filled to FSL at the conclusion" of a flood event.[403] I also accept that contention, so far as it goes, bearing in mind that retention of water at FSL at the conclusion of an event always remained an objective for flood operations and, at the conclusion of a flood event, the higher order objectives would have mostly fallen away. That said, the matters pointed to by the plaintiff would have also enabled a flood engineer to have greater confidence during a flood event that, even if they made releases below FSL then, depending on the forecasts, sufficient rain to fill the dams would be forthcoming.

4.10: Inundation of Rural Bridges in Late 2010

214 In his first affidavit, Mr Ayre noted that releases made during the October Flood Event inundated all of the downstream bridges, other than Mt Crosby Weir and Fernvale Bridge.[404] (That was also the position with the mid-December Event and the Late December Flood event.) Mr Drury noted that after that occurred "there followed a campaign by residents, the media and councils that there should be a stop to bridge closures".[405] Mr Pruss[406] and Mr Borrows were aware of these concerns.[407]

215 On 19 December 2010, the SEQ Water Grid Manager, Mr Dennien, wrote to Mr Drury seeking to alter the then current release strategy to minimise the impact on downstream bridges.[408] On 22 December 2010, Mr Bob Reilly (of DERM) emailed Mr Borrows asking whether Seqwater had *"provided them* [affected persons] *with some support arrangements to deal with these access issues*" because it was "one thing to ask for such people to be inconvenienced (in the absence of some support arrangements) for a few days once every 5 to 10 years, but it is another matter if these events occur on a monthly (or more frequent) basis – as may well happen over the next few months".[409]

[403] Plaintiff subs at [985].
[404] Ayre 1, LAY.SUN.001.0001_OBJ, [663].
[405] Drury 1, LAY.SEQ.006.0001_OBJ, [146].
[406] Pruss 1, LAY.SEQ.003.0001_OBJ, [57], [59], [60].
[407] Borrows 1, LAY.SEQ.005.0001_OBJ, [26].
[408] Email Dennien to Drury and others (19 December 2010), SEQ.016.002.7616.
[409] Email Reilly to Borrows, Drury and others (22 December 2010), SEQ.016.017.4970, at .4972.

216 Sometime around 22 December 2010, Messrs Tibaldi and Drury exchanged emails about the benefits of reducing Wivenhoe Dam to 95% of FSL.[410] In his affidavit, Mr Drury stated that this "correspondence related to the pressure from communities and councils to minimise impact on bridges"[411] (although the assessment report also addressed the effect on urban flooding).[412]

217 The plaintiff contended that these complaints and the associated campaign "created an atmosphere of '*pressure'*" by early January whereby the flood engineers were reluctant to inundate bridges and [were] determined to keep bridges open for as long as possible to avoid "*criticism*" and that instead "[i]t was easier in these circumstances to let natural flows close bridges where possible". The result, according to the plaintiff, was that the flood engineers "did not, turn their minds to how they could provide optimum protection of urban areas from inundation by 'pre-releases'".[413]

218 The flood engineers were clearly aware of the concerns raised about the impact of inundating downstream bridges.[414] In a draft Ministerial briefing note he prepared after the January 2011 Flood Event, Mr Tibaldi stated that in the three flood events leading up to the Late December Flood Event "pressure was experienced from residents impacted by bridge closures downstream of the dam to curtail releases as soon and as quickly as possible".[415] In his affidavit, Mr Tibaldi said that he understood that the Queensland Government had received complaints "*from the rural communities downstream of Wivenhoe Dam in relation to the bridge closures that occurred during the October 2010 Flood Event*".[416] In cross-examination, Mr Tibaldi maintained that it did not affect his approach to flood mitigation during the January 2011 Flood Event.[417]

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[410] SEQ.016.011.8145; SEQ.016.017.4970.
[411] Drury 1, LAY.SEQ.006.0001_OBJ, [77]; Email Tibaldi to Drury (22 December 2010), SEQ.016.017.4970.
[412] SEQ.016.008.9237 at .9239.
[413] Plaintiff subs at [995] to [997].
[414] See T 5226.13 (Malone); T 7877.31 (Ayre).
[415] Draft briefing note (15 January 2011), SEQ.001.018.7228 at .7232.
[416] Tibaldi 1, LAY.SEQ.004.0001_OBJ, [328]; T 5661.8 (Tibaldi).
[417] T 6136.47 to T 6137.11.

219 I address the contemporaneous evidence concerning the flood engineers' conduct during the January 2011 Flood Event in Chapters 6 and 7. I am overwhelmingly satisfied from that material that, when considered in light of the plain words of the Manual, the flood engineers unduly prioritised avoiding inundating downstream bridges at the expense of higher order objectives and, in particular, at various points unreasonably delayed increasing releases so as to allow natural downstream flows (and existing releases) to inundate bridges first. For the reasons discussed later, those findings support the findings of breach. It is not necessary to theorise why the flood engineers acted in that way, although I accept that their actions during the January 2011 Flood Event are consistent with them being unduly concerned about the prospect of criticism of the kind that was made throughout October to December 2010.

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CHAPTER 5: FULL SUPPLY LEVEL

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CHAPTER 5: FULL SUPPLY LEVEL

1 The first common question posed by the parties is whether Seqwater, SunWater or their employees and agents were prohibited by law from releasing water from Somerset Dam or Wivenhoe Dam below each Dam's Full Supply Level ("FSL") for the purposes of conducting flood operations and, if not, in what circumstances could such releases be made?[1]

2 At no stage during the course of the January 2011 Flood Event did the flood engineers have cause to consider whether to release water from below FSL in either Somerset Dam or Wivenhoe Dam. As explained in Chapter 6, the Late December Flood Event was declared over when both dams were still above FSL and their respective water levels never fell below FSL thereafter.

3 Nevertheless, the question of whether such releases could and should have been made is critical to at least some of Dr Christensen's counterfactual simulations. The plaintiff contended that the flood engineers were permitted, by both the statutory regime and the Manual, to make such releases[2] and that, if permitted to do so, it should have been done "as an obvious, common sense way to achieve a better outcome".[3]

4 The defendants made a number of responses to so much of the plaintiff's case that contended such releases were permissible. First, Seqwater contended that as a matter of law it, and consequently the flood engineers, was precluded from releasing water below FSL during flood operations.[4] Second, all of the defendants contended that the Manual precluded such releases save to allow refilling via baseflow.[5] Third, Seqwater and SunWater contended that the flood engineers reasonably believed that such releases could not be made and, as a consequence, a reasonably competent flood engineer in their position would not make such releases (*CLA* (Qld);

[1] See SBM.500.001.0001; see also T 10395.34 to T 10396.7.
[2] Plaintiff subs at [769], [778] to [781].
[3] Plaintiff subs at [775].
[4] Seqwater subs at [80].
[5] See SBM.500.001.0001; State subs at [19]-[21]; Seqwater subs at [168] to [170], [180(c)], [182], [193].

s 9(1)(c)).[6] Fourth, SunWater submitted that not releasing below FSL was "widely accepted by peer professional opinion … as competent professional practice" (*CLA* (Qld); s 22).[7] Fifth, SunWater contended that it was a common assumption of its contractual relationship with Seqwater that such releases would not be made.[8] Each of these matters is addressed below.

5.1: Prohibition on Releases Below FSL?

Chapter 2 of the Water Act

5 The relevant legislative provisions concerning dam operations and flood mitigation are addressed in Chapter 2 of this judgment. The source of the legislative prohibition on releases below FSL is said to be the *Water Act* and the various instruments made under it.

6 Section 19 of the *Water Act* vests in the State "[a]ll rights to the use, flow and control of all water in Queensland". The Dictionary in Schedule 4 defines "water" as meaning all or any of "water in a watercourse, lake or spring", "underground water", "overland flow water" and "water that has been collected in a dam". "Water in a watercourse or lake" is defined as including "water collected in a dam across the watercourse or lake".

7 Chapter 2 of the *Water Act* is entitled "Allocation and sustainable management". Its purpose is stated by s 10(1) to be "…to advance sustainable management and efficient use of water and other resources by establishing a system for the planning, allocation and use of water." Chapter 2 provides for the making of "water resource plans" prepared by the Minister and approved by the Governor in Council (ss 38-52), "resource operations plans" prepared by the Chief Executive and approved by the Governor in Council (ss 95-106A), "resource operations licences" granted by the Chief Executive (ss 107-108) and water allocations, being authorities to take water, granted by the Chief Executive (ss 121-123).

[6] SunWater subs at [597(a)]; Seqwater subs at [81].
[7] SunWater subs at [597(b)].
[8] Ibid at [2784] to [2795].

8 The *Water Act* includes a number of prohibitions on interfering with watercourses and the taking of water, to which some of the above authorities represent exceptions. Thus, ss 808(1) and (2) of the *Water Act* make it an offence to take, supply or interfere with "water to which this Act applies" unless authorised to do so under, inter alia, the Act. Section 107A(1) provides that a resource operations licence ("ROL") authorises the holder of the licence "to interfere with the flow of water to the extent necessary to operate the water infrastructure to which the licence applies". Section 813 makes it an offence for a holder of a ROL to contravene a condition of the licence.

9 The scheme of rights and obligations created by the *Water Act* in relation to water allocations is complex. It suffices to state that the scheme does not confer on recipients some form of legal title to a specified cross-section of water below FSL in any given piece of water infrastructure. Instead, the recipients receive a water allocation (s 122) which includes a nominal volume for the allocation (s 127(1)(b)). The taking of water under the allocation is subject to the terms of the relevant water resource plan. In broad terms, the combination of the *Water Act*, the relevant water resource plan and ROP operate to specify the conditions under which the recipient can interfere with the watercourse or otherwise take water up to the limit of their allocated entitlements.[9]

Water Resource (Moreton) Plan 2007 (Qld)

10 Section 38 of the *Water Act* empowered the Minister to prepare a "water resource plan" for any part of Queensland "to advance the sustainable management of water". One of the purposes of such a plan was to "define the availability of water for any purpose" (s 38(3)(a)). On 15 March 2007, the *Water Resource (Moreton) Plan* 2007 (Qld)[10] (the "Moreton WRP") was approved by the Governor-in-Council in accordance with s 50(2) of the *Water Act*. It was notified in the gazette on 16 March 2007.[11] Its purposes included "provid[ing] a framework for sustainably managing water and the taking of

[9] See, for example, Moreton ROP, s 79.
[10] LAW.700.012.0001.
[11] Queensland *Government Gazette*, No 63, 16 March 2007, at 1221.

water" (Moreton WRP, s 2(b)). The area to which the plan applied was identified in s 4 and schedule 1 and included Wivenhoe and Somerset Dams.

11 Section 9(1) of the Moreton WRP applied the plan to water in the plan area being "water in a watercourse or lake" or "in springs not connected to groundwater". As noted, "[w]ater in a watercourse or lake" is defined in Schedule 4 to the *Water Act* as including "water collected in a dam across the watercourse or lake". That is sufficient to include the water held back by each of Wivenhoe Dam and Somerset Dam.

12 Section 36 provided that water allocations for the "Central Brisbane River water supply scheme" and the "Stanley River water supply scheme" were to be managed under the applicable ROL for the scheme. Schedule 13 to the Moreton WRP specified that the water constituting the "*Central Brisbane River water supply scheme*" consists of the "full supply level of the impoundment of Wivenhoe Dam on the Brisbane River" and "Brisbane River downstream of Wivenhoe Dam at [adopted middle thread distance (AMTD)] 150.2km to Mt Crosby Weir at AMTD 90.8km". The schedule also specified that the area constituting the "*Stanley River water supply scheme*" consists of the "*full supply level of the impoundment of Somerset Dam at Stanley River*". "[F]ull supply level" is defined in the *Water Act* as "the level of the water surface when the water storage is at maximum operating level when not affected by flood".[12] A notation to Schedule 12 of the Moreton WRP described the "full supply level" of the impoundment of Wivenhoe Dam as "RL 67.00m AHD" and Somerset Dam as "RL 99.0m AHD". It was common ground that neither supply scheme included water above FSL.[13]

13 In its submissions, the plaintiff described the effect of sections 9 to 12 as establishing that the purpose of the Moreton WRP was to allocate and sustainably manage water in the plan area, including by balancing the needs for water use with environmental considerations.[14] Section 9 did not address the effect or purpose of the Moreton WRP. Sections 10 to 12 addressed the

[12] *Water Act*, Schedule 4.
[13] Plaintiff subs at [800]; Seqwater subs at [97] and [100].
[14] Plaintiff subs at [795].

"outcomes" for the Moreton WRP which are concerned with balancing the needs of water usage with water conservation and environmental concerns.

14 Subsection 95(2) of the Moreton WRP provided that a resource operation plan in relation to priority area 1 (which included the Central Brisbane River water supply scheme) was to be prepared within two years. Sub-section 95(3) provided that this resource operations plan which concerned priority area 2 (and which included the Stanley River water supply scheme) had to be amended within four years.

Moreton ROP

15 The *Moreton Resource Operations Plan* (December 2009) ("Moreton ROP")[15] implemented the Moreton WRP. It commenced on 7 December 2009.[16] Section 34(1)(a) of the Moreton ROP obliged the Chief Executive to grant a ROL to Seqwater for, inter alia, the Central Brisbane River supply scheme and the Stanley River water supply scheme. Subsection 34(2)(a) of the Moreton ROP provided that the infrastructure associated with these schemes was to be described in Attachment 5. The infrastructure included Wivenhoe Dam, Mt Crosby Weir and Somerset Dam.

16 Chapter 5 of the Moreton ROP was titled "*Central Brisbane River and Stanley River Water Supply Schemes*". Section 70 provided that the Chapter applied to the resource operations licence holder for both those schemes (ie, Seqwater) and all water allocations associated with the Central Brisbane River water supply scheme.

17 Part 1 of Chapter 5 was headed "Operating and environmental management rules". Within Part 1, s 72 provided:

> "Operating Levels for Infrastructure
>
> (1) The operating levels for the infrastructure in the Central Brisbane River and Stanley River water supply schemes are specified in Attachment 5, Table 1, Table 2 and Table 3.

[15] LAW.700.015.0001.
[16] Moreton ROP, s 2; see also Queensland *Government Gazette*, No 93, 4 December 2009 at 1047.

(2) The resource operations licence holder must not release or supply water from any infrastructure when the water level in that infrastructure is at or below its minimum operating level.

(3) The resource operations licence holder must not release *water* from any infrastructure unless the release is necessary to—

(a) meet minimum flow rates in section 75; or

(b) supply downstream demand." (emphasis added)

18 Table 1 of Attachment 5 specified the operating levels for Wivenhoe Dam, specifically a minimum operating level of EL 35.0m AHD and FSL at EL 67.0m AHD. Table 3 of Attachment 5 specified the operating levels of Somerset Dam, specifically a minimum operating level of EL 71.5m AHD and FSL of EL 99.0m AHD. The reference to supplying "*downstream demand*" in s 72(3) was to the water allocations provided for in Attachment 8 of the Moreton ROP. The largest water allocation in terms of nominal volume was to the Seqwater Grid manager.[17]

19 Sections 73, 74 and 75 of the Moreton ROP specified further "[o]perating and environmental management rules" for the dams, these concerning the quality of water releases, the necessity to change release rates incrementally and minimum release rates from Mt Crosby Weir respectively.

20 The definition of "water" in the *Water Act* means that the water referred to in s 72(3) of the Moreton ROP included water in a dam. It was common ground between the plaintiff and Seqwater that the operating and environmental management rule in s 72 (and presumably following) did not apply to water retained in Lake Wivenhoe and Lake Somerset above FSL.[18] This is so because that body of water did not form part of the Central Brisbane River water supply scheme or the Stanley River water supply scheme.

[17] Moreton ROP, LAW.700.015.0001 at .0142.
[18] Plaintiff's opening: T 212.4 – .15, T 214.1 – .5, T 215.22 – .28; Seqwater's Opening: T 364.17 - .20.

Seqwater's Resource Operations Licence

21 Pursuant to s 34(1) of the Moreton ROP, Seqwater was granted a resource operations licence on 7 December 2009 ("Seqwater ROL").[19]

22 Two matters should be noted about that grant. First, the effect of s 107A of the *Water Act* is that the Seqwater ROL authorised Seqwater to interfere with the flow of (all) "water" as defined "*to the extent necessary*" to operate the "*water infrastructure*" to which the licence applied, which included Wivenhoe Dam, Mt Crosby Weir and Somerset Dam. This meant that in taking, supplying or interfering with water when operating that infrastructure, Seqwater was not contravening s 808(1) or (2) of the *Water Act*. The plaintiff contended that this was sufficient to "permit the operation of Wivenhoe and Somerset Dams for flood mitigation purposes".[20] I agree that the grant of the ROL allowed the infrastructure in the form of a dam to be operated as a dam and release water from any level without contravening s 808. If it were otherwise, all flood releases would be prohibited because s 808 applied to all water in a dam not just that below FSL.

23 Second, it was an express condition of the Seqwater ROL that Seqwater comply with the operating arrangements and supply requirements detailed in Chapter 5 of the Moreton ROP, including s 72(3).[21] This was also the effect of s 110(1) of the *Water Act*. This meant that, if Seqwater contravened those requirements which related to water below FSL, then it was an offence under s 813(1) of the *Water Act*. Both of a breach of a condition of a ROL and a conviction under s 813(1) are a basis for cancelling Seqwater's ROL (*Water Act*, s 119(1)(a) and (b)).

Section 72(3) of the Moreton ROP and Releases Below FSL

24 Seqwater submitted that the combined effect of s 72(3) of the Moreton ROP and the above provisions was that the water below FSL in each of Wivenhoe

[19] 5ASOC, PLE.010.001.0001, [62]; Seqwater Resource Operations Licence (7 December 2009), ROD.900.001.0001.
[20] Plaintiff subs at [811].
[21] ROD.900.001.0001, Condition 1.1.

Dam and Somerset Dam could only be released to meet minimum flow requirements or supply downstream demand. It contended that the release of water below FSL in Wivenhoe and Somerset Dams for flood mitigation purposes was prohibited.[22]

25 The plaintiff made three submissions in response. First, it submitted that s 72(3) is not concerned with flood mitigation as releases for flood mitigation stand outside the scheme of the Moreton ROP. Second, it submitted that the approval of an interim program in December 2010 under s 13 of the Moreton ROP obviated the requirement to comply with s 72(3) in relation to flood mitigation.[23] Third, it submitted that s 14 of the Moreton ROP had the same effect.[24]

26 In relation to the first matter, the plaintiff submitted that the Moreton WRP and consequently the Moreton ROP were not concerned with the circumstance in which the dams were making releases for flood mitigation. It submitted that the purpose of the Moreton WRP was "to define the availability of water in the plan area, to provide a framework for sustainably managing water and the taking of water, and for allocating water" which was said to be "far removed from the operation of infrastructure in conducting flood mitigation".[25]

27 Seqwater made a number of submissions which appear to be directed towards establishing the proposition that the scheme of the legislation was directed to creating an inviolable body of water below FSL available only for water supply purposes.[26] Whether that is so can only be determined once all of the plaintiff's arguments have been addressed. At this point, it suffices to state that I cannot discern any basis for reading down the express words of s 72(3) of the Moreton ROP and the cognate provisions so as to exclude releases for flood mitigation from its operation. Subject to considering the effect of ss 13 and 14 of the Moreton ROP, in combination with the *Water Act*,

[22] Seqwater subs at [117]-[129].
[23] Plaintiff subs at [812] to [814].
[24] Ibid at [809].
[25] Ibid at [796].
[26] Seqwater subs at [117] to [129].

s 72(3) of the Moreton ROP precluded the release of water from below FSL in both Wivenhoe Dam and Somerset Dam for flood mitigation.

28 Otherwise, I note that none of the parties submitted that, as s 72(3) was only directed to releases by the ROL holder (ie, Seqwater), it therefore did not apply to the flood engineers conducting flood operations.

Interim Approval Under Clause 13 of the Moreton ROP

29 The plaintiff contended that during 2010 Seqwater obtained an interim approval under s 13 of the Moreton ROP to make releases of water from the Central Brisbane River water supply scheme and the Stanley River water supply scheme (ie, below FSL), for the purposes of flood mitigation.

30 Section 13 of the Moreton ROP provided:

> 13 Interim program
>
> (1) The chief executive and the resource operations licence holder must implement requirements of this plan as soon as is practical within the timeframes stated below.
>
> (2) Subsections 3 to 11 apply where a resource operations licence holder is unable to meet the requirements of this plan on the day this plan commences.
>
> (3) The resource operations licence holder must—
>
> (a) within 2 months of commencement of this plan, submit a *statement of programs currently in existence*, to the chief executive *for approval*; and
>
> (b) within 6 months of commencement of this plan, *submit a program* for meeting the requirements of this plan to the chief executive *for approval, including a timetable and interim methods to be used*.
>
> (4) The resource operations licence holder may, where an emergency or operational incident results in an inability to comply with any rules or requirements of this plan, submit an interim program for meeting the requirements of this plan to the chief executive for approval, including a timetable and interim methods to be used.
>
> (5) Where the submitted program relates to the Water Monitoring Data Collection Standards, the program must include the accuracy of methods currently used.

(6) The chief executive, in considering any *submitted program*, may request additional information.

(7) The chief executive, in considering any *submitted program*, may either—

(a) approve the program with or without conditions;

(b) amend and approve the amended program; or

(c) require the resource operations licence holder to submit a revised program.

(8) Within 10 business days of making a decision on a program submitted under this section, the chief executive must notify the resource operations licence holder of the decision.

(9) Following *approval of the program* by the chief executive, the resource operations licence holder must—

(a) implement and operate in accordance with the approved program; and

(b) make public details of the approved program on their internet site.

(10) Where there is conflict between the provisions of this plan and the provisions of an *approved program*, the approved program prevails for the time that the approved program is in place.

(11) Where this section applies, the resource operations licence holder may continue to operate under the *existing program* until the program submitted under this section is approved. (emphasis added)

31 It is necessary to consider s 13 in some detail. The section was clearly intended to ameliorate the position of a ROL holder who was "unable to meet the requirements" of the Moreton ROP and facilitate their transition to compliance with its terms.

32 To that end, a ROL holder who was unable to comply with its terms at the time it commenced, must have, within two months of the commencement of the Moreton ROP, submitted a "statement of *programs* currently in existence" to the Chief Executive "*for approval*" (s 13(3)(a)). Then, within six months of the commencement of the Moreton ROP, the ROL holder must have submitted "*a program* for meeting the requirements of this plan to the chief executive *for approval*" which was to include a "timetable and interim methods to be used". Each of sub-ss 13(3)(a) and 13(3)(b) referred to an approval by

the Chief Executive. The only power of approval given to the Chief Executive was by sub-s 13(7). That power related to a “submitted program”. Each of s 13(3)(a) and 13(3)(b) made provision for a “submitted program”, namely the “programs currently in existence” the subject of the statement submitted under s 13(3)(a) and the “program for meeting the requirements of the plan” submitted under s 13(3)(b). In relation to *both* types of submitted programs, the Chief Executive was empowered under s 13(7) to approve the program with or without conditions, amend and approve the program, or require the submission of a revised program. In addition, s 13(6) empowered the Chief Executive to request additional information in relation to a “submitted program”. What was notably absent from s 13(7) was a power to not approve or reject a submitted program. If the Chief Executive was dissatisfied with a submitted program then his or her (only) options appear to be to require the submission of a revised program, approve the program with conditions or amend the program and approve it.

33 Once a “submitted program”, that is either the programs the subject of the statement referred to in s 13(3)(a) or the interim program referred to in s 13(3)(b), was approved then it became an “approved program” and was required to be implemented (s 13(9)(a)). Most importantly it prevailed over the Moreton ROP “for the time that [it was] in place” (s 13(10)). Further, if a statement of programs currently in existence as referred to in s 13(3)(a) was approved, and regardless of whether the source of power for the approval was s 13(3)(a), s 13(7) or elsewhere, then each of the programs the subject of the statement became an “approved program” under s 13(10) and the “existing program” for the purposes of s 13(11). This means that the ROL holder may continue to operate in accordance with those programs until the approval of an interim program submitted under s 13(3)(b). Pending the approval of any interim program or any revised interim program, the existing programs continue to prevail over conflicting provisions of the Moreton ROP. Once an interim program was approved, then the ROL holder was required to implement that interim program (s 13(9)(a)) and the authority granted by s 13(11) to operate under the previously submitted program lapsed.

Chronology of Approval

34 As noted, on 7 December 2009 the Moreton ROP came into effect. On 5 February 2010, Seqwater wrote to DERM stating:[27]

> "Where Seqwater, as the ROL holder, is *unable to meet the requirements of the ROP*, a structured process is available whereby a statement of programs currently in existence can be prepared and submitted to the Department of Environment and Resource Management, to be following by an implementation program.
>
> The attached document sets out Seqwater's State of programs currently in existence (the Statement), as provided for under section 14 of the ROP.
>
> This Statement is submitted to the Department of Environment and Resource Management for approval." (emphasis added)

35 Seqwater admits its letter of 5 February 2010 was intended to comply with s 13(3)(a) of the Moreton ROP by providing a statement of current programs to the chief executive of DERM for approval.[28] That letter was provided within two months of the commencement of the Moreton ROP, as required by s 13(3)(a).

36 Enclosed with this letter was a table headed "*Moreton Resource Operations Plan – Statement of Programs Currently in Existence*" which was said to be "[c]urrent as at 5 February 2010".[29] That table comprised two columns, the first of which was entitled "Relevant ROP requirement" and the second of which was entitled "Programs Currently in Existence". Each row of the table identified a provision of the Moreton ROP in the first column and then made a statement as to whether Seqwater was currently compliant or the extent of the non-compliance in the second column. In relation to s 72(3) of the Moreton ROP, the second column of the table contained the following entry:

> "Not compliant with ROP (releases made for operational purposes and water quality and ecosystem health including fish management)"[30]

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[27] Email Claire Thorstensen to Tom Crothers (5 February 2010), SEQ.016.049.7624; Letter from Arun Pratap to Tom Crothers (4 February 2010), SEQ.016.049.7625.
[28] Seqwater Defence, PLE.020.012.0001, [102].
[29] Moreton Resources Operations Plan – Statement of Programs Currently in Existence (5 February 2010), SEQ.016.049.7626.
[30] Ibid at .7626.

37 The plaintiff noted that this entry does not expressly refer to releases for flood mitigation purposes but submitted that the reference to "*operational purposes*" in the case of Wivenhoe and Somerset Dams included flood mitigation given their "primary functions as multipurpose flood mitigation dams".[31] I agree. The reference to "operational purposes" could not simply be a reference to making releases to supply water downstream to meet demand as that would be compliant with s 72(3) of the Moreton ROP. As both Wivenhoe and Somerset Dams had a flood mitigation purpose, releasing water for flood mitigation is an obvious aspect of operating them. Any doubt about that evaporates when the document sent on 8 June 2010 described below is considered.

38 On 12 March 2010, the Acting General Manager, Water Allocation and Planning, DERM responded, stating, inter alia:[32]

> "…Thank you for submitting the statements of current programs as required under the relevant sections of the Gold Coast, Logan Basis and Moreton Resource Operations Plans 2010 (the plans).
>
> I am satisfied the submissions meet the requirements set out under the plans, *therefore the statement of current programs are approved*.
>
> …
>
> May I also take this opportunity to remind you that the Queensland Bulk Water Supply Authority is also required to submit interim programs for approval, under the plans. These programs… must include a timetable for meeting the plan requirements and outline the interim methods to be used". (emphasis added)

39 It follows from the above that this letter records an approval of the statement of programs submitted under s 13(3)(a) of the Moreton ROP. Regardless of whether the source of the power to approve was s 13(3)(a), s 13(7) or elsewhere, this approval rendered the programs the subject of the submitted statement "approved" for the purpose of s 13(10) and an "existing program" for the purposes of s 13(11). It follows that, unless and until an interim program was (validly) approved, Seqwater could continue to operate in accordance with those non-compliant programs, even where they conflicted with the terms of the Moreton ROP (s 13(10); s 13(11)).

[31] Plaintiff subs at [821].
[32] Letter from Lyall Hinrichsen to Peter Borrows (12 March 2010), QLD.001.001.0252.

40 On 8 June 2010, Seqwater wrote a further letter to DERM, stating:[33]

> "The Gold Coast, Logan Basin and Moreton Resource Operations Plans 2009 (the ROPs) commenced on 7 December 2009.
>
> The Queensland Bulk Water Supply Authority (trading as Seqwater) is a Resource Operations Licence (ROL) Holder under the ROPs.
>
> Where Seqwater, as the ROL holder, *is unable to meet requirements under any of the ROPs*, a structured process is available whereby a statement of programs currently in existence can be prepared and submitted to the Department of Environment and Resource Management, to be followed by an interim program.
>
> Seqwater submitted [a] statement of current programs to DERMs for all three ROPs on 4 and 5 February 2010.
>
> The attached documents set out Seqwater's Statement Interim Programs, as provided for under… Section 13 of the Moreton ROP.
>
> These Interim Programs are submitted to the Department of Environment and Resource Management for approval." (emphasis added)

41 This letter and its enclosures were clearly intended to comply with s 13(3)(b) of the Moreton ROP by submitting, within six months of the commencement of the Moreton ROP, a program for meeting the requirements of that plan to the Chief Executive for approval, including a timetable and interim methods to be used. This was admitted by Seqwater.[34]

42 The 8 June 2010 letter enclosed a table listing the requirements of the Moreton ROP and indicating whether Seqwater was complying or not, as well as a timetable for compliance.[35] It included the following entries:

Relevant ROP Requirement	**Programs Currently in Existence** **(as submitted to DERM in February 2010)**	**Interim Program, including Methodology**	**Timetable**
…….	……	……….	……..
Central Brisbane River and Stanley River Water	Not compliant with ROP (releases made for	Seqwater will continue to make releases from	Nil

[33] Seqwater Defence, PLE.020.012.0001, [105]; see also SEQ.016.005.9349; attached to SEQ.016.005.9342.
[34] Seqwater Defence, PLE.020.012.0001, [105].
[35] Seqwater Interim Program – Moreton Resource Operations Plan as at 25 May 2010, SEQ.016.005.9362.

Supply Schemes – Operating Levels for Infrastructure 72(3) The resource operations licence holder must not release water from any infrastructure unless the release is necessary to- (a) meet minimum flow rates in section 75; or (b) supply downstream demand.	operational purposes and water quality and ecosystem health including fish management)	infrastructure for consumption, *flood mitigation*, operational maintenance and fish recovery/maintenance.	
Central Brisbane River and Stanley River Water Supply Schemes – Streamflow Requirement 75 When critical water sharing arrangements are not in force, the resource operations licence holder must release a minimum flow of 8.64ML/day from Mount Crosby Weir	No operational outlet works at Mt Crosby Weir, therefore no managed releases made.	As there are no operable outlet works at Mt Crosby Weir (and cannot be implemented without significant investment, including possible reconstruction of the weir), overflows are dependent upon releases from Wivenhoe and projected water supply demands and local inflows, the latter two components being outside Seqwater control. As a result, Seqwater has very limited control over releases from Mt Crosby Weir on a daily basis. As such, it is proposed that this requirement be deemed as satisfied if a minimum **average** flow of 8.64ML/day (for any given month) flows over Mt Crosby Weir, rather than a minimum flow of 8.64ML/day (for any given day).	Seqwater would be compliant with a requirement for a minimum average flow of 8.64ML/day for any given month from 1 July 2010. Compliance is not able to be achieved for a minimum flow of 8.64ML/day for any given day.
***	***	***	***
Monitoring requirements – Releases from infrastructure 153(1) this section applies to the following infrastructure– (a) Cressbrook Dam; (b) Mount Crosby Weir; (c) North Pine Dam; (d) Perseverance Dam; (e) Somerset Dam;			

and (f) Wivenhoe Dam.			
153(2) The resource operations licence holder must measure and record for each release of water from infrastructure listed in subsection 1– (a) the daily volume released; (b) the release rate and for each change in release rate– (i) the date and time of the change; and (ii) the new release rate; (c) the reason for each release; and (d) the device used for each release. 153(3) The resource operations licence holder for infrastructure mentioned in subsection 1(c) and 1(f) must record– (a) the inlet level used for each release of water; and (b) the reason for taking water via a particular inlet level.	153(1)(b) No measured releases made 153(1)(c) Operational Log ex SunWater system 153(1)(e) Operational Log ex SunWater system 153(1)(f) Operational Log ex SunWater system 153(2) Data is recorded in Operational Log 153(3) Data is recorded in Operational Log	153(1)(b): No operable outlet works exist at Mount Crosby Weir and cannot be implemented without significant investment. Releases are not made – only overflows, which are monitored and recorded. A such, it is proposed Seqwater report the overflows in compliance with ss153(2) and 153(3) instead of releases since none are made.	1 July 2010 (note: overflows and not releases will be reported for Mt Crosby Weir).

Table 5-1: Seqwater compliance timetable

43 The plaintiff submitted that the effect of including "Nil" in the fourth column of the first row above meant there was no "time by which Seqwater would simply cease flood mitigation operations at multipurpose flood mitigation dams".[36] That should be accepted save that it did not exclude the possibility that it would be addressed in the future. The plaintiff also submitted that the proposal to "*continue to*" make releases for "*flood mitigation*" contrary to s 72(3) could "only be understood as a request for approval to *continue to*

[36] Plaintiff subs at [826].

make such releases below FSL" as s 72 applied only to the water below FSL in each of the dams.[37] Again, that submission should be accepted.

44 On 27 August 2010, Seqwater wrote to DERM on the same topic stating:[38]

> "As a step towards meeting the requirements of the South East Queensland Resource Operations Plan (ROP) released by the Department of Environment and Resource Management (DERM) in December 2009, Seqwater submitted interim programs to DERM in May 2010.
>
> Feedback was received from DERM in August 2010, *requesting that amended Interim Programs be submitted* in consideration of the comments provided by DERM.
>
> Accordingly, Seqwater has reviewed and updated the Interim programs (as enclosed) …" (emphasis added)

45 In its defence, the State denied that this could be charactered as an "*updated*" interim program, pleading that there existed no lawful authority (in the Moreton ROP or otherwise) for an interim program to be updated or amended by a person other than the Chief Executive.[39] However, the letter appears to evidence an exercise of the power conferred by s 13(7)(c) to require the ROL holder to submit a revised program and also contains Seqwater's response.

46 The updated program attached to this letter[40] was in similar form to that which was included with the 8 June 2010 letter. It included the same entries as those set out above, including the reference to "flood mitigation".

47 On 3 December 2010, the Acting General Manager, Water Allocation and Planning, DERM wrote to Seqwater confirming approval of the interim program.[41] The letter stated:[42]

> I am satisfied that the interim program as submitted meets the requirements set out under the Plan and accordingly, *I have approved the program*.

[37] Plaintiff subs at [827].
[38] Letter from Alex Fisher to Lyall Hinrichsen (27 August 2010), SEQ.016.049.5625. The letter was attached to an email from Claire Thorstensen to Lyall Hinrichsen (27 August 2010), SEQ.016.049.5618.
[39] State Defence, PLE.040.007.0001, [61(b)].
[40] SEQ.016.049.5636.
[41] SEQ.016.021.9607.
[42] SEQ.016.021.9607, .9607 to .9608.

> In considering the program, I noted *particular anomalous matters that the Authority will need to address in the foreseeable future as compliance with the requirements of the Plan* is necessary to ensure that water planning objectives and outcomes are achieved. These anomalies include the minimum flow requirements and tailwater monitoring for Mt Crosby Weir, tailwater monitoring at Somerset Dam *and releases from infrastructure for particular purposes not recognised under the Plan*.
>
> The Authority's interim methods for monitoring minimum average flow through the fishway and over the crest of Mt Crosby Weir will be acceptable as an interim arrangement, as also is the case for outflow estimations from the recorded opening of the gates, sluices and valves at Somerset Dam.
>
> However, as these interim methods will be insufficient to achieve necessary compliance with the Plan in the longer term, it will be necessary for the Authority to engage the Department of Environment and Resources Management at an early stage concerning potential solutions.
>
> The Authority's releases from infrastructure that do not comply with sections 72 and 75 of the Plan and that are made in extraordinary or emergent circumstances may be the subject of an operational report submitted in accordance with section 166 of the Plan. However, *any releases made contrary to the Plan provisions remain as instances of non-compliance, regardless of circumstances*.
>
> Accordingly, *while it will be necessary for the Authority to lodge an operational report on every occasion that it makes a release not authorised under the Plan*, it will not be appropriate to use this mechanism to deal with ongoing and routine releases that are unauthorised. Therefore, if the Authority intends to make presently unauthorised releases as part of continuing routine operations, it again should further engage the Department concerning potential solutions. (emphasis added)

48 On 15 December 2010, the letter of approval and the submitted program was circulated internally within Seqwater by email, including to Mr Drury and Mr Malone.[43] The covering email referred to the "DERM approval for the Interim Program submitted under the Central Brisbane W[ater] S[upply] S[cheme] under the Moreton ROP". The email also noted that in the approval letter there "are some references to improving monitoring or releases at Mount Crosby [Weir], and to completing an Operational Report every time releases are made that are not consistent with the provisions of the ROP".

49 Seqwater contended that this email does not suggest that the "penny dropped" for the author of the email that releases from FSL for flood mitigation

[43] SEQ.016.021.9594.

purposes could now be made.[44] It noted that the email only referred to "making operational reports" but did not refer to a "dramatic change in the way in which the dams might be used for flood mitigation".[45] However, on any view, the Manual expressly permitted releases below FSL in section 8.5 which, on Seqwater's view, was illegal. There is nothing to suggest that the "penny dropped" for the Seqwater employee who drafted the email that, if it acted in accordance with section 8.5, it could be prosecuted.

50 The plaintiff contended that the letter of 3 December 2010 constituted an approval of the (revised) interim program that was submitted on 27 August 2010.[46] This was admitted by the State in its defence,[47] but not admitted by SunWater.[48]

51 Seqwater's response was threefold. First, it contended that, on its proper construction, the approval did not excuse releases from below FSL for flood mitigation from being a breach of s 72(3) of the Moreton ROP.[49] Second, it contended that, if it had that effect, it was invalid.[50] Third, it pleaded that the releases for "flood mitigation" was a reference to releases made in accordance with the Manual, which did not authorise releases below FSL save for those relating to baseflow.[51]

The Extent of the Approval

52 Seqwater contended that the approval of the program in paragraph one of the letter of 3 December 2010 had to be read subject to the remainder of the letter which referred to releases that were contrary to s 72(3) as releases that were "for particular purposes not recognised under the plan", "instances of non-compliance" and "presently unauthorised".[52] It submitted that these descriptions were not apt if the approval extended to making those releases,

[44] Seqwater subs at [244(b)].
[45] Id.
[46] PLE.010.001.0001, [75].
[47] PLE.040.007.0001, [63].
[48] PLE.030.008.0001, [75].
[49] Seqwater subs at [142] to [146]; PLE.020.012.0001 at [111].
[50] Seqwater subs at [146] to [167]; PLE.020.012.0001 at [111A].
[51] PLE.020.012.0001 at [112].
[52] Seqwater subs at [142].

nor would the requirement to report referred to in s 166 or s 167 of the Moreton ROP be engaged as they were only engaged by non-compliance with a rule of the Moreton ROP itself, not a condition of an approved program.[53] Alternatively, Seqwater submitted that the approval should be interpreted as subject to a condition that excluded releases that were contrary to s 72 and s 75 from its scope.[54]

53 I do not accept Seqwater's submission. The qualifications on the approval were included so as to ensure that the various reporting requirements for releases that did not conform with ss 72 and 75 of the Moreton ROP were engaged. Section 166(a)(i) of the Moreton ROP required the Chief Executive to be notified within one business day of Seqwater becoming aware of, inter alia, a "non-compliance…with the rules within this plan". Similarly, s 167 provided that if the licence holder could not "comply with a rule in this plan … as a result of an emergency" they were required to notify the Chief Executive. In approving the revised interim program, the letter of approval expressed concern about "releases from infrastructure for particular purposes not recognised under the [Moreton ROP]". If releases for those purposes were unconditionally approved under s 13 then the reporting conditions in ss 166 and 167 would not be engaged when they occurred because, in that instance, there would not be a "non-compliance" or a failure to "comply with a rule". The letter of approval merely sought to preserve the reporting requirement while validating the release. Seqwater's email of 15 December 2010 suggests that Seqwater understood it in that sense and it was right to do so.

54 This conclusion is reinforced by considering that the letter of approval of 3 December 2010 reflects the exercise of power under s 13(7), the operation of which is outlined above. Two matters should be noted. First, as noted, the effect of the approval on 12 March 2010 was that it enabled Seqwater to continue to make "operational releases" including for flood mitigation from water the subject of Chapter 5 of the Moreton ROP (ie, below FSL) until the approval of an interim program by the Chief Executive under s 13(7). If

[53] Ibid at [142(e)].
[54] Ibid at [144].

Seqwater's construction of the letter of approval is correct, then it moved from a position where it was authorised to release water below FSL for reasons other than those specified in s 72(3) pursuant to the approval given on 12 March 2010 to the position that it was at risk of a penal sanction for doing so. If that was the intended effect of the letter then one would expect that to be clearly stated.

55 Second, as noted, the one power not expressly given to the Chief Executive under s 13(7) was the power to refuse approval of a submitted program. However, Seqwater's construction of the letter is that it constituted a rejection of so much of the submitted program that sought approval for releases for purposes other than those specified in s 72(3). The plaintiff's approach involves construing the letter as an approval "with conditions" as directly contemplated by s 13(7)(a). The plaintiff's construction is to be preferred.

The Validity of the Approval

56 As noted, Seqwater contended that approval granted on 3 December 2010 was invalid. It contended that two jurisdictional preconditions to the exercise of the power of approval of the interim program were not established, namely that Seqwater was not unable to comply with the Moreton ROP on the day it came into force, as required by s 13(2), and that, at least so far as compliance with s 72(3) was concerned, the proposed interim program did not include a "timetable and interim methods to be used to meet the requirements of the ROP".[55] Seqwater contended that, as both matters were threshold requirements that arose prior to any evaluation by the Chief Executive, they were both matters that had to be determined objectively and their absence invalidated the decision. Seqwater relied on the judgment of Spigelman CJ in *Timbarra Protection Coalition Inc v Ross Mining NL* (1999) 46 NSWLR 55; [1999] NSWCA 8 ("Timbarra"), especially at [50] to [51].[56] In *Timbarra*, a legislative requirement that a development application for certain types of land be accompanied by a species impact statement was held to be a jurisdictional

[55] Seqwater subs at [147].
[56] Seqwater subs at [155] to [167].

precondition to the power to approve the application and it was for the Court to decide objectively whether it was established.

57 In relation to s 13(2), Seqwater submitted that the evidence from three flood engineers and a number of other officers from Seqwater, specifically Mr Borrows, Mr Pruss and Mr Drury, "was that over a number of years (before and after December 2009) flood management of the dams was able to be (and was) conducted without making releases for flood mitigation below FSL" and thus s 72(3) of the Moreton ROP could be complied with. Seqwater contended that their evidence was also "to the effect that flood management of the dams had operated according to an understanding that water was not permitted to be released from below FSL for flood mitigation purposes, and the flood engineers and other officers of Seqwater considered that the dams were able to be operated in conformity to that understanding". Seqwater submitted that none of this evidence was challenged in cross-examination.[57]

58 I do not accept this contention. I address the evidence of the flood engineers' understanding in relation to FSL below but it suffices to state at this point that I do not accept it. In Chapter 4,[58] I found that during the May 2009 Flood Event releases were made from below FSL in Somerset Dam for flood mitigation purposes (and that was to occur again in March 2010).[59] Further, as at 7 December 2009, the flood engineers and Seqwater had completed their drafting of a revised flood mitigation manual that, on any view of its proper construction, explicitly contemplated the making of releases at both Wivenhoe Dam and Somerset Dam below FSL to accommodate their being refilled by baseflow.[60] During oral argument, Senior Counsel for Seqwater accepted that, if its argument was correct, then the Manual was purporting to authorise illegal releases.[61] Further, contrary to Seqwater's submissions,[62] in its letters and their attachments to the Chief Executive, it conceded that it was unable to comply with s 72(3) because as part of its operations, including the

[57] Ibid at [148].
[58] Section 4.4.
[59] Section 4.8.
[60] See Chapter 4 at [156].
[61] T 9656.41.
[62] Seqwater subs at [149]; T9657.3.

conduct of flood mitigation, it made releases for reasons beyond those specified in s 72(3) of the Moreton ROP. The letter of 5 February 2010 stated that it was unable to meet those requirements. The accompanying schedule said that Seqwater was “non-compliant”. These statements were reiterated in its letter of 8 June 2010 and its attachment.

59 As the party alleging invalidity, Seqwater carried the onus of proving that the approvals it sought were invalid. It has failed to demonstrate that, contrary to the statements it made to the Chief Executive, it was not unable to comply with the requirements of the Moreton ROP. In fact, the contrary has been shown.

60 The balance of Seqwater’s submissions concern s 13(3)(b). It contended that by merely stating that releases would continue and stating “nil” in the fourth column, it was neither specifying an interim method for bringing itself into compliance nor providing a timetable for doing so but instead proposing perpetual non-compliance.[63]

61 The requirements of s 13(3)(b) are to be read with the power that was given to the Chief Executive under s 13(7) to approve the interim program with or without conditions, amend and approve the amended program; or require the resource operations licence holder to submit a revised program. Subsection 13(10) makes it clear that the approval granted under subsection 13(7) could have only been for a temporary period, including by the imposition of conditions to that effect. On the face of it, the powers granted to the Chief Executive suggest that the remedy for an inadequate or ineffective “program” submitted under s 13(3) and s 13(4) was a matter for the Chief Executive to address and not a matter that denied him or her the power to act under s 13(7).

62 Seqwater submitted that it was a jurisdictional requirement that the submitted “program for meeting the requirements of this plan” specify the means and timeframe by which each and every non-compliant aspect of its current

[63] Seqwater subs at [150].

operations was to be rectified (although its submission allowed for the severance of the valid parts of the approved program from the supposedly invalid).[64] I do not accept that this is what the provision required. Section 13 contemplated that the ROL holders would have had multiple "programs currently in existence", that there may have been multiple "requirements" of the ROP that could not be complied with and accordingly there would need to have been an "interim program for meeting the requirements of the plan". In those circumstances, I do not construe ss 13(3) and (4) as having required the submission of a program in which every instance of non-compliance demanded rectification within a specified time period or timeframe.

63 It may be that, at the time of the ROP coming into force, the water infrastructure utilised by a ROL holder was damaged such that there was a widespread failure to comply with the ROP's requirements. The collapse of a dam is one such example. In such cases, it would be open to the ROL holder to seek approval of a program that has a time limit or timeframe for rectifying some non-compliances but none for others because they cannot all be practically addressed at that point. Whether it is acceptable to not specify a time limit or timeframe for compliance in all respects would be a matter for the Chief Executive exercising power under s 13(7) and within the bounds of reasonableness.

64 In applying s 13(3)(b), the ultimate question is overall whether what Seqwater submitted was capable of being characterised as "an interim program for meeting the requirements of this plan". The plan submitted by Seqwater instanced that some aspects of its non-compliance would be addressed within a specified timeframe but others, such as releases for flood mitigation and the absence of relevant infrastructure at Mt Crosby Weir, could not. It follows from the above that the fact that some of its non-compliances could not be addressed at this point did not deny the characterisation of what it submitted as an "interim program". Whether or not it was sufficient and whether it should have been amended or some timeframe imposed on the approval were all matters for the Chief Executive, but he or she was not to be denied the power

[64] Ibid at [166].

to take those steps because the submitted program did not proffer a time limit or timeframe for the rectification of all of the identified instances of non-compliance.

65 Both of subsections 13(3) and 13(4) specified that the submitted program must include a "timetable" and the "interim methods to be used". Clearly the "interim methods to be used" do not necessarily have to comply with the ROP, as in that event interim approval would not be required; ie, the reference to "interim methods" is, or least includes, an interim method of operating which by definition is not compliant. The suggested method of operating Mt Crosby Weir is an instance of this. Seqwater submitted that the reference to "interim methods" was the method of bringing the ROL holder into compliance,[65] but given the scope of the approval powers, the better view is that it is a reference to the method of operating in the interim period until there is compliance. What then was the requirement for the submission of a "timetable" at the application stage? Did it require the specification of a time or timeframe by which compliance of all of the operations that were noncompliant with the Moreton ROP would be achieved (as submitted by Seqwater),[66] or was it sufficient that it merely specify the proposed time or timeframe in which the non-compliant interim method would be adopted, which in this case was indefinitely? While no doubt the former would be preferable, it follows from the above that the latter would not undermine the statutory scheme, given the power of the Chief Executive under s 13(7) to impose conditions on the approval, require it to be revised or specify a timeframe in which it might lapse.

66 Accordingly, both s 13(2) and s 13(3)(b) were satisfied. However, I note two further points, each of which also deny Seqwater's assertion that it was prohibited by s 72(3) of the Moreton ROP from releasing below FSL during flood operations.

[65] Ibid at [164].
[66] Ibid at [165].

67 First, the plaintiff submitted that the Court should not allow a collateral challenge to the program's approval "at this late stage by the party who sought and relied on the approval".[67] This raises a difficult issue concerning the scope of such challenges and the relevance of discretionary considerations that affect the grant of prerogative-type relief. One assumption behind Seqwater's argument is that, if it established an absence of jurisdiction on the part of the Chief Executive to make the decision to approve the interim program, then it was invalid and it never had authority to release water from below FSL during the January 2011 Flood Event (or any other time) for any purpose other than those specified in s 72(3) of the Moreton ROP. Even though the usual consequence of a finding of jurisdictional error is that no decision was in fact made,[68] such a decision can still have some legal status.[69] Further, in such proceedings all forms or relief are discretionary.[70] Thus, in some circumstances, a decision may be left undisturbed notwithstanding a finding that it was affected by jurisdictional error.

68 As noted, Seqwater seeks to rely on *Timbarra*. *Timbarra* involved proceedings for judicial review brought by a third party who challenged the validity of a development application. The present context is private litigation where the decision maker is not a party. There is no doubt that the validity of a decision or instrument can be collaterally challenged as an incident of determining separate proceedings of this kind between parties who did not make the impugned decision,[71] although it is uncertain how wide the scope of the challenge may be and it is otherwise statute dependent.[72]

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[67] Plaintiff subs at [848].
[68] *Hossain v Minister for Immigration and Border Protection* [2018] HCA 34 at [24], per Kiefel CJ, Gageler and Keane JJ ("Hossain"); *Minister for Immigration and Multicultural Affairs v Bhardwaj* [2002] HCA 11; (2002) 209 CLR 597 at 615, [51] ("Bhardwaj").
[69] *Hossain* id; *Bhardwaj* at [46]; *Jadwan Pty Ltd v Secretary, Department of Health and Aged Care* (2003) 145 FCR 1 at 16, [42]; see Aronson, Groves and Weeks, *Judicial Review of Administrative Action and Government Liability* (6th ed, 2017, Thomson Reuters) at [10.90].
[70] *Re Refugee Review Tribunal; Ex parte Aala* [2000] HCA 57; (2000) 204 CLR 82 at [53] to [56] ("Aala").
[71] *Ousley v The Queen* (1997) 192 CLR 69; [1997] HCA 49 ("Ousley"); *DPP v Head* [1959] AC 83.
[72] *Ousley* at 80, per Toohey J; at 87, per Gaudron J; at 127, per Gummow J; cf at 100-102 per McHugh J; *Frugtniet v Attorney-General of NSW* (1997) 41 NSWLR 588 at 602G-603D, per Beazley JA; *Federal Airports Corporation v Aerolineas Argentinas* (1997) 76 FCR 582 at 599F-G;

69 Assuming that such a challenge can extend to the matters raised by Seqwater, this case involves the successful applicant for the approval of an interim program denying the approval's validity from the time of its grant because of its own supposedly defective proposal and in circumstances where it now has alleged that it incorrectly told the decision maker that it was unable to comply with the requirements of the Moreton ROP at the time it commenced. It seeks to rely on that invalidity in litigation commenced many years later where it is sued for not taking action in reliance on the approval it sought and obtained. If judicial review proceedings were commenced by Seqwater, those circumstances would demand the refusal of any relief to Seqwater on discretionary grounds, or at least the refusal of relief in a form which would have the effect of determining that any releases below FSL during flood operations during the January 2011 Flood Event were contrary to s 72(3) of the Moreton ROP. In *Aala* at [56], Gaudron and Gummow JJ cited with approval the statement of Lord Denning MR in *F Hoffmann-La Roche & Co AG v Secretary of State for Trade and Industry* [1975] AC 295 at 320 to the effect that a party may be denied relief if they have "acquiesced in the invalidity" of the decision. If Seqwater's argument is correct, then it did not just acquiesce in the "invalidity" of the decision, it caused it.

70 Whether discretionary considerations such as those that relate to Seqwater can defeat a collateral challenge to an administrative decision is a question that has not been explored much in the authorities.[73] In *Soh v The Commonwealth* (2008) 220 FCR 127; [2008] FCA 520 ("Soh"), Madgwick J found that a decision to a detain a prisoner under s 189 of the *Migration Act 1958* (Cth) and transfer him to a New South Wales prison was subject to a duty to afford procedural fairness which was breached (at [79] and [98]). However, his Honour held that Mr Soh's action for wrongful imprisonment failed because his "unconscionable" delay (at [102]) in bringing the proceedings meant that the "decision to put Mr Soh into a NSW prison should

Jacobs v Onesteel Manufacturing Pty Ltd and WorkCover Corporation of SA [2006] 93 SASR 568 at [90]-[91], per Besanko J.

[73] See Aronson, Groves and Weeks, *Judicial Review of Administrative Action and Government Liability*, (6th Ed, 2017, Thomson Reuters) at [10.340].

not now be considered to have such illegality as to make his detention there unlawful" (at [103]).

71 In *Precision Products (NSW) Pty Limited v Hawkesbury City Council* (2008) 74 NSWLR 102; [2008] NSWCA 278 at [119], Allsop P[74] emphasised the necessity for "coherence between administrative law doctrines and the imposition of monetary compensation". The usual role played by the concept of coherence is in ensuring there is no incompatibility between statutory duties and the imposition of duties of care.[75] However, as illustrated by the facts of *Soh*, there is no reason why the role of coherence should be so limited. To allow a party such as Seqwater to successfully litigate a claim of invalidity based on its own defaults in a common law action when it would be debarred from doing so in judicial review proceedings would be to promote incoherence between the law governing judicial review of administrative action and the law governing the imposition of monetary compensation. In circumstances where the State admitted the validity of the Chief Executive's approval, and SunWater, who was contracting through Seqwater, did not deny it,[76] I do not accept that Seqwater is entitled to obtain any finding of invalidity which would have a greater effect than the relief they would obtain through judicial review proceedings.

72 Second, it follows from the above analysis that, even if Seqwater was correct in establishing that its application for program approval did not comply with s 13(3)(b) and that this had the consequence that the approval on 3 December 2010 was no effective decision at all and was to be treated as such in these proceedings, that would not mean that the making of releases below FSL for flood mitigation was contrary to law. As stated, from 12 March 2010, Seqwater's existing statement of programs was approved and it could continue to operate under them "until the [interim] program submitted under … section [13(3)(b)] was approved" (s 13(11)); ie, validly approved. If, accepting Seqwater's case, the approval of the interim program was invalid and no

[74] As his Honour then was.
[75] *Sullivan v Moody* (2001) 207 CLR 562; [2001] HCA 59 at [50].
[76] See [50].

decision at all, then the authority conferred under s 13(10) and s 13(11) on 12 March 2010 to continue to operate under the "existing program" subsisted throughout the January 2011 Flood Event.

73 It follows that I am satisfied that at the time of the January 2011 Flood Event, it was not a contravention of section 72(3) of the Moreton ROP or the *Water Act* to make releases from both dams below FSL for flood mitigation purposes.

Section 14 of the Moreton ROP

74 As noted, the plaintiff also sought to rely on s 14 of the Moreton ROP as generating an exception to s 72(3) of the Moreton ROP.[77] Section 14(1) provides that the "operating and environmental management rules and monitoring requirements of this plan do not apply in situations where carrying out those rules and requirements would be unsafe to a person or persons." Seqwater contended that this submission was not open on the pleading.[78] In light of my conclusions in relation to s 13 of the Moreton ROP it is not necessary to resolve this issue.

Water Grid and Market Rules

75 One further matter should be noted about the legal regime governing the release of water. In its defence, Seqwater referred to two provisions of its "Grid Contract" made pursuant to s 360ZDD of the *Water Act* as potentially constraining its ability to release water below FSL.[79] Seqwater relied on those provisions as affecting whether any duty of care it owed extended to making or considering making releases below FSL.[80] It is convenient to outline the operation of those provisions at this point.

76 Part 5A of Chapter 2A of the *Water Act* established a wholesale exchange market for the supply of declared water services to the water grid manager

[77] Plaintiff subs at [810].
[78] Seqwater subs at [134] to [139].
[79] Seqwater Defence, PLE.020.012.0001, [99].
[80] Seqwater subs at [365], [376] to [380].

and the sale by the water grid manager of such declared water services (s 360ZCL). The Minister was empowered to make market rules for the operation of the market (s 360ZCX). Section 360ZDJ of the *Water Act* made it an offence for a relevant entity to contravene the market rules.

77 An aspect of that scheme was that the Minister was empowered to declare certain water services as being necessary for the water security of the South East Queensland Region (ss 360ZCM(a), 360ZCR-360ZCS). The Minister could make contracts binding on suppliers for the supply of declared water services to the water grid manager (ss 360ZDD–360ZDE). The Grid Contract was made pursuant to the exercise of that power on 28 June 2010.[81]

78 The two provisions of the Grid Contract relied on by Seqwater were clauses 9 and 11. Clause 9 of the Grid Contract obliged Seqwater to make certain water available to the water grid manager in accordance with, among other things, the Grid Contract and the market rules. Under subclause 11(c) of the Grid Contract, Seqwater was bound to "use its best endeavours to minimise, mitigate and measure water losses in the Service Provider Infrastructure, including storage losses (including evaporation and leakage), release losses, transport losses and treatment losses".

79 There was no evidence led to suggest that the requirements of the water grid manager were imperilled by any of Dr Christensen's proposed releases and a "best endeavours" requirement would be subject to any competing obligations of flood mitigation. In any event, all of Seqwater's obligations under the Grid Contract were subject to clause 24.1, which permitted Seqwater to interrupt or curtail the taking and delivery of water under the Grid Contract "*to prevent or minimise actual or imminent damage to the property of any person*", and to "*avoid actual or imminent injury or harm to any individual*.[82] This is more than sufficient to encompass making releases below FSL if that was necessary for flood mitigation.

[81] SEQ.001.022.8981
[82] Grid Contract, cl.24.1(c) and (d), SEQ.001.022.8981, .8999.

5.2: The Manual and FSL

80 The next issue that arises is whether the Manual precludes, permits or contemplates the level of Wivenhoe Dam being reduced below FSL *during* flood operations. Seqwater and SunWater submitted that this should only be addressed as part of a determination of whether the flood engineers reasonably believed that releases below FSL were not permitted.[83] However, for the reasons outlined in Chapter 3 at [124] to [129], the question must be first addressed in an "objective" sense. The first of the common questions posed required such an assessment and s 374 of the *Safety and Reliability Act* also required an assessment of whether the dam owner "observe[d] the operational procedures" in the Manual.[84]

81 I have already found that, after the declaration of a flood event, section 8.3 of the Manual precluded releases from the Wivenhoe Dam crest gates prior to the reservoir level exceeding EL 67.25m AHD.[85] It follows that releases below FSL from Wivenhoe Dam cannot be made during a flood event prior to that point having been first exceeded but section 8.3 does not preclude releases below FSL thereafter. The State queried the logic of having an initial trigger of EL 67.25m AHD but then later allowing releases below FSL[86]. The reasons for the trigger of EL 67.25m AHD were not explored but presumably it was included to allow for an initial assessment of the flood event and to ensure releases did not commence prematurely. That purpose is still given effect to if releases are later made from below FSL based on predicted storage levels that engage strategies such as W3 or W4. Otherwise, there is no equivalent restriction on releases from Somerset Dam and, as discussed in Chapter 4, flood releases from Somerset Dam were made below FSL during the March 2010 Flood Event.[87]

82 Beyond that, nothing in the Manual expressly provided that releases cannot be made from Wivenhoe Dam below FSL during a flood event. However, did

[83] Seqwater subs at [168]; SunWater subs at [670] and [672].
[84] See Chapter 2 at [32].
[85] Chapter 3 at [35].
[86] State subs at [503].
[87] Chapter 4 at [198].

the Manual implicitly preclude it or at the very least assume that that would not occur? In the end result, five parts of the Manual were principally[88] deployed by the parties in relation to this argument, bearing in mind that the Manual must be read as a whole, namely: the objective of retaining water at FSL at the conclusion of the flood event, which is repeated three times in the Manual;[89] the discussion of that objective in section 3.5;[90] the description of the "reservoir volume above FSL" in section 8.1;[91] the description of the gate closing strategies in section 8.5[92] and section 9.4,[93] and the entries in the appendices to the Manual.[94]

83 In considering these provisions (and the other provisions relied on), it must be remembered that, unlike its predecessor, the Manual's strategies are engaged by predicted levels formed by reference to rainfall forecasts. For so long as the Wivenhoe strategies are engaged by actual levels above EL 67.25m AHD then any consideration of whether releases can be made below FSL during flood operations can never arise as there is no applicable strategy that is capable of application below FSL.

84 The first two provisions noted in [82] provide no support for any contention that the Manual implicitly prohibits releases below FSL during flood operations, or even assumes they will not occur. In fact, they suggest the opposite. The flood objective concerning FSL is only addressed to the position at the conclusion of, and not necessarily during, the flood event.

85 By reference to the dictionary definitions that define "retain" as "keep[ing] possession of" and "contin[uing] to hold or have", Seqwater submitted that retain meant to "[c]ontinue to have or keep the storage at full supply level at the conclusion of the flood event".[95] It submitted that the use of the word "retain" contemplates that releases will not commence from Wivenhoe Dam

88 Although there were others – see [102].
89 See Chapter 3 at [6], [19] and [25].
90 See Chapter 3 at [25] to [26].
91 See Chapter 3 at [30] to [31].
92 See Chapter 3 at [68] to [75].
93 See Chapter 3 at [93].
94 See Chapter 3 at [98] to [101].
95 Seqwater subs at [253] to [254].

until after FSL is exceeded (ie, EL 67.25m AHD) and that the Manual contemplates reducing below FSL at or towards the end of the flood event with allowance for refill by backflow. In that sense, FSL is being retained. However, the word “retain” is only referable to “the conclusion of the flood event”. If the Manual (implicitly) prohibited, or at least assumed that flood operations could never take Wivenhoe Dam (or Somerset Dam) below FSL, then this objective is a waste of words as there is no possibility that water would not be “retained” at FSL at the conclusion of a flood event, save for the possibility that there is an underestimate of baseflow.

86 More significantly, this part of the Manual is not expressed as an outright limitation or prohibition but is instead only expressed as an objective which, most importantly, is subordinated to three higher objectives, namely, dam safety, optimising urban protection and minimising rural disruption. Of their nature, “objectives” are aimed for but not always achieved. Given that flood operations can only commence if the dam level is expected to exceed FSL and Wivenhoe Dam is above EL 67.25m AHD, then the only means by which the subordination of this objective to three higher objectives could ever be given effect to is by contemplating that, in some circumstances, the objective of retaining water at FSL will not be achieved because, for example, the flood engineers must give priority to the higher objectives and err on the side of caution by releasing at such a rate that risks the dam not returning to FSL.

87 Beyond parsing the text of the objective of retaining the dams at FSL at the conclusion of the flood event, none of the defendants’ submissions engaged with the consequences of the subordination of this objective to the higher objectives in the context of a Manual whereby strategies are engaged by predictions.[96] This is not addressed by pointing to the possibility of the dam falling below FSL and then returning to FSL via baseflow as reflecting the scope of the fourth flood objective. That only occurs at the point when section 8.5 is already engaged and the flood event is coming to an end. At that time, the higher level objectives will often have been met. In other words, the taking of the dam below FSL for refill by baseflow is not being undertaken

[96] See Seqwater subs at [247] to [263]; SunWater subs at [670] to [746]; State subs at [494] to [506].

to give effect to any higher order objectives and does not involve the subordination of the objective of retaining the dam at FSL to any such higher objectives.

88 Similarly, Seqwater also instanced the practical difficulties in timing gate closures at FSL as a reason for why there is an exhortation in the flood objective to close gates and end the flood event at FSL, rather than a rule preventing the dam from falling below FSL.[97] However, that circumstance does not involve the subordination of this flood objective to higher objectives either. Instead, the making of releases below FSL in, say, Strategy W3 or W4 based on a predicted height of the dam above either EL 68.5m or 74.0m AHD, does involve the subordination of the objective of retaining the dam at FSL to higher order objectives. No other form of subordination was suggested in the evidence or submissions. In this sense, the Manual's emphasis on objectives and their order of priority contemplates the possibility of making releases below FSL during flood operations. As noted below,[98] this was in part recognised by Mr Fagot, at least so far as dam safety is concerned.

89 This is reinforced by section 3.5 which states that there "should be no reason why the dams *should* not be full *following* the flood event". Mr Fagot treated this as more than a suggestion, deeming it a "requirement".[99] However, "should" is different to "must" and "following" does not mean "during". Section 3.5 is a discussion of one of the Manual's objectives, not its prohibitions. Seqwater submitted that, if the plaintiff's contention that flood releases below FSL were allowed, then, contrary to section 3.5, that would provide "a reason" for the dam not being filled to FSL at the end of a flood event (this reason presumably being that the forecast rain necessary to fill it up did not eventuate).[100] The State made a similar submission.[101] However, this argument merely represents an attempt to convert "should" into "must". At most, the admonition in section 3.5 suggests that the flood engineers should

[97] Seqwater subs at [251]; see also SunWater subs at [680]; State subs at [505].
[98] At [113].
[99] EXP.QLD.001.0524 at [111]; relied on by the State at State subs [501].
[100] Seqwater subs at [259].
[101] State subs at [26(a)].

exercise caution in releasing below FSL given the potential to compromise water security. As such, it supports the suggestion that such releases are not prohibited under the Manual.

90 I have set out the competing submissions on section 8.1 in Chapter 3 at [31]. Section 8.1 is headed "Introduction" and is descriptive of the minimum or exclusive flood storage of Wivenhoe Dam that is available to the flood engineers to conduct flood operations. Section 8.1 only states that the reservoir volume above FSL is always "available as temporary flood storage" because all water above that level from any previous flood event should have already been evacuated.[102] The Manual clearly contemplates the possibility that at the commencement of a flood event there might be storage space available below FSL, because a flood event is declared based on an expectation that FSL will be exceeded and not an actual level that is exceeded.

91 SunWater placed particular emphasis on sections 8.5 and 9.4, concerning gate closing strategies, as supporting the suggestion that releases below FSL from either dam were not permissible under the Manual save to allow refill by baseflow.[103] SunWater submitted that section 8.5 is not only directed to closing gates at the end of a flood event but is instead directed to the circumstances when the lake level begins to fall.[104] SunWater emphasised that section 8.5 states that "final gate closure should occur when the lake level has returned to FSL" as opposed to stating that the "final gate closure should occur at the conclusion of the flood event".[105]

92 Sections 8.5 (and 9.4) are addressed in Chapter 3.[106] In that discussion, I accepted that "final gate closure" is not necessarily synonymous with the end of a flood event but they are closely related.[107] At the risk of stating the obvious, the "*final* gate closure" could only be a reference to the closing of the

[102] Cf Seqwater subs at [260(a)].
[103] SunWater subs at [675] to [687]; see also Seqwater subs at [258].
[104] SunWater subs at [678].
[105] Ibid at [682] to [683].
[106] At [68] to [75], [93] and [136] to [147].
[107] Chapter 3 at [139].

last gate for the flood event which must be near its anticipated end. It is true that the first sentence refers to “gate closing” when the level of Wivenhoe Dam begins to fall, but that is prefaced by the words “in general”. When read with the second sentence, it suggests that section 8.5 is directed to the falling limb of the hydrograph and is not concerned with the circumstance of a temporary reduction in Wivenhoe levels before a predicted increase in inflows and levels; eg, a twin peak hydrograph. If this was the case, then there would be a conflict between section 8.5 and section 8.4, which specifies strategies by reference to predicted levels above EL 67.25m AHD. As explained in Chapter 7, there was a temporary reduction in Wivenhoe Dam levels on the morning of 9 January 2011 but no gate closing.[108]

93 Accordingly, I accept that section 8.5 is directed to gate closing towards the conclusion of a flood event and hence compliance with the objective of retaining storage at FSL. As noted by the plaintiff, “[a]t the end of a Flood Event, each of the three objectives ranking higher than the retention of storage at FSL will presumably have been satisfied” such that the objective of retaining storage at FSL remains to be achieved.[109]

94 If the water level is maintained above FSL before the next flood event, then that would be inconsistent with section 8.1 and the requirement to evacuate flood waters within seven days. Hence, to comply with those provisions, yet achieve the objective of retaining the storage at FSL at the conclusion of the flood event, it may be necessary to reduce the dam below FSL when the final gate is closed to allow baseflow to fill the dam to FSL over time. Beyond that, section 8.5 is not addressed to releases below FSL during flood operations. It does not expressly permit or preclude them, nor does it implicitly preclude them or assume they will not occur.

95 Accordingly, it follows that I do not accept that the Manual expressly, or implicitly, precluded releases during flood operations that take both Wivenhoe

[108] See Simulation Analysis, EXP.ROD.015.0461 at .0528.
[109] Plaintiff subs at [561].

Dam and Somerset Dam below FSL and nor did it operate on any assumption that that would not occur.

96 The defendants repeatedly emphasised that the Manual did not provide any express or "positive" direction to release below FSL.[110] They submitted that a flood engineer could reasonably expect some fairly detailed level of instruction as to how that would occur.[111] It is correct that the Manual did not provide any express permission to operate below FSL, save for the reference to baseflow in section 8.5. In that respect, it is another instance of the matter noted in Chapter 3[112] ie, a matter that leaves the relevant decision to the flood engineer to exercise their professional judgment on.

97 The defendants' longing for detailed guidance on making releases below FSL is an echo of the points noted in Chapter 3 concerning the absence of a detailed prescription of how to make releases based on forecasts. However, as explained in Chapter 3, the Manual spurned detailed prescriptions and instead emphasised a risk-orientated approach that, subject to certain restrictions and constraints, required the selection of strategies by reference to predictions and directed gate operations within those strategies by reference to the Manual's objectives in their order of importance. The Manual permitted, in the sense of not precluding, releases within any strategy to be made below FSL provided that "consideration is always given to [flood] objectives in [their] order" of priority.[113] One of those objectives that must be considered is the necessity to retain storage at FSL at the conclusion of the flood event. To that end, when giving effect to higher objectives by making releases below FSL, consideration must always be given to that objective which reflects the necessity to preserve water to meet downstream demand. In considering that objective, it must be borne in mind that there should be no reason why the dam should not be full at the completion of the flood event which, as noted, warrants caution in reducing water levels below FSL. Seqwater noted that the Manual does not address what would occur if

[110] Seqwater subs at [247(a)] and [260]; see also State subs at [24] to [25].
[111] Seqwater subs at [261] to [262].
[112] Chapter 3 at [132].
[113] Manual at 23 (.0173).

releases were made below FSL and the predicted inflows to return it to FSL did not materialise.[114] If that were to occur, it would simply mean the fourth flood objective was not achieved at least in part because the Manual directed that greater priority be given to the higher objectives. Otherwise, it is no different to the circumstance where at the end of a flood event the dams are below FSL and the calculated baseflow does not arrive.

98 Subject to considering any legal constraint on such releases, it further follows that in some circumstances such releases should be made if they are necessary to advance the Manual's objectives, accord with its strategies and do not violate any express constraint. This is especially so in circumstances where the Manual's strategies, and in turn release decisions made within those strategies, were informed and to an extent governed by maximum predicted storage levels ascertained by reference to rainfall forecasts. To take an extreme case, if (say) a highly reliable forecast predicted an amount of rain in three days' time which would rapidly fill the dam from a current level of EL 67.25m AHD to overtopping levels then the Manual's objectives would appear to require the making of large releases immediately even if that caused the dam to fall below FSL, despite carrying a risk that it would not fill if the rain did not materialise.

99 Three further points should be noted.

100 First, for the sake of completeness, I will address the other provisions of the Manual relied on by the parties. Seqwater referred to the restriction on opening the sluice gates and regulators until the actual level of Somerset Dam reaches EL 100.45 m AHD and contended that "this only makes sense if the water is to be at or above FSL throughout the flood event".[115] This is a reference to the first three conditions of S2. It does not apply to either S1 or the fourth condition of S2. As described in Chapter 4, releases through the

[114] Seqwater subs at [263].
[115] Seqwater subs at [260(c)].

regulator were made from below FSL within S1 during the March 2010 Flood Event.[116]

101 Seqwater also referred to the technical data for both dams in Appendices C and D of the Manual which do not define any flood capacity below FSL or any radial gate rating for Wivenhoe Dam at elevation levels below FSL.[117] This is partly addressed in Chapter 3 at [98] to [101]. Otherwise, the references to gate discharges do not advance the matter. Both appendices specify the maximum available discharges from either dam for elevation levels far below FSL arguably suggesting such discharges were contemplated.[118]

102 Seqwater referred to Table 10.2 in section 10.3 of the Manual which directed that gate operations be conducted by dam operators by reference to actual lake levels above FSL.[119] However, as explained in Chapter 3,[120] that section concerned the circumstance in which there was a loss of communications between the FOC and the dams so that the dam operators are left to direct gate openings and had no capacity to make predictions about storage levels. Seqwater also referred to the operations target line having no "contemplation that during a flood event the level of Wivenhoe Dam will be below EL 67 or the level of Somerset Dam will be below EL 99".[121] In fact, the target line is not engaged unless Somerset Dam is above EL 100.45m AHD and Wivenhoe Dam is above FSL and rising.[122] It only seeks to equalise the minimisation of flood peaks in both dams in relation to their associated dam failure levels. It has no role to play when Somerset Dam is below EL 100.45m AHD presumably because no such minimisation is necessary. The same would apply when Wivenhoe Dam was below EL 67.0m AHD.

103 Second, the State sought to draw a contrast between the Manual and the flood manual for North Pine Dam which it contended "expressly provide[d] for

[116] Chapter 4 at [198].
[117] Manual at 54 - 55; Seqwater subs at [260[d] and [e]].
[118] EL 57.0m AHD in the case of Wivenhoe Dam (Manual at 53), and EL 90.0m in the case of Somerset Dam (Manual at 59).
[119] Seqwater subs at [260(f)]; Manual at 45 (.0195).
[120] At [96] to [97].
[121] Seqwater submissions at [260(g)].
[122] Manual at 40 to 41.

pre-releasing water level below FSL at North Pine Dam".[123] It follows from the discussion in Chapter 3 that construing the Manual by reference to another flood mitigation manual is an incorrect approach, although it may be relevant to any consideration of the subjective understandings of the flood engineers.[124] None of the flood engineers who gave evidence sought to draw any comfort from the North Pine manual for any view that they held regarding the impermissibility of releases below FSL under the Manual. In any event, the express permission in the manual for North Pine Dam to which the State refers is the statement that "[u]nless a decision has been made to commence a pre-release of flood water to control the risk of dam overtopping, releases from the radial gates should not commence until the lake level exceeds FSL by 50 millimetres (39.65 m AHD)".[125] This appears to be an express exception to the equivalent statement in section 8.3 of the Manual concerning releases not being made prior to EL 67.25m AHD. However, the present discussion concerns releases after that point.

104 Third, the State submitted that, irrespective of the proper interpretation of the Manual, the flood engineers would not have been permitted by Seqwater to lower Wivenhoe Dam below FSL.[126] This submission takes the matter nowhere. As noted, this issue arises by reference to an assessment of the approach to be taken by the reasonably competent flood engineer in the position of the flood engineers. Up to this point, I have concluded that, after section 8.3 is satisfied, the Manual did not preclude such a flood engineer making releases below FSL and that giving effect to the Manual's strategies and objectives may have required it. It is no answer to a complaint that they failed to take that step to assert that, if they had, Seqwater might have sought to countermand their attempts to do so.[127]

[123] State subs at [24].
[124] See [124] to [128].
[125] QLD.002.003.0003 at .0025.
[126] State subs at [27].
[127] Chapter 13, section 13.5.6.

5.3: Expert Evidence and Practice at Other Dams

105 At this point I will address the expert evidence relied on by the parties concerning the making of releases below FSL. The following analysis confirms the findings made in section 7.2.

Mr Fagot

106 All of the defendants placed reliance on Mr Fagot's evidence on this topic with both SunWater and the State asserting that his evidence demonstrated the existence of an established practice of flood engineers not to make releases below FSL.[128]

107 I have addressed Mr Fagot's evidence generally in section 3.4 of Chapter 3. Mr Fagot concluded that the Manual did not permit flood engineers to release water below FSL during flood operations. In asserting this, Mr Fagot addressed, in an interrelated manner, both general flood engineering practice and the terms of the Manual.

108 In relation to the former, in his first report Mr Fagot described the "typical operation of a multi-purpose reservoir".[129] As part of his description, he identified such dams as having a "conservation pool" which is used "for storing water that is used for conservation or supply purposes",[130] a feature he regarded as "equivalent to FSL at Wivenhoe and Somerset". He then described the process for determining the "water supply yield" and how that determines the FSL. Under the heading "flood protection criteria" he stated:[131]

> "An important concept to understand regarding water supply (or other conservation purposes) and flood protection criteria is that they are in opposition to one another. In a multi-purpose reservoir, these competing purposes of conservation and flood protection *are given dedicated storage*. This storage is set by analysing the total amount of available storage along with the requirements needed for conservation and flood protection. The ultimate determination of that balance also reflects input from multiple

[128] Seqwater subs at [195] to [201]; SunWater subs at [697] to [703], [711]; State subs at [211], [228(e)], [228(g)] and [639(a)] and see also State subs at [498] to [501].
[129] EXP.QLD.001.0232 at [43].
[130] Id.
[131] Ibid at [47].

stakeholders which would usually include water supply users, hydropower producers, and downstream interested parties potentially affected by flooding. As was noted in the water supply criteria section above, there is a balance that must be achieved between providing for water supply and providing a degree of flood protection for downstream interests. Recognizing that this balance has been achieved through a significant analysis and stakeholder involvement, based on my experience, *reservoir engineers making real-time operational decisions do not change these levels on the fly during an event unless there is specific direction to do so in the flood mitigation manua*l. I have reviewed the flood mitigation manual for Wivenhoe and Somerset, and I have found no such direction for the reservoir engineers to change the supply level during the course of the event." (emphasis added)

109 Later in his affidavit, Mr Fagot stated that it "would be contrary to the widely accepted practice to assume that a reservoir engineer would have the authority to alter the FSL or use storage space designated as supply storage for flood mitigation".[132] He said that the "alteration of operational zones and rules is complex and time consuming process" being "not just an engineering calculation but a policy change".[133]

110 This aspect of Mr Fagot's evidence is clearly premised on an assumption that the water below FSL represents an inviolable supply pool arrived at as a result of "significant analysis and stakeholder involvement" and therefore it is inappropriate for the flood engineers to alter the level at which that pool is set, especially during the conduct of flood operations. However, the regulatory regime applicable to Wivenhoe and Somerset Dams during January 2011 did not create such an inviolable pool. It did not reflect any policy or government decision that flood operations could not affect or interfere with that pool. Instead, the effect of the interim approval (and the approval of the earlier statement of programs) reflected a determination by the Chief Executive that the storage space below FSL was not inviolable or solely dedicated to the water supply and could therefore potentially be used for flood mitigation. It follows that, contrary to Mr Fagot's evidence, the making of flood releases below FSL during flood operations does not involve an "alteration" of FSL or any operational zones or rules.

[132] EXP.QLD.001.0232 at [305].
[133] Ibid at [56].

111 Further, Mr Fagot's views on this topic were clearly the product of his experience in the USA with highly prescriptive flood operations manuals. Thus, Mr Fagot would not countenance Dr Christensen's simulation D which assumed Wivenhoe Dam could be taken below FSL to the extent that it could be refilled by water above FSL in Somerset Dam because "the flood mitigation manual contains no specific guidance" to that effect.[134] Of course there are a vast number of matters the Manual does not provide "specific guidance" on including, for example, setting release rates. Nevertheless, Mr Fagot did not express any in principle opposition to reducing water from below FSL per se. Thus, in cross-examination Mr Fagot stated that, if there was "loose language" in the Manual that said in effect "[i]f you feel based on forecasted rainfall that you can bring this down [below FSL]", then he would "*prefer* to see more specific guidance".[135] Later, he was cross-examined about the flood objective of retaining storage at FSL at the conclusion of the flood event. He said that, provided no constraints are violated, then "if I'm bringing the pool down below its fully supply without a guarantee that it is going to rise back up to its full supply level, I'm hoping I don't violate that constraint" being section 3.5 of the Manual.[136] When he was asked whether rain on the ground modelling was sufficient to provide him with that "guarantee" he said he was "okay with the concept" but considered it was inconsistent with the Manual setting aside space above EL 67.0m AHD for flood mitigation.[137] Similarly, with retaining water in Somerset Dam above FSL sufficient to refill Wivenhoe Dam, Mr Fagot said he was "okay with the suggestion" but expressed a concern about risks between the two dams not being equalised,[138] a matter that is addressed above at [100]. The findings in Chapter 3 at [374] to [376] are applicable to this aspect of Mr Fagot's evidence.

112 In relation to the Manual, in his second report Mr Fagot identified sections 3.4, 3.5, 8.1, 8.3 and 8.4 as the basis for concluding that the Manual does not

[134] EXP.QLD.001.0524 at [98].
[135] T 9028.10 - .13.
[136] T 9035.16.
[137] T 9035.31.
[138] T 9035.43.

authorise releases below FSL.[139] Those provisions have already been addressed. Consistent with his USACE experience, in his oral evidence Mr Fagot stated that unless there was specific authorisation in the Manual to "borrow from the supply storage for flood mitigation purposes", he would "consider that to be a prohibition against doing so".[140] In Chapter 3, I set out the conceptual flaws that effectively invalidated Mr Fagot's approach and they apply to this matter as well.

113 In addition, I note that Mr Fagot concluded that, given the order of priorities in the Manual, the "supply pool" could "be sacrificed if a dam safety issue becomes apparent as dam safety issues would also impact the rural and urban interests" but that the supply pool could not otherwise be compromised. He asserted that this was supported by the Manual and that this supported the interpretation of the flood engineers.[141] This was not the interpretation of the flood engineers or any other witness other than Mr Ickert.[142] Given the priorities in the Manual there is no logical reason why, if the FSL objective was subordinated to dam safety, it would not be subordinated to the other higher objectives as well.

Mr Pokarier

114 Seqwater also relied[143] on Mr Pokarier's evidence to the effect that he did not consider that "a reasonably competent engineer would interpret the Manual to allow operations below FSL" save for accounting for baseflow at the end of a flood event.[144] In support of this opinion, Mr Pokarier identified clauses 8.1, 8.3, 8.5, Appendices C and D, the definition of FSL and the Operations Target Line, all of which have been addressed.[145] Mr Pokarier was cross-examined on those aspects of the Manual.[146] He asserted that he construed the objective of retaining storage at FSL as a prohibition on releasing below

[139] EXP.QLD.001.0524, [163] to [169]; see also [106] to [118]; he also referred to section 8.5 in his first report, EXP.QLD.001.0232 at .0291, [114].
[140] T 9028.29.
[141] EXP.QLD.001.0524, [169].
[142] See below at [125].
[143] Seqwater subs at [193] to [194].
[144] EXP.SEQ.016.0001 at [92].
[145] Ibid at [91].
[146] T 6998 to T 7004.

FSL.[147] When asked whether that was inconsistent with the subordination of lower order objectives to higher order objectives, he stated that "[i]t is inconsistent because it is a different style of objective".[148] Again, I found Mr Pokarier's defence of his interpretation of the Manual unconvincing. For that reason, the reasons noted in Chapter 3 at [218] and what is explained next, I derived no assistance on this issue from Mr Pokarier's evidence on the proper interpretation of the Manual and flood operations.

115 In his report, Mr Pokarier listed one of the bases for his conclusion about FSL as follows:[149]

> "*Based on my experience*, the FSL is defined to provide a clear boundary between the competing priorities of water supply and flood storage compartments. It is not reasonable to operate a dual purpose (water supply and flood mitigation) dam during a flood without any regard to the water supply compartment." (emphasis added)

116 Mr Pokarier's qualifications and experience are described in Appendix 3. In short, he has been employed by Seqwater or SunWater for all of the relevant periods of his professional life.[150] The only dams he had seen operated during a flood event were owned and operated by Seqwater.[151] During the January 2011 Flood Event he was employed as a data collector and was only trained in flood operations afterwards. He agreed that the entirety of his training in flood operations was provided by Messrs Malone, Tibaldi and Ayre.[152] He agreed that "everything that [he] had been told about Revision 7 of the Manual was told to [him] after the flood event" by Messrs Malone, Tibaldi and Ayre (and well after the flood event actually occurred).[153] The plaintiff noted that that coincided with the period when the flood engineers were subject to close scrutiny regarding their actions during the January 2011 Flood Event.[154] Mr Pokarier stated that he could not interpret Revision 7 (ie, the Manual) without

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[147] T 6997.46.
[148] T 6998.8.
[149] EXP.SEQ.016.0001 at [91].
[150] T 6736.39.
[151] T 6737.30.
[152] T 6737.8.
[153] T 6738.24 to T 6739.41.
[154] Plaintiff subs at [1557].

considering subsequent versions of the Manual as clarifying its terms.[155] The combination of this, and my impressions of Mr Pokarier in giving evidence, meant that I treated his opinions on the Manual, and the conduct of flood operations under it, as no more than a recitation of the flood engineers' current opinions on the same topic.

117 In relation to the opinion noted in [115] above, Mr Pokarier said that the experience he was referring to included that which I have summarised but also his work in undertaking "water resource modelling" when he joined SunWater in 2006.[156] However, I do not accept that that experience in water resource modelling provides Mr Pokarier with any particular insight into whether or not "the FSL is defined to provide a clear boundary between the competing priorities of water supply and flood storage compartments". That topic is essentially a policy question for the executive government which it answered in approving an interim program which enabled releases below FSL for flood mitigation. Otherwise, it is not in dispute that "[i]t is not reasonable to operate a dual purpose (water supply and flood mitigation) dam during a flood *without any regard* to the water supply compartment." In his simulated flood operations, Dr Christensen sought to address water supply concerns by only reducing below FSL to the extent that either forecast rain, rain on the ground or water above FSL in Somerset Dam would return Wivenhoe Dam to FSL. Whether he did so in the manner that met the minimum required of a reasonably competent flood engineer is addressed in Chapters 8 to 10.

Mr Swain

118 In his report, Mr Swain referred to the Glendo Reservoir in the Missouri River which he said was similar to the reservoir storage allocation for Wivenhoe and Somerset Dams,[157] in that it provided for an inviolable "active conservation storage" for municipal uses. He stated that "[p]recautionary releases are never made out of the active conservation storage (below Full Supply Level) or flood control storage based on using QPF or PME rainfall forecasts to

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[155] T 6791.18.
[156] T 6989.36 to T 6990.15.
[157] Swain, EXP.SEQ.008.0065 at .0080.

estimate rainfall inflows.[158] Given his description of the active conservation storage zone, that conclusion must follow. He agreed that the USACE had no authority to "direct releases be made below the conservation pool level".[159] The assumptions given to Mr Swain effectively required him to assume the water below FSL could not be used for flood mitigation.[160] However, given the approval to operate below FSL, that does not translate to Wivenhoe and Somerset Dams.

Dr Christensen

119 Dr Christensen construed the Manual as permitting releases below FSL. He noted that there is no express prohibition in the Manual on releasing below FSL[161] but principally relied on his interpretation of the fourth objective and its subordination to the higher objectives.[162] He characterised the storage below FSL as available for both "storing water for water supply and for flood control".[163]

120 In its submissions, Seqwater noted that Dr Christensen conceded that the reasonably competent flood engineer would expect to see clear direction in the Manual as to what part of the water storage compartment would be available for flood mitigation.[164] Dr Christensen made that concession but added that he regarded the prioritisation of the flood objectives as a sufficiently clear statement.[165] Seqwater submitted that "Dr Christensen took it upon himself to decide that the limit on releases should be that the lake levels were not taken below more than 60% of the water supply storage".[166] It contended that, without any detailed analysis of water supply needs for South East Queensland, nor any discussion of the events of the Millennium Drought,

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[158] Ibid at .0084.
[159] T 7329.41.
[160] EXP.SEQ.008.000 at .0019.
[161] T 1228.11 - .18; see also February 2015 Report, EXP.ROD.001.0016 at [288].
[162] February 2015 Report, EXP.ROD.001.0016 at .0097, [237] - [238], [289]; see also Reply Report, EXP.ROD.004.0005 at .0055 - .0056, [173]-[175].
[163] February 2015 Report, EXP.ROD.001.0016 at .0113 to .0114, [282].
[164] Seqwater subs at [204]; T 2041.45 to T 2042.11.
[165] T 2042.7.
[166] Seqwater subs at [204]; T 1223.8 - .23; see also Reply Report, EXP.ROD.004.0005 at .0058, [183].

Dr Christensen was prepared to declare that Seqwater and the flood engineers should have known that Wivenhoe Dam had more than sufficient storage to meet the existing water supply demands.[167] Seqwater submitted that this was "a striking example of Dr Christensen taking [it] upon himself, and thrusting upon the flood engineers, a responsibility during a real time flood event to make decisions to disturb policy decisions made by the Queensland Government in setting and maintaining the FSLs".[168]

121 In fact, Dr Christensen did address the water supply concerns of releasing below FSL during the January 2011 Flood Event in his reports.[169] In particular, he noted that immediately before the flood event approval was given to reduce FSL to 95% of its existing levels and after it was in fact reduced to 75% of existing levels, both matters indicating a lack of concern about the security of the water supply at the time.[170] He also noted that Wivenhoe Dam was close to FSL and that significant new water storage was soon to become available when works at the Hinze Dam would be completed.[171] He also noted that, given the state of the catchments, it was "early in the wet season and in light of the ongoing La Niña event, there would have been a strong likelihood of that by the end of the season in March, the dams would have been back to their FSLs" even if the forecast rain in January 2011 had not eventuated.[172] The reference to "60% of the water supply" in Seqwater's submission is a reference to the answer given by Dr Christensen that a reasonably competent flood engineer would know that the trigger for drought storage in Wivenhoe Dam is 40% of FSL and that at 60% per cent, the water supply is secure.[173] The former figure was derived from a publication by the Queensland Water Commission in 2010, the 'South East Queensland Water Strategy'.[174]

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[167] Seqwater subs at [204]; February 2015 Report, EXP.ROD.001.0016 at .0099-0100, at [244].
[168] Seqwater subs at [204].
[169] February 2015 Report, EXP.ROD.001.0016 at [239] to [245] and [295]; Reply Report, EXP.ROD.004.0005 at [182] to [183].
[170] February 2015 Report, EXP.ROD.001.0016 at [241] and [243].
[171] Ibid at [244].
[172] Ibid at [182].
[173] T 1223.21.
[174] QLD.007.001.0109 at .0203; See also Reply Report, EXP.ROD.004.0005 at [184].

122 Otherwise, Dr Christensen addressed the practices of other dams in relation to the balancing of flood mitigation and water storage space. This is addressed below.

Mr Ickert

123 Mr Ickert addressed the issue of making releases below FSL in his second report[175] and, briefly, in his third report.[176]

124 In his second report, Mr Ickert accepted that there was a "tension" between the flood mitigation objectives and water supply objectives in the Manual but concluded that this tension was resolved by the "setting of the FSL".[177] Mr Ickert referred to sections 8.1, 8.5 (and 9.4) of the Manual and the absence of any specifications as to how a drawdown below FSL would be undertaken as supporting his opinion.[178] In his third report, Mr Ickert critiqued Dr Christensen's simulations and asserted that the Manual did not allow "pulling Wivenhoe Dam below FSL, [even] if there is water above the Somerset Dam FSL" to fill it.[179]

125 To a large extent, Mr Ickert retracted these opinions in cross-examination. He accepted that releases below FSL could be made when the safety of the dam was threatened[180] and, with some hesitation,[181] could also be made to avoid or minimise urban flooding,[182] although he stated that the circumstances would have to be "well defined" and allow for refill based on rain on the ground and not forecast rain.[183]

126 Mr Ickert was then questioned as to whether the same logic would allow releases below FSL from Wivenhoe if there was sufficient water above FSL in

175 EXP.SUN.008.0001_OBJ at [91] to [116].
176 EXP.SUN.009.0001_OBJ at [515], [548] and [555]; Mr Ickert's "first report" addressed loss rates; EXP.SUN.001.0001_OBJ, section L at [318].
177 EXP.SUN.008.0001_OBJ at [93].
178 EXP.SUN.008.0001_OBJ at [112] to [114].
179 EXP.SUN.009.0001_OBJ at [515].
180 T 8288.26.
181 T 8295.29.
182 T 8292.3 to .20; T 8296.2.
183 T 8293.18 to .19; T 8292.4.

Somerset Dam to refill it.[184] Mr Ickert accepted that there was nothing in the Manual that expressly excluded that approach but stated that he was "looking for something that expressly allows it".[185] He contended that this was not "contemplate[d]" by the Manual[186] but struggled to find textual support for his opinion.[187] The plaintiff's submissions were critical of Mr Ickert's lack of command of the Manual in answering these questions.[188] However, to my observation this was another instance of him seeking to engage with the logic of the line of questions addressed to him rather than a lack of independence.[189] That said, I accept the plaintiff's submission that no weight should be attached to his resistance to this proposition.[190] Once it is accepted that releases can be made below FSL, then provided it is consistent with the various strategies and does not violate any express constraint, an approach of maintaining water above FSL in Somerset Dam sufficient to refill Wivenhoe Dam to FSL meets the fourth of the flood objectives.

Other Dams

127 SunWater relied on the discussion in Mr Fagot's report of the practices at various dams in the USA in relation to not making releases from the supply compartment or supply pool.[191] Mr Fagot described the White River system with which he is familiar and noted that "drawing the pool into its supply storage based on a rainfall forecast has never occurred and would constitute a breach of the water control manual".[192] In his March 2017 report, Mr Fagot stated that there are "many lakes that have constant top of conservation levels and [which] are not drawn into their conservation pools based on a rainfall forecast".[193] In his April 2017 report, he identified 46 out of 60 projects within the USACE Southwestern division that did not vary its supply pool by way of a seasonal drawdown and stated that, of the other fourteen, he was

184 T 8296.4 to T 8302.1.
185 T 8299.8.
186 T 8296.22; T 8297.18.
187 T 8299.4 to T 8301.28.
188 Plaintiff subs at [1609] to [1611].
189 See Chapter 3 at [212].
190 Plaintiff subs at [1611].
191 SunWater subs at [662(h)] to [663].
192 EXP.QLD.001.0232 at [130].
193 EXP.QLD.001.0524 at [64].

aware that seven were not drawn down as a flood mitigation measure.[194] However, he qualified that by stating that in "some rainfall driven systems, there is a season that is typically wetter" which leads to a lowering of the elevation of the "bottom of flood storage".[195] Overall, there is no doubt that a number of USACE dams undertake seasonal drawdowns for flood mitigation purposes.[196]

128 In any event, the instances cited by Mr Fagot do not travel beyond that of describing the effect of the water control manuals for those dams. They do not demonstrate some established practice of not making releases from below the area devoted exclusively to flood storage. In his June 2017 report, Mr Fagot discusses the Missouri River Reservoir Zones which include an "Exclusive Flood Control Zone" and below that a "Flood Control and Multiple Use Zone" which can be used for flood control and other uses.[197] Mr Fagot concluded that Wivenhoe and Somerset Dams "do not have a zone equivalent to the annual flood control and multiple use zone".[198] Properly analysed, that statement is only an assumption about the regulatory context applicable to Wivenhoe and Somerset, which is invalidated by the above analysis. Otherwise, this is an example of a system that does not strictly demarcate between flood storage and other uses. Similarly, at least Mr Ayre and the State accepted that releases from below FSL were contemplated at North Pine Dam to avoid the risk of overtopping (see [103]). Ultimately, Mr Fagot agreed that "each region and river basin has its own unique requirements" and added that they are addressed in the "analysis that leads to the water control manual"[199] such that the "maintaining of the conservation pool is going to be based on the constraints that are found within the manual".[200]

129 In his first report, Dr Christensen engaged in overstatement by describing a "general practice" of using the storage area below the "exclusive flood control

[194] EXP.QLD.001.1305 at .1308 to .1310.
[195] EXP.QLD.001.0232 at .0485.
[196] EXP.SUN.008.0001 at [107] (Ickert).
[197] EXP.QLD.001.0505 at .0507 to .0511.
[198] Ibid at .0511.
[199] T 9008.22.
[200] T 9008.46.

storage” for both water supply and for flood control.[201] It is a precondition to the existence of such a general practice that the relevant regulatory regime and water control manual permit the practice. Whether it should generally be undertaken or only be undertaken in particular circumstances depends on the prevailing circumstances and the terms of the relevant water control manual. By way of example, ss 67 and 68 of the Water Sharing Plan for the Murrumbidgee Regulated River Water Source 2003, permitted the creation of “airspace” below its equivalent of FSL “no greater than that which will be refilled by storage inflows” (s 68(a)(a)).

130 At one point in his cross-examination, Mr Ayre was asked as follows:[202]

> “Q. I'm just addressing what you said a moment ago about what a flood operations engineer would expect, and this was put to Dr Christensen when he was being cross-examined, namely, that any competent flood operations engineer would expect there to be an express permission to go below FSL rather than leaving it to an experienced flood engineer to make such a decision if the flood engineer thought it was appropriate in the circumstances of a particular flood event. That's what I'm asking you to address, Mr Ayre - why you would have that expectation of an express permission as distinct from an expectation, if you couldn't do it, of an express prohibition.
>
> A. Well, as the manual indicates, the dams can be operated in any number of ways, and it could be by *pre-release*, it could be by *seasonal drawdown*. You could adopt a level pool routing approach, as per Scrivener Dam, for instance. *Each of those different operations are, indeed, well recognised by flood engineers on different schemes*, but there are no rules in this particular manual that suggest any or all of those approaches should be adopted. The rules as specified in revision 7 of the flood mitigation manual are predicated on surcharging the airspace above full supply level.” (emphasis added)

131 Mr Ayre’s contention that the Manual assumes operations above FSL is addressed below. The balance of this answer acknowledges that the adoption of methods such as pre-releases or seasonal drawdowns is “well recognised”. As stated, whether they are in fact adopted and how turns upon the circumstances of the particular dam and ultimately the approach adopted in the relevant water control manual.

[201] February 2015 Report, EXP.ROD.001.0016 at [282].
[202] T 7526.8 - .30.

5.4: The Flood Engineers' Evidence and FSL

132 Both parties addressed the evidence given by each of Messrs Malone, Tibaldi and Ayre concerning their capacity to release water from below FSL at length. The context in which that arose is unclear. As noted at [2], the question of whether to make releases below FSL during the January 2011 Flood Event appears not to have arisen at all as Wivenhoe Dam remained above FSL when the Late December Flood Event was declared over and remained above FSL thereafter. Instead, this issue arises in relation to the counterfactual inquiry into Dr Christensen's simulations, some of which operate below FSL. As explained in Chapter 12,[203] it was accepted that,[204] one way or another, the plaintiff must establish that a reasonably competent flood engineer in their position would have undertaken flood operations substantially in accordance with one of those simulations (*CLA* (Qld); s 9(1)(c)). To that end, just because one of the flood engineers might have believed that they were not permitted to do so by either the Manual or the Moreton ROP is far from determinative, although if they did and if it was reasonable for them to have done so, that could have significance.[205]

133 As explained below, each of Messrs Malone, Tibaldi and Ayre asserted that as at the time of the January 2011 Flood Event they believed that releases below FSL during a flood event were prohibited under the Manual and under the Moreton ROP. The plaintiff contended that their evidence to that effect should not be accepted,[206] and in any event those beliefs were unreasonable.[207] Accordingly, I will address the evidence of each of Messrs Malone, Tibaldi and Ayre concerning their subjective understanding first and will then address the reasonableness of any belief to the effect that releases below FSL were prohibited by the Manual or the Moreton ROP.[208]

[203] Chapter 12 at [15] and [39]; T 9419.20 (Senior Counsel for the plaintiff).
[204] Subject to the matter raised in *Rodriguez (No 9)* at [30].
[205] See Chapter 3 at [124] to [129].
[206] Plaintiff subs at [28] and [49] to [69].
[207] Plaintiff subs at [37] to [47] and [72] to [74].
[208] The reasonableness of the remainder of their views on the Manual is addressed in Chapter 3.

Mr Malone

134 At a number of points in his affidavits, Mr Malone stated that, on his understanding, the Manual did not permit the flood engineers to release water such that the dams were below FSL save for the reference in section 8.5 (and presumably section 9.4) to levels falling temporarily below FSL to take into account baseflow.[209] At the commencement of his cross-examination by Senior Counsel for the plaintiff, he asserted that he believed that during the January 2011 Flood Event there was an absolute prohibition on making releases below FSL for flood mitigation purposes save for allowing refill by baseflow.[210]

135 However, Mr Malone's certitude on this wavered as the cross-examination progressed. He asserted that he construed the Manual as prohibiting the practice if it was not expressly permitted but added that, if he was in any doubt, as a "reasonably competent engineer" he would have had "a look at precedents",[211] (ie, how the dam was actually operated in the past).[212] He asserted that his review of the precedents indicated that there had not been releases below FSL during the rising limb of the hydrograph.[213] However he agreed that, during the 2009 May Flood Event, there were releases made from Somerset Dam when it was below FSL for the "sensible and reasonable" reason that there "were no implications for the water supply".[214] He made the same concession with the March 2010 Flood Event.[215]

136 Each of the releases below FSL from Somerset Dam in May 2009 and March 2010 did not compromise the water supply because the water released from Somerset Dam was retained in Wivenhoe Dam. To similar effect, Mr Malone eventually came to accept that water could be released from below FSL in Wivenhoe Dam if it could be replenished from water above FSL in Somerset Dam. In his third affidavit, Mr Malone stated that it was not his understanding

[209] LAY.SEQ.007.0001 at [171], [258], [411(b)], [489], [933] and [939].
[210] T 4750.19.
[211] T 4990.45.
[212] T 4991.15.
[213] T 4991.30.
[214] T 5028.45 to T 5029.16.
[215] T 5034.31 to .37.

as at January 2011 “that the Manual allowed me to make releases from Wivenhoe to lower it below FSL to the extent that there was sufficient water above the Somerset FSL to refill Wivenhoe to its FSL” (as Dr Christensen modelled in some of his simulations) although he added that he did not “strongly disagree” with that approach provided it “only encompasses small differences in levels and water supply security is retained”.[216] However, in cross-examination he agreed that it was “permissible to reduce Wivenhoe Dam below full supply level” if there was “sufficient water in Somerset Dam [ready] to refill any depletion in Wivenhoe Dam” below FSL[217] because that would not involve “compromising water security”.

137 In Chapter 7 I note that, towards the conclusion of his cross-examination, Mr Malone conceded that he could not “remember how [he] interpreted and applied [the Manual] at any particular point of time during the [January] 2011 [F]lood [Event]”.[218] Having heard and observed Mr Malone give evidence in relation to FSL, I regard that concession as applicable to the topic of whether or not the Manual permitted or excluded releases below FSL.

138 So far as the Moreton ROP is concerned, in his first affidavit Mr Malone stated that the “water supply limit (FSL) was covered by legislation and could not be changed by the Flood Engineers at will”.[219] In cross-examination, it was suggested to Mr Malone that a flood engineer could “go below FSL and manage the dam so that at the conclusion of the flood event storage was at [FSL]”.[220] Mr Malone stated that “that was not understanding of the manual or the rules governing the release of water from Wivenhoe Manual”.[221] The reference to “rules” appears to be a reference to the Moreton ROP. Mr Malone asserted that a flood engineer “should have an understanding of what the ROP says about the water supply compartment”, which he explained to

[216] LAY.SEQ.013.0001 at [97].
[217] T 4898.7 to T 4898.23.
[218] T 5353.9 - .36; Chapter 7 at [453].
[219] LAY.SEQ.007.0001 at [923].
[220] T 4944.21.
[221] T 4994.25.

mean that "water released from below full supply level is only intended for water supply and environment purposes".[222] He was then asked:[223]

> "Q. Did you understand that the ROP actually addressed the question of whether or not water could be released below full supply level during a flood event if there was reasonable expectation that the dam would fill up again to fully supply level by the conclusion of the flood event?
> A. No, I didn't understand that.
>
> Q. When you say you didn't understand it, you don't know one way or the other or you know it doesn't say that?
> A. I don't know whether it says that."

139 This qualification of his understanding of the Moreton ROP is significant because this passage was preceded and succeeded by concessions from Mr Malone that releases could be made, or at least had been made, from below FSL provided water security was not compromised.[224]

140 In re-examination, Mr Malone was taken to the Moreton ROP.[225] He stated that he was aware that it existed but could not "say that he was aware of the specifics"[226] but stated that water could only be "release[d] ... for water supply purposes or environmental purposes".[227] He said he did not know whether that understanding applied to each dam or the two dams considered collectively.[228]

141 Seqwater contended that Mr Malone's evidence on the Moreton ROP and FSL was not challenged in cross-examination.[229] This overlooks how the evidence emerged. The cross-examiner secured a concession from Mr Malone that he had no recollection of how he interpreted the Manual and applied it during the January 2011 Flood Event;[230] that releases were in fact made below FSL from Somerset Dam during the flood events in May 2009 and March 2010; an acceptance that such releases were permissible as they

[222] T 4945.8 - .16.
[223] T 4945.18 - .27.
[224] T 4898 - .20; T 5028.45 to T 5029.5.
[225] T 5362.9 to T 5363.28.
[226] T 5363.5.
[227] T 5363.13.
[228] T 5363.19.
[229] Seqwater subs at [189].
[230] T 5353.36.

did not affect water security (as did releases from below FSL in Wivenhoe Dam if it could be refilled by water above FSL in Somerset Dam); and an asserted lack of knowledge from Mr Malone that the Moreton ROP precluded releases from below FSL if it was expected to be filled up again by the end of the flood event. Otherwise, Mr Malone's acceptance that the Manual expressly permitted releases below FSL to allow refilling by baseflow is inconsistent with any asserted belief that might be attributed to him that the Moreton ROP prohibited any and all releases from below FSL for any purpose other than water supply or environmental uses including flood mitigation. In these circumstances, I do not accept that Mr Malone had any belief that the Moreton ROP precluded releases from below FSL from either dam for flood mitigation when there was a reasonable expectation that it would refill by the conclusion of a flood event.

Mr Tibaldi

142 Mr Tibaldi addressed releases below FSL in his first and second affidavits.[231] Under cross-examination by counsel for SunWater, Mr Tibaldi stated that he had a "strong view that the flood engineers did not have the authority under the [M]anual to draw the dam below FSL".[232] This "strong view" apparently applied to both dams in that Mr Tibaldi agreed that "you couldn't bring Somerset below full supply [level] and couldn't bring Wivenhoe below full supply [level]" in a flood event.[233]

143 In his first affidavit, Mr Tibaldi nominated the flood objective of retaining storage at FSL at the conclusion of the flood event,[234] the discussion of that objective in section 3.5,[235] the restriction on opening Wivenhoe gates below EL 67.25m AHD in section 8.3 and the gate closing strategies in section 8.5 of

[231] LAY.SEQ.004.0001 at [145], [188] to [193] and [304] to [322]; LAY.SEQ.014.0001 at [91] to [94].
[232] T 5474.9.
[233] T 5474.19.
[234] LAY.SEQ.004.0001_OBJ, [310(c)].
[235] LAY.SEQ.004.0001_OBJ, [307].

the Manual[236] as the sources of his belief that the Manual precluded releases below FSL during a flood event.

144 Mr Tibaldi's asserted belief about section 8.3 does not address whether the Manual allowed releases below FSL during a flood event, as he accepted that once the EL 67.25m AHD threshold was exceeded it did not require gate closure if the level dropped to or below EL 67.25m AHD.[237]

145 In relation to the nominated flood objective and its explanation in section 3.5 of the Manual, Mr Tibaldi accepted in cross-examination that on a "literal interpretation" there was no absolute prohibition on releasing below FSL[238] but maintained that such releases were prohibited.[239] Mr Tibaldi stated that his understanding was in part based on his reading of old versions of the manuals. In cross-examination, he referred to Version 6 and Table 6-1[240] (which does not contemplate releases being made below an actual level of EL 67.25m AHD) as supporting his view.[241] He agreed that that table was removed from Version 7 but denied that there were significant changes to Version 6,[242] despite describing the changes as significant in an email to Messrs Pruss and Drury on 15 October 2009.[243] Of course, one of the changes was the introduction of the flood objective of retaining storage at FSL at the conclusion of a flood event. Mr Tibaldi denied that this objective would be otiose if releases below FSL other than to allow refill by baseflow were prohibited.[244]

146 Otherwise, as noted in Chapter 3,[245] Mr Tibaldi asserted that he understood that the Strategy W1 and its sub-strategies, as well as Strategy W3, operated

[236] LAY.SEQ.004.0001_OBJ, [310(b) and (d)].
[237] T 6121.19.
[238] T 5907.4.
[239] T 5904.27.
[240] Chapter 4 at [22].
[241] T 5896.17.
[242] T 5896.37 - .45.
[243] SEQ.206.006.8743; T 5897.33.
[244] T 5902.27.
[245] At [152].

by reference to actual lake levels.[246] If that was correct, then no occasion to operate below FSL would ever arise.

147 The only part of his affidavits that addressed any restriction on making releases below FSL other than the Manual was the following:[247]

> "*My understanding since becoming directly involved in the operation of Wivenhoe Dam and Somerset Dam in 1996 has been and still is that Queensland Government policy dictates that the urban water supplies stored in Wivenhoe Dam and Somerset Dam are not to be compromised for flood mitigation purposes. This means that* Wivenhoe Dam and Somerset Dam must be full at the end of a Flood Event and to ensure this happens, a Flood Event end time must be established once the lake levels in the Dams fall towards the FSLs. It also means that the Darns are not to be operated significantly below their FSLs during Flood Events." (italicised portion subject to order under s 136; underlined emphasis added)

148 In cross-examination, Mr Tibaldi stated that reference to "significantly below" was to those parts of the Manual that allowed releases below FSL subject to refill by baseflow.[248]

149 Mr Tibaldi stated that the understanding set out in [147] was "reinforced" by discussions with Messrs Borrows, Pruss and Drury "[i]n the years leading up to the December 2010 and January 2011 Flood [E]vents".[249] He also stated that "prior to that time", the understanding was informed by previous versions of the flood manual as well as discussions with other flood engineers, the Queensland Dam safety regulator, the Chairman of Seqwater and the CEO of Seqwater. He said he "cannot…recall the specifics of any of these discussions or exactly when they occurred, but what is listed is my best recollection".[250]

[246] LAY.SEQ.004.0001 at [249]; T 5557.25 and T 5559.41.
[247] LAY.SEQ.004.0001 at [190].
[248] T 5890 to T 5891.6.
[249] LAY.SEQ.004.0001 at [191].
[250] Id.

150 Mr Tibaldi also stated that he “understood that this [ie, the distinction between water supply storage and flood mitigation storage] was the intention of the Moreton [ROP]”.[251]

151 Of the various persons Mr Tibaldi nominated in this part of his affidavit as the source of his “understanding”, only Messrs Borrows, Pruss and Drury gave evidence. None of them stated that they had any discussion with him that supported the above understanding, much less any conversation that addressed the distinctions of significance to the plaintiff’s case; eg, whether there is a prohibition on releasing below FSL during a flood event as opposed to before a flood event and what is the relationship between the Manual’s reference to reducing below FSL in section 8.5 and the Moreton ROP? The evidence from each of Messrs Borrows, Pruss and Drury is discussed below. However, it never rose higher than stating their understanding of the Manual and to some extent the Moreton ROP. It does not assist in ascertaining whether any discussion they might have had with Mr Tibaldi supported the above understanding, including so much of the understanding that allowed some reduction below FSL albeit not “significantly”.

152 I have already addressed the cross-examination of Mr Tibaldi on that part of his understanding that was said to be based on old versions of the manuals, especially Version 6. In addition, in his Explanatory Notes for the revision of Version 6 he described each of the flood objectives and stated “[n]aturally, at the end of an event, a primary objective is to ensure that the dams are at full supply levels.”[252] Consistent with the new objective that was inserted, that explanation is directed to the position at the end of the flood event and not during.

153 Mr Tibaldi also asserted that he was told that the distinction between the water supply storage and flood mitigation storage was developed on the basis of modelling undertaken for the Queensland Government’s Regional Water

[251] Ibid at [193].
[252] SEQ.004.048.0083 at .0086.

Security Program for South-East Queensland.[253] However, that document made no reference to the FSL[254] and his understanding rose no higher than assuming that Wivenhoe Dam would always be filled to FSL after a flood event rather than throughout a flood event.[255] Leaving aside the Moreton ROP, none of the documents instanced by Mr Tibaldi as supporting his assertion suggested that there was a prohibition on making releases below FSL during a flood event as opposed to returning to FSL at the end of a flood event.[256]

154 In relation to the Moreton ROP, in cross-examination Mr Tibaldi was asked about the various documents embodying government policy. It was suggested to him that none of them addressed the concept of releasing below FSL during a flood event, as opposed to prior to a flood event being declared. Mr Tibaldi responded, "I don't know. You'd have to show me the documents that you are referring to and I'd need to have a look at them".[257] In re-examination, he nominated the Moreton ROP as one of the documents.[258] He then asserted that it was his understanding that the "ROP only allows it to be released for two purposes – one is water supply and the other one is for environment purposes".[259] Shortly afterwards, Mr Tibaldi was asked as follows:[260]

> "HIS HONOUR: Q. Just going back to 2010, wasn't water being released from … Somerset Dam, below full supply level, for flood mitigation purposes?
> A. No, well, in my view, that wasn't for flood mitigation purposes. Again it's the balancing of the storage …"

155 As noted in Chapter 4 at [186], at the commencement of the March 2010 Flood Event, Mr Tibaldi issued a flood directive to make releases from

253 SEQ.001.015.1015; LAY.SEQ.004.0001 at [192].
254 T 5967.17 - .29.
255 T 5972.24 and .29.
256 This included the 2001 Feasibility Study: SEQ.004.030.2564; referenced at T 5989.8 and LAY.SEQ.014.0001 at [92(a)]; Connell Wagner discussion paper: ROD.901.001.1115; LAY.SEQ.014.0001 at [92(b)].
257 T 5961.16.
258 T 6526.15.
259 T 6528.13.
260 T 6530.19.

Somerset Dam when it was below FSL.[261] He agreed that he directed these releases during a flood event from Somerset Dam when it was below FSL[262] and agreed that the releases from Somerset Dam to Wivenhoe Dam were not for water supply purposes.[263] The making of those releases was inconsistent with the above answer and that part of his evidence when he agreed that "you couldn't bring Somerset below full supply [level] and couldn't bring Wivenhoe below full supply [level]" in a flood event.[264]

156 At the time this evidence was given, I was sceptical of the contrast between Mr Tibaldi's inability in cross-examination to nominate the Moreton ROP as the source of his understanding of "government policy" and his recollection of its terms in re-examination. My misgivings about the reliability of his evidence on this topic were reinforced by his denial of releasing water below FSL from Somerset Dam for flood mitigation purposes when he clearly did so.

157 If, as at times he stated he did,[265] Mr Tibaldi adhered to a construction of the Manual that tied the determination of the applicable Wivenhoe strategy to actual levels, then one possibility is that he did not contemplate flood operations below FSL. In any event, for the reasons explained elsewhere, Mr Tibaldi's evidence was completely unreliable.[266] In particular, his conduct of flood operations on the weekend of 8 and 9 January 2011[267] and his attempts at documenting the course of the flood event thereafter were not consistent with his assertion as to how he interpreted the Manual.[268] So far as releases below FSL are concerned, the only persuasive objective materials concerning his attitude to these releases are his involvement in releasing water from Somerset Dam below FSL during the May 2009 and March 2010 Flood Events and his central involvement in the drafting of Version 7 (which introduced forecasts and predicted levels and rewrote the flood objectives by introducing an objective of retaining water at FSL, as opposed to introducing a

[261] SEQ.083.001.0390.
[262] T 6205.25.
[263] T 6168.29.
[264] T 5474.19.
[265] Chapter 3 at [152].
[266] Ibid at [152], [191]; Chapter 7 at [91] to [93], [412], [420], [432], [434], [450] – [451] and [455].
[267] Chapter 7 at [99] and [461].
[268] Chapter 7, sections 7.10, 7.11, 7.12, 7.13, 7.14 and 7.15.

rule that releases could not be made below FSL).[269] Having regard to those matters, I do not accept Mr Tibaldi's evidence concerning his interpretation of the Manual including the evidence that he believed that either the Manual or the Moreton ROP or both precluded the making of releases below FSL from either dam during flood operations.

158 One further matter should be noted. In its submissions, Seqwater asserted that Mr Ayre had given a direction "throughout the [January 2011 Flood Event] ... for releases to be made from water above FSL".[270] The only evidentiary basis for this assertion was a non-responsive part of an answer given by Mr Tibaldi where he described his role "as an engineer in the flood, work[ing] under the direction of a senior flood engineer".[271] However, Mr Tibaldi did not in that answer or elsewhere assert that he received any direction about FSL from Mr Ayre. Seqwater also submitted that this was supported by evidence from Mr Ayre to the effect that, if a flood engineer had made releases below FSL, then he would have overridden the decision.[272] Mr Ayre's evidence is addressed below. At this point, it suffices to state that that is not evidence that any such direction was given.

Mr Ayre

159 In section 14 of Chapter 2 of his first affidavit, Mr Ayre stated that, based on investigations he carried out in 2001 and 2006, he concluded that pre-releases or precautionary releases in advance of a wet season or an "imminent flood event" were "not viable".[273] The 2001 study was the pre-release study described in Chapter 4[274] and the 2006 study was the Connell Wagner investigation also described in Chapter 4.[275] He stated that nothing after that time indicated that such releases could be made. He referred to FSL as having been set by the Moreton ROP and said that he "regarded the FSLs

[269] See Chapter 4 at [159].
[270] Seqwater subs at [184(c)].
[271] T 5904.12; Seqwater subs at [184(c)], footnote 88.
[272] T 7481.28; Seqwater subs at [185].
[273] LAY.SUN.001.0001 at [395].
[274] At [4] to [12]
[275] See Chapter 4 at [29] to [46].

as having been set by the Queensland Government".[276] He stated that he did not understand the Manual to authorise the alteration of FSL and that he thought that the Manual, especially the gate trigger level in section 8.3, did not permit the early release of water.[277]

160 In cross-examination, Mr Ayre reiterated his understanding that, under the "water resources legislation", if he released water from below FSL he would be infringing water entitlements[278] and that he had no "authority to act in that legislation".[279] Later, he identified the Moreton ROP as defining FSL and restricting releases below FSL "for specific purposes".[280] Mr Ayre was then referred to the manual for the North Pine Dam which expressly permitted releases below FSL and agreed that, to his understanding, the water below FSL in North Pine was also subject to the Moreton ROP.[281] He agreed that the North Pine Dam manual did not expressly refer to the Moreton ROP but contemplated reductions below FSL.[282] He was then asked:[283]

> "Q. So why would it not be an exception to the Moreton ROP if the manual for Wivenhoe and Somerset Dam implicitly permitted releases below full supply level?
>
> A. I guess I haven't turned my mind to the North Pine clause, as such, but I still think the fact that the pre-release clause that was consciously removed from the Wivenhoe/Somerset flood mitigation manual meant that that option wasn't available to us, as such."

161 Four matters should be noted about this answer. First, in the passage of questioning that led to this answer, Mr Ayre presented as reluctant to directly respond to the questions which were clearly raising an issue as to how he could reconcile his asserted understanding of the Moreton ROP and what he understood was expressly permitted by the manual for the North Pine Dam.[284] Second, in the above answer, Mr Ayre does not address this inconsistency but returns to his construction of the Manual and not the terms of the Moreton

[276] LAY.SUN.001.0001 at [397].
[277] LAY.SUN.001.0001 at [398] to [399].
[278] T 7642.19.
[279] T 7642.14.
[280] T 7661.38.
[281] T 7663.28; see sub-section 97(2) and Attachment 6 of the Moreton ROP.
[282] T 7663.41 to T 7664.11.
[283] T 7664.13.
[284] T 7660.45 to T 7663.39.

ROP. Third, the same inconsistency with the Moreton ROP pertains with the Manual because, on any view, it expressly permits releases below FSL in section 8.5. Fourth, as the subsequent questioning of Mr Ayre pointed out, the removal of the pre-release clauses in earlier manuals occurred at a time when strategies were based on actual levels and not predicted levels.[285] Otherwise, I note that Seqwater's submissions asserted that the North Pine manual "does not say that pre-releases can be made from water below FSL".[286] That contention was inconsistent with the State's submissions[287] and, in any event, it overlooks Mr Ayre's concession that it did contemplate releases below FSL.[288]

162 In section 15 of Chapter 2 of his first affidavit, Mr Ayre expressed the same view in relation to releases below FSL during a flood event as he expressed in relation to pre-releases. He asserted that a reduction below FSL during a flood event was "illegal, having regard to my understanding that the FSL was fixed by law".[289] In relation to the Manual, he referred to section 8.1, section 3.1 (so far as it concerns the evacuation of stored flood waters above FSL), the discussion of the flood objective in sections 3.1 and 3.5, the trigger gate level in section 8.3, the specification that peak outflow should generally not exceed peak inflow in section 8.5 and the gate closing strategy in section 8.5.[290] He accepted that section 8.5 contemplated releases below FSL to allow refilling by baseflow but said that it would "only be minimal amounts and for limited duration".[291] In cross-examination, Mr Ayre accepted that there was no express prohibition in the Manual on releasing below FSL but stated that there was no express permission granted either.[292] He asserted that the inclusion of an objective of retaining storage at FSL at the conclusion of a flood event as opposed to prohibition on releases below FSL was just a

[285] T 7664.25.
[286] Seqwater subs at [220].
[287] State subs at [24]; see above at [103].
[288] T 7664.7.
[289] LAY.SUN.001.0001 at [412(a)].
[290] Ibid at [412(b)].
[291] Ibid at [413].
[292] T 7667.20.

reflection of the fact that the dams are “multifunction” dams, ie, used for water supply and flood mitigation.[293]

163 Mr Ayre’s views on releases below FSL cannot be divorced from his understanding of the other parts of the Manual. As noted in Chapter 3, it was Mr Ayre’s evidence that, under the Manual, the selection of W1 and its sub-strategies was dependent on actual lake levels and that a transition to either W2 or W3 would not occur until the actual lake level exceeded EL 68.5m AHD.[294] He stated that it was not until after the January 2011 Flood Event that he came to understand that a literal reading of section 8.4 reveals that forecasts are part of the process of selection of strategy.[295] He explained this as follows:

> “… but I suppose given the context of my background with the flood mitigation manual and, I suppose, my understanding of what the revision process was intending to achieve, I guess I never just - I never picked up on the fact that there was a fundamental change associated with that, incorporated in the manual. So I suppose up until January 2011, it didn't register with me that that would be the case.”

164 There are two significant matters that bear upon my acceptance of this explanation, and which have contributed to my being unable to accept his evidence as to how he interpreted the Manual during the January 2011 Flood Event, including his evidence concerning the Manual’s approach to predictions, forecasts and releases below FSL. The first is that I do not accept that Mr Ayre could have participated in the “revision process” in 2009 and afterwards received a copy of the FPM yet somehow not understood as at January 2011 that Version 7 of the Manual reflected a “fundamental change” in the conduct of flood operations with its emphasis on predicted levels, rainfall forecasts and flood objectives.[296]

165 Second, as explained in Chapter 7, the conduct of flood operations through the weekend of 8 and 9 January 2011 involved the flood engineers, including Mr Ayre, conducting operations as though they were in Strategy W1 when

[293] T 7673.12.
[294] Chapter 3 at [52] and [154]; T 7505.41.
[295] T 7507.38.
[296] See Chapter 4 at [160].

after 8.00am on 8 January 2011 the actual level of Wivenhoe Dam exceeded EL 68.5m AHD.[297]

166 Further, in relation to releases below FSL, in the May 2009 Flood Event, Mr Ayre accepted that there were releases made as part of flood operations which reduced Somerset Dam below FSL.[298] Otherwise, in both Chapter 4 and Chapter 7 I conclude that particular aspects of Mr Ayre's evidence (including the above) have caused me to doubt the reliability of so much of Mr Ayre's evidence that is not corroborated by contemporaneous material.[299] All of these matters have left me unable to accept Mr Ayre's evidence concerning how he construed the Manual, including his evidence to the effect that during the January 2011 Flood Event he positively believed that the Manual did not require the use of rainfall forecasts and predicted height levels in the selection of strategies and prohibited all releases from below FSL or that the Moreton ROP also had the latter effect.[300]

Reasonableness of any Belief about Releases below FSL

167 I have just concluded that I am not satisfied that during the January 2011 Flood Event the flood engineers had any specific belief that the Manual precluded releases from Wivenhoe Dam below FSL during flood operations. Even if I had found to the contrary, I would consider that to be an unreasonable opinion to hold. The difficulty in isolating any such belief that a reasonably competent flood engineer may have held on this topic and labelling it "reasonable" is that any analysis of this aspect of the Manual cannot be divorced from a consideration of that particular engineer's articulated views on the other parts of the Manual concerning predictions and forecasts, which, although varied, were generally unreasonable. For so long as a flood engineer adheres to such views, namely that a flood event does not commence until the level of Wivenhoe Dam exceeds EL 67.25m AHD, that strategies are determined by actual levels and not predictions, that rainfall

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297 See Chapter 7 at [458].
298 T 7802.23; Chapter 4 at [69].
299 Chapter 4 at [106] and [160]; Chapter 7 at [36], [206] - [207], [418] and [463].
300 As submitted by the plaintiff: SBM.010.011.0001 at [26].

forecasts should not be used for anything other than situational awareness and that peak outflow can never exceed peak inflow to date, then there is no reason for such an engineer to contemplate releasing below FSL during flood operations. On that approach, when the water level in Wivenhoe Dam is below FSL there is no flood event, no strategy is engaged and there is nothing in the future beyond inflow of rain on the ground that can legitimately be considered in predicting a storage level, much less warranting the release of water.

168 However, once those blinkers are removed then the possibility of construing the reasonableness of releasing below FSL arises. A reasonably competent flood engineer reading the Manual would recognise the matters noted in section 3.3.6 of Chapter 3, namely, the importance of the flood objectives and their order of priority, the requirement to use predicted levels to determine strategies and to make those predictions based on stream flow information and rainfall forecasts. Once they appreciated those matters, and acknowledged that section 8.3 was only an initial constraint, then such an engineer would recognise that releases below FSL during flood operations were not prohibited by the Manual. Instead, they would realise that they should be undertaken when necessary to give effect to the Manual's objectives and strategies, bearing in mind that there should be no reason why the dam would not return to FSL at the end of the flood event (section 3.5).

169 So far as the Moreton ROP was concerned, it can be accepted that a reasonably competent flood engineer might make some inquiries about the regulatory significance of FSL and the nature of the division between water above and below FSL, although they might confine themselves to the Manual. It can also be accepted that, if they had, this would have led them to the Moreton ROP, but it would have also led them to the interim approval for releases for flood mitigation that operated as an exception to the Moreton ROP. If knowledge of the restrictions in s 72(3) of the Moreton ROP is to be attributed to the hypothetical reasonably competent flood engineer then I cannot discern any basis for why they would not be attributed with the

knowledge of an express approval sought by and granted to Seqwater to operate outside of it.

170 In his evidence, Mr Tibaldi said that he was not aware of the interim program.[301] He was then shown the letter of approval but had difficulty in construing it.[302] Seqwater also pointed to Mr Drury's evidence when he was shown the letter of approval for the interim program in cross-examination in which he said he read it as stating that "the releases that do not comply are the subject of an operational report [however they] … may still be considered non-compliant".[303] When pressed, Mr Drury was unable to say whether the letter suggested such releases were a breach of the law.[304] However, to the extent a reasonably competent flood engineer needed assistance on this topic, then the likely response they would have received is the summary in the covering email that circulated the interim approval on 15 December 2010 which adequately summarised its effect. It did not suggest that flood releases made outside of the scope of the Moreton ROP would be a breach of the law.[305]

171 Otherwise, I note that Mr Drury received that email but said he did not "recall reading or understanding totally the [reference to non-]compliance".[306] At the time he received it, Mr Drury was aware that approval was sought for releases for "consumption, flood mitigation, which was under the manual, operational maintenance and fish recovery".[307] He said that interim approval was included as a "cover-all rather than any major change to the interim program".[308] In those circumstances, I expect that if Mr Drury, or anyone else in Seqwater, construed the interim approval as leaving Seqwater exposed to prosecution for non-compliant releases, then the matter would have been taken further.

[301] T 6570.40.
[302] T 6570.42 to T 6572.23 and T 6574.17 to T 6576.25.
[303] T 6657.43; Seqwater subs at [243].
[304] T 6660.40.
[305] SEQ.016.021.9594; see [46] to [47].
[306] T 6661.16.
[307] T 6659.28.
[308] T 6660.19.

172 Three further matters should be noted about the position of the reasonably competent flood engineer in relation to the Manual, the Moreton ROP and the interim approval.

173 First, Seqwater contended that it was incumbent on the plaintiff to plead that the reasonably competent flood engineer ought to have been aware of the approval of the interim program[309] and failing that, it had to demonstrate actual knowledge of the interim program on the part of the flood engineers.[310]

174 I do not accept that contention. This dispute concerns the scope of the precautions available to the reasonably competent flood engineer conducting flood operations during January 2011 and whether that included making releases below FSL. I have found that, by reason of the approval of the interim program, it was not contrary to law to make releases below FSL. I have also found that such releases were not inconsistent with the Manual. Despite those findings, an issue raised by the defendants[311] as potentially *arising out of the flood engineers' evidence* was the possibility that those engineers, and by extension a reasonably competent flood engineer, might have reasonably believed that such releases were inconsistent with the Manual and prohibited by the ROP.[312] I have rejected the flood engineers' evidence that they had any such belief in relation to the Manual and the Moreton ROP. I have also rejected the defendants' contention that a reasonably competent flood engineer would have that belief. In relation to the Moreton ROP, I have rejected a contention that such an engineer could reasonably form such a belief based on the Moreton ROP without having knowledge of the interim approval.

175 Thus, the plaintiff deployed the interim approval in two ways. First, consistent with its pleading,[313] it was deployed as a means of demonstrating that releases below FSL for flood mitigation were lawful. Second, it was deployed

[309] Seqwater subs at [81] to [84].
[310] Ibid at [228] to [229].
[311] Ibid at [168].
[312] Ibid at [168].
[313] 5ASOC, PLE.010.001.0001 at [68] to [76].

as a response to Seqwater's contention, based on the flood engineers' evidence, that a reasonably competent flood engineer's knowledge of the legality of releases below FSL would be limited to the Moreton ROP alone.[314] I do not accept that the second use had to be pleaded.

176 Second, in its submissions, Seqwater noted that no question was put to any of the flood engineers about the interim approval, including no questions suggesting that they should have been aware of the potential for such an approval to be given.[315] In fact, Mr Malone received a copy of the interim approval with the email noted at [48][316] and Mr Tibaldi was questioned about it.[317] In any event, in light of the above findings, the question of actual or imputed knowledge of the existence of the interim approval is only relevant to the position of the hypothetical reasonably competent flood engineer and not Messrs Malone, Tibaldi or Ayre.

177 Third, as noted in Chapter 4,[318] there was some debate about whether a flood engineer's involvement in the process of revising the Manual forms part of any assessment of the "position of the person" for the purposes of s 9(1)(c) of the *CLA* (Qld); ie, should it be attributed to the reasonably competent flood engineer? Even if it does, it does not assist the defendants on this topic.

5.5: Messrs Borrows, Pruss and Drury and SunWater's Alleged Common Understandings

178 The submissions of the parties addressed the evidence given by Messrs Borrows, Pruss and Drury concerning their understanding that releases below FSL for flood mitigation were prohibited and, if so, by what.[319] In short, their evidence on that topic and the related topic of using forecasts to make releases was as follows. Mr Borrows stated that sometime on or after 24 December 2010 he formed the understanding that "Seqwater was not

[314] Plaintiff subs at [893].
[315] Seqwater subs at [239] to [240].
[316] SEQ.016.021.9594.
[317] See [170].
[318] At [165] to [167].
[319] Plaintiff subs at [875] to [879]; Seqwater subs at [269] to [278]; SunWater subs at [2800] to [2803], [2822] to [2824] and [2841] to [2842].

authorised to release water from Wivenhoe Dam or Somerset Dam to below their FSLs".[320] In cross-examination by Senior Counsel for SunWater, he stated that he held the view that Seqwater was not authorised to release water from Wivenhoe Dam or Somerset Dam below their FSLs[321] and knew that SunWater had operated on that basis during the October 2010 Flood Event.[322] This understanding appears to have been based on his knowledge of the Manual.[323] He only referred to the Moreton ROP as precluding pre-releases.[324]

179 Mr Pruss stated that it was his understanding that "water stored below the FSL could not be released for flood mitigation purposes and that was reflected in the Flood Operations Manual".[325] He also stated that he never understood that the flood engineers would be "acting only or primarily on the basis of rainfall forecasts"[326] and he thought that they were too inaccurate to be used for the purpose of gate operations.[327] At this point, it is only necessary to note that he was cross-examined on these aspects of this evidence.[328]

180 In his first affidavit, Mr Drury stated that "[a]t no stage during [the relevant] period did I or, so far as I am aware, did anyone within Seqwater consider that flood mitigation releases could be made below the FSL".[329] I have discussed Mr Drury's role in the May 2009 Flood Event in Chapter 4.[330]

181 At least so far as Messrs Borrows, Pruss and Drury stated that their understanding was that releases below FSL were prohibited by the Moreton ROP, then it was disputed.[331] However, assuming that it was accepted, how is it relevant? The plaintiff contended that, as these witnesses disavowed any

[320] LAY.SEQ.005.0001_OBJ at [37]; subject to s 136 order.
[321] T 4023.3.
[322] T 4031.7 - .13.
[323] T 4032.27.
[324] See T 4104.24 - .35; see also at T 4018.6 - .8; T 4035.6 - .14 and .33 - .45; T 4070.8 - .9; cf Seqwater subs at [272].
[325] LAY.SEQ.003.0001_OBJ at [48].
[326] Ibid at [89(b)].
[327] T 4230.6 - .9.
[328] T 4311.11 to T 4323.5; T 4332.13 to T 4334.3 and T 4355.11 to T 4357.43.
[329] LAY.SEQ.006.0001_OBJ at [169].
[330] At [48] to [72].
[331] Plaintiff subs at [875] to [879].

suggestion that they could or did control the flood engineers during the January 2011 Flood Event, their evidence on this topic was "irrelevant to the pleaded breaches",[332] presumably because the "pleaded breaches" all concern the conduct of the flood engineers. Seqwater made the same submission.[333]

182 Nevertheless, Seqwater contended that the evidence of their subjective understandings was relevant for two reasons. First, it submitted that each of their individual understandings of the Moreton ROP and the Manual to the effect that releases below FSL could not be made "corroborate[s] the reasonableness of the views held by the flood engineers".[334] However, I do not accept that the flood engineers held those views. Even if they did, I do not consider them to be reasonable, even on the assumption that I accepted that Messrs Borrows, Pruss and Drury held the same views based, as they were, on having less familiarity with the Manual and its revision process in 2009 than the flood engineers and not considering the effect of the interim approval.

183 Second, Seqwater also contended that the fact that these witnesses held those views somehow corroborates Mr Tibaldi's evidence, and to a lesser extent Mr Malone's, because Mr Tibaldi asserted that his views were informed in part by discussions with Messrs Borrows, Drury and Pruss.[335] I have already addressed and rejected that contention (at [151]).

184 In addition, at this point it is appropriate to note one part of SunWater's case which relied on the evidence of Messrs Borrows, Pruss and Drury. SunWater contended that, as between SunWater and Seqwater, there were various common understandings as to how the Manual was to be construed and flood operations conducted which affected both the content of any duty of care owed to the plaintiff and created estoppels by convention between itself and Seqwater.

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[332] Plaintiff subs at [875].
[333] Seqwater subs at [267].
[334] Ibid at [268(a)].
[335] Ibid at [268(b)].

185 In its defence (and its defence to Seqwater's cross-claim),[336] SunWater pleaded the existence of four common understandings said to have been adhered to by Mr Ayre during the January 2011 Flood Event to the knowledge of Seqwater. One was the "2009 Review Intention" which has been addressed and rejected in Chapter 4.[337] Of the other three, the first was an understanding that the Manual did not authorise or require releases to be made below FSL during a flood event (the "*FSL Common Interpretation*").[338] The second was that the Manual did not provide for or contemplate precautionary releases (the "*No Precautionary Release Common Interpretation*"), which is presumably a reference to releases in advance of rain falling.[339] The third was the "*Forecast Rainfall Common Intention"*. It is defined as a common understanding between SunWater and Seqwater that "for the purposes of choosing strategies … (i) forecast rainfall was inherently unreliable"; "(ii) to the extent that any forecast rainfall was appropriate to be utilised, that forecast rainfall was rain on the ground or the 24 hour Quantitative Precipitation Forecasts (1 Day QPFs)"; and "(iii) predictions as to lake levels in Lake Wivenhoe and Lake Somerset were most reliably made utilising actual rainfall, stream flow information and loss rates".[340] To the extent that SunWater pleaded Seqwater's sharing of these assumptions, it appears to be a reference to the state of mind of Messrs Malone and Tibaldi, Borrows, Drury and Pruss.[341]

186 Six matters should be noted about this part of SunWater's case. First, as the above analysis and Chapters 3, 6 and 7 demonstrate, in their evidence, each of Messrs Ayre, Malone and Tibaldi recited different understandings of the Manual's requirements in various respects.[342]

187 Second, in relation to all three of the alleged common assumptions, releases below FSL in advance of and because of forecast rainfall were made from

[336] PLE.030.009.0001 at .0007 to .0008.
[337] At [181].
[338] PLE.030.008.0001 at [58(j)].
[339] Ibid at [58(e)].
[340] Ibid at [106(b)].
[341] SunWater subs, section 18.3.2.
[342] Plaintiff subs at [585].

Somerset Dam during the May 2009 and March 2010 Flood Events. Those releases were inconsistent with those assumptions.

188 Third, in its submissions, SunWater set out the chronology of events between 25 October 2010 and 31 December 2010 surrounding the consideration of a proposal to temporarily reduce FSL to 95%.[343] This culminated in an email from Mr Borrows sent on 30 December 2010 stating that "[f]or this event we'll go to fsl"[344] and an email from Mr Drury to Mr Malone the next day referring to a discussion with Mr Borrows to the effect that they were expected to "finish at FSL regardless of whether we can drop below".[345] SunWater submitted that releases from below FSL "would have required SunWater to act in a way which was fundamentally inconsistent with its client approach to the issue, *known to Mr Ayre of SunWater*".[346] However, there is no evidence that that email was sent to Mr Ayre.[347]

189 Fourth, to the extent that the "*No Precautionary Release Common Interpretation*" is a reference to making releases from Wivenhoe Dam prior to a flood event, or prior to it first attaining a height of EL 67.25m AHD during a flood event,[348] then I accept that was an understanding common to all the flood engineers. However, it does not engage with the plaintiff's case or any part of the cross-claim as neither the plaintiff, nor Dr Christensen, contended that such releases should have been made.

190 Fifth, properly analysed, the "*Forecast Rainfall Common Intention*" is an alleged common intention that relates to the construction of the Manual because it relates to "choosing strategies" (see [185]).

191 Sixth, and most critically, I have already found that I am not persuaded that Mr Malone, Mr Tibaldi or Mr Ayre adopted or applied any particular interpretation of the Manual in conducting flood operations during the January 2011 Flood

[343] SunWater subs at [638].
[344] SEQ.016.017.5054.
[345] SEQ.001.018.6155.
[346] SunWater subs at [642].
[347] See T 9641.8.
[348] See SunWater subs at [2837].

Event, including any belief that the Manual or the Moreton ROP precluded releases from Wivenhoe Dam below FSL during flood operations. Those findings are fatal to the establishment of what remains of the alleged common intentions, regardless of whether or not I accepted the disputed evidence of Messrs Borrows, Pruss and Drury.[349]

192 Save for the matter noted in [189], it follows that I do not accept that during the January 2011 Flood Event employees of Seqwater and SunWater shared any of the common interpretations pleaded by SunWater. This aspect of its case fails at a factual level.

193 Accordingly, it is not necessary to address the plaintiff's challenge to the evidence of Messrs Borrows, Pruss and Drury noted above.[350]

5.6: Section 22 of the *CLA* (Qld) and Releasing Below FSL

194 Sub-section 22(1) of the *CLA* (Qld) provides that a "…professional does not breach a duty arising from the provision of a professional service if it is established that the professional acted in a way that, at the time the service was provided, was widely accepted by peer professional opinion by a significant number of respected practitioners in the field as competent professional practice." SunWater pleaded reliance on s 22 but did not particularise the "way" in which the flood engineers acted that was said to be widely accepted by peer professional opinion as "competent professional practice".[351] In its submissions, SunWater contended that "on the basis of Mr Fagot's evidence" the Court should conclude that "in multi-purpose dams, not drawing dams (*with a constant FSL*) down below FSL on the basis of rainfall forecasts was widely accepted by peer professional opinion by a significant number of respected practitioners in the field as competent professional practice".[352]

[349] See SunWater subs at [2790].
[350] At [181].
[351] See, for example, PLE.030.008.0001 at [212(d) and (e)].
[352] SunWater subs at [711]; Seqwater made a similar submission: Seqwater subs at [1721(f)].

195 I address s 22 in Chapter 11. At this point, I address the evidentiary basis for this contention. Mr Fagot's evidence has been addressed above,[353] as has SunWater's reliance on practice at other dams.[354] It follows from that analysis[355] that his evidence did not establish the existence of a practice relevant to the circumstances of Wivenhoe and Somerset Dams in relation to releasing below FSL. Instead, at most his evidence only established a practice that if, by operation of a water control manual or some other means, the storage space reserved for the supply pool was not available for use in flood mitigation, then flood engineers would respect that distinction. Put another way, at most the only practice that was established concerned the circumstance where the existence of a "constant *and inviolable* FSL" was established and the practice was to observe that constraint. As I have stated, the effect of the interim approval (and the earlier existing programs) was that the water below FSL was available for flood mitigation. Where there was permission to use the supply pool, Mr Fagot only stated that he would "prefer" to see "more specific guidance",[356] that "he had no problem with the concept of releasing below FSL if rain on the ground modelling indicated it could be filled" and that he was "okay with the suggestion" that Wivenhoe Dam be lowered to a point if it could be filled up by Somerset Dam, provided no constraints were violated.[357] Otherwise, Mr Fagot accepted that the more storage available the "better off you will be in terms of flood mitigation operations".[358] Mr Fagot's preference for specific guidance was a product of his experience in the USA with highly prescriptive manuals. As I have explained, the Manual was not of that character.

196 Thus, the only relevant practice that was established was a practice of not releasing from a constant and inviolable water supply pool. In terms of s 22(1), during the January 2011 Flood Event the flood engineers did not act "in a way" that was in accordance with the practice that was established. Instead, they did not release water from below FSL in circumstances where

[353] At [106] to [113].
[354] At [127] to [131].
[355] Especially at [110].
[356] T 9028.14.
[357] See [111].
[358] T 9012.10.

there was a violable supply pool. Where there was a water supply pool that could be the subject of releases for flood mitigation purposes then it was not established that there was any practice of nevertheless keeping it pristine.

5.7: Conclusion

197 It follows that neither the regulatory regime, the Manual or peer professional practice precluded the making of releases below FSL from either Dam during flood operations in the course of the January 2011 Flood Event.

198 The utility of making such releases to achieve better flood mitigation is obvious. In his discussion about making releases below FSL in first report, Dr Christensen appears to take that as a given.[359] As noted, Mr Fagot accepted that the more storage available, the "better off you will be in terms of flood mitigation operations",[360] although he added that "it also depends on how the storage is used and how quickly you fill the storage".[361] One of the advantages of additional storage according to Mr Fagot was that it will allow more time "before you need to make the higher releases that are required for the safety of the dam".[362] Mr Malone agreed that reducing below FSL and thus "increasing the airspace … gives you a better outcome" but added that "it also depends upon how you – what the pattern of release is you make after you use that airspace".[363] Mr Tibaldi agreed that if FSL was lowered "you will get a certain amount of flood mitigation benefit" although it could be "zero".[364]

199 Given that releases below FSL during flood operations are permissible and have obvious advantages, what are the limits on making such releases and when should they be made? In its submissions, the plaintiff contended that, as releases had these benefits, then the "real question is therefore simply whether the Flood Engineers could" make them.[365] SunWater contended that the correct test was whether a reasonably competent flood engineer "would"

[359] February 2015 Report, EXP.ROD.001.0016 at [281] to [295].
[360] T 9012.10.
[361] T 9012.27.
[362] T 9026.6.
[363] T 5084.42; T 4947.25 and T 5364.29.
[364] T 6120.42.
[365] Plaintiff subs at [775].

have operated the dams by releasing water below FSL (in the way proposed in Dr Christensen's simulations).[366]

200 As stated, ultimately the plaintiff must establish that a reasonably competent flood engineer in their position *would* have undertaken flood operations substantially in accordance with one of those simulations which, in most cases, include releases from below FSL. Whether that is so depends on the prevailing circumstances, the action proposed and the reasons for it. However, at this point it suffices to state that such releases should be made if they are necessary to give effect to the Manual's objectives, bearing in mind the admonition that there should be no reason why the dam would not return to FSL at the end of the flood event,[367] and otherwise observing the various constraints imposed by the Manual. Further, the making of releases below FSL from Wivenhoe Dam when there is sufficient water above FSL in Somerset Dam to refill Wivenhoe Dam to FSL is an operation that will not compromise the Manual's objective of retaining storage at FSL at the conclusion of a flood event and thereby is consistent with section 3.5. However, that does not necessarily exhaust the circumstances in which flood releases below FSL can be made.

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[366] SunWater subs at [745].
[367] Manual, section 3.5.

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CHAPTER 6: THE JANUARY 2011 FLOOD EVENT TO 7 JANUARY 2011

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CHAPTER 6: THE JANUARY 2011 FLOOD EVENT TO 7 JANUARY 2

1 This chapter consists of a narrative of the January 2011 Flood Event until the end of 7 January 2011. The parties' written submissions addressed this topic in tandem with the plaintiff's allegations of breach of duty.[1] As I consider it necessary to address Dr Christensen's evidence and simulations before making findings on breach, those topics have been separated although, in discussing the flood event, many of the plaintiff's criticisms of the flood engineers' approach and the defendants' response are addressed.

2 The relationship between those criticisms and the pleaded case needs explaining.[2] From an early stage of the proceedings, the plaintiff was required to re-plead its case by confining its allegation of breach to complaints about positive acts or failures to act in terms of flood operations.[3] It was precluded from pleading the thought processes of the flood engineer or the adoption or failure to adopt various methodologies per se as acts of negligence.[4] In most respects, the plaintiff complied with this stricture. This meant that many of the general criticisms of the flood engineers levelled by the plaintiff against them were not pleaded (and not permitted to be pleaded) as particulars of negligence.[5] Contrary to Seqwater's submissions,[6] that does not mean that the plaintiff could not advance them. Instead within the constraints imposed by *Rodriguez (No 1)* those criticisms are the suggested reasons why they were negligent in failing to release any or sufficient water during the January 2011 Flood Event (*Rodriguez (No 3)* at [6]). Although the precise allegations of breach are addressed in Chapter 12, many of those criticisms are addressed in this Chapter and Chapter 7.

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[1] Plaintiff subs at [998ff]; Seqwater subs at [974ff]; SunWater subs at [1768ff]; State subs at [118ff].
[2] It is further addressed in Chapter 12; section 12.3.
[3] *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority t/as Seqwater* [2014] NSWSC 1565 at [63]; "Rodriguez (No 1)"; *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority t/as Seqwater (No 3)* [2015] NSWSC 838 at [6]; "Rodriguez (No 3)".
[4] *Rodriguez (No 1)* at [63] and *Rodriguez (No 3)* at [6] and [22] to [25].
[5] See for example Plaintiff subs at [5].
[6] See for example Seqwater subs at [996].

6.1: Overview

3 In the circumstances described in this Chapter, the Late December Flood Event was declared over and gate operations ceased at Wivenhoe and Somerset Dams early in the morning of 2 January 2011, even though both dams were above FSL. A flood event was declared again early in the morning of 6 January 2011 and gate operations resumed at 3.00pm on 7 January 2011. The overall course of the January 2011 Flood Event can be gauged from the following numbers which represent a "snapshot" of some of the relevant data at the specified times:

Date/Time	Wivenhoe Level (m, AHD)[7]	WD Inflows (m^3/s)	WD Outflows (m^3/s)	Rainfall received (mm)[8]	QPF – 1 day forecast (mm)[9]	4 day PME (mm)[10]	8 day PME (mm)[11]
2 Jan 11.00am	67.10	143	112	Som:0 UB:1 MB:0	Less than 5 to 10	1 to 10	15 to 25
3 Jan 11.00am	67.16	78	50	Som:10 UB:4 MB:2	5 to 10	50 to 100	75 to 150
4 Jan 11.00am	67.18	44	50	Som:0 UB:0 MB:0	10 to 20	75 to 150	90 to 150
5 Jan 11.00am	67.24	24	50	Som:19 UB:29 MB:17	20 to 30	50 to 100	100 to 150
6 Jan 11.00am	67.34	177	50	Som:38 UB:38 MB:34	30 to 50	50 to 125	100 to 200
7 Jan 11.00am	67.81	2225	50	Som:28 UB:24 MB:25	20 to 30	50 to 150	100 to 320
8 Jan	68.59	1399	1085	Som:53	30 to 50	100 to	100 to

7 The source of these figures is outlined in section 6.5.
8 This represents the rainfall received in the 24 hours from 9.00am of that morning to 9.00am the following morning in the three catchments upstream of Wivenhoe Dam, namely Somerset, Upper Brisbane and Middle Brisbane. Figures taken from Mr Malone's "Observed Rainfall Analysis" report (SEQ.004.046.0230).
9 This represents the morning QPF forecast for the day in question.
10 This is the Plaintiff's contention as to what was demonstrated by the 4-day PME forecast available to the flood engineers at midnight the previous evening for the 4-day period starting 10.00pm the previous night. There was some dispute over those figures: see Table 9-2 in Chapter 9 at [138].
11 This is the Plaintiff's contention as to what was demonstrated by the 8-day PME forecast available to the flood engineers at midnight from the previous evening for the 8-day period starting 10.00pm the previous night. There was some dispute over those figures: see Table 9-3 in Chapter 9 at [161].

11.00am				UB:22 MB:11		300	320
9 Jan 11.00am	68.54	1646	1332	Som:210 UB:124 MB:126	40 to 60	75 to 300	100 to 400
10 Jan 11.00am	71.95	8059	2044	Som:103 UB:103 MB:150	50 to 100	75 to 225	75 to 225
10 Jan 10.00pm	73.17	4488	2705				
11 Jan 10.00am	74.10	9606	3533	Som:122 UB:14 MB:121	In excess of 100	40 to 120	40 to 120
11 Jan 7.00pm[12]	74.97	6876	7464				
12 Jan	74.78	2510	2547	Som:5 UB:2 MB:2	10	10 to 50	25 to 50

Table 6-1: Inflows, forecasts and rainfall depths for the January 2011 Flood Event

4 It can be seen that there was a rapid increase in inflows from 9 January 2011 to early on the morning of 10 January 2011, then a reduction for the rest of that day before another rapid increase throughout 11 January 2011. At 1.00pm on 11 January 2011, the rate of inflow into Wivenhoe Dam peaked at 11561m^3/s. From around 11.00am, the flood engineers commenced raising the gates rapidly so much so that by 7.00pm the peak rate of outflow of 7464m^3/s was reached, with the Wivenhoe Dam storage level peaking at EL 74.97m AHD. Flooding of homes and businesses downstream commenced during 11 January 2011 with the peak flooding occurring in urban areas the following day. As noted in Chapter 1, this flooding is to be distinguished from the flash flooding that occurred in Toowoomba and the Lockyer Valley late on 10 January 2011.

5 The type of rainfall forecasts that were available to the flood engineers during the January 2011 Flood Event, ie, the catchment-specific 24-hour QPF and the one, four and eight-day PMEs, as well as the SILO meteograms, and the times they were available, are discussed in Chapter 2. There was some

[12] Peak height and peak outflow.

disagreement about what the PMEs predicted for the catchment areas above and below the dams. The various estimates are set out in Tables 9-2 and 9-3 in Chapter 9.[13] The differences are not material to the narrative of the January 2011 Flood Event in this Chapter and the following Chapter. The above table utilises the plaintiff's summary of the effect of those PMEs. The following narrative sets out what the plaintiff and the State contended that a visual inspection of the relevant PMEs revealed. The extent to which the differences in interpretation of the PMEs may be material to a consideration of Dr Christensen's simulations is addressed in Chapters 9 and 10.

6 The material provided by the parties also contained different methods of analysing the rain that fell by breaking it down into different areas and time periods.[14] Again, for ease of explanation, the above table and following narrative adopts the 24 hours to 9.00am rainfall figures produced by Mr Malone in his "Observed Rainfall Analysis" report for the catchment areas above and below the dam.[15]

6.2: Unpredictable Rain?

7 The above table indicates the prodigious amount of rain that fell in the catchments above and below Wivenhoe Dam during the period of the flood event, especially from 8 January to 11 January 2011. Using this data, the four-day catchment average rainfall totals for the period from 9.00am on 8 January 2011 to 9.00am on 12 January 2011 for the three catchments above Wivenhoe Dam, being Somerset, Upper Brisbane and Middle Brisbane, were 488mm, 263mm and 408mm respectively.

8 A report by the BoM prepared for the QFCI described the flooding across Queensland in late 2010 and early 2011 as "consist[ing] of a number of

[13] Chapter 9 at [138] and [161].
[14] AID.500.022.0001 (Plaintiff); AID.500.026.0001 (Seqwater).
[15] SEQ.004.046.0230.

different types of rainfall and flooding events", as described in the following table:[16]

Event one: 28 November 2010 to 22 December 2011	A sequence of large scale rain events across the state	Major flooding of rivers across the Southern half of the State
Event two: 23 to 28 December 2010	A single 6 day event covering almost the entire state. Record rainfalls.	Record flooding in central and Southern Queensland. Inundation of the cities of Bundaberg, Rockhampton and Emerald and many other towns.
Event three: 10 to 12 January 2011	A concentrated rainfall event on the scale of several hundred kilometres, occurring directly over several small river basins.	Flooding of the cities of Brisbane and Ipswich and many other towns.
Event four: 10 January 2011	Intense rainfall from a thunderstorm complex over several hours directly over a region with steep topography channelling the flow.	The flash floods in Toowoomba and Lockyer Valley.

Table 6-2: Major Rainfall events leading to the January 2011 Flood Event

9 The BoM report stated that the third of these events was "largely responsible for the flooding of the cities of Brisbane and Ipswich as well as for the flash floods in Toowoomba and the Lockyer Valley".[17] It was described as "an unusual type of rainfall event with the major rain system having a scale of only several hundred kilometres, in this case over a concentrated region of south eastern Queensland".[18] The rainfall causing the Brisbane and Ipswich floods was said to have been "caused by an onshore moist easterly trade wind flow in Southern Queensland interacting with an upper level cut-off low". This was described as "unusual … at th[at] time of year" and caused by a phenomenon that was "not well understood".[19]

10 SunWater submitted that the rainfall in January 2011 was "unusual" in three respects. The first was that the prevailing climate, specifically the summer monsoonal period, was exacerbated by the occurrence of a major La Niña

[16] ROD.519.001.0527 at .0545, [64].
[17] Ibid at [78].
[18] Id.
[19] Ibid at [79].

event which itself was unusually intense,[20] a matter I have already noted[21] and accept.

11 The second aspect of the rainfall that was said to be unusual was the high level of accumulated rainfall in this period.[22] Professor Manton noted that the one-day rainfall totals in the period December 2010 to January 2011 for the Lower Brisbane and Bremer catchments were "not even in the top ten records", although the rainfall in the 24-hour period up to 9.00am on 10 January 2011 in the upstream catchments was the fourth highest on record.[23] However, he stated that the accumulated rainfall for a number of periods beyond one day ending on 12 January 2011 (or 14 January 2011) were the highest amounts recorded since 1900,[24] although this did not include the flood events of 1841 and 1893 and at least the latter was relevant from a meteorological perspective in anticipating the rainfall in January 2011.[25]

12 The third aspect of the rainfall that was said to be unusual was the concentration of rain in the north of the catchment above the dams after the storms tracked south west from the coast.[26] Although the evidence cited by SunWater in support of this was more directed to the flash flooding in Toowoomba and the Lockyer Valley than the northern part of the upstream catchment,[27] there is some support for this contention in Professor Manton's report.[28]

13 By reference to the first two factors, Professor Manton stated that he disagreed with what he asserted was the "implication" of Professor Walsh and Mr Kane that "the dam operators should have anticipated the rainfall event of 9-11 January 2011".[29] Two matters should be noted about that statement.

20 SunWater subs at [1771] to [1781].
21 Chapter 2 at [53] to [56].
22 SunWater subs at [1782] to [1789].
23 EXP.SEQ.004.0131 at .0167.
24 At .0167 to .0168; T 3612.16.
25 T 3610.38.
26 SunWater subs at [1791] and [1801].
27 Eg, ROD.519.001.0527 at .0549, [81] cited in SunWater subs at [1795].
28 EXP.SEQ.004.0131 at .0172.
29 EXP.SEQ.010.0011 at [68].

First Professor Manton overstated Professor Walsh and Mr Kane's conclusions. Professor Walsh merely concluded that, given what was known about the strong La Niña event, it "would have been reasonable for a meteorologist to assume that seasonal conditions during January 2011 would be conducive to heavier than normal 5-day rainfall events".[30] Similarly, Mr Kane concluded that the material available suggested "at the very least, the probability of rainfall in the … three months [to the end of January 2011] was higher than no rainfall, with a high likelihood of greater than normal accumulations".[31] I accept both of those opinions.

14 Second, Professor Manton's concept of an anticipated event is not the same as foreseeability or possibility. In cross-examination, he said that he equated "anticipation with foreseeability"[32] but conceded that rainfall in the amounts that fell was something that was "possible".[33] When taken to a four-day PME that suggested rain of 250mm in the relevant period, he agreed that "it's possible that 350mm or 400mm would fall but it wouldn't be anticipated".[34] He then explained that "I'm talking about expectations of 90 per cent and so on. So – I mean, possible's different from probable".[35]

15 While the rain that fell in the period 9 to 11 January 2011 exceeded the maximum forecast amounts set out in the PMEs, those forecasts, including the defendants' contention as to what the PMEs showed, were still predicting very large amounts of rain. Further, as explained below, during the course of the January 2011 Flood Event forecast assessments were made by the flood engineers and Seqwater staff that yielded very significant amounts of rainfall, approximating to what in fact fell. For example, an email sent on 5 January 2011 by a Seqwater employee referred to an eight-day forecast of 300mm to 400mm of rain in an area that included the dam catchments.[36] Mr Malone

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[30] EXP.ROD.014.0034 at .0049, [3.2].
[31] EXP.ROD.011.0011 at [127].
[32] T 3619.43.
[33] T 3620.7.
[34] T 3621.26.
[35] T 3621.37.
[36] SEQ.016.007.5397.

made a similar assessment on 6 January 2011.[37] He distributed an email on the morning of Friday, 7 January 2011 which forecast 155mm to 350mm over five days.[38] Later that afternoon, Mr Malone suggested that the estimate had doubled.[39] A daily breakdown of available PMEs set out in a flood engineers' report issued at 6.00pm on 7 January 2011 predicted between 175mm and 450mm over the following three days.[40]

16 It can be accepted that the precise combination of weather events, the precise rainfall amounts and the distribution of rainfall were not readily capable of being predicted in the immediate period prior to 9 to 12 January 2011. However, as Professor Walsh and Mr Kane stated, there was a strong likelihood of higher than average rainfall throughout the entire period of December 2010 to January 2011. The forecasts and internal assessments that were produced during the period of the flood event pointed to a likelihood of very large falls occurring in an already saturated catchment. In those circumstances, there was clearly a reasonable possibility of rainfall in, around and below the upstream catchments in amounts higher, sometimes much higher, than the forecasted amounts and which approximated to the amount of rain that actually fell.

17 The following narrative also summarises the severe weather, storm and flood warnings issued throughout each of the relevant days. In relation to the flood warnings, Mr Malone stated that the information they contained was available to the Flood Operations Centre (the "FOC") in real time as both it and the BoM were receiving the same rainfall data and they were operating "very similar models".[41]

[37] LAY.SEQ.007.0001 at [570].
[38] QLD.001.001.2330.
[39] SEQ.001.018.6305.
[40] SEQ.004.019.2495; SEQ.004.019.2497; SEQ.004.019.2499.
[41] T 5261.46.

6.3: RTFM Runs

18 The January FER states that, during the January 2011 Flood Event, the gate operations spreadsheets generated by the RTFM were continuously updated with hourly results and manual gauge readings and that a “single ‘live’ spreadsheet [was] always available for flood operational decision making”.[42] This meant that not all outputs from the RTFM, specifically gate operations spreadsheets generated during flood operations, were saved separately.[43]

19 The end result is that, in reviewing the January 2011 Flood Event, three forms of model runs with associated gate operations spreadsheets must be considered. The first are gate operations spreadsheets that were exported from RTFM runs and saved from time to time during the course of flood operations up to 6.00pm on 1 January 2011 and then from 8.00am on 6 January 2011 (the “operational spreadsheets”).[44] The file name of the operational spreadsheet indicates the time of the model run. For example, “SDWD-201101081500” is a model run that was undertaken at 3.00pm on 8 January 2011. Both the properties of these files and the contents of the spreadsheets indicate that they were modified after the time of the run by the inclusion of data, which was usually (a few hours of) gauge board readings which allowed the projected lake levels to be compared to the observed levels in the immediate period after the spreadsheet was prepared. For some of these spreadsheets, the corresponding screenshots of the data input into FLOODOPS such as rainfall, loss rates, temporal and spatial distribution were tendered.[45]

20 The second set of spreadsheets is a set of gate operations spreadsheets prepared by Mr Malone[46] when he was compiling the January FER, a summary of which is listed in Appendix A to that report (the “Appendix A

[42] SUN.016.001.0280 at .0525.
[43] Id.
[44] The operational spreadsheets from 6 January 2011 are summarised in Annexure C4 to the affidavit of Robert Ayre sworn 6 June 2016: LAY.SUN.001.0001 at .0772.
[45] See AID.500.021.0001.
[46] T 5318.22; 5320.26 (Malone); T 6369.45; T 6319 to T 6322.11 (Tibaldi).

model runs")[47]. In preparing Appendix A, Mr Malone recreated model runs using the stored RTFM data and also prepared "*with forecast*" runs for each of these runs using the most recent QPF data.[48] It is not known whether these spreadsheets were actually created during the course of the event.

21 The plaintiff sought to rely on the Appendix A runs in two ways. First, the plaintiff contended that the Appendix A runs, especially the "with forecast" modelling, represented material that was reasonably available to the flood engineers from data in the RTFM during the January 2011 Flood Event.[49] Second, Dr Christensen used the "with forecast" Appendix A runs as a basis for predicting the level of downstream flows over the ensuing 24 hours in his simulations.[50] Seqwater contended that it was not open to the plaintiff to rely on the Appendix A runs in the manner it sought. That contention is addressed next.

22 The third type of spreadsheets are gate operations spreadsheets that were individually recreated after the flood event, and in some cases after this litigation was commenced, from data retained within FLOODOPS ("Reconstructed GOS").[51] The most significant Reconstructed GOS was created from a 72-hour "with forecast rainfall" RTFM run undertaken by Mr Ruffini at 10.00pm on 7 January 2011 (the "Ruffini 7 Jan 22:00 72-hour run").[52]

6.4: The Appendix A "with Forecast" Runs

23 Seqwater contended that it was not open to the plaintiff to contend that the Appendix A model runs that incorporated forecast rainfall which were created after the January 2011 Flood Event demonstrate what would have been available during the flood event to the flood engineers had such a model run

[47] This is the terminology used by the plaintiff: plaintiff subs at [1156].
[48] SUN.016.001.0280 at .0526 and .0527, described as "Summary of Operational Runs".
[49] Eg, Plaintiff subs at [1156].
[50] Reply Report, EXP.ROD.004.0005 at [71].
[51] This is the terminology in plaintiff subs at [1213].
[52] QLD.008.001.0416.

been undertaken.[53] It contended that such a proposition was not put to the flood engineers who gave evidence when it should have been.[54] It also contended that the flood engineers were thereby deprived of explaining why those runs should not be relied on to show what was available during the flood event and that there was evidence to suggest that the loss rates and gate settings used might have been different.[55]

24 The January FER describes the Appendix A model runs "with forecast" rain as having been derived by "apply[ing] the full 24-hour catchment average rainfall forecast from the BoM QPFs to the model run ... regardless of the model run time in relation to the issue time of the forecast, and regardless of the rainfall since the forecast was issued".[56] It stated that "[i]n effect, this provides a 'worst case' 24-hour scenario".[57] Mr Giles' analysis of the runs demonstrated that they used the upper bound of the QPF figure and not the average, the time attributed to the run was after the forecast was issued (which meant that some of the rain that was predicted to fall may have actually fallen and thus been picked up in the rain on the ground component of the run), and the RTFM modelling adopted an "aggressive" temporal pattern that assumed 57% of the daily total fell within the first six hours and 22% fell in a single hour.[58] The plaintiff embraced these conclusions as demonstrating Dr Christensen's conservatism in using rainfall forecasts for predicting downstream flows as this modelling would tend to produce higher estimates of downstream flows and promote caution in Dr Christensen's release strategy.[59]

25 In cross-examination Mr Malone was asked:[60]

> "Q. And these [the Appendix A model runs] were replicating, for *illustrative* purposes, runs that had been or could have been done during the

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53 Seqwater subs at [1023(b)].
54 Ibid at [1023(b)], [1029] to [1051] and [1378].
55 Seqwater subs at [1032].
56 January FER at .0525.
57 Ibid at .0525.
58 Giles 2, EXP.QLD.001.0813 at 832 to 834.
59 See plaintiff's oral submissions at T 10168.21 to T 10170.38.
60 T 5318.22.

flood event which had been overwritten or otherwise not available; correct?
A. Correct." (emphasis added)

26 He was also asked the following by the Court:[61]

"Q. I think everyone else knows it, just so I understand it, I think you said you did this after the event?
A. Yes.

Q. To replicate what you knew had been done on the day?
A. Similarly to what was done on the day, using the same, exactly the same observations, rainfall observations, water level observations, gate settings, but I think the difference was that during this series of runs the losses would have been kept constant for the whole series of runs, whereas during the actual runs losses *may well have changed* from one time to another, *slightly*." (emphasis added)

27 In its written submissions, Seqwater contended that the reference in these passages to a potential change in loss rates between the Appendix A runs and operational runs was sufficient to "cast doubt" on the inflow estimates produced by these runs as being available to the flood engineers during the January 2011 Flood Event.[62] I reject that contention. Mr Malone only referred to the loss rates possibly changing and only "slightly". In fact, a comparison undertaken by the plaintiff of the loss rates used in the two sets of runs reveals that the differences in loss rates were insignificant, being mostly related to initial loss rates and initial losses that would have been absorbed by 6 January 2011.[63]

28 Mr Ayre was cross-examined on the Appendix A runs.[64] He agreed that they were created by retrieving data preserved from the RTFM.[65] At one point, he was cross-examined on three "with forecast" runs undertaken on 7 January

[61] T 5319.35.
[62] Seqwater subs at [1032].
[63] SBM.010.007.0001 at .0074 to .0080.
[64] T 7618.27; T 7736.8; T 7645.32.
[65] T 7736.3; T 7647.14.

2011.[66] Mr Ayre did not raise any misgivings with the results of those runs or any other Appendix A runs he was referred to.[67]

29 Mr Tibaldi was cross-examined on the particular Appendix A model runs relevant to his shift.[68] He adverted to the possibility that, had the flood engineers been utilising the Appendix A model runs, then “in practice” the gate operations would have been different especially in seeking to comply with the operational target line.[69] Seqwater contended that this meant there is potential for doubt as to whether the predicted height levels in the Appendix A model run would have been achieved.[70] However, the fact that gate operations might have been different had the Appendix A model runs been utilised does not mean that the plaintiff cannot rely on them in the manner that it did in its written submissions. A difference in gate operations does not affect inflow estimates (or estimates of downstream flows excluding Wivenhoe Dam releases). Otherwise, the proposition that utilising forecast runs as the bases for flood operations would have led to different gate operations (and different storage levels), is the foundation of the plaintiff’s case.

30 Overall, Seqwater contended that it was not open to the plaintiff to submit that the Appendix A “with forecast” runs reveal what would have been determined by the flood engineers had they been undertaken during the January Flood Event “without having put them [the runs] to Mr Malone or Mr Ayre as *representative* of what would have been shown during the event”.[71] I reject that submission. I do not discern any difference in substance between Mr Malone agreeing that they were “illustrative” and him agreeing that they were “representative”. As noted, accepting the various limits noted above, Mr Ayre did not appear to cast any doubt on their accuracy. Otherwise, in circumstances where all the relevant witnesses denied that the “with forecast” RTFM runs should be used as the basis for flood operations, I do not accept

[66] T 7645.44.
[67] See for example T 7959.21.
[68] See T 6372 and T 6439.
[69] T 6372.32 to .43.
[70] Seqwater subs at [1033].
[71] Ibid at [1378].

that it was incumbent on the cross-examiner to put each and every forecast run it is said that a flood engineer should have performed and used as a basis for flood operations (*Vines v ASIC* (2007) 73 NSWLR 451 at [409]; [2007] NSWCA 126). Further, insofar as Dr Christensen relied on the Appendix A model runs, his use of them was foreshadowed in his reports long before the hearing commenced. If the defendants wanted to challenge his use of them and, in doing so, attack the veracity of their own flood engineers' modelling, it was open for them to do so.

31 It follows that I do not consider that any *Browne v Dunn*[72] issue arises in relation to the plaintiff's reliance on the Appendix A model runs. I am satisfied they represent information that was readily available to the flood engineers had they conducted RTFM runs in accordance with the specified inputs and parameters at the times they indicated. That said, in ascertaining their meaning and effect, the matters identified by Mr Giles should be noted as well as the fact that had they been used for conducting flood operations then different gate operations might have ensued.

6.5: Inflow Figures for the Period 2 January to 6 January 2011

32 As noted, a flood event was declared on 6 January 2011. However, a number of documents prepared after 6 January 2011 referred to the flood event commencing from 2 January 2011,[73] a matter the plaintiff relies on. In fact, Wivenhoe Dam remained above FSL from 2 January 2011 and Dr Christensen treated the January 2011 Flood Event as a continuation of the Late December Flood Event. One practical consequence of this is that the data concerning the water inflows into Wivenhoe Dam during the period 2 January 2011 to 6 January 2011 was not included in the January FER.

33 In preparing his simulations, Dr Christensen used the inflow data from the January FER in his simulations for the period from 9.00am on 6 January 2011 onwards, but for the period from 2 January 2011 to 9.00am 6 January 2011,

[72] (1893) 6 R 67 (HL).
[73] Eg, QLD.001.001.2456 at .2457.

he used figures he derived from a QFCI exhibit.[74] However, with the figures derived from the QFCI exhibit, he erred in that he included flows from the Stanley River (ie, Somerset catchment) in both his inflow figures for Somerset Dam and Wivenhoe Dam and thus double counted them.[75] In the weeks prior to giving evidence, Dr Christensen reassessed his inflow figures by “reverse routing”, that is, working back from the observed height increases in the dams to calculate inflows and produced revised inflow figures for the period 2 to 6 January 2011.[76] Dr Christensen agreed that this meant that there was an overestimation in the inflow figures for Wivenhoe that he used, although he added “but not very much”.[77] To a large extent this was confirmed by a schedule provided by Seqwater during submissions in relation to a different topic, namely whether in two of Dr Christensen’s simulations there was the capacity for Wivenhoe Dam to be refilled up to FSL by baseflow or water held above FSL in Somerset Dam.[78] Later, at the request of the Court, Seqwater provided a further schedule addressing the effect of the error on Dr Christensen’s simulations.[79] This is addressed in Chapter 10.[80]

34 The impact of this error on Dr Christensen’s simulations is addressed later. The present relevance of this topic is that, in respect of the period up to the start of 6 January 2011, the above table and following narrative uses the inflow rates for that period into Wivenhoe Dam taken from Dr Christensen’s revised reverse routed figures.[81] For the period from 9.00am on 2 January 2011 up to 6 January 2011, it uses the storage levels for Wivenhoe and Somerset Dams set out in the first operational spreadsheet prepared after a flood event was declared on 6 January 2011.[82] The (actual) storage levels and inflow figures for on and after 6 January 2011 in the following narrative are taken from Dr Christensen’s reports which are derived from the January

[74] ROD.503.001.1782; T 1812.7 (Christensen).
[75] T 1813.2 - .13.
[76] MSC.010.146.0001; T 1952.17.
[77] T 1813.13.
[78] SBM.020.012.0001.
[79] Ibid at .0004.
[80] Chapter 10 at [70ff].
[81] MSC.010.146.0001.
[82] SUN.002.002.3607.

FER. Also, to illustrate the degree of difference between the parties, the following narrative contrasts the position at the end of each day with one of Dr Christensen's simulations, Simulation A ("SIM A"). In SIM A, Dr Christensen assumes that dam operations continue from the Late December Flood Event, that the Somerset Dam crest gates remained fully open with an estimated failure level of 107.46m AHD and the dams could be operated below FSL during a flood event. To an extent, the modelled dam levels in SIM A are affected by the inflow error but not in a manner that is material to the discussion in this Chapter.

6.6: Tuesday, 28 December 2010 to Saturday, 1 January 2011

35 By 1 January 2011, the flood engineers were closing gates and looking to end flood operations for the Late December Flood.

36 There was a debate in the submissions about the origin of the decision to end flood operations on 2 January 2011. The first reference to ending flood operations was in a situation report issued by Mr Malone at around 6.39pm on 28 December 2010.[83] (A situation report is a standard form of email distributed by the duty flood engineer to the other flood engineers, certain Seqwater and SunWater staff, as well as various government agencies, such as local councils and the police). In the report, Mr Malone stated that it was expected that releases would gradually increase on that day and Wednesday 29 December 2011, such that combined flow downstream would be 1600m^3/s. He said that flow would be "maintained until at least Saturday [1 January 2011] when it is expected that shut down procedures will commence".[84]

37 The situation report issued at 6.42am on 29 December 2010, apparently by Mr Ruffini, made the same statement.[85] This report stated that no rain had fallen in the catchments in the previous 12 hours with the exception of 2mm to 4mm in the upper Somerset Dam catchment and the BoM forecast for South

[83] SEQ.001.018.4346.
[84] Ibid.
[85] SEQ.001.018.4329.

East Queensland for the "next few days is mostly fine with a few showers". Releases continued throughout the day.[86]

38 Just before 6.00pm on 29 December 2010, Mr Malone issued a situation report.[87] He noted that there had not been any significant rainfall for 24 hours and that the forecast "over the next few days [was] mostly fine with a few light showers". The report stated that the existing level of releases was to be maintained "until late Friday/early Saturday when shut down procedure will commence and gates are expected to be fully closed Sunday morning".[88]

39 Mr Ayre issued a situation report just after 6.00am on Thursday, 30 December 2010.[89] It was not relevantly different to Mr Malone's report from the previous night, although it stated that shutdown procedures would commence at midday the following day. These statements were repeated in a situation report issued by Mr Malone just before 6.00pm that evening.[90] Mr Ruffini issued the next situation report at 5.43am on 31 December 2010.[91] He advised that the shutdown procedure would commence "late Friday 31 December" with the "gates expected to be fully closed by Sunday 2 January [2011]".

40 Just before 1.00pm on 31 December 2010, Mr Malone sent an email advising that gate closing would commence at midnight with the aim of reaching "full closure" by noon on Sunday, 2 January 2011, with releases through the regulator thereafter.[92] Later that afternoon, Mr Drury emailed Mr Malone requesting that it start earlier ("say 9pm") and finish "9am Sunday" to avoid fish recovery (ie, the retrieval of stranded fish in front of the crest gates) occurring during the heat of the day.[93] Mr Malone agreed.[94] Just before 4.00pm, Ipswich Council was advised that gate closing would commence at

[86] SEQ.001.010.9597.
[87] SEQ.001.018.4299.
[88] SEQ.001.018.4299.
[89] SEQ.001.018.4282.
[90] SEQ.001.018.4264.
[91] SEQ.001.011.4735.
[92] SEQ.001.018.4245.
[93] QLD.002.001.4583.
[94] T 4712.46.

9.00pm that evening.[95] Mr Malone's situation report issued at 6.09pm on 31 December 2010 stated that gate closure would commence that evening with the aim of closing the last gate at Wivenhoe Dam at 9.00am on 2 January 2011.[96] The plaintiff contended that this is evidence that Mr Drury involved himself in the conduct of flood operations.[97]

41 One-day PME forecasts were available to the flood engineers at 6.00pm on 31 December 2010. They predicted 1mm to 5mm of rain in the catchment areas for the 24 hours from 10.00pm on 31 December 2010 to 10.00pm on 1 January 2011.[98] The four-day PME available at midnight predicted 10mm to 25mm of rain in the catchment areas for the period 10.00pm on 31 December 2010 to 10.00pm on 4 January 2011.[99] The eight-day forecast issued at the same time predicted 15 to 25mm for the eight-day period.[100]

42 Mr Ruffini assumed the conduct of flood operations from Mr Malone at around 6.30pm on 31 December 2010. At 8.30pm, he issued a directive to close the Wivenhoe Dam gates by five increments between 9.00pm that evening and 2.00am the following morning.[101] He issued another such directive at midnight.[102]

43 At around 6.49am on 1 January 2011, Mr Ruffini emailed the situation report.[103] He reported that there had been no significant rainfall in the catchments above the dam since 9.00am on 29 December 2010 and that the "current BoM forecast for SE Qld over the next week is mostly fine with a few light showers although there is a chance of storms on Thursday" 6 January 2011. Mr Ruffini noted that the "catchments remain wet and are likely to generate additional run off in the event of rain". He recorded that Somerset Dam was at FSL at 6.00am and "essentially steady". One regulator valve at

[95] QLD.001.001.1338.
[96] SUN.001.001.1845.
[97] Plaintiff subs at [1009].
[98] SEQ.013.004.1213.
[99] SEQ.013.004.1223.
[100] SEQ.013.004.1224.
[101] SEQ.001.010.9602.
[102] SUN.002.001.6428.
[103] SUN.002.001.6429; SEQ.001.011.4737.

Somerset Dam was open "as small baseflows continue to flow into the Dam". In relation to Wivenhoe Dam, Mr Ruffini stated that the dam was at EL 67.38m AHD and "falling slowly". Wivenhoe Dam was releasing around 1140m^3/s and it was stated that the gates were expected to be fully closed by 9.00am the next day. Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge were closed. He advised that the Wivenhoe Dam gates were expected to be "fully closed by 0900 Sunday 2 January 2011".

44 Mr Malone signed on for duty at 6.45am and Mr Ruffini signed off at 7.00am.[104] At 10.00am, Mr Malone prepared a rain on the ground model run that provided for the final gate closure at Wivenhoe Dam to occur at 9.00am on 2 January 2011 at a predicted height of 67.088m AHD and for releases of 40m^3/s to be made via the regulator thereafter. The modelling predicted that after gate closure Wivenhoe Dam would rise to around 67.17m AHD on 4 January 2011. Even with releases from the regulator, Wivenhoe Dam was not projected to return to FSL until 14 January 2011.[105] The position was the same with Somerset Dam.

45 The QPF was issued shortly after 10.00am. For the 24-hour period to 9.00am on 2 January 2011, less than 5mm of rain was forecast.[106] This forecast was repeated in a QPF issued at 4.00pm for the 24 hours to 3.00pm on 2 January 2011.[107]

46 At 8.00am and 3.00pm, Mr Malone issued a gate directive, with each requiring gate closures of five increments.[108]

47 At 5.31pm, Mr Malone issued a further situation report which reported that there had been "light falls of up to 20mm" in the Somerset (and North Pine) catchments in the 8 hours to 5.00pm. He also noted that the "current BoM forecast for SE Qld over the next week is for light showers". Wivenhoe Dam

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[104] SEQ.004.026.0009.
[105] Model run: SDWD-201101011000.xls; QLD.001.001.1941.
[106] SEQ.001.019.6806.
[107] SEQ.001.019.6807.
[108] SEQ.001.018.4230; SEQ.001.020.3660; SUN.002.001.6439.

was reported at EL 67.23 AHD “and falling slowly” with 687m^3/s being released, with the same five bridges inundated as reported on that morning.[109] He advised that “shut down procedures are continuing and gates will be fully closed by 0900 Sunday 2 January 2011”.

48 Sometime around or shortly after 6.00pm, Mr Malone performed a further rain on the ground model run (the “1 Jan 6.00pm ROG run”). It was similar to the model run conducted at 10.00am.[110] The spreadsheet is annotated with recorded gauge levels in Wivenhoe Dam until 9.00am on 2 January 2011. It also predicted further inflows after that time based on rain that had already fallen in the catchments above the dam. It predicted that after gate closure and even with releases through the regulator and assuming no further rain, Wivenhoe Dam would rise to EL 67.2m AHD on 6 January 2011 and still be just above FSL on 14 January 2011.

49 At 6.30pm, Mr Ayre replaced Mr Malone as the duty engineer. At 8.30pm, Mr Ayre issued a directive requiring gate closure of four increments between 10.00pm and 1.00am.[111]

50 By midnight the gate closings had reduced, or were at least predicted to reduce, the outflow to 394m^3/s, although the five bridges noted above were still inundated. At midnight, the level of Wivenhoe Dam was 67.15m AHD.[112]

51 Mr Malone’s “Observed Rainfall Analysis” report records catchment average rainfall in the 24 hours to 9.00am on Saturday 1 January 2011 of 4mm, 0mm and 1mm for Somerset, Upper Brisbane and Middle Brisbane respectively.[113] For the 24 hours to 9.00am on Sunday 2 January 2011 it records average rainfall of 15, 6 and 9mm for those catchments respectively.[114] Dr

[109] SEQ.001.018.4219.
[110] SDWD-2011010111800.xls; QLD.001.001.1955.
[111] SUN.002.001.6452.
[112] SDWD-2011010111800.xls; QLD.001.001.1955.
[113] SEQ.004.046.0230 at .0265.
[114] SEQ.004.046.0230 at .0266.

Christensen determined that there was 1mm of rain in the catchments above the dam on 1 January 2011.[115]

6.7: Sunday, 2 January 2011

52 The one-day PME forecast available to the flood engineers at 6.00pm on 1 January 2011 predicted 1mm to 5mm of rain in the dam catchments for the 24 hour period from 10.00pm on 1 January 2011 to 10.00pm on 2 January 2011[116]. The four-day PME forecast available to the flood engineers from midnight predicted 1mm to 10mm of rain in the catchment areas for the period of 10.00pm on 1 January 2010 to 10.00pm on 5 January 2011,[117] (although the State placed the area below the dam in the 1 to 5mm range).[118] The eight-day forecast issued at the same time predicted 15mm to 25mm of rain for the eight-day period to 10.00pm on 9 January 2011.[119]

53 Mr Ayre issued a further directive at 5.20am requiring the final open gate, Gate 3, to be lowered six increments to effect full closure between 6.00am and 9.00am.[120]

54 At 5.59am, Mr Ayre issued the morning situation report.[121] The light rain referred to in Mr Malone's report from the previous evening had continued. The report stated that there had been "light falls" of up to 30mm in the Somerset and North Pine catchments and that more light falls were forecast for the following week, with a "chance of storms on Wednesday and Thursday next week". Wivenhoe Dam was at EL 67.11m AHD and releasing around 350m^3/s. Somerset Dam was at EL 99.07m AHD and reported to be "rising slowly". Shut down procedures were said to be continuing. It was expected that the Wivenhoe gates would close at 9.00am.

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115 EXP.ROD.001.0583 at .0680.
116 SEQ.013.004.1226; AID.500.035.0001; AID.500.022.0001.
117 SEQ.013.004.1236; AID.500.035.0001; AID.500.022.0001.
118 AID.500.035.0001.
119 SEQ.013.004.1237; AID.500.035.0001; AID.500.022.0001.
120 SEQ.004.026.0144.
121 SEQ.001.018.4207.

55 Mr Ayre noted that Twin Bridges, Savages Crossing, Colleges Crossing and Burtons Bridge remained closed and would "remain so until late Sunday morning 2 January 2011". The road had resurfaced at Kholo Bridge but it remained closed due to surface damage sustained during flooding on 26 December 2010.[122] He reported that the "catchments remain wet and are likely to generate additional run off in the event of rain".

56 At 6.45am, Mr Ayre was replaced on duty by Mr Malone.[123] Mr Malone supervised the closure of the remaining gates at Wivenhoe Dam. In an email sent just before 9.00am, a dam operator recorded that all of the Wivenhoe Dam gates were closed with the storage level at EL 67.10m AHD.[124] Around that time, Mr Malone sent the dam operators an email noting that at the closure of the gates, the dam would still be above FSL. He advised that once the fish recovery operation was complete, releases through the hydro and a "fully open" regulator should continue amounting to a combined release of 4,200 ML/day or 49m^3/s.[125] His email contained the statement that "[a]t the closure of the last gate at 0900, Wivenhoe Dam will still be above FSL and will require small releases to continue". The plaintiff noted that this release rate was the rate that Mr Malone had modelled on 1 January 2011. It submitted that this is contemporaneous record that Mr Malone expected that Wivenhoe Dam would remain above FSL after the gates closed.[126] I agree. In fact, as Mr Malone conceded,[127] having regard to the rain that had fallen in the Somerset Dam catchment and even assuming no further rain, the time it would take to drain down to FSL would take even longer than was modelled.

57 At 9.27am, Mr Malone issued an updated situation report which repeated the forecast and statement about catchment conditions in the earlier report.[128] He noted that, at 7.30am that morning, Somerset Dam was at EL 99.10m AHD and rising slowly, and that, at 9.00am, Wivenhoe Dam was at 67.10m AHD

[122] Ayre 1, LAY.SUN.001.0001_OBJ at [1964].
[123] SEQ.004.026.0009.
[124] QLD.001.001.1993.
[125] SEQ.001.020.3648; LAY.SEQ.007.0001 at .0136, [493] (Malone).
[126] Plaintiff subs at [1027] to [1028].
[127] T 5114.12.
[128] SEQ.001.018.4199.

with gates fully closed, and that "fish recovery" operations had commenced. The email stated that once fish recovery was completed "a regulator will be fully opened to manage continued low inflows to the dam." Mr Malone noted that this was the final situation report for the event and that "routine monitoring will resume with Terry Malone". Mr Malone demobilised the FOC at 10.00am.[129]

58 The QPF issued at 10.00am on 2 January 2011 for the 24 hour period to 9.00am on 3 January 2011, forecast "less than 5-10mm" in the Wivenhoe and Somerset Dam catchments.[130] The QPF issued at 4.00pm for the 24-hour period to 3.00pm on 3 January 2011 forecast 5mm to 10mm rain in the dam catchments.[131]

59 The 2010 FER noted that there was no significant rainfall in the 24 hours to 9.00am on 3 January 2011. Mr Malone's "Observed Rainfall Analysis" report records catchment averages of 0mm, 1mm and 0mm for the 24 hours to 9.00am on Monday, 3 January 2011 for the Somerset, Upper Brisbane and Middle Brisbane catchments respectively.[132] Dr Christensen determined that 3mm of rain had fallen above the catchments on 2 January 2011,[133] presumably on the basis of the rain that fell before 9.00am.

60 Midnight on 2 January 2011 (ie, 24:00 on 1 January 2011) represents the relevant point of departure between the plaintiff's case and the flood engineers' operation of the dams. Five of Dr Christensen's simulations commence at midnight on 2 January 2011.[134] Dr Christensen concluded that flood operations should not have ended on 2 January 2011 but instead should have continued from the Late December Flood Event given that Wivenhoe Dam was still above FSL at that time and, absent releases, the combination of remaining inflows from rain on the ground and rain from eight-day forecasts,

[129] T 4718.15.
[130] SEQ.001.019.6808.
[131] SEQ.001.019.6811.
[132] SEQ.004.046.0230 at .0267.
[133] EXP.ROD.001.0583 at .0680.
[134] Simulations A, B, C, D and I.

as well as base flow, would keep the dam well above FSL.[135] Nevertheless, given the weather outlook, Dr Christensen agreed that the flood operations should have been conducted on the basis that they would end shortly.[136] His simulated flood operations on 2 January 2011 in Simulation A involved more aggressive releases than the flood engineers. His releases were undertaken with the objective of allowing all of the downstream bridges to open earlier and the reduction of storage levels below FSL to allow for their refill from projected inflows as well as baseflow.

61 Throughout 2 January 2011, the rate of inflows exceeded what was predicted by the model run done at 6.00pm on 1 January 2011. At midnight, Wivenhoe Dam was at EL 67.14m AHD[137] and the rate of inflows was 83m^3/s, with 50m^3/s being discharged through the regulator.[138] Somerset Dam was at EL 99.11m AHD with 34m^3/s being discharged through the cone valve.

62 The Plaintiff submitted that the failure of Mr Malone to continue flood operations on 2 January 2011 and, in particular, the failure to continue to drain down Wivenhoe Dam to the point that it was no longer expected to exceed FSL was a breach of his duty of care.[139] I address those contentions in Chapter 12[140]. At this point, I will address two related matters, namely, who assumed responsibility for ending flood operations and whether that was consistent with the Manual.

Ending Flood Operations

63 In relation to the first issue, Seqwater noted that Mr Malone did not issue the directive to effect the last gate closure on 2 January 2011 as that had been given by Mr Ayre at 5.20am that morning.[141] It contended that Mr Malone's actions "conformed to the general strategy that had been set by Mr Ayre prior

[135] February 2015 Report, EXP.ROD.001.0016 at [777], [782] and [787].
[136] Reply Report, EXP.ROD.015.0005 at .0053.1; Response Report, EXP.ROD.015.0261 at .0286.
[137] SUN.002.002.3607.
[138] Simulation Analysis, EXP.ROD.015.0461 at .0466.
[139] Plaintiff subs at [1037].
[140] Section 12.5
[141] Seqwater subs at [1094].

to the shift beginning"[142] and it should be found that "Mr Malone's operation of Wivenhoe Dam during this shift was in accordance with the general strategy set by the SFOE" (ie, Mr Ayre) pursuant to clauses 2.3 and 2.4 of the Manual.[143] This strategy was said to have been articulated in Mr Ayre's situation report issued at 6.00am on 30 December 2010.[144] SunWater noted that Mr Malone referred to the gate closing in his situation report issued at 6.00pm on 31 December 2010 and modelled the effect of the gate closures on that day.[145] The submissions of the respective parties on the delineation of authority between the SFOE and DFOE are set out in section 3.3.12 of Chapter 3.

64 In his first affidavit, Mr Malone stated that he "had directed the final gate closure, had considered forecast rainfall and demobilised the FOC".[146] In his fifth affidavit, he said that the decision to close the gates to end flood operations was made by the duty engineer at around 9.00pm on 31 December 2010, ie, Mr Ruffini.[147] As noted, a gate operations directive issued by Mr Ruffini at around 8.30pm that evening required gate closures to commence from 9.00pm.[148] Mr Malone was cross-examined about this as follows:[149]

> "Q. Can I ask you to have a look at your fifth affidavit, if you have that; that's the most recent one. You will see that in 91(a), you say that the decision to close the Wivenhoe gates was made by the duty engineer at 2100 on 31 December 2010?
> A. That's correct.
> Q. Isn't it the case that it was made before that, after your discussion with Mr Drury?
> A. *That was the plan*, but the actual decision to close the gates was made by the duty engineer at the time." (emphasis added)

65 The reference to the "plan" in this passage is to the exchange between Mr Malone and Mr Drury noted above (at [40]) concerning the fact of, and the

142 Id.
143 Seqwater subs at [1095].
144 Ibid at [1090] to [1091].
145 SunWater subs at [1841] to [1842].
146 LAY.SEQ.007.0001 at [501].
147 LAY.SEQ.016.0001 at [91(a)].
148 SEQ.004.026.0138.
149 T 4717.11.

timing of, the closure of the Wivenhoe Dam gates. Otherwise, two matters should be noted. First, at no point in his evidence did Mr Malone nominate Mr Ayre as having given some general direction or the like to the effect that gate closure and the end of flood operations would start on 31 December 2010 and cease on 2 January 2011. Second, although Seqwater sought to identify the specification of the general strategy by Mr Ayre as the situation report on the morning of 30 December 2010, the first discussion of gate closing was in Mr Malone's own situation report issued on 28 December 2010.

66 Neither the documentary nor the oral evidence supports any suggestion that Mr Ayre expressly or implicitly made some determination of "overall strategy" or "general strategy" that resulted in the last of the gate closures and demobilisation of the FOC on 2 January 2011. Instead, the documentary material suggests that there was a general consensus amongst the three flood engineers to orientate towards that outcome. In Mr Malone's case he made, and participated in the making of, a number of decisions that led to that, including agreeing with Mr Drury as to the timing of the closures and issuing gate directives on the evening of 1 January 2011. Irrespective of the involvement of others in the ending of flood operations, from 6.00am on 2 January 2011, Mr Malone was vested with responsibility to "follow [the] Manual in managing Flood Events" and authorised to "[p]rovide instructions to site staff to make releases of water from the Dams during Flood Events … in accordance with the Manual" (section 2.4). He was not limited from doing so by the specification of any "general strategy" or "overall strategy" issued by the SFOE, Mr Ayre.

67 Like Mr Malone, Mr Ayre joined in the consensus to end flood operations and took active steps during the evening of 1 January 2011 and the morning of 2 January 2011 to effect that. By the operation of clause 2.2 of the Manual, Mr Ayre was designated to be in charge of flood operations at all times during a flood event and that included the capacity to take action to have the flood operations engineer rostered on duty comply with the Manual. It follows that,

at the very least, Mr Ayre "permitted" Mr Malone to end flood operations on 2 January 2011.[150]

Compliance with the Manual

68 The precise allegations of breach are addressed in Chapter 12. At this point it suffices to state that, consistent with an interpretation of the Manual that I have already accepted,[151] the plaintiff contended that it was contrary to the Manual to declare an end to the flood event while the dam was above FSL and it was expected to be so for a considerable period.[152] It submitted that the planned releases through the regulator would not have been sufficient to evacuate the water retained above FSL.[153]

69 As noted, Mr Malone was the DFOE when the gates at Wivenhoe Dam closed at around 9.00am on 2 January 2011 and the FOC was demobilised at 10.00am.[154] Mr Malone did not specifically address the circumstances in which a flood event ended in his affidavits but did discuss the drain down requirements in section 8.5 of the Manual.[155] He noted that if further rain occurred during the draindown sequence then he "could move back into a W Strategy or accommodate the additional runoff by keeping gates open a little longer".[156] He stated that it was difficult to time gate closing sequences so that final gate closure occurred when the dam was at FSL as the "Duty Engineer was required to make a decision as to when the final gate would be closed approximately 36 hours in advance of this actually occurring".[157] He asserted that if a "dam was slightly above FSL at the time of gate closure, operational releases through the regulators at Somerset Dam and/or the

[150] Plaintiff subs at [1468].
[151] Chapter 3 at [142].
[152] Plaintiff subs at [1027]; 5ASOC at [207].
[153] Plaintiff subs at [1028].
[154] T 4718.15.
[155] LAY.SEQ.007.0001 at .0080 to .0081, [255] to [261].
[156] Ibid at [256].
[157] Ibid at [258].

hydro and regulator at Wivenhoe Dam would continue but this activity was not conducted under the auspices of the Manual".[158]

70 In his first affidavit, Mr Malone stated that as at 2 January 2011 he did not consider the flood event was continuing and that "[o]perational releases [had] recommenced using the hydro and regulators". He accepted that both dams were above FSL but asserted that the "potential for [that] to exacerbate flooding was negligible".[159] He said that his intention was to return Wivenhoe Dam to FSL via "operational releases".[160] He stated that if "flood releases" had continued (presumably through the Wivenhoe Dam gates) then "they would have reached FSL in a very short time" and that the rain forecasts available on the morning of 2 January 2011 "suggested that there would be practically no rain for three days".[161]

71 As noted, Mr Malone arranged the timing of the gate closure with Mr Drury so as to allow fish recovery operations during the morning of 2 January 2011. He said that there was uncertainty as to whether a gate closing process that was designed to end on the morning of 2 January 2011 would end at FSL. In cross-examination, Mr Malone conceded that the "closing of the [Wivenhoe] gates after the late December event [was] ... not strictly in accordance with the [M]anual" but considered it "something that was sensible to do".[162] He accepted that there three options available to him were: firstly, declare the flood event over and declare a new flood event as clause 2.1 of the Manual was engaged; second, continue the existing flood event; or thirdly, end the flood event.[163] He said the first option was not reasonable.[164] He justified not continuing flood operations because of the cost and inconvenience of maintaining the FOC open including staffing costs and inconvenience to

[158] Ibid at [259].
[159] LAY.SEQ.007.0001 at [501].
[160] Ibid at [493].
[161] Ibid at [504(b)].
[162] T 4938.32 (Malone).
[163] T 5115.33.
[164] T 5115.29.

staff.[165] He also referred to "unnecessarily taking out bridges" if gate releases had continued.[166]

72 In his third affidavit, Mr Malone modelled an alternative operation that involved delaying the gate "closing sequence" until 5.00pm on 2 January 2011 with all gates closed by midnight on 3 January 2011.[167] By that time, he estimated Somerset Dam would have been slightly above FSL and Wivenhoe Dam slightly below FSL.[168] He stated that, with "operational releases implemented" at that time, Wivenhoe Dam would not be expected to reach "gate trigger level for the next few days" although it would still be above FSL.[169] He described how inconvenient this approach would be because gate closure at midnight would not enable "fish recovery" to be undertaken during morning daylight hours. It is not entirely clear what sequence was modelled but it appears to have been the maintenance of around nine increments and releases of approximately 443m^3/s which were the gate settings at 11.00pm on 1 January 2011.[170] Two matters should be noted about this analysis. First, other than it being less likely that volunteer labour was available on Monday, 3 January than Sunday 2 January 2011, there is no reason why it could not be adjusted to allow fish recovery on the morning of 3 January 2011 if considered appropriate. Second, it still reduces Wivenhoe Dam to a level where the expectation is that it will rise above FSL very shortly.

73 I have addressed the proper construction of the Manual in relation to gate closure and the end of a flood event in Chapter 3.[171] As stated, it is unreasonable to construe the Manual as permitting the conclusion of a flood event while either dam remains above FSL, although it is possible to close gates with the dam at or above FSL and make releases through the regulator.[172] However, taking the latter course could only be justified if there

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165 T 4937.2 to T 4938.32.
166 T 5116.23.
167 EXP.SEQ.013.0001 at [131(d)].
168 Ibid at [1323].
169 Id.
170 QLD.001.001.1955.
171 Chapter 3; section 3.3.3.
172 Chapter 3 at [142] to [143].

was a reasonable expectation of draining down to FSL within a relatively short period especially as at midnight on 2 January 2011 the peak of the flood event was already more than five and a half days previous; ie, 4.00pm on 27 December 2010.[173]

74 Mr Malone stated that, as at 2 January 2011, it was his expectation that Wivenhoe Dam would drain down to FSL.[174] This expectation had no reasonable basis. The modelling that Mr Malone undertook on 1 January 2011 did not suggest that releases from the regulator would evacuate the water above FSL within a remotely reasonable period. Further, Mr Ayre's situation report for the morning of 2 January 2011 advised that there had been "light falls of up to 30mm" of rain that had fallen in the Somerset Dam catchment overnight (and a "chance of storms on Wednesday and Thursday next week"). Mr Malone agreed that "it was apparent to him" that as a result of that rain, the drain down process would take longer than what he had modelled at 6.00pm on 1 January 2011.[175] Seqwater responded to this by pointing to Mr Malone's own observed rainfall analysis which showed that 15mm of rain had fallen in the Somerset Dam catchment and 6mm of rain had fallen in the Wivenhoe Dam catchments to 9.00am on 2 January 2011[176] and the uncertainty in the modelling process including its scale factors.[177] Neither matter undermines Mr Malone's concession. The amount of rain that in fact fell was significant enough given the saturated state of the catchments. Mr Malone did not raise concerns over the modelling process when made his concession. Otherwise, Mr Malone's modelling only addressed rain on the ground. Given the climatic conditions, it was unreasonable to consider that the evacuation of water above FSL could be adequately addressed by releases from the regulator.

[173] ROD.650.003.6506 at 6606.
[174] T 5108.47.
[175] T 5114.16.
[176] Seqwater subs at [1220(b)]; SEQ.004.046.0230.
[177] Seqwater subs at [1220(c)].

75 It follows from the discussion in Chapter 3[178], that ceasing gate operations and ending flood operations prematurely on the basis of concern about cost and inconvenience is not justified by the Manual. Ultimately, it would be a matter for Seqwater as to what staff would need to be allocated to the FOC and at the dams if a flood event was still ongoing. The maintenance of the flood event means that the trigger of EL 67.25m AHD is not required before gate releases can continue. The concerns about keeping downstream bridges closed by continuing gate releases do not add much. Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge were all closed on 1 January 2011 and remained closed at the time gate operations ceased (see [55]). Absent further rain, higher releases for a shorter period would have allowed all the bridges to be open earlier.

76 Mr Ayre justified the decision to end gate operations by reference to the fourth dot point in section 8.5 of the Manual which relaxes the requirement to evacuate stored flood waters within seven days of the peak "to obtain positive environmental outcomes" provided there is "a favourable weather outlook".[179] Mr Ayre stated:[180]

> "Well, I think we complied with the manual requirements in the closure sequences. We had a good environmental outcome because we were able to undertake the Seqwater fish recovery policy on a weekend, which meant that volunteers were available to rescue the rare and threatened species, such as lung fish. We were, as I said, below gate trigger level; the outlook was favourable in terms of no real rain forecast until the chance of storms on Wednesday and Thursday. We had achieved the seven-day draindown for the Boxing Day event. I believe it was appropriate that the flood response team stood down, grabbed what relief they could until such time as they had to come back."

77 Three matters should be noted about this. First, the fourth dot point in section 8.5 does not relate to ending a flood event. Instead, it allows for the closure of gates above FSL even though stored flood water had not yet been evacuated. In that event the flood event continues.

[178] Chapter 3 at [145].
[179] T 7857.5; see Chapter 3 at [68] to [69]
[180] T 7862.12.

78 Second, as I have explained, the draindown from the Late December Flood Event had not been achieved as at midnight on 2 January 2011 and was not going to be achieved by releases from the regulator given Mr Malone's modelling and the further rain that had fallen to 9.00am on 2 January 2011.

79 Third, contrary to Mr Ayre's evidence, there was not a "favourable weather outlook" as at 2 January 2011 that was sufficient enough to justify attempting to return to FSL using the regulator. The eight-day PME was predicting 15 to 25mm of rain, his situation report had referred to "a chance of storms" on 5 and 6 January 2011, and the seasonal conditions bolstered by the experience in December 2010 pointed to the likelihood of further storms.

80 SunWater's submissions contended, inter alia, that there is no basis for assuming that forecast rainfall is relevant to a decision to end a flood event.[181] I have already rejected that contention in Chapter 3[182]. In any event and on any view, forecasts are clearly relevant to a decision to declare a flood event and, if a flood event was ended on 2 January 2011, it had to be immediately declared again. Also, to the extent that Mr Ayre sought to justify closure of the gates above FSL by reference to environmental concerns, that required a "favourable weather outlook" and hence a consideration of forecasts.

81 Accordingly I am satisfied that a proper application of the Manual required a continuation of the flood event on 2 January 2011. Whether gate operations had to continue is addressed in subsequent Chapters.

6.8: Monday, 3 January 2011

82 The PMEs that were made available to the flood engineers at 6.00pm and midnight on 2 January 2011 predicted very significant rain in the catchments from 5 January 2011 onwards. The one-day PME made available at 6.00pm the previous night predicted 0mm to 5mm in the 24-hour period to 10.00pm on

[181] SunWater subs at [1871(b)].
[182] Chapter 3 at [140].

3 January 2011.[183] The four-day PME forecast made available at midnight relating to the period 10.00pm on 2 January 2011 to 10.00pm on 6 January 2011, predicted 50mm to 100mm of rain for above the dam[184] (and 25 to 100mm for below the dam, according to the State).[185] The third defendant's expert meteorologist, Mr Giles, broke down the daily forecasts within the PME so that they only predicted 4mm of rain across 3, 4 and 5 January 2011 but 62mm of rain on 6 January 2011.[186] The eight-day PME for the period 10.00pm on 2 January 2011 to 10.00pm on 10 January 2011 fell within the 75mm to 150mm band according to the plaintiff[187] and within the 50mm to 150mm band(s) for above the dam according to the State (and 25 to 150mm for below the dam).[188]

83 The morning QPF was issued at 11.36am and predicted 5mm to 10mm of rain in the catchments in the 24-hour period to 9.00am on 4 January 2011.[189] By the afternoon, that forecast had doubled. The 4.00pm QPF predicted 10mm to 20mm of rain in the catchments in the 24-hour period to 3.00pm on 4 January 2011.[190]

84 The weather was volatile. A severe thunderstorm warning for South East Queensland with predictions of flash flooding for the Lockyer Valley was issued by the BoM at 12.13pm[191] with another at 1.33pm[192] before they were cancelled at 2.06pm.[193] They were reissued again from around 4.00pm in the afternoon[194] and then later cancelled at 6.29pm.[195]

[183] SEQ.013.004.1239; AID.500.022.0001; AID.500.035.0001.
[184] AID.500.022.0001; AID.500.035.0001.
[185] SEQ.013.004.1249; AID.500.035.0001.
[186] EXP.QLD.001.1359 at .1370.
[187] AID.500.022.0001.
[188] AID.500.035.0001.
[189] SEQ.001.019.6814.
[190] SEQ.001.019.6831.
[191] QLD.002.002.1992; SUN.002.001.2126.
[192] QLD.002.002.1983; SUN.002.004.0960.
[193] QLD.002.002.1980; SUN.002.004.0959.
[194] QLD.002.002.1972.
[195] QLD.002.002.1961.

85 Just before 8.00am, an email was circulated advising that Wivenhoe Dam was at EL 67.15m AHD,[196] which was above the height predicted by the RTFM runs undertaken by Mr Malone on 1 January 2011. Another email sent a few minutes later recorded the height of Somerset Dam at EL 99.20m AHD.[197] At 8.28am, Mr Malone received an email from Mr Drury querying the level of Somerset Dam and inquiring whether further releases should be made above the 34m^3/s being released from the cone valve. At 12.27pm, Mr Malone responded that the releases should remain at their current level because it "[l]ooks like we'll be doing it [ie, flood operations] all again Thursday so we can open more earlier then".[198] Mr Malone agreed that his response concerning resuming flood operations was based on the rainfall forecasts.[199]

86 Mr Malone stated that he continued to monitor the dams remotely throughout 3 January to 5 January 2011.[200] Mr Ayre stated that he also monitored the dams from his home during this period.[201]

87 Releases of 50m^3/s from the regulator at Wivenhoe Dam and of 34m^3/s from the cone valve at Somerset Dam continued throughout the day. It seems likely that during the course of 3 January 2011, all of the remaining downstream bridges were reopened, although Kholo Bridge was still closed to traffic because of surface damage.[202]

88 Mr Malone's "Observed Rainfall Analysis" report records catchment averages of 10mm, 4mm and 2mm for the 24 hours to 9.00am on Tuesday 4 January 2011 for the Somerset, Upper Brisbane and Middle Brisbane catchments

[196] QLD.001.001.2004.
[197] QLD.001.001.2005.
[198] SEQ.016.019.4108.
[199] T 5117.7.
[200] T 4723.40 to T 4724.7.
[201] Ayre 1, LAY.SUN.001.0001_OBJ, [1732].
[202] T.7704.31.

respectively.[203] Dr Christensen determined that there was no rain in the catchments above the dam on 3 January 2011.[204]

89 By midnight on 4 January 2011 (ie, 0:00), Wivenhoe Dam was at EL 67.17 AHD and Somerset Dam was at EL 99.23m AHD.[205] The rate of inflow to Wivenhoe Dam was 76m^3/s.[206]

90 By contrast, in some of Dr Christensen's simulations that commenced on 2 January 2011, the revision to the PME forecasts caused him to continue releases at around the same rate as the previous day; not for the purpose of ending flood operations quickly but instead to evacuate rain from the dams below FSL in advance of the forecast rain falling and flowing into the dams. In Simulation A, by midnight on 4 January 2011 (ie, 0:00) Wivenhoe Dam was at EL 65.77m AHD and Somerset Dam at EL 97.91m AHD. The maximum release rate during the course of 3 January 2011 in Simulation A was 1430m^3/s. The outflows in Simulation A would have closed all downstream bridges other than Fernvale and Mt Crosby Weir.[207]

91 The Plaintiff submitted that, in circumstances where Mr Malone was aware that both dams were above FSL, both he and Mr Ayre were obliged to continue a flood event (and gate releases) or otherwise declare a new flood event.[208] I address that below.

6.9: Tuesday, 4 January 2011

92 The one-day PMEs made available to the flood engineers at 6.00pm on 3 January 2011 continued to predict significant rain in the catchments from 5 January 2011 onwards. The plaintiff contended that the one-day PME showed forecast rain for the 24-hour period to 10.00pm on 4 January 2011 in

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[203] SEQ.004.046.0230 at .0268.
[204] EXP.ROD.001.0583 at .0680.
[205] SUN.002.002.3607.
[206] MSC.010.146.0001.
[207] Simulation Analysis, EXP.ROD.015.0461 at .0466 to .0467.
[208] Plaintiff subs [1041] to [1053].

the 5mm to 15mm range,[209] whereas the State contended it showed no rain.[210] With the four-day PME that was available from midnight on 4 January 2011, the plaintiff contended that it forecast 50mm to 100mm of rain in the period from 10.00pm on 3 January 2011 to 10.00pm on 7 January 2011[211] whereas the State contended it forecast rain in the 50mm to 150mm band.[212] With the eight-day PME available from midnight on 4 January 2011, for the period from 10.00pm on 3 January 2011 to 10.00pm on 11 January 2011, the plaintiff contended that it predicted between 75mm and 150mm of rain[213] whereas the State contended that it predicted between 50mm and 150mm of rain.[214]

93 The morning QPF was issued at 11.30am on 4 January 2011 and predicted 10mm to 20mm of rain in the catchments in the 24-hour period to 9.00am on 5 January 2011.[215] The 4.00pm QPF predicted 5mm to 15mm of rain in the catchments in the 24-hour period to 3.00pm on 5 January 2011.[216]

94 Just before 7.00am, the recorded storage level of Wivenhoe Dam was EL 67.19m AHD.[217] Mr Ayre agreed that this showed the dam was continuing to rise.[218]

95 Just before midday on 4 January 2011, Mr Ayre emailed Mr Malone querying whether, "in light of the forecast for Wednesday [5 January 2011] to Friday [7 January 2011]", he had given consideration to increasing releases from Wivenhoe Dam as it "may help prevent a full mobilisation".[219] He also stated

[209] AID.500.022.0001.
[210] AID.500.035.0001.
[211] AID.500.022.0001; SEQ.013.004.1262.
[212] AID.500.035.0001.
[213] AID.500.022.0001.
[214] AID.500.035.0001; SEQ.013.004.1263.
[215] SEQ.001.019.6842.
[216] SEQ.001.019.6859.
[217] QLD.001.001.2009.
[218] T 7865.25 - .29 (Ayre).
[219] SUN.001.006.1384.

that this would need to be "clear[ed] with Peter Allen" which appears to be a reference to seeking approval for a departure from the Manual.[220]

96 In cross-examination, Mr Ayre explained that clearance from Mr Allen was required because these releases would be contrary to the Manual as they were being made below the trigger level of EL 67.25m AHD.[221] He accepted that he was proposing to make a release based on forecast rainfall to increase storage in the dams, although he added that it would merely be accelerating the drain down to FSL.[222] Mr Ayre accepted that, if the Late December Flood Event had not been declared over on 2 January 2011, and drain down continued, then neither the releases nor Mr Allen's permission would have been required.[223]

97 Mr Malone responded to Mr Ayre's email shortly afterwards and copied his response to Messrs Tibaldi and Ruffini. He stated that:

> "We have discuss[ed] the possibility. However given the likelihood of heavy rain on Thursday and Friday and subsequent inflows to North Pine. Somerset and Wivenhoe, it is likely that we will have to open gates anyway. So we've decided to leave it until then".[224]

The Plaintiff submitted that it should be inferred from the reference to "we" that Mr Malone was referring to Messrs Tibaldi and Ruffini. Mr Malone said he was "not sure" who the "we" was referring to but accepted that it was possibly Mr Ruffini and Mr Tibaldi.[225] However, this was not taken up with Mr Tibaldi in cross-examination. In the absence of that, I am not prepared to infer that he spoke to Mr Malone prior to the email being sent.

98 In his first affidavit, Mr Malone set out a daily breakdown of the PMEs which he said were available "on the morning of Tuesday 4 January 2011" being 0 to 5mm for Tuesday, 1 to 15mm for Wednesday, 25 to 100mm for Thursday and

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[220] T 4722.37 to T 4723.4 (Malone).
[221] T 7866.21.
[222] T 7866.6 - .18.
[223] T 7866.26.
[224] SUN.006.001.3943.
[225] T 5121.12 and .15; see also T 4723.15.

1 to 25mm for Friday.[226] He referred to the eight-day PME as suggesting rainfall "to be only up to 200mm".[227] Although not clear, this appears to be a reference to the 1200UTC PMEs available from 6.00am that morning.[228] Mr Malone suggested that the daily PME figures meant that "the expectation was that it was not going to be essential to open gates until Thursday 6 January but even then the run-off from the forecast rain was well within the available capacity of the dams".[229]

99 Mr Malone's assessment of Wivenhoe Dam's capacity to absorb runoff rain is addressed below. At this point it suffices to state that, on any view of the objective evidence (and Mr Malone's affidavit), the trigger for declaring a flood event in section 2.2 of the Manual had been engaged by this point. Similar to the position on 3 January 2011, the Plaintiff submitted that Mr Malone was obliged to declare a flood event and Mr Ayre was obliged to cause Mr Malone to do so.[230] I address that contention below.

100 In any event, a flood event was not declared and both Mr Ayre and Mr Malone continued the monitor the dams.[231] Releases of $50m^3/s$ from the regulator at Wivenhoe Dam and $34m^3/s$ from the cone valve at Somerset Dam continued throughout 4 January 2011. By midnight on 5 January 2011 (ie, 0:00), Wivenhoe Dam was at EL 67.21m AHD[232] and Somerset Dam was at EL 99.29m AHD.[233] The rate of inflow to Wivenhoe Dam was around $75m^3/s$.[234]

101 By contrast, in Dr Christensen's Simulation A, Wivenhoe Dam releases of around $1400m^3/s$ continued throughout 4 January 2011, that being sufficient

[226] LAY.SEQ.007.0001 at [528].
[227] Id.
[228] See EXP.SEQ.014.0219 at .0327.
[229] LAY.SEQ.007.0001 at [528].
[230] Plaintiff subs [1069] to [1070].
[231] T 7867.9 (Ayre); Malone 1, LAY.SEQ.007.0001_OBJ at [528].
[232] SUN.002.002.3607.
[233] Id.
[234] MSC.010.146.0001.

to inundate all downstream bridges other than Fernvale and Mt Crosby Weir.[235]

102 Mr Malone's "Observed Rainfall Analysis" report records catchment averages of 0mm for the 24 hours to 9.00am on Wednesday, 5 January 2011 for each and all of the Somerset, Upper Brisbane and Middle Brisbane catchments.[236] Dr Christensen determined a figure of 2mm of rain in the catchments above the dam on 4 January 2011[237] (which was similar to the January FER weighted catchment average).[238]

6.10: Wednesday, 5 January 2011

103 The one-day PMEs made available to the flood engineers at 6.00pm on 4 January 2011 continued to predict significant rain in volumes similar to those published 24 hours earlier. For the period from 10.00pm on 4 January 2011 to 10.00pm on 5 January 2011, the PME predicted 5mm to 15mm of rain.[239] The plaintiff contended that the four-day PME available from midnight placed the catchments above the dam in the 75mm to 150mm range for the period from 10.00pm on 4 January 2011 to 10.00pm on 8 January 2011.[240] The State contended that it predicted 25mm to 100mm of rain above the dam and 50mm to 100mm below the dam.[241] The plaintiff contended that the eight-day PME predicted between 100mm and 150mm of rain for the 8-day period from 10.00pm on 4 January 2011 to 10.00pm on 12 January 2011,[242] whereas the State contended that it was in the 50mm to 150mm range.[243]

104 At 6.30am on 5 January 2011, the recorded level of Wivenhoe Dam was 67.23m AHD and at 7.00am Somerset Dam was at EL 99.28m AHD.[244] The morning QPF was circulated shortly after 10.00am and predicted a forecast

[235] Simulation Analysis, EXP.ROD.015.0461 at .0467.
[236] SEQ.004.046.0230 at .0269.
[237] EXP.ROD.001.0583 at .0680.
[238] SUN.016.001.0280 at .0683.
[239] AID.500.035.0001; AID.500.022.0001.
[240] SEQ.013.004.1275; AID.500.022.0001.
[241] SEQ.013.004.1275; AID.500.035.0001.
[242] AID.500.022.0001.
[243] SEQ.013.004.1276; AID.500.035.0001.
[244] QLD.001.001.2023; QLD.001.001.2022; SEQ.001.019.2770; SEQ.001.019.4445.

catchment average rainfall for the 24 hours to 9.00am on 6 January 2011 of 20mm to 30mm.[245] This figure increased in the afternoon QPF, issued around 4.00pm, which forecasted 30mm to 50mm of rain across the catchments in the 24 hour period to 3.00pm on 6 January 2011.[246] Both QPFs were emailed to Mr Ruffini.[247]

105 At around 6.00am, the 1200UTC PMEs became available.[248] They were predicting more rain than the PMEs just noted above. According to the plaintiff, the four-day PME predicted 50 to 150mm of rain and the eight-day PME predicted 150mm to 300mm.[249] Professor Manton's assessment was that the 8-day PME predicted 187.9mm of rain above the dam.[250]

106 In his first affidavit, Mr Malone set out a daily breakdown of the 1200UTC PMEs as follows:[251]

Day and Date	Forecast
For the rest of Wednesday, 5 January	5 to 25 mm
Thursday, 6 January	50 to 150 mm
Friday, 7 January	25 to 100 mm
Saturday, 8 January	5 mm
Sunday, 9 January	25 to 50 mm
8-Day total to 12 January	Up to 300 mm

Table 6-3: Mr Malone's breakdown of 5 January 2011 1200 UTC PME forecasts

107 Mr Malone said that these figures were estimates that he made shortly prior to swearing his affidavit but his "practice" was to look at the "daily [PME]

245 SEQ.001.019.6861.
246 SEQ.001.018.7970.
247 QLD.001.001.2033; QLD.001.001.2035.
248 4-day UTC – SEQ.013.005.0453; 8-day UTC – SEQ.013.005.0454.
249 Plaintiff subs at [1073]; SEQ.013.005.0453; SEQ.013.005.0454.
250 AID.500.026.0001; EXP.SEQ.004.0131 at .0180 (Figure 27).
251 Malone 1, LAY.SEQ.007.0001_OBJ, [532].

images".[252] In his first affidavit, Mr Malone set out various calculations of the amount of rainfall run-off necessary to fill Wivenhoe Dam. His evidence on that topic is addressed below.

108 Just prior to 11.00am, the BoM issued a severe weather warning for a number of areas to the east of the Wivenhoe catchments with the trough "expected to intensify as it move[d] slowly east over the next 24 hours".[253] Another severe weather warning was issued for those areas at 11.30pm on 5 January 2011.[254] At 4.22pm that afternoon, the BoM issued a severe weather warning for South East Queensland, warning of damaging winds, flash flooding and large hailstones for parts of Brisbane, the Lockyer Valley, Moreton Bay and Somerset Council areas. At 4.20pm, the BoM also stated that severe thunderstorms were detected on the weather radar near Esk and northern Lake Wivenhoe.[255]

109 At around 11.15am, Mr Malone emailed the other flood engineers and Seqwater personnel stating that the "rainfall forecast for the next few days indicates there will be some significant totals during" 5, 6 and 7 January 2011, "with totals up to 100 to 200mm possible". He stated that it was "likely" that the FOC and the dam would be mobilised on the next day and that flood operations would be ongoing over the weekend of 8 and 9 January 2011.[256]

110 At 1.26pm, a Seqwater engineering officer, Graham Keegan, emailed Mid-Brisbane River Irrigators and other local residents warning of the possibility of rainfall of "100 to 200mm" during the "next few days". He stated that "[a]s the catchments are still wet (low expected initial losses) it is likely that we will be releasing floodwaters in the near future if BoM's forecasts are accurate".[257]

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[252] T 5123.10.
[253] SEQ.001.018.8642.
[254] QLD.002.002.1938.
[255] SEQ.001.018.8639.
[256] QLD.001.001.2034.
[257] SEQ.016.007.5035.

This assessment of the state of the catchments is consistent with the contents of the situation report issued the following day.[258]

111 Just after 2.04pm, a Seqwater ranger forwarded Mr Malone's email to other Seqwater staff and observed "I think it will be really on this time – 8 day rainfall forecast is in fact 300 – 400mm!!".[259] This was most likely a reference to the 1200UTC forecasts (see [106]). The plaintiff contended that emails such as these demonstrate that the amount of rain that actually fell was both "foreseeable and foreseen".[260]

112 Just after 8.00pm, Mr Malone sent an email to the other flood engineers and Mr Drury updated them on the amount of rainfall in the catchments.[261] He advised them that parts of Somerset catchment had received up to 45mm of rain but "[n]othing much in the top end" and that Somerset Dam "may get to 99.5 with further overnight rain". He also said that Wivenhoe Dam had received "between 20 and 40mm in several areas" and that it was likely that there would be "good runoff" during the following two days such that the dam may rise to EL 67.8m AHD with "no gate openings". He said that he would monitor the rainfall overnight and attend the FOC the following morning.[262] In his first affidavit, Mr Ayre says he telephoned Mr Malone after receiving this email. He said that Mr Malone advised him that he would "monitor the situation overnight and mobilise the FOC on Thursday morning if necessary".[263]

113 Mr Malone's "Observed Rainfall Analysis" report records catchment averages of 19, 29 and 17mm for the 24 hours to 9.00am on Thursday 6 January 2011 for the Somerset, Upper Brisbane and Middle Brisbane catchments

[258] QLD.001.001.2256; cf SunWater subs at [1924].
[259] SEQ.016.007.5397.
[260] Plaintiff subs at [1083].
[261] SEQ.016.015.3519.
[262] SEQ.016.015.3519.
[263] LAY.SUN.001.0001, [1770].

respectively.[264] Dr Christensen determined actual rainfall on 5 January 2011 upstream of Wivenhoe Dam as 26mm.[265]

114 Releases of 50m^3/s from the regulator at Wivenhoe Dam and of 34m^3/s from the cone valve at Somerset Dam continued throughout most of 5 January 2011. By midnight on 6 January 2011 (ie, 0:00), Wivenhoe Dam was at EL 67.29m AHD and Somerset Dam was at EL 99.37m AHD.[266] Until 8.00am, the rate of inflows to Wivenhoe Dam was around 75m^3/s. For the rest of the day the rate was around 100m^3/s.[267] At midnight on 5 January 2011, the rate of inflows into Somerset Dam was around 49m^3/s.[268]

115 By contrast, in Dr Christensen's Simulation A, Wivenhoe Dam releases of around 1100m^3/s to 1200m^3/s continued throughout 5 January 2011 and all downstream bridges other than Fernvale and Mt Crosby Weir would have been inundated.[269] Under Simulation A, by midnight on 6 January 2011, Wivenhoe Dam would have been at EL 64.03m AHD.[270]

Compliance with the Manual

116 As noted, the plaintiff contended that under the Manual the Late December Flood Event should not have ended on 2 January 2011. It contended that, as neither dam ever fell below FSL and, based on the forecasts and level of releases, was always expected to exceed FSL, the flood event should have continued on 3 January 2011 (and thereafter).[271] By the same reasoning, it contended that a flood event should have been declared on 3, 4, and 5 January 2011.[272]

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[264] SEQ.004.046.0230 at .0270.
[265] EXP.ROD.001.0583 at .0680.
[266] SUN.002.002.3607.
[267] MSC.010.146.0001.
[268] Id.
[269] Simulation Analysis, EXP.ROD.015.0461 at .0467 to .0468.
[270] Ibid at .0468.
[271] Plaintiff subs at [1053].
[272] Ibid at [1069]; [1088].

117 I have already concluded that a proper application of the Manual meant that flood operations could not cease on 2 January 2011. Given that both dams remained at FSL throughout the days that followed, as Wivenhoe Dam was rising and the forecasts were worsening, that assessment applies throughout the period. Further, given that the actual level of both dams was above FSL, and that both Mr Malone and Mr Ayre had an expectation that they would remain there, it follows that the obligation to declare a flood event persisted throughout that period.

118 I have already adverted to Mr Malone's evidence on the obligation to declare a flood event.[273] He accepted that the Manual referred to an "expectation" that the water level in either dam would exceed FSL[274] but stated that the concept of a flood event without rainfall was "foreign to me".[275] Mr Malone asserted that the definition was not "fully descriptive of the actual situation"[276]. He pointed to both the gate trigger level of EL 67.25m AHD in section 8.3[277] and the necessity to allocate resources such as the FOC and operations staff in a cost effective manner.[278] He said the definition had to be applied with "practical common sense"[279] and with regard to the "lead time" between the expectation and the likelihood as to when gate operations would commence.[280] Thus, he stated that if a flood engineer expected the gate trigger to be exceeded "for example, tomorrow morning, I may well declare an event now, but if it was an expectation on three or four days time, I wouldn't necessarily declare an event now".[281]

119 Seqwater referred to this evidence and submitted that the obligation to declare a flood event in clause 2.2 is subject to an implied requirement that "performance should occur within a reasonable time".[282] Thus, it was

[273] See Chapter 3 at [144]
[274] T 4900.18 to T 4901.21.
[275] T 4901.20.
[276] T 4753.29.
[277] T 4753.34.
[278] T 4753.40.
[279] T 4900.39.
[280] T 4936.1.
[281] T 4936.6.
[282] Seqwater subs at [1256].

submitted that the declaration of a flood event had to occur only within a reasonable time of forming the expectation referred to in clause 2.2.[283] It further contended that Mr Malone's evidence as to the circumstances of the period from 3 to 5 January 2011 supported a finding that a reasonable time had not elapsed before his formal declaration of a flood event on the morning of 6 January 2011.[284] I reject both contentions.

120 With the first contention, as discussed in Chapter 3, clause 2.2 of the Manual obliges to the DFOE to "constantly review weather forecasts and catchment rainfall", and then provides that they "must declare" a flood event if the relevant expectation is formed based on the assessment of "prevailing or predicted weather conditions".[285] This definition is to be found in a Manual that acknowledges the uncertainty of rainfall forecasts,[286] identifies the "prime purpose" of adopting flood control measures at both dams as being to "reduce flooding in the urban areas" below the dams[287] and requires that "it [the Manual] must be used".[288]

121 Although the Manual acknowledges the limitations on the provision of "resources in a cost effective manner",[289] it imposes an obligation on Seqwater to provide those resources.[290] The Manual does not concern itself with whether and how those resources are allocated once a flood event is declared; it is silent on that topic. Instead, how resources are allocated upon the declaration of a flood event is left to the FPM, a document that was not the subject of any external approval but entirely internal to Seqwater.[291] The FPM vested responsibility in the DFOE to declare a flood event and mobilise the FOC. It mandated the mobilisation of the FOC if the DFOE considered it possible for FSL to be exceeded as a result of rainfall occurring in the

[283] Ibid at [1257].
[284] Ibid at [1267].
[285] Manual at 5.
[286] Ibid at 3.
[287] Ibid at 10.
[288] Ibid at 4.
[289] Ibid at 3.
[290] Ibid at 5.
[291] SEQ.004.028.0001 at .0030 (section 5.2).

catchments.[292] Arguably, it left some discretion not to mobilise the FOC if a flood event was declared based on forecast rain. However, that is of no present significance, as at all times from 2 January 2011 both dams were above FSL.

122 Subject to such time as may be necessary to monitor and confirm the forecasts, these matters all point to there being no period of delay between the forming of the expectation and the declaration of a flood event. If there is a concern about causing a misallocation of resources by reason of a declaration of a flood event before gate openings could occur, it was open to Seqwater to address it via amendments to the FPM which do not need external approval. As noted in Chapter 4[293], the 2010 FER records that there were delays between mobilisation and storage levels at Wivenhoe reaching gate opening trigger levels for each of the October to December flood events and this "allowed the Flood Operations Centre to be well prepared for the events and provided time for the Dam Operators to prepare the dam sites for the releases and undertake all operational checks".[294] In the case of the Early December Flood Event, the delay between mobilisation and gate releases was in excess of two days.[295]

123 In relation to the second point made by Seqwater noted in [119] three matters should be noted. First, on my findings the trigger level was not an impediment to making gate releases because the flood event should not have been declared over on 2 January 2011.

124 Second, Mr Malone's stated approach to delaying the declaration of an event is not borne out by what occurred on 5 January 2011. As at 6.30am, Wivenhoe Dam was at EL 67.23m AHD. This is just below the trigger level of EL 67.25m AHD, such that it was inevitable that the trigger would be exceeded that day, as it was. Yet he did not "declare an event now" (see

[292] Ibid at .0012 (section 2.2).
[293] Chapter 4 at [203].
[294] ROD.650.003.6506 at .6514.
[295] Id.

[118]) but instead waited until the following morning. This was the first flood event under the Manual in which the declaration of the flood event and the mobilisation of the FOC occurred well after the trigger level for releases from Wivenhoe Dam was exceeded. As the above passage from the 2010 FER illustrates, one advantage of mobilising the FOC when the expectation is formed is that it will allow for better “preparation for events”.

125 Third, one point made by Mr Malone in his evidence was that the amount retained above FSL during the period from 3 to 5 January 2011 was capable of being evacuated in the first few hours of flood operations.[296] However, that presupposes that downstream conditions permit those releases and that is a matter that a FOC that has been mobilised can assess. As events transpired, even though the FOC was mobilised the following day, no gate releases took place until the afternoon of 7 January 2011, being approximately two days after the gate trigger level was exceeded. By that time, Wivenhoe Dam was at EL 68.03m AHD, being almost 115,000ML above FSL.[297]

126 In relation to Mr Ayre and the position on 3 January 2011, he agreed that “we were all pretty much aware that there was a large likelihood that we would be all back into the flood operations centre later, yes”. He also agreed that that amounted to an “expectation” of the kind referred to in the Manual for the declaration of a flood event and that the Manual did not confer a discretion not to declare a flood event.[298] Nevertheless, he said it was Mr Malone’s decision as DFOE and he was “comfortable” with his decision not to declare an event but instead “just to continue to monitor” given that “we had … been in operation for about four weeks”.[299] Mr Ayre said that “the decision was to wait to see what happened on Wednesday and Thursday to see if it was necessary for us to respond”.[300]

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[296] Malone 1, LAY.SEQ.007.0001_2 at [539] to [541].
[297] See Response Report, EXP.ROD.015.0261 at .0464.
[298] T 7864.5 - .10.
[299] T 7863.27 - .43.
[300] T 7867.9.

127 In relation to 5 January 2011, Mr Ayre agreed that, by the morning of that day when the storage level was just below the trigger level, there was an expectation that “both gate operations would be required and that the water level was already well over FSL”. He said that he spoke to Mr Malone about mobilising the FOC.[301] However, he denied that mobilisation should have occurred on 5 January 2011 (“Well, again, given the fact that we had been operational for an extended period, I didn't see that it was a major drama to wait until the actual forecast rainfall came to fruition”).[302]

128 In its submissions, SunWater noted that there was a level of imprecision in the measurement of dam heights, that the level of Wivenhoe Dam remained below the trigger level and, in considering forecasts for the purposes of declaring an event, nothing in that part of clause 2.1 of the Manual which refers to the DFOE’s obligation to declare a flood event requires a consideration of four-day or eight-day forecasts.[303] It is correct that the Manual does not specify which forecasts must be used in relation to the declaration of a flood event. However, any dispute about this does not arise at this point. Throughout the period from 3 to 5 January 2011, Wivenhoe Dam remained above FSL and it continued to rise even with the releases through the regulators. Whatever forecast product was consulted, the expectation that both dams would remain above FSL would have subsisted.

129 As for the gate trigger level, I have explained that it was not an impediment to releases because the flood event should not have ceased on 2 January 2011 but, even if it was, it was not a justification for failing to declare a flood event.

130 Accordingly, I find that a proper application of the Manual required the continuation of the flood event from 2 January 2011 and, failing that, the further declaration of a flood event.

[301] T 7868.8.
[302] T 7868.15.
[303] SunWater subs at [1883] to [1884].

Mr Malone's Inflow Calculations

131 As noted, in preparing his affidavit, Mr Malone extracted the daily PME forecasts on 4 and 5 January 2011. In relation to the latter, he said that these forecast totals were "*well within the available capacity of the dams as discussed in paragraph 537 below*".[304] In paragraph 537, he includes a calculation of the available capacity of Wivenhoe Dam up to each of EL 74.0m AHD, EL 75.7m AHD and EL 80.0m AHD (and the same capacity for EL 109.7 AHD at Somerset Dam). He also addresses the amount of "excess rainfall" (ie, runoff) necessary to fill Wivenhoe Dam to those levels on the morning of each of 3, 4 and 5 January 2011 respectively. On the morning of 3 January 2011, those excess rainfall figures were 159mm, 205mm and 347mm respectively.[305] On the morning of 4 January 2011, those excess rainfall figures were 158mm, 205mm and 346mm respectively.[306] On the morning of 5 January 2011 those excess figures were 157mm, 204mm and 345mm respectively.[307] For each of those excess rainfall figures, he stated that "accounting for losses and any flood releases during the intervening period, the depth of the gross rain [ie, before losses] required to fill this volume would be a larger value".[308] He also concluded that 536mm of excess rainfall was need to fill Somerset Dam from its then level of EL 99.26m AHD to its maximum safe level of EL 109.70m AHD.[309]

132 The plaintiff contended that these calculations were erroneous. It noted that in cross-examination, Mr Malone conceded that, in calculating the excess depth of rainfall necessary to fill Wivenhoe Dam to those levels, he had divided the storage volume by the area of the Upper Brisbane and the Middle Brisbane catchments and excluded the Somerset catchment.[310] It noted that Mr Malone agreed that when that was done the amount of excess rainfall needed to fill

[304] Malone 1, LAY.SEQ.007.0001_OBJ at [532].
[305] Ibid at [537(d)].
[306] Ibid at [537(f)].
[307] Ibid at [537(h)].
[308] Ibid at [537].
[309] Ibid at [537(g)].
[310] T 5127.1.

Wivenhoe Dam to EL 74.0m AHD on the morning of 5 January 2011 becomes 130mm (assuming no releases).[311]

133 Mr Malone agreed with the plaintiff's calculations, but he also added that if a rainfall depth across the entirety of the catchment above Somerset Dam was to be assessed, it would also be necessary to take into account the storage capacity of Somerset Dam as well.[312] As at 6.30am on 5 January 2011, Wivenhoe Dam was at EL 67.23m AHD and Somerset Dam at EL 99.28m AHD.[313] The storage capacity of Wivenhoe Dam to EL 74.0m AHD was 889,676ML.[314] The storage capacity of Somerset Dam to the point on the Operating Target Line that appears to correspond to EL 74.0m AHD for Wivenhoe Dam (ie, EL 104m AHD) was 255,000ML.[315] The total of the two storages was 1,144,676ML. When that figure is divided by a total area of the catchments above Wivenhoe Dam (ie, 7001km^2),[316] it yields a figure of 163.5mm of runoff across all the catchments above Wivenhoe Dam. Allowing for the amount the dams were already filled, that figure is not materially different to Mr Malone's assessment of the depth of rain necessary to fill Wivenhoe Dam set out in his first affidavit (ie, 157mm).

134 Accordingly, subject to one matter, I do not accept that Mr Malone made some mathematical error in his calculations in his affidavit.[317] However, equally, I do not accept that those figures provided him with any real comfort about the capacity of Wivenhoe Dam to deal with the forecast rainfall to avoid urban flooding as a basis for justifying not declaring a flood event and undertaking gate releases. On the defendants' suggested construction of that part of the Manual that describes Strategy W4, which I broadly accept, once the storage level in Wivenhoe Dam exceeds EL 74.0m AHD then the ability to conduct flood operations to avoid adverse outcomes downstream is

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311 T 5126.43 to T 5127.11.
312 T 5128.23. Note that the cross-examination was then directed to the separate issue of filling Wivenhoe Dam from below FSL to FSL: T 5128.26.
313 LAY.SEQ.007.0001_OBJ at [537(g) and (h)].
314 Ibid at [537 (h)(ii)].
315 645,000ML – 390,000ML (corresponds to existing height of EL 99.28m): see Manual at 59.
316 Malone 1, LAY.SEQ.007.0001_OBJ at [76].
317 Seqwater subs at [1287] to [1288].

dramatically reduced as gates must be opened to address the rising storage levels.

135 The one possible "error" in Mr Malone's calculations is that there is no express account for rain on the ground. Put another way, in describing the amount of runoff rain necessary to fill Wivenhoe Dam to EL 74.00m or higher, I understand Mr Malone's figures to be a reference to rain that has fallen but not arrived at the dams and rain that will fall.

136 As at 5 January 2011, Mr Malone expected that there would be "*good runoff*" from any falls on 6 and 7 January[318] and presumably more if rain continued to fall. (This is supported by his own assessment in the situation report issued the following morning.[319]) On the morning of 5 January 2011, the 5-day PME figures cited by Mr Malone totalled between 110mm and 330mm. There is nothing improbable about 300mm of rain producing 160mm of runoff or more sufficient to fill Wivenhoe Dam to EL 74.0m AHD, given the wetness of the catchments and the amount of runoff produced in the Late December Flood Event. To the contrary, a ratio of runoff to rain of 160:300 (or 53%) is far below all the estimates of the ratio for the Late December Flood Event, namely, 75% to 86% which concerned much less rain, namely 85mm to 94mm.[320] These figures only reduce if account is made for rain on the ground inflows which were not calculated by the flood engineers at this point but were calculated by Dr Christensen. Thus, if Dr Christensen's midnight rain on the ground figures are included with Mr Malone's estimate of the catchment response during the Late December Event, only 198mm of rain would be required to produce 157mm of runoff necessary to fill Wivenhoe Dam to EL 74.0m AHD.[321] If Dr Christensen's estimate of the catchment response during the Late December Flood Event is used, then that result would be produced by 179.7mm of rain.[322] Given the uncertainties about whether more or less rain would fall, where it would fall and how intensely it would fall, Mr Malone's

[318] T 5128.47.
[319] See LAY.SEQ.007.0001_OBJ at [154]
[320] See Chapter 8 at [91]; Chapter 9 at [187] and [191].
[321] (5673km^2 x 157mm – 14,000ML) / (5673km^2 x .77).
[322] (5673km^2 x 157mm – 14,000ML) / (5673km^2 x .86).

figures do not support the conclusion that the rainfall forecasts were small enough to be "*well within the available capacity of the dams*", if that is meant to somehow justify delaying the commencement of flood operations.

137 As noted, Mr Malone suggested that he derived extra comfort from the knowledge that releases would be made in the period while much of the rain was falling. To similar effect, both Seqwater and SunWater submitted that considering the possibility of 160mm of runoff rain being received ignores the timeframe over which it would runoff and that invariable releases would be made in the interim.[323] However, this overlooks the potential that, if that rain fell upstream, then similar or even greater amounts could fall downstream and thus downstream flows could inhibit those releases or exacerbate their effect. This is borne out by the subsequent failure of the flood engineers to make any releases until the afternoon of 7 January 2011. SunWater also submitted that this aspect of the analysis assumes that releases are made on the basis of four-day PMEs, a matter hotly in dispute (but which I accept).[324] However, it does not. This aspect of the analysis is considering the potential justifications for not following the Manual and declaring a flood event (or continuing one).

138 The outlook on 3 and 4 January 2011 was more benign but did not warrant complacency. As at 3 and 4 January 2011, there had been some drying out of the catchments but it was still likely to be saturated given the amount of rain that fell throughout December and the assessment of catchment conditions in the situation report issued on the morning of 2 January 2011 (see [55]). The 00UTC eight-day forecast made available at midnight on 3 January 2011 predicted either between 75 and 150mm or 50 and 150mm of rain (see [82]). The four-day PME was also substantial. Mr Malone's assessment of the 1200UTC available at around 6.00am on the morning of 4 January 2011 yielded predicted totals of between 25 and 145mm over 4 days with an 8-day estimate of up to 200mm.[325]

[323] Seqwater subs at [1289(b)]; SunWater subs at [1921(b)] and [1921(c)].
[324] See Chapter 9 at [128].
[325] See [98]

139 Of themselves, the high end of these assessments would not, according to Mr Malone's figures, be sufficient to produce approximately 160mm of run-off sufficient to fill Wivenhoe Dam to EL 74.0m AHD. However, given the seasonal conditions, the rate of runoff experienced in the Late December Event and the particular problem of the forecasts not predicting extreme rainfall events, there was certainly a reasonable possibility of rain falling in excess of those figures sufficient to fill Wivenhoe Dam to that level. Using Dr Christensen's rain on the ground inflow figure,[326] and Mr Malone's estimate of 77% runoff during the Late December Flood Event, the further rainfall required to produce runoff to EL 74.0m on 3 January 2011 is around 200mm of rain[327] and on 4 January 2011 it is around 198.6mm of rain.[328] If Dr Christensen's estimate of the catchment response during the Late December Flood Event is used (ie, 86%) then those figures are around 180mm and 178mm respectively. The possibility that rainfall in excess of the forecasts sufficient to fill the dam to EL 74.0m or higher is no doubt the very reason that the Manual asserts it "must be used" for the operation of the dam during flood events[329] as the "prime purpose" of incorporating flood mitigation measures into the Manual was to reduce flooding in the urban areas of the flood plains below Wivenhoe Dam.[330]

140 This is exemplified by the following passage from the cross-examination of Mr Ayre when he was asked about the email sent by Mr Malone at 11.00am on 5 January 2011 warning of up to 200mm of rain:[331]

> "Q. You appreciated that if there were forecasts of between 100mm and 200mm of rain, then there was a possibility that more rain might fall?
> A. So the forecasts could be underestimated - is that what you are suggesting?
>
> Q. Yes.
> A. Yes.

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[326] Chapter 9 at [235]; Table 9-6.
[327] (5673 x 159) – 25,000 / 5673 x .77.
[328] (5673 x 158) – 29,000 / 5673 x .77.
[329] Manual at 4.
[330] Ibid at 10.
[331] T 7869.28 to T 7871.2.

Q. And if you had done the calculations prescribed by the flood procedures manual, then you would have done some modelling based on falls of 400mm; correct?
A. Well, it's a guideline. It's not a mandatory requirement to do that.

Q. If you had followed the guideline, then you would have done modelling based on falls of 400mm, wouldn't you?
A. Well, that's a possibility, yes.

Q. In circumstances where there had already been four flood events that season, and where the season outlook had been for well above average rainfall during the whole wet season up until April, and you were only in January, you needed to take a cautious approach to forecasts of significant totals up to 100 to 200 [mm] being possible in the next few days, didn't you?
A. Well, the QPFs weren't that significant for the ensuing 24 hours, so I still believe we had time to adequately respond, as such.

Q. Because you weren't expecting much to happen in terms of rainfall over the next 24 hours?
A. Well, that's true, and the fact that there would still be losses taken into account.

Q. That very circumstance would have made it apparent to you that there was a window of opportunity to make releases from Wivenhoe Dam against the possibility that there was 200mm or much more than that in three or four days' time; correct?
A. Well, that's one of the considerations that could have been made, yes.

Q. Did you turn your mind to that?
A. Well, I was comfortable with the prospect that we were going to be mobilising the following day and that in all likelihood we would be commencing gate operations accordingly.

Q. You knew that if you had waited until the next day, then you would lose 24 hours during which you could possibly make releases from Wivenhoe Dam in anticipation of forecast rain which would reduce the dam level to at least full supply level, didn't you?
A. Well, that's a possibility, yes.

Q. Well, when you say "that's a possibility", you knew that waiting might reduce your capacity to provide effective flood mitigation operations?
A. Well, it would have depended on what was happening downstream as well in terms of the downstream tributary flows, as to what capacity of releases we could possibly have made at that point in time.

Q. In order to make an assessment of that possibility, the only source of information at that point of time were forecasts, because there had been little or no rain downstream in the past several days; correct?
A. Or upstream, as such, yes."

141 As noted, during this exchange, reference was made to that part of the FPM that specified the preparation of hydrographs "using a variety of rainfall

scenarios" including "as a guide ... [a]ctual rainfall plus 200% of forecast rainfall".[332] That reference reflects the realistic possibility that significantly more rainfall could occur than was forecast given the seasonal outlook and immediate past experience. Mr Ayre also conceded that at least one possibility was using the current window of opportunity to make releases as future rainfall downstream may have made later releases more difficult. At the very least, it was certainly a circumstance that warranted mobilisation of the FOC.

142 Further, the rainfall analysis of Mr Malone summarised above addresses the amount of runoff necessary to produce various levels in Wivenhoe and Somerset Dams. Ultimately, the critical issue facing a flood engineer was whether the level of forecast (or actual) rainfall was such as to raise the likelihood, or at least the potential, of sufficiently high dam levels to cause uncontrolled or damaging releases. Such an assessment requires a consideration of the actual or potential catchment response to predicted rainfall. This is addressed in Chapters 8 to 10 and 12. As noted, the estimates of the catchment response during the Late December Flood Event were that for rainfall between 85mm and 94mm it produced runoff in the range of 75% to 86% of the rain that fell.[333]

143 At this point, it suffices to state that Mr Malone's rainfall analysis does not provide any justification for any failure to continue the flood event or declare a new flood event during the period 3 to 5 January 2011.

Responsibility to Declare a Flood Event

144 There is no doubt that as DFOE Mr Malone had the authority under clause 2.2 of the Manual to declare a flood event. However, one issue raised by the submissions on breach, which can be conveniently dealt with at this point, concerned the scope of Mr Ayre's authority as SFOE to direct the DFOE to declare a flood event. The plaintiff's submissions presupposed that in the

[332] SEQ.004.028.0001 at .0018 to .0019.
[333] Chapter 8 at [91]; Chapter 9 at [187] and [191].

period 3 to 5 January 2011, Mr Ayre could either direct Mr Malone to continue the flood event from 2 January 2011 or declare a flood event himself.[334] SunWater contended that Mr Ayre had no authority under the Manual to do so.[335] I accept that contention.

145 Clause 2.2 of the Manual vests the SFOE with responsibility "to be in the charge of Flood Operations at all times *during a Flood Event*". Clause 2.3 vests the SFOE with responsibility for setting the "overall strategy for management of the Flood Event" but that only arises "[w]hen rostered on duty during a Flood Event".[336] Leaving aside the reasonable discretion provisions of clause 2.8, these provisions appear to restrict the SFOE to taking action during a flood event. They reflect the position that the dam is owned and operated by Seqwater and control is only ceded on the declaration of a flood event.

146 The plaintiff sought to attribute a de facto authority to Mr Ayre to direct the declaration of a flood event. It relied on evidence from Mr Malone to the effect that decisions to mobilise were "normally" made in "consultation" with the SFOE.[337] However, that does not advance the matter. The email exchange between Mr Ayre and Mr Malone on 4 January 2011 about the possibility of making gate releases as an exercise of reasonable discretion, concluded with Mr Malone stating that "we've decided" to leave making gate releases until Thursday 6 January 2011.[338] Although it is not clear who the "we" was, it certainly was not Mr Ayre. The email suggests that it was accepted that he was not in a position to require the declaration of a flood event.

[334] Plaintiff subs at [1053].
[335] SunWater subs at [1886].
[336] Manual at 5.
[337] Citing Malone 1, LAY.SEQ.007.0001_OBJ at [41].
[338] SUN.006.001.3943; see above at [97].

147 Further, in one part of its submissions on breach,[339] the plaintiff referred to the evidence given by Mr Ayre immediately before the extract in [140]. He was asked:[340]

> "Q. Firstly, under the manual, surely you needed to intervene and say to Mr Malone, "No, the dam flood operations centre needs to be mobilised now"?
> A. I was comfortable with the decision that Terry had made, that we would be mobilising on the Thursday.
>
> Q. And, secondly, as you would have realised at the time, a reasonably competent senior flood operations engineer would have said to Mr Malone, "No, the dam flood operations centre needs to be mobilised now"?
> A. Well, I was aware that both Terry and myself were monitoring the situations remotely, Terry from his office at Seqwater and me from home, so if indeed the rainfall had escalated significantly, *then I would have taken that course of action*." (emphasis added)

148 In this passage, Mr Ayre appears to accept that he had the capacity to direct Mr Malone to declare a flood event. However, in the absence of any identified source of authority, evidence of an occasion when such a direction was given, or acknowledgement of that capacity by Mr Malone, I cannot conclude that Mr Ayre could have given such a direction.

6.11: Thursday, 6 January 2011

149 The one-day PMEs made available to the flood engineers at 6.00pm on 5 January 2011 continued to predict significant rainfall. According to the plaintiff, the one-day PME forecast for the 24-hour period to 10.00pm on 6 January 2011 was 5mm to 15mm of rain,[341] whereas the State contended that the forecast fell in the 15mm to 50mm bands.[342] A visual inspection of the forecast supports the State's position. The plaintiff contended that the four-day PME, which was available from midnight (ie 0:00 on 6 January 2011), predicted rain in the 25mm to 150mm range for the four day period to

[339] Plaintiff subs at [1090].
[340] T 7869.12 - .26.
[341] AID.500.022.0001.
[342] SEQ.013.004.1278; see AID.500.035.0001.

10.00pm on 9 January 2011.[343] The State agreed with that figure[344]. The plaintiff contended that the eight-day PME, which was also available from midnight, predicted rain in the 100mm to 200mm bands,[345] whereas the State contended that it was in the 50mm to 200mm range above the dam and in the 50 to 300mm range below the dam.[346]

150 The morning QPF issued shortly after 10.00am predicted 30mm to 50mm of rain for the 24 hours until 9.00am on 7 January 2011.[347] The 4.00pm QPF forecast predicted 20mm to 30mm of rain in the 24 hours to 3.00pm on 7 January 2011, although rain had been falling in the meantime.[348] The BoM issued severe weather warnings throughout 6 January 2011 for the Wide Bay and Burnett areas to the north east of Wivenhoe and the south east coast, specifically at 3.39am,[349] 8.33am,[350] 10.46am,[351] 4.50pm[352] and 10.54pm[353].

151 The BoM also issued and then revised flood warnings for the catchments immediately above and below Wivenhoe Dam on 6 January 2011. At 3.24pm, the BoM release stated that "[h]eavy rainfall of up to 60mm today has led to fast creek and river level rises along the upper Brisbane River and tributaries" and that "[m]oderate, possibly major flood levels are forecast at Gregors Creek overnight".[354] At 7.49pm, the BoM stated that the "heavy rainfall has cleared from the upper Brisbane River catchment" although "[f]ast creek and river level rises are continuing during Thursday evening along the upper Brisbane River and tributaries" which lead to some minor to moderate flooding

343 AID.500.022.0001.
344 SEQ.013.004.1288; see AID.500.035.0001.
345 AID.500.022.0001.
346 SEQ.013.004.1289; see AID.500.035.0001.
347 SEQ.001.019.6916.
348 SEQ.001.019.6977.
349 QLD.002.002.1932.
350 SEQ.001.018.8626.
351 QLD.002.002.1923.
352 SEQ.001.018.8617.
353 QLD.002.002.1899.
354 SEQ.001.018.8619.

in sections upstream with "[h]igher levels … possible but dependent on further heavy rainfall".[355]

152 For downstream catchments, flood warnings for the Lockyer and Warrill Creeks and the Bremer River were issued by the BoM at 10.47am,[356] 2.28pm,[357] 5.26pm[358] and 8.33pm.[359] The first three warned of heavy rainfall causing fast rises in Lockyer and Warrill Creeks. This was said to be likely to cause moderate flooding in the Lockyer Creek, minor flooding in the Warrill Creek and minor to moderate flood levels in the Bremer River on that day and the following day. The warning issued at 2.28pm referred to "rainfall of up to 60mm in the 6 hours to 2pm". The warning issued at 9.33pm noted that the rainfall had "eased during Thursday evening", that "minor to moderate flooding [had] peaked" in the Lockyer Creek between Helidon and Showground Weir but major and moderate flooding was being experienced elsewhere. Both Warrill Creek and Bremer River were said to have peaked or be nearing a peak.[360]

153 Commencing at around 7.00am on 6 January 2011, data collectors working in the FOC commenced recording various activities within the centre in a spreadsheet entitled "Flood Control Centre – Event Log" (the "Event Log").[361] The first entry in the Event Log is at 7.00am on 6 January 2011 and records Mr Malone arriving in the centre[362] "to assess strategies". It also records that Wivenhoe Dam was at EL 67.31m AHD and rising slowly while Somerset Dam was at EL 99.34m AHD and also rising slowly. In relation to Wivenhoe Dam, the Event Log records that "[g]ates will be opened in the next 24 hours to manage the inflows from the Upper Brisbane River and outflow from Somerset". At around 7.45am, Mr Malone sent an email "mobilis[ing] staff for

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355 SEQ.001.018.8612.
356 QLD.002.002.1921.
357 QLD.002.002.1919.
358 QLD.002.002.1909.
359 QLD.002.002.1902.
360 Ibid.
361 QLD.002.001.8660; T 6742.17 (Pokarier).
362 He signed on for duty at 7.30am; SEQ.004.024.0014.

gate operations" which he expected to commence later that day. He noted that "further totals [of] up to 150mm were expected during the next 2 days".[363]

154 Just after 8.00am, Mr Malone issued his morning situation report.[364] The report noted that "[s]ince 9am Wednesday, there have been widespread falls of 30mm with isolated heavy falls up to 50mm in the Somerset and Wivenhoe catchments" and that "[t]he forecast for the next 24 to 48 hours is for totals [of] up to 150mm in SE Qld." The report referred to opening gates at Wivenhoe Dam in the following 24 hours and advising the Council accordingly after a full assessment was undertaken. Mr Malone stated that he anticipated releases would be less than 500m^3/s and they would "at least impact upon Twin Bridges, Savages Crossing, Kholo Bridge and Colleges Crossing for several days". The report stated that "[t]he catchments remain wet and are likely to generate additional runoff in the event of rain". In his affidavit, Mr Malone described the catchments as "likely to generate additional runoff in the event of sufficiently intense rain".[365] The contemporaneous observation is to be preferred.

155 In his affidavit, Mr Malone refers to the 1200UTC PMEs available to him as at 6.00am on 6 January 2011 as suggesting that falls of up to 150mm per day "in the coming days were forecast to occur with a total of up to 400mm [forecast] in the seven days ending Thursday 13 January 2011". Mr Malone provided the following breakdown of the daily 1200UTC PMEs:[366]

Day and Date	Forecast
Thursday, 6 January	Highest falls up to 150mm (centred off northern NSW coast)
Friday, 7 January	Highest falls up to 100mm (centred off the Sunshine Coast)
Saturday, 8 January	Highest falls up to 50mm (centred off the Sunshine Coast)
Sunday, 9 January	Highest falls up to 100mm (centred on the northern NSW coast)

[363] QLD.001.001.2252; SEQ.001.020.3644.
[364] SUN.001.001.1236; QLD.001.001.2256.
[365] LAY.SEQ.007.0001, [569]; see also T 5139.22; T 5139.33.
[366] Malone 1, LAY.SEQ.007.0001 at [570] to [571]; copies for catchments at EXP.SEQ.014.0219 at .0353 to .0360.

Monday, 10 January	Highest falls up to 150mm (centred on the northern NSW coast)
8-Day total to 13 Jan	Up to 400mm

Table 6-4: Mr Malone's breakdown of 6 January 2011 1200 UTC PME forecasts

156 Mr Malone stated that the heaviest rainfall was forecast offshore and to the south-east of the Brisbane River basin. He said that this "suggested to me that the higher rainfall was likely to be in the catchments downstream of Wivenhoe Dam rather than above the dam".[367] He identified the place of the highest rainfall as off the Queensland coast.[368] He said that this "highlighted that rainfall with totals [of] up to 150mm per day was possible in South East Queensland but also highlighted the uncertainty as to when and where the highest rainfall was likely to occur". Thus, he concluded that the "PME daily forecasts suggested that the higher totals would be in catchments other than Somerset and Wivenhoe Dams".[369]

157 In its written submissions, Seqwater emphasised the predicted location of this rainfall. It contended that it covered "a vast area far beyond the dam catchments", namely South East Queensland, and that one could not conclude that "they were directed to the dam catchments".[370] However, those observations only reinforced that caution warranted making immediate releases. The potential for widespread heavy rainfall over coming days raised the realistic possibility of downstream flows being sufficiently high to cause damage with releases made from upstream catchments only after rain had fallen. Further, the uncertainty over the location of where rain might fall warranted consideration of the realistic possibility that the forecast rain would fall upstream instead of, or together with, rainfall downstream.

158 In cross-examination, Mr Malone accepted that one possibility was that the rainfall of "up to or even more than 400m" could fall above the dam

[367] LAY.SEQ.007.0001 at [570].
[368] Id.
[369] Ibid at [572].
[370] Seqwater subs at [1329]; see also [1344] and [1379(a)].

catchments,[371] that it was a "*clear possibility*" that there could be a considerable amount of rain in the dam catchments over the next eight days, and that there was temporal and spatial uncertainty in connection with the rainfall forecasts in this regard.[372] Mr Malone agreed that this was one possibility he needed to address.[373]

159 At 10.27am, Mr Malone emailed the other three flood engineers as well as various Seqwater and SunWater staff to update them on his operational strategy.[374] In relation to Wivenhoe Dam, the email stated:

> "Based upon rain to date, expecting about 70,000ML from upper Brisbane. Lockyer Ck peak of about 100m^3/s Friday afternoon. This will take out Twin Bridges and nearly inundate Savages Crossing. Colleges Crossing could be taken out by a combined Lockyer and local runoff.
>
> Current strategy is to keep Burton Bridge free. On this basis, we will commence opening Wivenhoe at 1800 Thursday and ramp up to about 300m^3/s by 2200. This would limit mid Brisbane flows to just under 400m^3/s (Burtons capacity 450m^3/s). If rainfall increases and Lockyer and local runoff also increase, we can close/reduce Wivenhoe accordingly to ensure that that 450m^3/s is not exceeded unless necessary.
>
> Councils have been advised of this strategy and are contacting residents."

160 Four matters should be noted about the approach set out in this email. First, Mr Malone said the assessments reflected in this report were based on the rain on the ground assessments (ie, they did not use forecasts)[375] and that the strategy would only change in the event that "actual rainfall increased".[376]

161 Second, the aim of keeping flows to a level to ensure Burtons Bridge remained open is consistent with the objective of Strategy W1B or W1C (although the Manual refers to Burtons Bridge being inundated at 430m^3/s not 450m^3/s). Both Mr Malone and Mr Ayre said the objective of flood operations at this point was to keep downstream bridges open based on rain on the

[371] T 5151.13.
[372] T 5151.24.
[373] T 5151.30.
[374] QLD.001.001.2259.
[375] T 5153.43.
[376] T 5154.12.

ground.[377] Kholo Bridge remained closed on 6 January 2011 due to damage to its road surface.[378] Thus, once Burtons Bridge was inundated, the next relevant downstream impact was the possible closure of Mt Crosby Weir Bridge which required a flow rate of 1900m^3/s.

162 Third, Mr Malone contemplated addressing any deterioration in downstream flows that might eventuate by closing gates at Wivenhoe Dam.

163 Fourth, this email was sent before the first flood warning for the Lockyer Creek was issued at 10.48am. However, after the flood warning was issued, the proposal to open the gates at Wivenhoe at around 6.00pm on 6 January 2011 was referred to in emails sent from the FOC up to and including 1.20pm.[379]

164 The first substantive operational RTFM run that has been saved was undertaken around midday on 6 January 2011 (the "6 Jan 12:00 ROG run").[380] No gate openings were modelled and only rain on the ground was included. (Mr Ayre accepted that it was effectively a "no release" run[381]). The gates operations spreadsheet produced by the run commenced the flood event at 9.00am on 2 January 2011. The model run allowed for releases of 50m^3/s from Wivenhoe Dam through the regulator. The model run predicted Wivenhoe Dam reaching EL 68.2m AHD sometime on 11 January 2011, with a maximum inflow into the dam of around 815m^3/s and a natural peak flow rate at Moggill of 612m^3/s, both due to occur early in the morning of 7 January 2011. The predicted natural peak flow at Lowood was 447m^3/s early in the morning of 7 January 2011 which would have been sufficient to inundate Burtons Bridge even without any further rain falling.

[377] T 5153.38 (Malone); T 7877.13 (Ayre).
[378] Ayre 1, LAY.SUN.001.0001_OBJ at [1964].
[379] QLD.002.001.4687 at .4695; QLD.002.001.4662; SEQ.001.011.5011 – 12.00pm technical situation report.
[380] QLD.001.001.2264; SDWD-201101061200.xls.
[381] T 7879.46.

165 At 12.14pm, Mr Malone emailed the flood engineers advising them, inter alia, that gates would be opened at Wivenhoe at 6.00pm, with one gate progressively opened to 2.5m by 10.00pm with the aim of keeping Burtons Bridge open.[382] However, at 1.30pm, Mr Malone emailed the other three flood engineers and other staff. His emailed was entitled “Revised Operating Strategy 1200 6/1/2011”. He advised them of some of the figures produced by his model run and stated that Lockyer Creek could be “as high as 600m^3/s peaking Saturday”. He stated that the flows from Lockyer Creek may close Burtons Bridge without releases from Wivenhoe Dam and that “[t]he opening of the Wivenhoe gates will therefore be delayed until the Lockyer peak passes”.[383] Mr Malone was not sure of the origin of the figure of 600m^3/s but thought it might have been a further (rain on the ground) model run.[384]

166 In his affidavit, Mr Malone said that at this time he recognised releases would be required from Wivenhoe Dam but considered it better to delay them so as to not inundate bridges. He contended that this was consistent with the “objectives of the Manual in minimising disruption to rural life after the higher-level objectives of dam safety and urban flood mitigation had been satisfied”.[385]

167 Mr Malone issued a further situation report at 2.54pm that afternoon.[386] He stated that there had been total falls of approximately 30mm since 9.00am with some “isolated heavy falls [of] up to 60mm in the Somerset and Wivenhoe catchments” with forecast totals of up to 100mm to fall in South East Queensland in “the next 24 to 48 hours”. Once again, the catchments were described as “remain[ing] wet and … likely to generate additional runoff in the event of the rain”. Mr Malone stated that there had been “significant rainfalls in the Lockyer [Creek] catchment since 0900 Thursday and a peak of about 600m^3/s is expected from the Lockyer late Friday” which meant that the Wivenhoe gates would be opened after flood levels in the “lower Lockyer

[382] QLD.001.001.2265.
[383] QLD.001.001.2267; SEQ.001.018.4171.
[384] T 5163.12; T 5170.10.
[385] LAY.SEQ.007.0001 at [579].
[386] SUN.002.001.6497; QLD.001.001.2270; SEQ.001.011.4756.

subside" and those releases could be as "high as 1,500m^3/s and continue for a couple of days". He noted that Councils affected by bridge closures had been notified and that at least Twin Bridges, Savages Crossing, Kholo Bridge and Colleges Crossing would be impacted by Locker Creek flows and Wivenhoe Dam releases "for several days."

168 Two operational model runs undertaken by Mr Malone at around 3.00pm on 6 January 2011 have been preserved (the "6 Jan 15:00 ROG run"[387] and the "6 Jan 15:00 test run").[388] Both only modelled rain on the ground and did not assume any releases from Wivenhoe Dam other than 50m^3/s through the regulator. The 6 Jan 15:00 ROG run predicted Wivenhoe Dam reaching a peak height of 68.497m AHD at 10.00am on 11 January 2011, a peak inflow rate of 1286m^3/s at 5.00am on 7 January 2011, a naturally occurring peak flow rate for Lockyer Creek (ie, Moggill) of 497m^3/s at 1.00pm on 7 January 2011 and a naturally occurring peak flow rate at Moggill of 731m^3/s at 6.00am on 7 January 2011. The 6 Jan 15:00 test run modelled slightly larger inflows and larger downstream flows and thus produced correspondingly higher predictions of naturally occurring peak flow rates downstream, namely 1029m^3/s at Lowood and 1348m^3/s at Moggill. It predicted Wivenhoe Dam peaking at 68.51m AHD at 11.00am on 11 January 2011 and predicted a peak inflow rate of 1280m^3/s at 7.00am on 7 January 2011.

169 Thus, in effect, both of these rain on the ground model runs predicted Wivenhoe Dam reaching 68.5m AHD with no releases. The Plaintiff contended that, given the prevailing forecasts, these results should have caused Wivenhoe Dam to exceed EL 68.5m AHD and thus trigger W2 or W3.[389] It noted Mr Malone's evidence that "*there was no doubt"* that Wivenhoe would exceed EL 68.5m AHD if forecast rainfall eventuated and he *"didn't need to run a model to be able to assess that*".[390] As the above

[387] QLD.001.001.2274; SDWD-2201101061500.xls.
[388] QLD.001.001.2275.
[389] Plaintiff subs at [1135].
[390] T 5300.30 - .35 (Malone).

demonstrates, by this time there was significant ongoing rain in the upstream catchments.

170 Just after 3.00pm, Mr Malone replied to an email from Mr Graham Keegan, a dam operator employed by Seqwater. Mr Keegan inquired about whether releases would be made. Mr Malone responded by saying there would not be releases that night but instead they would "wait for the Lockyer" and that the "Upper Brisbane [catchment was] getting interesting [with] about 7m expected at Gregors [Creek]."[391] Mr Malone agreed that by this time initial losses would have been satisfied.[392]

171 Mr Malone undertook a further model run at around 4.00pm (the "6 Jan 16:00 ROG run").[393] It predicted that Burtons Bridge would be inundated by naturally occurring downstream flows sometime around midday on 7 January 2011.[394] Based on a similar level of inflows to the 3.00pm run, he now incorporated releases from the Wivenhoe Dam gates commencing at 4.00pm on 7 January 2011, that being after the naturally occurring modelled peaks at Lowood and Moggill. Those releases reached a peak discharge rate of 467m^3/s on the morning of 10 January 2011 with Wivenhoe Dam only returning to FSL at 1.00am on 14 January 2011. The revised maximum predicted height of Wivenhoe Dam was EL 68.415m AHD at 4.00pm on 8 January 2011. The predicted maximum rate of inflow was 1286m^3/s at 7.00am on 7 January 2011.[395]

172 The Plaintiff contended that this exemplifies the problem with rain on the ground modelling, in that it effectively adopts what the plaintiff describes as a "can release assumption" to gate operations; ie, this modelling assumes that water can be released after the rain on the ground modelled peak in the Lockyer river has passed. This run modelled releases on 8 January 2011 and

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[391] SEQ.001.023.8590.
[392] T 5178.40 (Malone).
[393] SDWD-201101061600.xls; QLD.001.001.2277.
[394] Gate operation tab, row 119, column AJ + Lowood flows at 7.00am (Input data P126) + 4.5 hours travel time to Burtons Bridge.
[395] Input data tab, row 126.

then during the period 9 to 11 January 2011 when the forecasts available to the flood engineers predicted that this would be the period of the most intense rain.[396] Mr Malone's analysis of the 1200UTC one-day PMEs predicted there would be intense rainfall downstream of the dam in that period (see [155] to [156]).[397]

173 Mr Malone issued a further situation report at 5.33pm.[398] By that time, Wivenhoe Dam had risen from EL 67.31m AHD in the previous report to EL 67.39m AHD. It was said to be "rising slowly". Somerset Dam had increased from EL 99.34m AHD in the previous report to EL 99.45m AHD. The report reiterated that Lockyer Creek was expected to peak at around 600m^3/s late on Friday 7 January 2011 but noted some uncertainty as to whether it would impact Burtons Bridge. Mr Malone added "[a]t this stage Wivenhoe releases will commence late Friday/early Saturday and may be as high as 1,500m^3/s, similar to recent events, and continue for a couple of days" and that the "relatively high Lockyer flows will adversely impact upon Twin Bridges, Savages Crossing, Kholo Bridge and Colleges Crossing for several days and may impact upon Burtons Bridge early Saturday".

174 The situation report stated that the "estimated event inflow volume into Wivenhoe Dam is 180,000 ML including Somerset Dam outflow". The report did not state when the "event" commenced. However, the 4.00pm rain on the ground model run estimated the volume of inflows into Wivenhoe Dam commencing at 9.00am on 2 January 2011 to be 176,484 ML.[399] The report noted that the "forecast for the next 24 to 48 hours is for totals up to 100mm in SE Qld".

[396] Plaintiff subs at [1143] to [1144]; see daily PMEs published at 6.00am on 6 January 2011; EXP.SEQ.014.0355 (8 Jan); EXP.SEQ.014.0356 (9 Jan); EXP.SEQ.014.0357 (10 Jan); daily PMEs published at 6.00pm on 6 January 2011; EXP.SEQ.014.0362 (8 Jan); EXP.SEQ.014.0363 (9 Jan); EXP.SEQ.014.0364 (10 Jan); EXP.SEQ.014.0365 (11 Jan).
[397] Malone 1, LAY.SEQ.007.0001_OBJ at [570].
[398] SEQ.001.011.4766.
[399] Cell H7 in "input data" tab; QLD.001.001.2277.

175 At 6.30pm, Mr Ayre signed on as the duty flood engineer. Mr Malone signed off fifteen minutes later.[400]

176 At around 9.00pm, Mr Ayre prepared two operational runs, both of which modelled rain on the ground (only) and incorporated proposed gate releases.[401] Both runs predicted naturally occurring peaks at Lowood and Moggill on the afternoon of 7 January 2011. One model run appeared to be designed to keep Burtons Bridge open in that it modelled a maximum release of 408m^3/s with gate operations not commencing until 8 January 2011 and Wivenhoe Dam not returning to FSL until 9.00pm on 15 January 2011 (the "6 Jan 21:00 Burtons Bridge run").[402] This yielded a predicted peak height of EL 68.47m AHD at 6.00am on 9 January 2011. Mr Ayre confirmed that he modelled this run to see if he could keep Burtons Bridge open.[403] However, it appears that this could not be achieved because the naturally occurring Lockyer peak at Lowood was 467m^3/s in that run and the combined peak at Lowood was predicted to be 480m^3/s.[404]

177 The other run then modelled gate operations commencing at 11.00pm on 7 January 2011 with gate openings increasing to yield a peak release rate of 1225m^3/s at 10.00pm on 8 January 2011 and a return to FSL at around 6.00pm on 10 January 2011 (The "6 Jan 21:00 ROG run").[405] This modelling predicted a peak height of EL 68.24m AHD being reached at 11.00am on 8 January 2011 and a peak rate of inflows of 1238m^3/s at 8.00am on 7 January 2011. This spreadsheet appears to be the origin of the gate operations that were conducted throughout 7 January 2011 and much of 8 January 2011 (see below). It contains gauge readings up until 6.00am on 7 January 2011. This run predicted a naturally occurring peak at Lowood of 467m^3/s at 3.00pm on 7 January 2011 and a peak at Moggill of 578m^3/s at

[400] SUN.002.005.0002 at .0003.
[401] QLD.001.001.2299; SDWD-201101062100.xls; QLD.001.001.2298; SDWD-201101062100-Burton.xls.
[402] QLD.001.001.2298; SDWD-201101062100-Burton.xls.
[403] T 7708.1 - .11.
[404] Ayre 1, LAY.SUN.001.0001_OBJ at [1872(g)].
[405] QLD.001.001.2299.

1.00pm on that day. It also predicted that Burtons Bridge would be inundated sometime around 3.00pm to 4.00pm.[406]

178 The plaintiff noted Mr Ayre's evidence that the 6 Jan 21:00 ROG run was based on the rain on the ground modelling[407] and submitted that this did not take into account forecast rainfall.[408] The 6 Jan 21:00 ROG run proposed releases at a level that would inundate all downstream bridges other than Mt Crosby Weir Bridge and Fernvale Bridge but waited for natural flows to close the bridges before making releases.[409] The plaintiff contended that it was an exemplification of the "can release" assumption in that the modelled height and level of releases assumed that substantial releases could be made "three or four days into the future … [even though the] forecasts indicated a likely significant worsening in downstream (and upstream) conditions", which they did.[410] The 6 Jan 21:00 ROG run modelled substantial releases of $120m^3/s$ from the evening of 8 January 2011 to the evening of 10 January 2011.

179 Just after 11.00pm on 6 January 2011, Mr Ayre sent an email to Mr Drury:[411]

> "Somerset-Wivenhoe depends upon Lockyer Creek peak as it will be touch and go if Burtons Bridge will remain open due to Lockyer flows. Either way the gate operations will extend over the weekend and probably into middle of next week."

180 Mr Ayre agreed that he adopted the approach of "not making any releases from Wivenhoe Dam until you had learnt whether Burtons Bridge had actually been closed by downstream flows". [412]

181 Mr Malone's "Observed Rainfall Analysis" report records catchment averages of 38, 38 and 34mm of rainfall for the 24 hours to 9.00am on Friday,

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406 Gate operations tab, row 123, column AJ plus Lowood flows at 11.00am (InputDataP130) plus 4.5-hour travel time from Lowood to Burtons Bridge.
407 T 7703.16.
408 Plaintiff subs at [1153].
409 Ibid at [1154].
410 Ibid at [1155]; EXP.SEQ.014.0219 at .0363 (9 Jan) and at .0364 (10 Jan).
411 SEQ.001.018.4155.
412 See T 7889.12.

7 January 2011 for the Somerset, Upper Brisbane and Middle Brisbane catchments respectively.[413] It also records catchment average rainfall in the 24 hours to 9.00am on 7 January 2011 in the Lockyer, Bremer and Lower Brisbane catchments as 25, 31 and 35mm respectively. Dr Christensen determined actual rainfall on 6 January 2011 upstream of Wivenhoe Dam to be 38mm.[414]

182 Despite the declaration of a flood event, the only releases on 6 January 2011 were the 50m^3/s made from the regulator at Wivenhoe Dam and the 34m^3/s to 35m^3/s made from the cone valve at Somerset Dam. By midnight on 7 January 2011 (ie, 0:00), Wivenhoe Dam was at EL 67.46m AHD and Somerset Dam was at EL 99.52m AHD.[415] At around 1.00pm on 6 January 2011, the rate of inflow into Wivenhoe Dam had dropped to 177m^3/s, however by 11.00pm it was 660m^3/s and by midnight it was 1047m^3/s.[416]

183 By contrast, in Dr Christensen's Simulation A, releases continued at rates between 1100m^3/s and 1200m^3/s throughout 6 January 2011 and all downstream bridges other than Fernvale and Mt Crosby Weir would have continued to be inundated.[417] Under Simulation A, by midnight on 7 January 2011 (ie, 0:00) Wivenhoe Dam would have been at EL 63.26m AHD.[418]

Mr Malone and the Use of Forecasts

184 In his affidavits, Mr Malone stated that he did not interpret the Manual as requiring him to "input forecast rainfall figures in[to] the RTFM and then make releases based on the model results produced". Instead, he said he understood that the Manual "left it to me to determine as a matter of professional judgment what, if any, reliance should be placed on rainfall

[413] SEQ.004.046.0230 at 0271.
[414] EXP.ROD.001.0583 at .0680.
[415] QLD.001.001.2302; QLD.002.001.1350; Simulation Analysis, EXP.ROD.015.0461 at .0468 and .0478.
[416] Simulation Analysis, EXP.ROD.015.0461 at .0468.
[417] Id.
[418] Id.

forecasts when making releases".[419] He said that his approach in relation to the use of forecasts was informed by his knowledge of the uncertainties involved in flood forecasting based on rainfall forecasts especially uncertainty as to depth as well as spatial and temporal distribution.[420] He said that in his 20 years of experience with the BoM he could not recall "an instance where forecast rainfall was used to generate a quantitative forecast … with a high degree of certainty".[421] He referred to the memo that Mr Peter Baddiley from BoM provided to Seqwater in 2006 concerning forecasting rainfall for the Wivenhoe Dam catchments[422] which was re-sent in early December 2010. He said that he "understood the substance of the advice was that the BoM could not produce sufficiently reliable rainfall forecasts which could be used for the purpose of operating the dams".[423] That memo was addressed in Chapter 4.[424] Mr Malone described the QPF forecasts as the "better forecast product" because it was reviewed by a senior meteorologist before it was issued.[425]

185 Mr Malone then described a series of uses that he said he made of rainfall forecasts during December 2010 and January 2011, namely:[426]

> "(a) set staff rosters;
> (b) assess when gate operations might be required and the FOC mobilised;
> (c) assess potential inflow volumes;
> (d) advise management and local councils of the potential for significant inflows and releases;
> (e) assess when gate closure might commence;
> (f) assess whether upstream water levels had peaked or whether rises to continue or were likely to recommence;
> (g) assess[ing] whether maximum flood levels had been reached in dams; and
> (h) assess[ing] where the heaviest rainfall was likely to occur in the future (ie above or below the dams)."

419 LAY.SEQ.007.0001 at .0063 at [190]; LAY.SEQ.016.0001 at [44(a)] and [48(b)].
420 Ibid at [193].
421 Ibid at [195].
422 SEQ.001.018.9372 and .9373.
423 LAY.SEQ.007.0001 at [196] to [197].
424 Chapter 4; section 4.3
425 LAY.SEQ.007.0001 at [198].
426 Ibid at .0066, [199].

186 The email exchanges during the period 3 to 5 January 2011 appear to be examples of the use referred to in (a) and (b). Mr Malone's analysis of the 1200UTC PME forecasts for 6 January 2011 in his affidavit appears to be an example of (h). The concept of assessing the location of forecast rainfall was taken further in Seqwater's submissions. It submitted that the "decision to defer making releases to account for the downstream flows in the Lockyer was affected by the forecasts at that time".[427] It referred to various passages in Mr Malone's affidavit where on 6 January 2011 he uses rainfall forecasts to determine the likelihood of heavier rainfall downstream of the dams[428] and how that affected his approach.[429] Seqwater emphasised that as an example of Mr Malone not ignoring forecasts per se, but instead considering them in a qualitative sense.[430] This is addressed further in Chapter 7.[431] At this point it suffices to state that analysing rainfall forecasts to determine the location of future rainfall as a justification for *not* making releases, but not for other reasons such as making releases, was a flawed approach. It relied on one of the most unreliable aspects of a rainfall forecast, namely location of rainfall,[432] as a justification for reducing the flood storage component of the dam. It is the very antithesis of what Professor Schleiss described as "hav[ing] the chance on your side".[433] Otherwise, the above extract from Mr Malone's affidavit refers to using rainfall forecasts to "assess potential inflow volumes". However, Mr Malone agreed that he did not undertake any "with forecast" modelling on 6 January 2011.[434]

187 In his affidavit, Mr Malone also stated that "[i]n determining *strategies* from Wivenhoe Dam and Somerset Dam during December 2010 and January 2011, I used the QPF and PME forecasts qualitatively, rather than quantitatively".[435] It is unclear whether the reference to "strategies" was to

[427] Seqwater subs at [1375].
[428] Malone 1, LAY.SEQ.007.0001 at [570] to [572].
[429] Ibid at [581] and [598(c)].
[430] Seqwater subs at [1373] to [1375].
[431] Section 7.17
[432] See Chapter 9, section 9.2.
[433] T 2950.44.
[434] T 5180.16.
[435] LAY.SEQ.007.0001 at [200].

Wivenhoe strategies or releases. As noted in Chapter 3, in cross-examination, Mr Malone stated that he construed the Manual as requiring the use of rainfall forecasts in the selection of strategies but not in the conduct of gate operations[436] and ultimately he stated that he could not recall how he interpreted the Manual at the time of the January 2011 Flood Event.[437] However, Mr Malone agreed that forecasts were not used in the selection of strategies throughout the January 2011 Flood Event.[438] Mr Malone stated that he was in W1B on 6 January 2011[439] and that is only consistent with the use of actual lake levels as the determinant of strategy. I am satisfied he did not use rainfall forecasts (or even inflow forecasts) to select strategies.

188 In relation to setting gate operations Mr Malone agreed that forecast rainfall was not used in determining gate settings.[440] No gate operations occurred on 6 January 2011 and all of Mr Malone's modelling only modelled inflows from rain on the ground. His 6 Jan 16:00 ROG run sought to evacuate those inflows over seven days[441] and delayed releases until after the anticipated peak in the Lockyer River the following day. In explaining his approach to determining gate releases, Mr Malone stated that he would consider "mostly rain on ground because the window [he was] using to determine … gate settings is only six to 12 hours" and "forecast rainfall in two or three days' time is not going to have a huge decision on those gate settings".[442] He said that he would reconsider gate settings for the next 6 to 12 hours based on "further observed rainfall".[443]

189 Seqwater submitted that this did not exclude the use of rainfall forecasts but instead meant that gate directives were based "mostly" or "largely" on rain on the ground because that's what contributes to inflows in the immediate 6 to

[436] Chapter 3 at [153].
[437] T 5353.36.
[438] T 5323.1; T 5339.42 and T 5299.14 -.28.
[439] T 5180.31.
[440] T 5165.8; T 5167.33 and T 5168.8.
[441] It returned to FSL just after 1.00am on 14 January 2011; cf SunWater subs at [1980] which assert that they did so over three to four days.
[442] T 5167.37.
[443] T 5167.45.

12 hours in the future.[444] It contended that these were regularly reassessed in light of further rainfall and that Mr Malone used forecasts in the various qualitative ways noted above.[445]

190 Neither this approach nor Seqwater's submissions engage with the plaintiff's case. Given the characteristics of the dam system, a planning horizon of 6 to 12 hours that only addresses rain on the ground is simply too short. It means that the estimate of inflows that must be evacuated and the estimate of downstream flows to be navigated will always be the minimum. In circumstances where releases are delayed, such as 6 January 2011, it means that the flood engineer must assume or determine that releases can be made beyond the 6 to 12-hour period. Thus, on 6 January 2011, Mr Malone delayed making any releases and modelled making releases much later during a period of high forecasted rainfall downstream and which could have also fallen upstream. Using Mr Malone's timeframe and rain on the ground modelling as the basis for gate operations will inevitably lead to an underestimate of inflows upstream and downstream. It will tend to push the timing of releases back as the flood engineer assumes that less releases are required and that they can be made later. It means that the opportunity to release water in advance of forecast rainfall will be lost.

191 SunWater responded to the criticism of the flood engineers' decision to delay releases even though there was a forecast of up to 300 to 400mm of rain in the region by contending that it was entirely reasonable for Mr Malone to allow Wivenhoe Dam to rise as he was in Strategy W1.[446] That contention, and many other contentions SunWater made in response to the plaintiff's submissions concerning 6 January 2011, assumed that the determination of strategies was governed by actual lake levels and, as Wivenhoe Dam did not exceed EL 67.5m AHD, the flood engineers were restricted to W1B.[447]

[444] Seqwater subs at [1370] citing Mr Malone's evidence at T 5167.37 and T 5168.12.
[445] Seqwater subs at [1372] to [1373].
[446] SunWater subs at [1960(a)].
[447] Ibid at [1943(a)], [1948(a)], [1965(a)], [1972(a)], [1995] and [1998].

Seqwater made similar contentions.[448] For the reasons set out in Chapter 3[449], I reject that assumption.

192 SunWater also submitted that the criticism of the flood engineers for delaying releases in the face of those forecasts assumes that rainfall in the following four to six days constituted a reliable basis upon which to make release decisions and that Mr Kane expressly disavowed such a proposition.[450] I have already addressed the limitations on Mr Kane's evidence in Chapter 3.[451] He was not in a position to disavow anything of relevance to the flood engineers' use of his quantitative analysis of inflow volumes. Otherwise, Mr Malone's own reasoning assumed that one aspect of forecast rainfall, namely its location downstream of the dam, was a basis for a "release decision", namely a decision not to release water at that point. As explained in Chapter 9,[452] that reasoning materially ignored (one of) the most significant drivers of uncertainty with rainfall forecasts, location of the rain. Otherwise, whatever the level of unreliability of the PME forecasts, if they forecast that amount of rain over four days, it meant that there was a strong chance that a large amount of rain would fall.

193 Three further points should be noted.

194 The first point concerns what forecast modelling would have revealed if it had been undertaken. I have already noted Mr Malone's concession, in relation to the 6 Jan 15:00 ROG run, that if forecast rain had eventuated then, at least on a no release basis, the predicted maximum height of Wivenhoe Dam would have exceeded EL 68.5m AHD. In fact, one of the Appendix A Model runs prepared by Mr Malone after the event was based on the data available at 6.00pm on 6 January 2011 and used forecast rain for a 24-hour period as predicted by the most recent QPF. This run used the same proposed gate opening sequences and times as the 6 Jan 21:00 ROG run. It yielded a peak

[448] Seqwater subs at [1359], [1366], [1377(g) and (h)].
[449] Chapter 3; section 3.3.4.
[450] SunWater subs at [1960].
[451] Chapter 3 at [247] to [251].
[452] Section 9.2.

level in Wivenhoe Dam of 68.93m AHD at 4.00pm on 8 January 2011 (with high rates of discharge thereafter).[453] The plaintiff correctly noted that, had the flood operations been operated based on those predictions and modelled releases, then W3 would have been engaged, as the proposed releases for Wivenhoe would have exceeded the naturally occurring peak at Lowood (invalidating W2).[454] In any event, I am satisfied that "with forecast" modelling of only 24-hour rainfall would have yielded a predicted height of Wivenhoe Dam of greater than EL 68.5m AHD if conducted on either a no release basis or the gate releases suggested by the 6 Jan 21:00 ROG run.

195 The second point concerns the significance of the primary objective of the applicable strategy to the decision to delay releases on 6 January 2011. As events transpired, gate operations did not commence until 3.00pm on 7 January 2011 when Wivenhoe Dam was at EL 68.03m AHD.[455] This was 32 hours after personnel commenced arriving in the FOC when Wivenhoe Dam was at EL 67.31m AHD (see [153]). This substantial delay in commencing releases and loss of flood storage space was solely attributable to a decision to allow naturally occurring downstream flows to inundate one bridge, Burtons Bridge, before commencing gate releases. Subject to the points raised next, that approach could not be justified if a flood engineer was operating in W3, even though it allows for consideration of lower level objectives.

196 In its submissions, SunWater referred to the potential for rain, on the afternoon of 6 January 2011, to "fall directly into the Lockyer Creek, Bremer River and Brisbane River"[456] and noted that a flood warning was issued at 5.25pm[457] that warned of heavy rainfall causing fast river rises in the Lockyer catchment and along the Bremer River.[458] However, nothing in those warnings or any other flood warnings suggested that the combination of

[453] Cf SunWater subs at [1965(b)].
[454] Plaintiff subs at [1158]; cf SunWater subs at [1965(d)].
[455] QLD.001.001.2409.
[456] SunWater subs at [1972(d)].
[457] SUN.002.001.2144.
[458] SunWater subs at [1973].

releases from Wivenhoe Dam and downstream flows would exceed the thresholds for non-damaging flows, which is the primary concern of W3, or that they could even exceed the inundation levels for Fernvale and Mt Crosby Weir Bridges.

197 The third point concerns the constraining effect, if any, of the statement in the Manual concerning peak outflow generally not exceeding peak inflow. Mr Malone agreed that the strategy of delaying releases recorded in his 14:54 situation report would cause Wivenhoe Dam to rise[459] and he proposed it knowing that there could be rainfall of 300mm or 400mm in the catchments. In cross-examination Mr Malone agreed that, if it was permissible to make releases on the rising limb of the hydrograph and to make releases below FSL, then the afternoon of 6 January 2011 would have been a "good time" to do so, "up to the [inundation] level of Fernvale and Mount Crosby … yes".[460] There was a debate in the submissions as to whether his agreement that it was a "good time" meant that he conceded it was necessary to do so.[461] It is not necessary to resolve the debate as I accept both premises of the question and that it was necessary to make the releases. In relation to the ability to make release on the rising limb of the hydrograph, as noted in Chapter 3, Mr Ayre and Mr Ickert accepted that the reference to peak inflow in the Manual's statement that generally peak outflows should not exceed peak inflows is a reference to the higher of the peak inflows to date and those predicted by rain on the ground of modelling.[462] Even if one accepts that view, which I do not, Mr Malone's modelling on the afternoon of 6 January 2011 predicted peak inflows of around 1280m^3/s on the morning of 7 January 2011, and the peak inflow during the Late December Flood Event was 2200m^3/s which provided considerable leeway for releases.[463] (In Chapters 9 and 10, I address, and largely accept the validity of Dr Christensen's forecast modelling which predicted a much higher peak.)

[459] T 5173.40.
[460] T 5174.10.
[461] Plaintiff subs at [1167]; Seqwater subs at [1172(g)]; [1174], [1331] to [1332]; SunWater subs at [1961].
[462] Chapter 3 at [273].
[463] Cf Seqwater subs at [1333].

Mr Ayre and the Use of Forecasts on 6 January 2011

198 In his affidavit, Mr Ayre stated that "releases on 6 January 2011 were consistent with Strategy W1" and that "Strategies W2/W3 would have been inappropriate, because Lake Wivenhoe was not predicted (with rain on the ground) to exceed EL 68.50m AHD". This statement falls short of asserting that on 6 January 2011 Mr Ayre was consciously operating in W1. Indeed, there were no releases made at all on 6 January 2011. However, I agree that the flood engineers' approach on 6 January 2011 of delaying all releases until Burtons Bridge was inundated was generally consistent with the primary objective of W1. Even though in his affidavit Mr Ayre referred to the absence of a prediction that the storage height would exceed EL 68.5m AHD, in cross-examination, he clarified that while the actual level remained below this height, neither W2 nor W3 could be invoked[464] I have already rejected that approach. Further, the no release operational runs undertaken at 3.00pm on 6 January 2011 did predict Wivenhoe Lake reaching EL 68.5m AHD and the different maximum heights predicted by the model runs undertaken thereafter were all a product of different release strategies for many days into the future. They only highlighted the difficulties with using a can release assumption in determining the applicable strategy.

199 Mr Ayre agreed that his 6 Jan 21:00 ROG run was prepared by reference to rain on the ground.[465] Like Mr Malone's 6 Jan 16:00 ROG run, it assumed that releases could be made during a period some days hence, despite the available forecasts suggesting substantial rain both downstream and possibly upstream. Subject to three matters the findings made above in relation to Mr Malone apply equally to Mr Ayre's approach.

200 First, Mr Ayre stated that the average time between rainfall falling and lake level responding, was "in the order of 12 to 15 hours"[466] which means that

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[464] T 7884.33.
[465] T 7703.16.
[466] LAY.SUN.001.0001 at [623].

predictions based on rain on the ground had a 12 to 15 hour lag time.[467] As a consequence, he identified the "forecast horizon" of the flood engineer was only "12 to 24 hours" and not beyond as otherwise might be implied by the GOS they prepared.[468]

201 Second, there is a debate about whether forecast rainfall played any part in the release strategy set out in Mr Ayre's 6 Jan 2100 ROG run and the subsequent gate operations spreadsheets that he prepared (or those prepared by the other flood engineers). Mr Ayre's approach to the use of forecasts is further addressed in Chapter 7 at [16] – [37]. As explained there, at one point in his cross-examination, Mr Ayre asserted that he adopted the practice of reducing the seven-day period of draindown to FSL of rain on the ground predicted inflows in order to leave a "buffer" for further forecast rain. However, for the reasons given in Chapter 7, I do not accept that Mr Ayre modelled and then set release plans with an intention to leave a "buffer" or window for further releases in the event that forecast rain fell.[469]

202 Third, there was a debate about whether Mr Ayre undertook any "with forecast" modelling on the evening of 6 January 2011.[470] In his affidavit Mr Malone stated that his "*usual practice* when modelling was to model a 'no forecast rain scenario' and a 'with 24 hour rain' scenario (based primarily on the 24 hour QPF)" but which also modelled the 72 hour SILO meteogram.[471] This statement was not challenged per se and there is evidence that some with forecast runs were undertaken during the January 2011 Flood Event. No such run was preserved for 6 January 2011 but its absence does not mean it did not exist. However, Mr Ayre was also asked about the 6 Jan 21:00 ROG run as follows:[472]

467 Ibid at [625].
468 Ayre 1, LAY.SUN.001.0001 at [646].
469 Chapter 7 at [36]
470 Plaintiff subs at [1164]; SunWater subs at [1994].
471 LAY.SUN.001.0001_OBJ at [644].
472 T 7703.12.

> "Q. So this proposed gate operations sequence, which increases releases up to about 1,225cumecs, was something that you worked on before there were *any with forecast RTFM runs; correct*?
>
> A. *Yes*, so the rain on ground was the basis of assessing the potential opening sequence, yes." (emphasis added)

203 Later in his evidence, Mr Ayre stated that he was "reasonably confident" that he undertook a "sensitivity run" using forecast rainfall taken from a QPF at around 9.00pm on 6 January 2011.[473] This arose in the context of Senior Counsel for the Plaintiff returning to (closely) scrutinise Mr Ayre's assertion that he utilised a buffer for forecast rainfall when modelling and then setting gate releases during the January 2011 Flood Event. As stated, I do not accept that part of Mr Ayre's evidence and I prefer the concession made in the above extract to his later assertion of undertaking a "sensitivity run". While I do not exclude the possibility that Mr Ayre may have undertaken a with forecast model run at some stage on his overnight shift beginning on the evening of 6 January 2011, I am satisfied that he did not undertake any such modelling before preparing his 6 Jan 21:00 ROG run.[474]

Mr Malone's Inflow Analysis

204 In his first affidavit, Mr Malone noted that at 6.31am on 6 January 2011 the storage level of Wivenhoe Dam was EL 67.31m AHD with around 882,000ML of extra storage space before the storage level reached EL 74.0m AHD. He said that that was equivalent to 156mm of excess rainfall before any consideration of the ability to make releases in the meantime. He denied that, in those circumstances, there was a significant risk of insufficient flood storage space unless releases were immediately commenced such that releases at a level that would cause urban flooding would become necessary.[475] He stated that risk only becomes "real and quantifiable once the rain is actually on the ground".[476]

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[473] T 7706.45.
[474] cf Seqwater subs at [1168].
[475] Malone 1, LAY.SEQ.007.0001 at .0166 to .0167, [588] to [590].
[476] Ibid at [590].

205 Four points should be noted. First, Mr Malone's own assessment of the five individual 1200UTC PMEs and the eight-day PME on the morning of 6 January 2011, together with his assessment of the catchment's wetness, demonstrates that there was more than a realistic possibility of receiving 156mm of excess rain in the ensuing days. The potential location of higher amounts of rainfall suggested that the ability of the flood engineers to release the inflows in the coming days could be inhibited.

206 Second, nothing in this analysis justifies the approach taken by the flood engineers on 6 January 2011. As noted, they decided to delay releases until the following afternoon, by which time the flood storage capacity would be (and was) further compromised. Both the 6 Jan 16:00 ROG run and the 6 Jan 21:00 ROG run, modelled no releases until the storage level of Wivenhoe Dam had risen above EL 68.1m AHD.

207 Third, an assessment of risk in this context must take into account the exponential increase in property damage once Moggill flows exceed 4000m^3/s. A risk with a low mathematical probability can be still be serious if the potential consequences of it materialising are widespread devastation. Otherwise, a risk does not have to be "quantifiable" to be either "real" or "significant". Further, contrary to Mr Malone's assertion, once rain in sufficient quantities is "actually on the ground" there is no longer a "risk" of urban damage but an inevitability of such damage if sufficient storage space is not available.

208 Fourth, consistent with the analysis for previous days, an assessment of the likelihood or potential for that amount of rain being received can be undertaken by reference to the catchment response during the Late December Flood Event. Using Mr Malone's assessment of 77% of rain becoming runoff, and Dr Christensen's estimate of rain on the ground inflows as at midnight on 6 January 2011,[477] then further rainfall of approximately

[477] 79,000ML; Chapter 9 at [235]; Table 9-6.

185mm could have produced the requisite runoff.[478] Using Dr Christensen's estimate of the runoff response during the Late December Flood Event, then further rainfall of 165mm could have produced the requisite runoff.[479] Rainfall in those amounts was (much) more than reasonably possible given the state of the forecasts.

Conclusion

209 During the morning of 6 January 2011, there was an expectation that gate operations at Wivenhoe would commence in the early evening, but that was put back significantly when rain fell in the Lockyer Valley. Both Mr Malone and Mr Ayre modelled rain on the ground inflows upstream and downstream of Wivenhoe Dam and only modelled making releases after Burtons Bridge was inundated. In each of the model runs, those proposed gate openings did not commence until at least 24 hours after the model run was conducted. In each of the model runs, the period of significant releases generally coincided with the period wherein Mr Malone's assessment of the weather forecasts suggested that there would be significant rainfall, this being more intensive downstream but also capable of falling upstream as well.

210 In none of the contemporaneous documents did the flood engineers identify the relevant Manual strategy that was engaged. The only consideration adverted to in the materials was the potential inundation of Burtons Bridge, that being consistent with W1B.

211 Mr Malone did not undertake "with forecast" modelling on 6 January 2011 and Mr Ayre did not do so prior to preparing his 6 Jan 21:00 ROG run. It follows that no initial assessment of the flood event was undertaken in accordance with section 8.3. Further, assuming that either Mr Malone or Mr Ayre did advert to a strategy, they certainly did not do so based on predicted dam heights, much less predictions based on modelling using forecasts. If such an assessment had been undertaken with a no release assumption, as the

[478] (5673 x 156 – 79000) / (5673 x .77).
[479] (5673 x 156 – 79000) / (5673 x .86).

Manual required, then it would have yielded the selection of Strategy W3 (and S2) regardless of which forecast product was used. In turn, this would have directed the flood engineers to prioritise urban protection over the maintenance of keeping rural bridges open. If that priority was considered, it is difficult to see how a flood engineer could have chosen to delay making releases to avoid the premature inundation of one bridge with the consequence that larger releases would then be required at a time when there was a realistic possibility that they would coincide with downstream flows to cause, or threaten to cause, urban damage.

212 Instead, despite an already wet catchment and significant rain forecasts for the next 24 hours and following, a decision was made not to open gates until well into 7 January 2011. That decision was based on rain on the ground modelling and involved two important assumptions about future rainfall. The first was that the water stored could be released in the manner which was modelled without combining with downstream flows to risk causing downstream damage. The second was that there would be no further rainfall at times and in amounts that would require making potentially damaging releases because of the lost flood storage capacity resulting from the closed gates. In light of all the forecasts that were available on 6 January 2011, both of those assumptions were dubious and involved an unjustified assumption of risk.

6.12: Friday, 7 January 2011

213 According to the plaintiff, the one day PME available at 6.00pm on 6 January 2011 for the 24 hour period to 10.00pm on 7 January 2011 predicted rain in the 15mm to 20mm range,[480] whereas the State placed it in the 15mm to 50mm range both above and below the dam.[481] A visual inspection of the forecast supports the State's interpretation.[482] The plaintiff contended that the four-day PME, which was available from midnight, predicted rain in the 50mm

480 AID.500.022.0001.
481 SEQ.013.004.1291; AID.500.035.0001 at .0003.
482 EXP.SEQ.011.0219 at .0361.

to 150mm range for the period 10.00pm on 6 January 2011 to 10.00pm on 10 January 2011,[483] whereas the State contended that it was in the 25mm to 150mm range above the dam and the 50mm to 200mm range below the dam.[484] The plaintiff contended that the eight-day PME predicted rain in the 75mm to 200mm range for the period 10.00pm on 6 January 2011 to 10.00pm on 14 January 2011,[485] whereas the State contended that it predicted between 50mm to 200mm of rain above the dam and between 100mm to 300mm below the dam.[486]

214 The morning QPF issued shortly after 10.00am, predicted between 20mm to 30mm of rain for the 24 hours until 10.00am on 8 January 2011.[487] The 4.00pm QPF forecast had the same prediction for the 24 hours to 4.00pm on 8 January 2011, although rain had been falling in the meantime.[488] The BoM issued severe weather warnings throughout the day for the Wide Bay and Burnett areas to the north east of Wivenhoe Dam as well as the south east coast of Queensland continuously throughout 7 January 2011.[489]

215 As rain continued to fall on 7 January 2011, the BoM continued to issue flood warnings for the catchments above and below the dams. The flood warning issued at 7.28am for the Brisbane River above Wivenhoe Dam noted that 50mm to 70mm of rain had fallen over the catchment on the previous day. It stated that, while flooding levels in the tributaries were easing, they may rise if forecast rain fell.[490] This warning was apt because the update that was issued just after 5.00pm noted that there had been further rainfall of between 20mm and 40mm in the upper Brisbane catchment since 9.00am, leading to renewed rises and "minor to moderate flooding".[491]

[483] AID.500.022.0001.
[484] SEQ.013.004.1301; AID.500.035.0001 at .0003.
[485] AID.500.022.0001.
[486] SEQ.013.004.1302; AID.500.035.0001 at .0003.
[487] SEQ.001.019.6886; QLD.001.001.2345.
[488] QLD.001.001.2389
[489] 5.25am – QLD.002.002.1896; 8.26am - SEQ.001.018.8599; 11.25am - QLD.002.002.1883; 3.33pm – QLD.002.002.1875; at 11.50pm – QLD.002.002.1861
[490] QLD.002.002.1891
[491] QLD.002.002.1867

216 The flood warning issued just before 7.15am for the Lockyer and Warrill Creeks and the Bremer River noted that 40mm to 70mm of rain had fallen since 9.00am the previous day and that, while it had eased, further rainfall was expected that day.[492] The update issued at 4.24pm noted that rainfall in these catchments had continued to ease, with less than 7mm recorded in the previous three hours, but noted that minor to moderate downstream flooding continued.[493]

Balance of Mr Ayre's Shift

217 In his (lengthy) affidavits, Mr Ayre does not suggest that he undertook any further modelling in his overnight shift after the runs undertaken at 9.00pm on 6 January 2011, although I have not excluded the possibility that at some stage he undertook a "with forecast" sensitivity run. An Appendix A run undertaken using the available data at 2.00am on 7 January 2011 and the 24-hour forecast rainfall from the most recent QPF and then planned gate operations, predicted the Wivenhoe Dam level would rise to EL 68.75m AHD.[494] Otherwise, the January FER suggests that there was a change in strategy from W1A to W1B at 2.00am on 7 January 2011.[495] I address the evidence concerning the preparation of the January FER below. It suffices to state that this entry only reflects the fact that by that time Wivenhoe Dam had reached EL 67.52m AHD. It does not reflect any conscious decision or change in approach by the flood engineers.

218 Significant inflows were observed at Wivenhoe Dam from midnight until 6.00am when Mr Ayre issued a situation report. At that time, up to 1342m^3/s was flowing into Wivenhoe Dam. Despite this, there were still no releases from the dam other than 50m^3/s from the regulator.[496] Mr Ayre said that at 6.00am he reviewed the ACCESS forecast available from midnight "and noticed that the four and five-day forecasts showed estimates of rainfall

[492] QLD.002.002.1893
[493] QLD.002.002.1869
[494] Gate Operations Spreadsheet 02:00 "*with forecast*" Appendix A Model Run (Model Run 5), QLD.001.001.2313 (Gate Operations tab, line 156); 2011 Flood Report, SUN.016.001.0280 at .0527.
[495] SUN.016.001.0280 at .0482.
[496] Simulation Analysis, EXP.ROD.015.0461 at .0468.

between 100 to 200mm" and that "this was the first indication of an escalation of forecast rainfall, which had not been apparent in earlier forecasts".[497]

219 In his situation report issued just after 6.00am, Mr Ayre noted the rainfall above and below the dam. He advised that the "forecast for the next five days is for totals between 100 and 200mm in [South East Queensland]" and that "[g]iven the saturated condition of the catchments further runoff will likely to be generated from this rainfall".[498] He noted that Wivenhoe Dam was at EL 67.64m AHD "and rising slowly", that a "peak of about 470[m^3/s] [was] expected from Lockyer Creek by mid-afternoon" which could inundate Burtons Bridge and that gate releases would commence after the impact of flows from Lockyer Creek on Burtons Bridge was known and the flood levels in the lower Lockyer Creek subsided.[499] He also noted that Somerset Dam was at EL 99.59m AHD "and rising slowly". He stated that "[i]t is proposed that Wivenhoe releases [would] commence late Friday/early Saturday and may be as high as 1200[m^3/s]". The situation report provided "estimated event inflow volume[s]" for each of Somerset and Wivenhoe Dams which appear to be based on inflows commencing 9.00am on 2 January 2011.

Mr Malone's Shift

220 Mr Malone signed on at 6.45am and Mr Ayre signed off at 7.00am.[500] In his affidavit, Mr Ayre says that at his handover with Mr Malone he discussed the timing of the inundation of Burtons Bridge by natural downstream flows and stated that it was decided "on that basis, Mr Malone would proceed with Wivenhoe Dam gate openings after that peak had passed from Lockyer Creek".[501] Mr Ayre said that he passed on his estimate of forecast rainfall of between 100mm to 200mm over the next five days.[502]

[497] Ayre 1, LAY.SUN.001.0001 at [1906].
[498] QLD.001.001.2319.
[499] Ibid at.2320; see also TSR issued at 7am – SEQ.001.011.5014.
[500] SUN.002.005.0002 at .0003.
[501] LAY.SUN.001.0001_OBJ at [1912].
[502] Id.

221 In his affidavit, Mr Malone provides a breakdown of the daily 1200UTC PMEs available from 6.00am that morning:[503]

Day and Date	Forecast
Friday, 7 January	Highest falls up to 200mm centred around Bundaberg
Saturday, 8 January	Highest falls were up to 100mm centred off Fraser Island
Sunday, 9 January	Highest falls up to 100mm centred around southern parts of South East Queensland
Monday, 10 January	Highest falls up to 100mm centred around the coastal areas of South East Queensland
Tuesday, 11 January	Highest falls were up to 100mm centred on the Sunshine Coast

Table 6-5: Mr Malone's breakdown of 7 January 2011 1200 UTC PMEs

222 Mr Malone said that the four and eight-day PMEs "still showed a bullseye in South East Queensland but clearly indicated that the highest totals were going to be very coastal". He said that this "indicated to me that while there was still the possibility of significant inflows to the dams in the coming days, the highest rainfalls were still likely to be downstream of Wivenhoe Dam".[504]

223 Three points should be noted about this. First, this analysis shows that the overall rainfall outlook for South East Queensland was continuing to deteriorate. The daily figures set out above cumulate to rainfall totals of up to 600mm of rain.

224 Second, Mr Malone's analysis of the location of where the rain was predicted by the PMEs to fall within South East Queensland fixes upon one of the most uncertain factors in rainfall prediction, namely the location of the rainfall.

225 Third, in an email to the flood engineers sent just after 8.00am on 7 January 2011,[505] Mr Malone stated that significant volumes of inflows to the dams "will be generated" as opposed there being a "possibility of significant inflows". Mr

[503] Malone 1, LAY.SEQ.007.0001 at [615].
[504] Ibid at [618].
[505] QLD.001.001.2330.

Malone's contemporaneous email is the best evidence of his expectation of inflows. It is to be preferred.

226 The Event Log records that at 8.00am advice was received from the BoM that stated that South East Queensland "can expect some high rainfall totals over the next 5 days up to Tuesday[506] with the largest falls predicted for Sunday and Monday".[507] Mr Malone sent Seqwater staff the email just noted. It was entitled "[o]perating strategy over the next week"[508] shortly afterwards. The email broke down the five day forecast as follows.

> "Advice from BoM indicates that SE Qld can expect some high rainfall totals over the next 5 days.
>
> Friday: Rain at times 15-50mm with higher falls along the coast
> Saturday: Rain light at times 15-50mm with higher falls along the coast
> Sunday: Widespread rain with totals between 50-100mm
> Monday: Widespread rain again with totals between 50-100mm
> Tuesday: Rain easing with totals between 25-50mm
>
> Given the saturated conditions of the dam catchments, *significant volumes of inflows to our dams will be generated*.
>
> On this basis, the operating strategy for Somerset, Wivenhoe and North Pine needs to consider the current state of the storages and the project[ed] inflows." (emphasis added)

227 Mr Malone also advised that it was "intended to ramp up the release from Wivenhoe to about 1,200m^3/s later today" but warned that "given the *high likelihood* of significant inflows in the next week, this may be increased to 1,500m^3/s in order to drain the current temporarily stored flood waters as soon as possible."

228 However, later that morning he emailed the flood engineers to advise that releases would commence at 3.00pm but "would only be slowly increased to about 1,200m^3/s by 1400 Saturday" and then "held around this level until Sunday morning at which time the release strategy will be reviewed and be

[506] 11 January 2011.
[507] QLD.002.001.8660.
[508] QLD.001.001.2330; SEQ.211.003.5402.

dependent upon further rainfall".[509] To that end, a directive was issued at midday requiring gradual gate openings at Wivenhoe Dam up until 9.30pm that evening when the release rate would reach 400m^3/s.[510]

229 There was a debate in the submissions as to whether Mr Malone expected that the rainfall described in his email was likely to fall upstream of the dams.[511] In his affidavit, Mr Malone stated that he "would have taken the forecast figures[512] from the South East Coast District Forecast on the BoM's website".[513] Seqwater submitted that those figures were for "SE Qld" which it described as a "vast area, much of which is outside the dam catchments".[514] However, the relevant point is that the dams are in "SE Qld". The above email clearly conveys Mr Malone's understanding that the forecasts were predicting between 155mm and 350mm of rain over five days for an area that *included* the dam catchments, with higher falls expected in coastal areas on the first two of the five days listed. It was the forecast rainfall in "SE Qld" that suggested "significant volumes of inflow to our dams will be generated" and warranted his warning of a "high likelihood of significant inflows" in the next week". As for the coastal areas, his breakdown of the 1200UTC PMEs, as set out above, totals falls of up to 600mm for the following days. It follows from what I have stated that these forecasts carried an appreciable risk of substantial rain falling above the catchments (and in the downstream catchments).

230 In his affidavit, Mr Malone asserted that "there was nothing in the current inflow information and forecast rainfall information that suggested that current and projected inflows would exceed the volume available for temporary flood storage".[515] Later in his affidavit he stated that the available flood storage to EL 74.0m AHD at 5.00pm on 7 January 2011 was the equivalent of 140mm of

[509] QLD.001.001.2356; SEQ.001.018.4136.
[510] QLD.002.001.3160.
[511] Seqwater subs at [1403] to [1407]; Plaintiff subs at [1180]; SunWater subs at [2024].
[512] In the email set out at [226].
[513] LAY.SEQ.007.0001 at [621].
[514] Seqwater subs at [1405(a)].
[515] LAY.SEQ.007.0001 at [623].

excess rainfall.[516] I address these calculations at [265]. At this point, the position can be considered at the commencement of Mr Malone's shift. As at 8.00am on 7 January 2011, Wivenhoe Dam was at EL 67.71m and Somerset Dam was at EL 99.63m AHD[517] with substantial rain on the ground inflows expected. In cross-examination, Mr Malone accepted that the best available information at that time was that the largest falls were expected on Sunday, 9 January, and Monday, 10 January.[518] He also accepted that, if those forecasts came to pass, it might not be possible for Wivenhoe Dam to make releases on those days without combined flows at Moggill exceeding 4,000m^3/s.[519] If the forecast rain materialised, then there was real risk of it having to be stored and pushing Wivenhoe Dam above EL 74.0m AHD or releasing it and risking urban flooding in combination with downstream flows.

231 An operational spreadsheet derived from a model run using rain on the ground undertaken by Mr Malone at around midday on 7 January 2011 was saved (the "7 Jan 12:00 ROG run").[520] Consistent with Mr Malone's emails, the gate operations spreadsheet referable to this run modelled gate openings commencing at 3.00pm that day and releases reaching around 1200m^3/s the following afternoon with 24 increments open. Those increments were to be maintained until midday (12.00pm) on 9 January 2011 before gates would start to close, with final closure at midday (12.00pm) on 10 January 2011 with the dam at EL 67.44m AHD. Thus, the gate operations were similar to those set out in Mr Ayre's 6 Jan 21:00 ROG run, although they commenced eight hours earlier. This run predicted that the natural peaks at Lowood and Moggill would occur that evening, a maximum height of Wivenhoe Dam of EL 68.32m AHD at 4.00am on 8 January 2011 and a maximum flow rate at Moggill of 1615m^3/s at 2.00pm on 8 January 2011.

[516] Ibid at .0180, [636(b)].
[517] Simulation Analysis, EXP.ROD.015.0461 at .0468 and .0478.
[518] T 5185.27.
[519] T 5186.9.
[520] QLD.001.001.2357; SDWD-201101071200.xls.

232 As foreshadowed, the first gate opening took place at 3.00pm[521] (and Burtons Bridge was closed around that time[522]). Gates were opened by one increment and then by one increment an hour thereafter. A few minutes later, a Brisbane City Council officer contacted the FOC to express a concern that a flow rate of 1500m^3/s in the lower Brisbane river would increase the anticipated water level by 200mm in the city area, having regard to abnormally high tides. Mr Malone contacted the BoM and advised the Council that that it would only add around 50mm to the river levels.[523]

233 Mr Malone distributed a situation report just before 6.00pm.[524] He advised that since 9.00am there had "been widespread 20 to 40mm [of rainfall] throughout North Pine, Somerset and Wivenhoe catchments with isolated higher totals of 70mm in the upper reaches of the Brisbane River". He repeated the forecasts for the following four days set out in his email sent at 8.00am that morning which totalled between 140mm and 300mm (and between 115mm and 250mm over the following three days). He again stated that "[g]iven the saturated conditions of the catchments, significant inflows to Seqwater dams *will be generated*, especially following the forecast rainfall on Sunday/Monday".

234 The situation report also noted that Somerset Dam was at EL 100.04m AHD and a regulator was "open 100%" (although it was expected to be closed). It stated that Wivenhoe Dam was at EL 68.10m AHD and currently releasing 168m^3/s. it also stated that the intention remained to increase the Wivenhoe release rate to 1200m^3/s over the following eighteen hours which would inundate all the downstream bridges other than Mt Crosby Weir and Fernvale. The report then stated:[525]

> "However, given the high likelihood of significant inflows in the next week, this [ie, the release rate of 1200m^3/s] may be increased later on the weekend. Since the commencement of the event on 02/01/2011, approximately

[521] QLD.002.001.3151.
[522] Ayre 1, LAY.SUN.001.0001_OBJ at [1940].
[523] QLD.002.001.8660; QLD.001.001.2386.
[524] QLD.001.001.2406.
[525] QLD.001.001.2406 at 2407.

> 140,000ML has flowed into Wivenhoe Dam with a further 160,000ML expected (including Somerset release) based on the recorded rainfall to date. Approximately 24,000ML has been released from Wivenhoe via the hydro and regulator at about 50m^3/s."

235 The 160,000ML referred to in this extract was a rain on the ground estimate.[526] The plaintiff (correctly) noted that these figures total 300,000ML, that the Late December Flood Event involved 450,000ML of runoff derived from 85mm of rain while further rain of up to 300mm was forecast and that Mr Malone was aware of those figures.[527] Mr Malone stated the increase in releases referred to in this extract would not occur until there was rain on the ground ("until we were reasonably confident, yes").[528]

236 The situation report also summarised the effect of the discussions with the Brisbane City Council and the BoM that combined flow in the Brisbane River would only add 50mm to 100mm in the water levels near the city, although the lower river would already be "0.4 to 0.5 metres higher than predicted tides". The situation report referred to the "commencement of the event on 02/01/2011". Shortly after issuing the situation report, Mr Malone issued a directive to the Somerset Dam gate operators instructing them to close the regulator and open a sluice gate.[529]

237 A rain on the ground model run resulted in the production and saving of an operational spreadsheet bearing the code SDWD-201101071800.xls, suggesting that it was undertaken at around 6.00pm on 7 January 2011 (the "7 Jan 18:00 ROG run").[530] One material difference between this run and the 7 Jan 12:00 ROG run was that inflow volumes increased from 219,856ML to 286,542ML, which meant that the use of the same gate releases lead to a forecast maximum height of Wivenhoe Dam of 68.51m AHD at 2.00pm on 8 January 2018. This model run predicted that the naturally occurring peaks

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[526] T 5203.11.
[527] T 5203.23 - .37; Plaintiff subs at [1200].
[528] T 5202.40.
[529] LAY.SEQ.007.0001 at .0178, [630].
[530] SDWD-201101071800.xls; QLD.001.001.2409.

at Lowood and Moggill had passed but that, with Wivenhoe Dam releases, Moggill would peak at 1641m^3/s at 2.00pm on 8 January 2011.

238 The proposed gate settings in this run were similar to those set out in Mr Malone's 7 Jan 12:00 ROG run; ie, continuing gate openings to 24 increments and releasing around 1200m^3/s from 2.00pm on 8 January 2011. However, this level of increments was now extended between midday on 9 January 2011 until midnight on 11 January 2011, which was 36 hours longer than in the 7 Jan 12:00 ROG run and which coincided with the period when the heaviest rainfall was predicted to occur.

239 This model run contains gauge readings until 7.00am the following morning. Seqwater submitted that it is "likely that this version of the model run was done at or after 0700 on 8 January and not by Mr Malone" who finished at 7.00pm on 7 January 2011. It contended that this accorded with Mr Malone's evidence to the effect that when he left the FOC on 7 January, he "did not expect Lake Wivenhoe to reach EL 68.5m".[531] This is a surprising submission given that, in his affidavit, Mr Malone agreed that he produced the gate operations spreadsheet.[532] Instead, Mr Malone queried whether the spreadsheet may have been altered after he finished the shift to yield the predicted height of EL 68.51m AHD.[533] I do not accept that, but in any event, given the conclusion in [257], it does not matter.

Mr Ruffini's Shift

240 Mr Ruffini signed on for his first shift as the DFOE at 6.45pm and Mr Malone signed off at 7.00pm.[534]

241 It is necessary to note the forecast information available to Mr Ruffini at the time his shift commenced. As noted, the 4.00pm QPF predicted 20mm to 30mm of rain for the 24 hours to 4.00pm on Saturday 8 January 2011. He

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[531] Seqwater subs at [1417] citing Malone 1, LAY.SEQ.007.0001 at [639(c)].
[532] LAY.SEQ.007.0001 at [639(a)]; see also [653].
[533] Ibid at [639(c)]; T 5204.45.
[534] SUN.002.005.0002 at .0003.

inherited a situation report from Mr Malone that recited forecasts predicting between 115mm and 250mm of rain over the following three days and between 140mm and 300mm over the following four days.[535]

242 At 6.00pm, the one-day 00UTC PMEs for the following five days became available. According to the plaintiff, the PME for the 24-hour period to 10.00pm on 8 January 2011 predicted rainfall of between 10mm to 50mm,[536] whereas according to the State, it predicted between 1mm to 25mm above the dam and between 5mm to 50mm below the dam.[537] The one-day PME for 9 January 2011 appeared to predict rainfall across the catchments above and below the dams of between 25mm and 150mm or 200mm.[538] The PME for Monday 10 January 2011 appeared to predict rainfall of between 25mm and 100mm across the same area.[539] According to the plaintiff, the four-day PME available from midnight which reflected the one-day PMEs, predicted rainfall of between 100mm to 300mm.[540] According to the State, it predicted between 50mm to 300mm above the dam and between 100mm to 400mm below the dam.[541]

243 As an indication of the amount of rain predicted by the one-day PMEs available from 6.00pm, in his first and third reports, Mr Giles broke down the daily PMEs which were available to Mr Ruffini at 6.00pm on 7 January 2011 into predicted rainfall figures for each of the above dam and below dam sub-catchments in the RTFM.[542] For the five upper Brisbane sub-catchments, the three-day figures ranged from between 74mm and 111mm, while the Wivenhoe catchment figure was 152mm and the Somerset catchment figure was 154.5mm.[543] The four-day totals from the individual PMEs for WDI and SDI were 197 and 196.5mm respectively. The total predicted rainall

[535] QLD.002.001.3151.
[536] AID.500.022.0001.
[537] AID.500.035.0001; SEQ.013.004.1304.
[538] EXP.QLD.001.0611 at .0748 (Giles).
[539] Ibid at.0749 (Giles).
[540] AID.500.022.0001.
[541] AID.500.035.0001 at .0003.
[542] Giles 1: EXP.QLD.001.0611 at .0791 (table C4); Giles 3: EXP.QLD.001.1359 at 1405 (table 4-1).
[543] Calculated by adding the three daily figures for 8/01, 9/01 and 10/01 on EXP.QLD.001.0611 at .0791.

calculated by Mr Giles from the four-day PME for WDI and SDI were 210mm each.[544] The three daily totals for the downstream catchments totalled between 108.5mm and 170mm for the Lockyer Creek sub-catchments, 188mm and 240mm for the Bremer sub-catchments and between 207mm and 248mm for the Lower Brisbane sub-catchments.[545]

244 Similarly, Professor Manton broke down the rain predicted by the four-day PME available from midnight, which reflected the combined effect of the individual PMEs. Professor Manton attributed 156mm of rain to the catchments above the dams, 163mm to the Lockyer catchment, 215mm to the Bremer catchment and 339mm to the Lower Brisbane catchment.[546]

245 During the evening, Mr Ruffini was clearly considering the rainfall forecasts for the forthcoming days. At 9.14pm, he emailed another Seqwater employee and noted that there are "[s]ome fairly interesting rainfall totals being predicted for Sunday [9 January 2011]".[547] At 9.45pm, Mr Ruffini issued "Wivenhoe Directive 2", requiring Wivenhoe to be opened a further seven increments at a rate of one per hour commencing at 10.00am.[548] These were consistent with the gate increments set out in the gate operation spreadsheet for the 7 Jan 18:00 ROG run.

246 Tendered in evidence were screenshots of the inputs for an RTFM run that was conducted that bore the time 10.00pm and included forecast rainfall over a 72-hour time period, indicating that an RTFM run using predicted rainfall over a 72-hour period was undertaken at that time.[549] No gate operations spreadsheet referable to the run was saved. However, sometime *after* the

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[544] EXP.QLD.001.1359 at .1405.
[545] EXP.QLD.001.0611 at .0791.
[546] AID.500.026.0001.
[547] QLD.008.001.0415.
[548] SEQ.004.024.0289.
[549] MSC.010.354.0001; Dr Christensen saw evidence of the run being conducted: EXP.ROD.002.0001 at [67].

January 2011 Flood Event, Mr Ruffini recreated a spreadsheet based on the RTFM run parameters ("the Ruffini 7 Jan 22:00 72-hour run").[550]

247 The Ruffini 7 Jan 22:00 72-hour run utilised the same gate operations as the 7 Jan 18:00 ROG run and yielded an initial peak height for Wivenhoe Dam of EL 68.9m AHD at 9.00pm on 8 January 2011, followed by a reduction in the level in Wivenhoe Dam to EL 68.6m AHD at 3.00am on 10 January 2011, before the dam rose again with reduced and then no gate operations, leading to a second peak of EL 69.8m AHD on 23 January 2011. The peak outflow was around 1200m^3/s on the afternoon of 8 January 2011, with the natural peaks of the Bremer River and Lockyer Creek having (already) occurred in the afternoon and evening of 7 January 2011 respectively.

248 The competency of this run was much in contest and is addressed next. It suffices to note that I am satisfied that, on the information available at the time it was said to be conducted, Mr Ruffini's 7 Jan 22:00 72-hour run yielded a serious underestimate of the likely inflows into Wivenhoe Dam from existing rainfall and rain forecast to fall over the following 72 hours.

249 Otherwise, two matters should be noted about the recreated gate operations spreadsheet. First, it clearly showed Wivenhoe Dam exceeding EL 68.5m AHD, which was sufficient to engage W3 at least, yet there was no change to flood operations on the evening of 7 January 2011 (or during the next days) to reflect that. In any event, Mr Ruffini inherited the 7 Jan 18:00 ROG run which showed a predicted height above EL 68.5. The likelihood of that storage level being exceeded was overwhelming given the height of Wivenhoe Dam, the rainfall to date and the forecasts they had received.

250 Second, as noted, the model run produced a second peak occurring on 23 January 2011. Thus, it suggested that a revision to the proposed gate operations was warranted, being either an increase in releases or an extension of releases beyond the morning of 11 January 2011.

[550] QLD.008.001.0416; see also MSC.010.304.0001; see Giles 2, EXP.QLD.001.1359 at .1414.

251 In its submissions, the State responded to criticisms of the gate operations modelled in the recreated gate operations spreadsheet by noting that a gate operating spreadsheet was “not exported at the time” the run was undertaken and in fact was not “generated at the time the modelling was done”.[551] However, the State also made submissions about the “modelled result” of Mr Ruffini’s RTFM run.[552] In any event, the submissions seek to prove too much. Mr Ruffini did not give evidence. If no gate operations spreadsheet was created, and if the recreated gate operations spreadsheet is not indicative of what he ascertained when he undertook an RTFM run on the evening of 7 January 2011, then I am not left with any information to gauge what Mr Ruffini might have learnt about the predicted height of Wivenhoe Dam, likely inflows and likely downstream flows other than the forecasts themselves. In any event, I am not prepared to draw any inference that the RTFM run that underlay the Ruffini 7 Jan 22:00 72-hour run provided him with any relevant information other than a predicted storage level that exceeded EL 68.5m based on the existing planned releases which he continued.

252 Mr Malone’s “Observed Rainfall Analysis” report records catchment averages of 28mm, 24mm and 25mm of rainfall for the 24 hours to 9.00am on Saturday, 8 January 2011 for the Somerset, Upper Brisbane and Middle Brisbane catchments respectively.[553] Dr Christensen determined actual rainfall on 7 January 2011 upstream of Wivenhoe Dam to be 28mm.[554] Mr Malone’s “Observed Rainfall Analysis” report records catchment average rainfall in the 24 hours to 9.00am on 8 January 2011 in the Lockyer, Bremer and Lower Brisbane catchments of 14mm, 12mm and 10mm respectively.

253 Despite the declaration of a flood event more than 24 hours previously, gate releases from Wivenhoe Dam did not commence until 3.00pm. By midnight, 509m^3/s was being released from Wivenhoe Dam and 206m^3/s was being released from Somerset Dam, although further gate openings at Wivenhoe

[551] State subs at [184] to [185].
[552] Ibid at [182].
[553] SEQ.004.046.0230 at .0272.
[554] EXP.ROD.001.0583 at .0680.

Dam were planned. At midnight, Wivenhoe Dam was at EL 68.32m AHD and Somerset Dam was at EL 100.31m AHD.[555] Three gates at Wivenhoe Dam were open to a total of 10 increments.[556] At 7.00pm, one sluice gate at Somerset Dam was opened and it remained open at midnight.[557] Thus, sluice gates were opened at Somerset Dam while Wivenhoe Dam levels were rising and Somerset Dam levels were below EL 100.45m AHD.[558] The gate opening sequences to this time were completely consistent with what was modelled in the 7 Jan 12:00 ROG run and the 7 Jan 18:00 ROG run. Burtons Bridge had been closed since 3.00pm.

254 By contrast, in Dr Christensen's Simulation A, releases would have continued at rates of between 1100m^3/s and 1200m^3/s throughout 7 January 2011 and all downstream bridges other than Fernvale and Mt Crosby Weir would have continued to be inundated.[559] Under Simulation A, by midnight on 8 January 2011 Wivenhoe Dam would have been at EL 63.39m AHD.[560]

Conclusions

255 The plaintiff contended that during 7 January 2011 the flood engineers maintained the "wait and see" strategy formulated by Mr Malone and Mr Ayre on 6 January 2011, namely they delayed making releases until the modest peak from Lockyer Creek passed and modelled releasing water after that peak during the period of 8 to 11 January 2011, notwithstanding the forecasts of heavy rain in that period. To the extent that operated in any Wivenhoe strategy, it was W1 and definitely not W3. The plaintiff submitted that, until the evening of 7 January 2011, no forecast modelling had been undertaken, but if it had been it would have demonstrated what was otherwise obvious, namely, that the predicted peak of Wivenhoe Dam would exceed EL 68.5m

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555 QLD.001.001.2433; QLD.001.001.2434; Simulation Analysis, EXP.ROD.015.0461 at .0469 and .0479.
556 SUN.016.001.0280 at .0450.
557 January FER at .0464.
558 See Manual at 40.
559 Simulation Analysis, EXP.ROD.015.0461 at .0468 to .0469.
560 Ibid at .0469.

AHD, that W3 should have been adopted and flow rates should have been increased.[561]

256 These contentions should be accepted save that, given that the operational run spreadsheets were overwritten, the possibility that “with forecast” modelling may have been undertaken prior to 10.00pm on 7 January 2011 cannot be excluded. Leaving that aside, the available material either did demonstrate, or should have demonstrated, to each of Messrs Ayre, Malone and Ruffini the strong likelihood, bordering on certainty as the day progressed, that the storage level of Wivenhoe Dam would exceed EL 68.5m AHD. The 6 Jan 21:00 ROG run and the 7 Jan 12:00 ROG run predicted dam peaks of EL 68.24m and 68.32m AHD with no further rain. As recognised by Mr Malone’s email of 8.00am, the predicted rainfall meant that “significant volumes will be generated”. By 6.00pm, the 7 Jan 18:00 ROG run predicted a storage level above EL 68.5m AHD with no further rain and, at the very least, the forecasts were not improving. The position only becomes stronger if releases are excluded.

257 Seqwater’s submissions maintained their consistent theme that no submission to the effect that a transition to W3 was required should be countenanced in the absence of that position being expressly put to Mr Malone in cross-examination.[562] However, Mr Malone addressed that very suggestion in his affidavit. He denied that he was required to do so when the rain on the ground predictions in the 7 Jan 12:00 ROG run predicted a storage level in Wivenhoe Dam of less than EL 68.5m AHD and, as noted, queried whether the form of the 7 Jan 18:00 ROG run that he prepared predicted a storage level in excess of that.[563] Thus, Mr Malone was on notice of the allegation and addressed it by stating that, at least up until 6.00pm on 7 January 2011, rain on the ground modelling suggested that the Wivenhoe Dam storage level would not exceed EL 68.5m and that he doubted that he saw the final version of the RTFM run conducted at 6.00pm. Otherwise, he stated that throughout

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561 Plaintiff subs at [1239] to [1244].
562 Seqwater subs at [1422].
563 LAY.SEQ.007.0001 at [639].

the Flood Event he acted on the basis that strategy selection was determined by actual levels,[564] a proposition I reject. Further, once it is concluded that forecast rainfall must be considered and given Mr Malone's twice repeated statement on 7 January 2011 that the forecasts and catchment conditions mean that "significant inflows" will be generated (see [226] and [233]), then the prediction of a storage height exceeding EL 68.5m AHD based on the proposed releases was inevitable regardless of the forecast period.

258 To the extent that the flood engineers were operating consistently with any strategy on 7 January 2011 it could only have been W1, in that no releases were undertaken prior to 3.00pm so as to keep Burtons Bridge open and relatively low releases were made after that time with a view to reaching a level of releases that kept Fernvale Bridge and Mt Crosby Weir Bridge open in subsequent days. Even though Strategy W3 allows consideration of lower level objectives, in light of the available forecasts, the delaying of any releases prior to 3.00pm was inconsistent with that strategy, as were the modest gate openings thereafter for the balance of the day. Otherwise, the analysis of Mr Malone and Mr Ayre's approach above[565] applies equally to 7 January 2011.

259 The plaintiff's specific allegations of breach of duty in respect of 7 January 2011 are addressed in Chapter 12.[566] However, at this stage it is necessary to note five matters.

260 First, Seqwater and the State submitted that, on their respective shifts on 7 January 2011, Mr Malone and Mr Ruffini were obliged to act, and did act, in accordance with a "general strategy" set by Mr Ayre during his overnight shift from 6 January 2011 to 7 January 2011.[567] To that end, the State submitted that it was not open to Mr Ruffini to "unilaterally move to Strategy W3 and increase dam releases" as that was a decision for SFOE.[568] Both it and Seqwater contended that, in his situation report on the morning of 7 January

564 T 5323.1.
565 At [184ff] and [198ff]
566 Section 12.10.
567 Seqwater subs at [1098] to [1106] and [1426]; State subs at [121], [128] to [130] and [194].
568 State subs at [194].

2011 (and consistent with his conversation with Mr Malone as set out at [220]), Mr Ayre specified a general strategy of delaying releases until Burtons Bridge was inundated and then increasing releases to around 1200m^3/s on the afternoon of 8 January 2011.[569]

261 I accept that in issuing his situation report, promulgating his 6 Jan 21:00 ROG run and in conversing with Mr Malone, Mr Ayre was setting an "overall strategy" or "general strategy" for the management of at least part of the Flood Event to the effect that releases would be delayed until Burtons Bridge was inundated and then gradually increased over the subsequent 24 to 30 hours to approximately 1200m^3/s. Mr Malone modified that approach to a degree by bringing forward the first gate opening to 3.00pm on 7 January 2011, although that was largely consistent with what he was told by Mr Ayre on the morning of 7 January 2011.[570]

262 However, consistent with the conclusion in Chapter 3,[571] I do not accept that either Mr Malone or Mr Ruffini were excused by that general strategy from their obligation to address the latest forecast rainfall and stream flow information to determine the applicable Wivenhoe strategy, in turn ascertain the relevant "primary consideration" and then "within [that] strategy" consider the flood objectives in making "decisions on dam releases".[572] As flood engineers, it was their responsibility to provide instructions to "site staff to make releases of water from the Dams during Flood Events that are in accordance with the Manual".[573] As the rain fell and forecasts of rain accumulated throughout 7 January 2011, that obligation persisted. On the proper construction of the Manual, each of Mr Malone and Mr Ruffini should have recognised that, at the very least, Strategy W3 was applicable and reorientated their release decisions accordingly.

[569] Seqwater subs at [1098] to [1106]; State subs at [129].
[570] Seqwater subs at [1101].
[571] Chapter 3 at [326].
[572] Manual at 24.
[573] Manual at 6.

263 Second, as part of its allegation of breach, the plaintiff alleged that, during the period he was not on duty, Mr Ayre was obliged to intervene and direct the flood engineers who were.[574] I address that allegation in Chapter 12[575] but at this point it suffices to state that I am satisfied that Mr Ayre had that authority and was in a position to exercise it.[576] As SFOE, he was "designated to be in the charge of Flood Operations at all times during a Flood Event".[577] Mr Ayre said that throughout the Flood Event he was "at all times … kept in the loop in relation to strategies and release rates" and, other than one matter, he "agreed with the operational decisions made by the other Flood Operations Engineers".[578] The one matter of exception was on the evening of 11 January 2011 when he intervened and cancelled a directive to close gates.[579]

264 Third, in its submissions, SunWater emphasised the various BoM alerts about storms and flash flooding occurring downstream of Wivenhoe Dam during 7 January 2011.[580] However, as with 6 January 2011,[581] none of those warnings or advice suggested any risk of downstream flow rates sufficient to combine with Wivenhoe Dam releases and become capable of exceeding either the threshold for non-damaging flows or, depending on the release rate, the inundation levels for Fernvale and Mt Crosby Weir Bridges. Instead, the only downstream effect that weighed on the flood engineers' deliberations was a concern about inundating Burtons Bridge. Over that day and the following days, the flood engineers were able to manage releases by first avoiding inundating Burtons Bridge and then avoiding inundating Mt Crosby Weir Bridge. If they did that then, factoring in an allowance for the further distance downstream to Moggill, they would have been able to manage releases to avoid exceeding the thresholds for non-damaging flows downstream and that would be so even if forecasts of rainfall affecting downstream areas were considered.

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574 Plaintiff subs at [1243].
575 Section 12.10
576 Cf SunWater subs at [2069].
577 Manual, clause 2.2; at 5 (.0155).
578 Ayre 1, LAY.SUN.001.0001 at [313].
579 Ibid at [2599] to [2611].
580 SunWater subs at [2019(i)], [2051(c)], [2060(d)].
581 See [196].

265 Fourth, as noted, in his affidavit Mr Malone stated that as at 5.00pm, Wivenhoe Dam was at EL 68.10, the available volume was 790,098ML and that was equivalent to “140mm excess rainfall” (ie, runoff). Allowing for losses and releases during the intervening period, he denied that, unless releases were increased in accordance with strategies W3 and S2, there would be insufficient flood storage capacity to avoid releases in volumes that would cause urban flooding. As at 6.00pm Wivenhoe Dam was slightly higher (EL 68.12m). According to Mr Malone’s situation report, 160,000ML of rain that already had fallen was still to flow into Wivenhoe Dam (see [235]). This accords with the 7 Jan 18:00 ROG which predicted 161,485ML inflows from 6.00pm on 7 January 2011.[582] Using Mr Malone’s estimate of the catchment response during the Late December Flood Event, the 140mm of excess rainfall could be produced by rain on the ground inflows and 145mm of further rain.[583] Using Dr Christensen’s estimate of the catchment response, that amount of runoff could be produced by rain on the ground inflows and a further 130mm of rainfall.[584] All reasonable estimates of the four-day PME forecasts available in daily format at 6.00pm that evening exceeded those figures.[585] Mr Malone’s situation report referred to four-day totals of 140mm to 300mm and the saturated condition of the catchment such that “significant inflows will be generated”. The forecasts he referred to suggested higher rainfall downstream which could seriously impede the capacity to make releases at later times, and which otherwise had the potential to also fall upstream.

266 Thus, given the forecasts and the saturated catchment, the prospect of 140mm of runoff was very likely. In those circumstances there subsisted a serious and significant risk that if sufficient releases were not made at that time, releases would have to be made from above EL 74.0m AHD later. The same observations apply with even greater force to the circumstances faced

582 QLD.001.001.2409; SUM [H137:H488] x 3.6 = 161,485ML.
583 (5673 x 140 – 160,000) / (5673 x .77).
584 (5673 x 140 – 160,000) / (5673 x .86).
585 Chapter 9 at [138]; Table 9-2.

by Mr Ruffini, given the forecast information he received (see [241ff]) and the findings I have made about the Ruffini 7 Jan 22:00 72-hour run.

267 Fifth, at this point it is worthwhile contrasting the release plan in place as at midnight on 8 January 2011 with that proposed by Dr Christensen in his Simulations F and H, which commence at that time. As at midnight, Mr Ruffini was releasing 509m^3/s and proceeding in accordance with a plan to release around 1200m^3/s on the afternoon of Saturday 8 January 2011, being a rate designed to keep Fernvale Bridge and Mt Crosby Weir Bridge open. In Simulation F and Simulation H, Dr Christensen modelled immediately increasing releases to inundate those bridges later that morning but maintaining releases to keep combined downstream flows below the 4000m^3/s threshold for non-damaging flows which he attempts to do for a number of days.[586] At least so far as midnight on 8 and 9 January 2011 is concerned, the principal difference between Dr Christensen on the one hand and Mr Ruffini and the other flood engineers on the other, is whether the circumstances, including the rainfall forecasts, warranted abandoning the attempt to safeguard the bridges and instead evacuating water to optimise protection against later urban inundation from downstream flow rates above 4000m^3/s.

6.13: The Ruffini 7 Jan 22:00 72-hour Run

268 At this point it is necessary to digress and consider the plaintiff's contention that the Ruffini 7 Jan 22:00 72-hour run produced unreasonable predictions of inflows and thus did not constitute a proper basis for conducting flood operations.

269 The significance of this is three-fold.

270 First, it is relevant to any consideration of whether the results of the Ruffini 7 Jan 22:00 72-hour run justified his conduct of flood operations on the evening of 7 January 2011 into 8 January 2011.

[586] Simulation Analysis, EXP.ROD.015.0461 at .0846 to .0850 and .0931 to .0933.

271 Second, the debate over the loss rates used to model future inflows in the Ruffini 7 Jan 22:00 72-hour run echoes one aspect of the defendants' criticisms of Dr Christensen's methodology and simulations.

272 Third, it is relevant to a consideration of Mr Ayre's conduct of flood operations in the following shift and Mr Tibaldi's conduct of flood operations during his shift from the evening of 8 January 2011 into the morning of 9 January 2011. The evidence suggests that at around 9.00am and 3.00pm on 8 January 2011, Mr Ayre performed two 72-hour RTFM runs[587] (the "8 Jan 09:00 72-hour run" and the "8 Jan 15:00 72-hour run" respectively). A gate operations spreadsheet for the run at 3.00pm was saved.[588] Although they were updated to include inflows and rain on the ground in the interim,[589] both runs adopted the same rainfall depths, temporal patterns and loss rates as the Ruffini 7 Jan 22:00 72-hour run.[590]

273 In his first affidavit, Mr Ayre stated that the outcome of the 8 Jan 15:00 72-hour run (and a rain on the ground run performed at the same time) "confirmed that the current releases would satisfy the primary consideration of W3 whilst allowing for Fernvale Bridge and Mt Crosby Weir Bridge to remain open".[591] Mr Tibaldi addressed the 8 Jan 15:00 72-hour run in his second affidavit.[592]

RTFM Input Parameters

274 The depth of forecast rain, its spatial distribution, its temporal distribution and the applicable loss rates used in the Ruffini 7 Jan 22:00 72-hour run can be ascertained from the tendered screenshots. Thus, for the Somerset Dam catchment ("SDI"), Mr Ruffini allocated 130mm of rainfall and used a continuing loss rate of 0.5mm per hour. For the middle Brisbane catchment, WDI, Mr Ruffini allocated 100mm of rainfall and used a continuing loss rate of

[587] See Chapter 7 at [44] and [53].
[588] QLD.001.001.2542.
[589] Ayre 3, LAY.SUN.007.0001 at [56].
[590] T 7752.24; T 7752.41; T 7753.18 (Ayre).
[591] Ayre 1, LAY.SUN.001.0001 at .0474, [2040].
[592] Tibaldi 2, LAY.SEQ.014.0001 at .0029, [43].

2.5mm per hour. For the five upper Brisbane sub-catchments, CRE, COO, LIN, EMU and GRE, he allocated 80mm, 60mm, 80mm, 60mm and 110mm of rain respectively and used continuing loss rates of 2.5mm/hr, 0.5mm/hr, 0.5mm/hr, 0.5mm/hr and 0.5mm/hr respectively.[593] Mr Ruffini also allocated initial loss rates for each of these catchments and sub-catchments[594] but they need not be considered at this point as they were satisfied by this stage of the January 2011 Flood Event.

275 Mr Ruffini selected a temporal pattern for a storm of six days, "PMP-144 Hours (C)", but used a shorter term storm duration, namely three days.[595] The RTFM accommodates this by compressing the six-day temporal pattern over three days. However, the critical issue, so the plaintiff contended is that, even though this temporal pattern does not assume an even amount of rainfall throughout the entire period, like all RTFM temporal patterns it assumes an even amount of rainfall within discrete periods that span a number of hours. The temporal pattern for "PMP/144hr.pmp" as displayed in the RTFM was as follows:

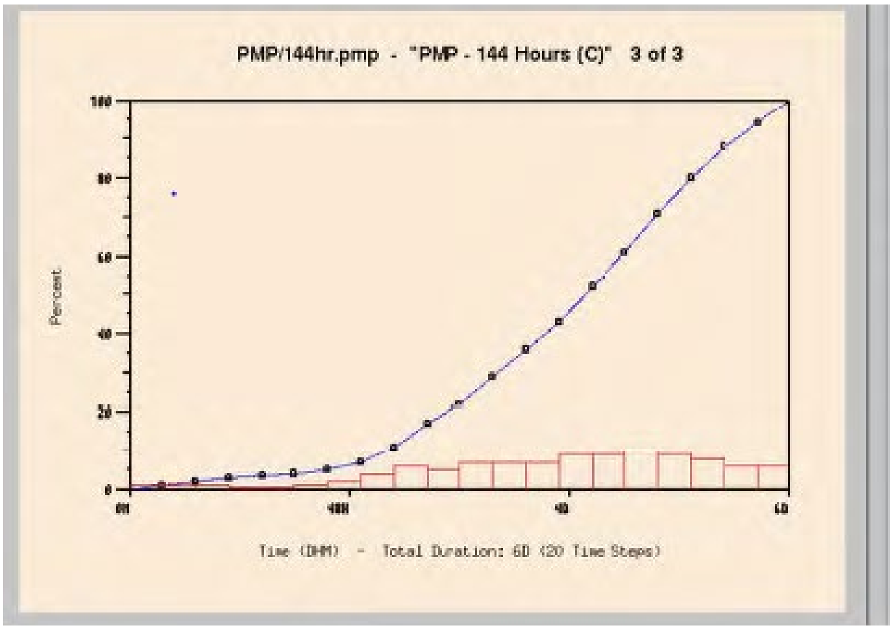

Figure 6-1: RTFM 144 hour storm temporal pattern

[593] MSC.010.354.0001 at .0002 and .0005.
[594] MSC.010.354.0001 at .0004.
[595] T 8770.41 to T 8771.7 (Giles).

276 Thus, as the temporal pattern uses “20 time steps”, when it is applied to a 72-hour storm period, it still assumes a continuous amount of rainfall in periods of just over three and a half hours each (72/20).

277 The plaintiff contended that there were three errors in the Ruffini 7 Jan 22:00 72-hour run.

Too Short a Modelling Period

278 According to the plaintiff, the first error was that Mr Ruffini used a modelling “period that was too short for the analysis, with the effect that he did not capture all of the inflows”.[596] Mr Ruffini entered an event start time of 9.00am on 2 January 2011 and a period of analysis of 240 hours[597] which meant that no inflows were generated for the period after 9.00am on 12 January 2011 (even though inflows would have been continuing after that time).[598] This is clearly correct but is also relatively immaterial. Mr Ruffini may have been seeking to only address the flood engineers’ position over the next few days and the last modelled inflow figure for Wivenhoe Dam was 204m^3/s which is relatively low. I do not treat this matter as indicative of either incompetence or rendering the model unreasonable.

Rainfall Depths

279 The second error contended for by the plaintiff was that Mr Ruffini allocated rainfall depths that were too low.[599] As I will explain, it was suggested that the rainfall depths used in these forecast runs were based on SILO meteograms (“SILO”). In his oral evidence, Mr Ayre suggested, with some hesitation, that SILOs were updated at 6.00am and 6.00pm every day (“or something like that”).[600] It follows that Mr Ruffini would have had available to him a SILO

[596] Plaintiff subs at [1215].
[597] The complete set of screenshots for this run is shown in MSC.010.354.0001. Mr Malone and Mr Ayre were shown a document with a subset of these screenshots, being MSC.010.304.0001. For convenience, references to both documents are given below.
[598] Reconstructed GOS, QLD.008.001.0416 (Input Data tab, line 249); T 5207.22 (Malone); T 7743.16 (Ayre).
[599] Plaintiff subs at [1216].
[600] T 7734.43.

updated at 6.00pm on 7 January 2011 and Mr Ayre a SILO updated at 6.00am on 8 January 2011. However, none of the SILOs obtained during the event were retained and apparently they were not recoverable. In any event, none were tendered. In that event, it is necessary to consider the evidence that Mr Ruffini considered a SILO and the evidence as to what it might have shown.

280 The plaintiff noted that the rainfall depths used in the Ruffini 7 Jan 22:00 72-hour run were below the forecasts for South East Queensland that Mr Malone had referred to in his situation report issued at 6.00pm on 7 January 2011 (ie, 115mm to 250mm). Those predictions were consistent with the 00UTC one-day PMEs for the period beginning at 10.00pm on 7 January 2011 which were available from 6.00pm on 7 January 2011 (see above). I have summarised Mr Giles' analysis of those PMEs above (at [243]). Contrary to the State's submissions,[601] his analysis reveals three-day figures well in excess of the rainfall depths used by Mr Ruffini.[602] Mr Giles accepted that the modelled rain in the Ruffini 7 Jan 22:00 72-hour run was too low if it was based on the available PMEs,[603] although Mr Giles doubted that a flood engineer was able to break down the PMEs to obtain catchment specific daily forecasts as he did.[604] In re-examination, Mr Giles explained that he broke down the PMEs by utilising software that had a georeferencing capability, a licence for which cost between $1,000 and $2000.[605] However, a visual inspection of the one-day PMEs does not support the rainfall depths used in the Ruffini 7 Jan 22:00 72-hour run either.[606]

281 Prima facie, the plaintiff has pointed to material which casts doubt upon whether there was any justifiable source for the rainfall depths used by Mr

[601] State subs at [168].
[602] For WDI it is 152mm (v 100mm), for Somerset it is 154.5mm (v 130mm), for COO it is 74mm (v 60mm), for LIN it is 101mm (v 80mm), for EMU it is 92mm (v 60mm), for GRE it is 110mm (v 110mm and for CRE it is 111mm (v 80mm).
[603] T 8860.15; Mr Giles appears to have assumed that the 4 day and 8 day PMEs were available from 6.00pm. The five individual daily PME forecasts were available from that time (Chapter 2; section 2.10).
[604] T 8860.30 -.39.
[605] T 8933.7 - .41.
[606] EXP.SEQ.014.0377; EXP.SEQ.014.0378; EXP.SEQ.014.0379.

Ruffini. What then was the asserted justification for them? As noted, in his report Mr Giles asserted that it was based on a "combination of QPF, four-day PME and SILO rainfall data". He cited Mr Ruffini's unread affidavit in support.[607] Even though Mr Giles' hearsay evidence on this matter is admissible to prove the truth of what is asserted,[608] I would not act on it alone, especially as the rainfall depths were not consistent with Mr Malone's (or anyone else's) breakdown of the PMEs. In cross-examination, Mr Ayre stated that Mr Ruffini indicated to him at their change over the following morning that he obtained the sub-area rainfall forecast from a SILO.[609] Seqwater seized on this as evidence to support the contention that it was so based.[610] The same observations apply to that hearsay evidence as it does to Mr Giles' especially as the following demonstrates that the documentary evidence does not support the suggestion that a SILO updated at 6.00pm on 7 January 2011 justified those rainfall depths.

282 Mr Giles (and the State)[611] pointed to an entry in Table 6.2.2 in the January FER that corresponded to "07/01/2011 12:00" as justifying the rainfall depths used in Mr Ruffini's modelling.[612] Table 6.2.2 and the accompanying text state:[613]

> "As well as examining and modelling the QPFs, the Access model result data provided by the BoM allowed three days and five day rainfall forecasts to be examined and considered in flood event decision making.
>
> A summary of this data is shown in the following table that contains translated rainfall forecasting results using ACCESS model result data provided by the BoM during the critical period of the Event (between Thursday 6 and Tuesday 11 January 2011). Following the Event, the original BoM data has been translated to forecast catchment average quantitative rainfall results, based on a derived catchment centroid rainfall, estimated by using Seqwater's FEWS system (see Appendix J)."

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607 EXP.QLD.001.1359 at .1414.
608 *Evidence Act 1995*, s 60.
609 T 7744.6.
610 Seqwater subs at [1436].
611 State subs at [162].
612 T 8857.28; January FER at .0351 to .0352; see the mathematical analysis in the State subs at [161].
613 January FER at .0351 – .0352 and .0928.

Comparison of actual and forecast rainfall from the BoM ACCESS model								
Forecast date and time	Somerset Dam catchment average rainfall				Wivenhoe Dam catchment average rainfall (excluding Somerset Dam catchment)			
	3 Days from		5 Days from		3 Days from		5 Days from	
	Forecast rainfall (mm)	Actual rainfall (mm)	Forecast rainfall (mm)	Actual rainfall (mm)	Forecast rainfall (mm)	Actual rainfall (mm)	Forecast rainfall (mm)	Actual rainfall (mm)
06/01/2011 00:00	73	90	115	403	90	79	114	275
06/01/2011 12:00	85	150	133	515	51	87	78	335
07/01/2011 00:00	189	298	206	568	133	180	144	347
07/01/2011 12:00	123	321	137	536	79	183	89	322
08/01/2011 00:00	191	332	206	527	207	205	218	309
08/01/2011 12:00	165	447	169	527	136	284	139	309
09/01/2011 00:00	230	500	231	510	267	298	268	301
09/01/2011 12:00	140	441	141	446	170	271	171	273
10/01/2011 00:00	463	278	465	280	171	169	171	170
10/01/2011 12:00	59	218	60	219	389	140	390	141
11/01/2011 00:00	19	196	19	197	231	105	231	105

The text that follows this table refers to the three day forecasts "*issued* between 00:00 on Thursday, 6 January 2011 and 12:00 on Sunday, 9 January 2011".

283 The entry for "07/01/2011 12:00" suggests a three-day forecast total for the Wivenhoe catchment(s) of 79mm and the Somerset Dam catchment of 123mm, which is broadly comparable to the rainfall depths used in Mr Ruffini's modelling. However, the figures in the immediately preceding row and the following row are significantly greater.

284 The three-day forecasts referred to in this table are not the SILO outputs but they are related. In his affidavit, Mr Kane cited a BoM publication as stating that SILO used, as a "source input", the "Access-G 7-day global model with 80km grid space resolution in 2010/11".[614] According to advice given by the

[614] Kane, EXP.ROD.011.0011 at 0031, [62].

BoM to the QFCI, Access-G was one of three Access model BoM products that Seqwater subscribed to on a cost recovery basis.[615]

285 The explanatory notes to Table 6.2.2 make it clear that the above figures are derived from the "Access model result data provided by the BoM".[616] Appendix J to the January FER records that the Access model result data referred to consisted of the output of five "Access" models run by the BoM of varying resolutions, one of which was Access-G (being the model used to compile SILOs[617]) and another of which was Access-A.[618] The BoM advised the QFCI that as Access-G and Access-A (as well as Access-C) "operate at different resolutions, [they] each provide *slightly* different results".[619] Further, three of the five Access models used to compile the above table, Access-R, Access-T and Access-A, concern a smaller geographic area than that covered by Access-G and use Access-G as the source input for boundary conditions.[620] This suggests there was likely to be a reasonable degree of correlation between Access-G outputs and the other models.

286 The text preceding Table 6.2.2 notes that the BoM Access data has been "translated" to "forecast catchment average quantitative rainfall results" using Seqwater's "FEWS" system, which is discussed in Appendix J to the January FER. Appendix J to the January FER explains this system of translation as follows:[621]

> "Seqwater commenced development of a new flood modelling system, FEWS, in March 2010. A prototype was delivered in early November 2010 at which time forecast rainfall from the Bureau of Meteorology's (BoM) ACCESS Numerical Weather Prediction models was imported into the system *several times per day*. These models provide coverage at varying resolutions and are *generated at different times of the day*. The results of the models are merged, downscaled to the Brisbane area and gridded to produce the forecast images on the following pages. The grid of the actual rainfall is based upon all

[615] ROD.519.001.0527 at .0593, [250].
[616] January FER at .0351.
[617] Ibid at .0928.
[618] Ibid at .0352 and .0928.
[619] ROD.519.001.0527 at .0593, [251].
[620] MSC.010.275.0001 at .0007.
[621] January FER at .0928.

available ALERT stations in the Enviromon data collection system and is generated by FEWS using surface fitting techniques." (emphasis added)

287 Appendix J to the January FER then sets out a map of the areas that are covered by each Access model and continues:[622]

Model	Domain	Resolution (km)	Duration (hours)	Runs (UTC)
ACCESS-G	Global	~80	+240	00,12
ACCESS-R	Regional	~37.5	+72	00,12
ACCESS-T	Tropical	~37.5	+72	00,12
ACCESS-A	Australia	~12	+48	00,06,12,18
ACCESS-BR	Brisbane	~5	+36	00,12

"A full description of the ACCESS Numerical Weather Prediction models can be found on BoM's web site. *While FEWS outputs were not available during the Event*, the forecast rainfalls used (QPF, Silo and Interactive Weather and Wave Maps) are based upon the ACCESS model outputs. The scale shown below has been adopted in all of the maps below and indicates the rainfall depth in millimetres (mm). The following maps have been transformed into the quantitative forecasts contained in Table 6.2.2 in the body of the Report." (emphasis added)

288 Appendix J includes diagrammatic representations of the forecasts compared to actual rainfall levels that resemble PME forecasts.[623] The diagrams containing the 72-hour forecasts suggest that the period of the forecast was from 9.00am each morning for three days hence.[624]

289 The italicised text in [287] confirms Mr Malone's evidence that the FEWS system did not operate during the January 2011 Flood Event;[625] ie, Table 6.2.2 and its individual catchment forecast figures were compiled and calculated after the January 2011 Flood Event.

290 Thus, in summary, a SILO meteogram was based on the Access-G model output which was one of the input models to the PME forecast. The Access-G model output was also one of the five Access models whose outputs were translated by Seqwater's FEWS system after the January 2011 Flood Event to

[622] Id.
[623] Ibid at .0929 to .0933.
[624] Ibid at .0933.
[625] Malone 1, LAY.SEQ.007.0001 at [137] and [204(e)].

derive the catchment average forecasts for three and five days set out in Table 6.2.2 of the January FER.[626] Subject to one matter addressed next, given the BoM's statement as to the relationship between the model outputs noted above and the description of FEWS, it is likely that there was a reasonable degree of correlation between an Access-G output and thus a SILO output on the one hand and those figures included in Table 6.2.2 on the other, although they are inherently unlikely to be the same.

291 Most importantly, given the movement in the results for both catchments between 00:00 on 7 January 2011 and 12:00 on 8 January 2011 shown in Table 6.2.2 and the movement in the PME forecasts which are derived from some of the same models, I am satisfied that it is overwhelmingly unlikely that the quantitative result of a SILO for a 72-hour period that was updated at 6.00pm on Friday 7 January 2011 was identical or even relatively close to a SILO for a 72-hour period that was updated at 6.00am on Saturday 8 January 2011. Thus, while the figures listed against 12:00 on 7 January 2011 might justify one or other of Mr Ruffini's modelling or Mr Ayre's modelling, they could not justify both. The remaining question is whether they can justify any of them. This depends on the relationship, if any, that can be discerned between the time of the forecast in the first column of Table 6.2.2 and the time at which SILOs were updated.

292 The extract from Appendix J to the January FER noted above (at [287]) refers to the time of an Access-G run as being 00UTC (ie, 10.00am Brisbane time) and 1200UTC (ie, 10.00pm Brisbane time). A BoM publication stated that a 00UTC Access-G forecast and an "assimilation" was made available at 530UTC (ie, 3.30pm Brisbane time).[627] An "assimilation" is a method of combining the model outputs with observed data.[628] Similarly, a 1200UTC Access-G forecast with an assimilation was made available at 1730UTC (ie,

[626] See [282].
[627] MSC.010.275.0001 at .0007.
[628] Ibid at.0004 to .0005.

3.30am Brisbane time).[629] It follows that a SILO available at 6.00am Brisbane time utilised the 1200UTC Access-G forecast available from 3.30am Brisbane time and a SILO available at 6.00pm Brisbane time utilised the 00UTC Access-G forecast available from 3.30pm Brisbane time.

293 There was a debate in the submissions as to whether the times in the first column of Table 6.2.2 (in [282]) were UTC or Brisbane times. Seqwater contended that the listed times correlate to the 00UTC and 1200UTC times.[630] On that logic, the entry for midday on 7 January 2011 in Table 6.2.2 incorporates the 1200UTC Access-G forecast and thus the corresponding SILO that incorporates that forecast is the one that was updated at 6.00am on 8 January 2011 because that Access-G forecast was available from 3.30am on 8 January 2011.[631] This largely supports the depths in the 8 Jan 15:00 72-hour run. It would, however, be fatal to any attempt to justify Mr Ruffini's use of the 6.00pm SILO from the previous evening as the relevant part of Table 6.2.2 that would utilise the same Access-G output is the row for "07/01/2011 00:00", which has significantly higher forecasts for both catchments (189mm v 123mm, and 133mm v 79mm).

294 However, I do not accept the first column of Table 6.2.2 in the January FER is a reference to UTC time. Instead, I am satisfied that it is a reference to the time at which the FEWS translation is undertaken of the output of the five Access models. Where a time listed in a table in the January FER is UTC time that is expressly indicated.[632] Other than error, there is no reason why the January FER would confuse readers by referring to forecast times that were ten hours behind Brisbane time when, unless the contrary was indicated, the other tables in the January FER used local times.[633] Most importantly, to interpret the first column of Table 6.2.2 as a reference to UTC time ignores the explanation of how and when those catchment averages were derived,

[629] And the same forecast with a further assimilation was made available at 00:30 (ie, 10.30am Brisbane time): MSC.010.275.0001 at .0007.
[630] T 9629.7; that is the premise of the submission in Seqwater subs at [1442(d) and (e)] which are addressed to Mr Ayre's 72-hour runs the following day.
[631] Seqwater subs at [1442(f)].
[632] Eg, January FER at .0928.
[633] Eg, January FER at .0351.

namely by the translation of five model outputs using the FEWS system. Appendix J makes it clear that, even though the five models mostly have 00UTC and 1200UTC run times, the outputs of the model “are generated at different times of the day”. This is borne out by the BoM publication explaining the implementation of the Access models, which confirms that the outputs of the five models are made available at different times throughout the relevant 12-hour period.[634] Those outputs, presumably the most recent, are then “imported into the [FEWS] system several times day”. Table 6.2.2 indicates that those times were midday and midnight with the results of the translation available immediately. Hence the reference in the January FER to forecasts “issued” at the listed times.[635] The forecasts in Table 6.2.2 could only have been “issued” by FEWS as long as it was translating the BoM Access data and differentiating between the two catchments. Further, they were only notionally “issued”, as FEWS outputs were not available during the January 2011 Flood Event. None of the BoM’s publications of the output of any of the five Access models were ever “issued” at 00UTC or 1200UTC.[636]

295 The three-day rainfall forecast diagrams in Appendix J to the January FER[637] indicate that the forecast period provided by FEWS is a three-day period beginning at 9.00am although, as I have said, the FEWS output was notionally produced at midday and midnight Brisbane time. The above analysis means that, in so far as the forecast entries in Table 6.2.2 for the row “07/01/2011 12:00” incorporate Access outputs, they include the Access-G output from the 6 January 2011 1200UTC run available at 3.30am on 7 January 2011.[638] A SILO updated at 6.00pm on 7 January 2011 and available to Mr Ruffini that evening would have utilised the output of a 7 Jan 00UTC run of Access-G that was available at 3.30pm on 7 January 2011.[639] The output of that Access-G is reflected in the row for “08/01/2011 00:00” which is a FEWS-translated forecast derived from the five Access models and

[634] MSC.010.275.0001 at .0007.
[635] January FER at .0352.
[636] See MSC.010.275.0001 at .0007.
[637] January FER at .0933.
[638] MSC.010.275.0001 at 0007; or the assimilation available at 10.30am on 7 January 2011.
[639] Ibid at .0007.

which yielded a forecast of 191mm for the Somerset Dam catchment and 207mm for the Wivenhoe Dam catchments. A SILO updated at 6.00am on 8 January 2011 and available to Mr Ayre that morning would have utilised the output of a 7 January 1200UTC run of Access-G that was available at 3.30am on 8 January 2011.[640] The output of that Access-G run is reflected in the row for “08/01/2011 12:00” which is a FEWS-translated forecast derived from the five models yielding a figure of 165mm for the Somerset Dam catchment and 136mm for the Wivenhoe Dam catchments. That SILO would have remained operative until 6.00pm 8 January 2011.

296 So far as Mr Ruffini is concerned, this excruciating fossick through the materials was necessitated by an assertion based on hearsay that the rainfall depths in 7 Jan 22:00 72-hour run could be justified by reference to a SILO that was available to him from 6.00pm. I am not satisfied that it is so. I consider it much more likely that, if he accessed a SILO, it showed much greater rainfall depths than he modelled. As noted, so far as rainfall depths were concerned, the plaintiff pointed to rainfall assessments in Mr Malone’s 6.00pm situation report as predictions of greater amounts of rain and that is supported by the one-day PMEs available to Mr Ruffini from 6.00pm (and his own situation report issued at 6.32am the following morning).[641]

297 Finally, on this issue I note that Seqwater submitted that there was reason to doubt the figures in Table 6.2.2 of the January FER because of the movement in the forecast figures from the row “10/01/2011 00:00” to the following two rows, which show an extraordinary drop in the forecasts for Somerset Dam and extraordinary increase in the forecast for the Wivenhoe Dam catchments.[642] I agree that those figures and the immediately preceding row appear unusual, especially in light of the prevailing PMEs for that time, but beyond that it cannot be taken any further. I have just explained this exercise commences with Mr Ruffini seeking to justify his forecast figures by reference to Table 6.2.2 of the January FER. If those figures are erroneous then that is

[640] Ibid at .0007.
[641] Chapter 7 at [9]; cf SunWater subs at [2062(b)].
[642] Seqwater subs at [1446].

his and the State's problem not the plaintiff's. It was not incumbent on the plaintiff to ask Mr Malone about Table 6.2.2 of the January FER when the PME figures did not support Mr Ruffini's rainfall depths and the SILO was not available.

298 Accordingly, I am satisfied that Mr Ruffini significantly underestimated the depth of forecast rainfall in performing the 7 Jan 22:00 72-hour run. The position so far as Mr Ayre's 72 hour forecast runs are concerned is addressed in Chapter 7.

Combination of Temporal Pattern and Loss Rates

299 The third reason identified by the plaintiff as rendering the modelling in the Ruffini 7 Jan 22:00 72-hour run unreasonable concerns the interaction between the RTFM's temporal patterns and the use of loss rates calibrated to past rainfall.[643] The plaintiff accepted that there was nothing "*per se* unreasonable in Mr Ruffini's selection of the temporal pattern" noted above (at [275]).[644] However, as noted, that pattern assumes that rain falls continuously in discrete time periods whereas, in the period prior to the forecast, rain had fallen in short bursts and the continuous loss rates had been calibrated accordingly. The plaintiff contended that to apply loss rates calibrated to relatively short bursts of rain in the past to model inflows from future rain that assumed rain would fall continuously produced an unrealistically low outcome. For the reasons that follow, I accept that contention.

300 The position is best illustrated by considering the WDI catchment which comprises 20% of the total catchment area above Wivenhoe Dam.[645] The following image is a screenshot from Mr Ruffini's 7 Jan 22:00 72-hour run on the RTFM at 10.00pm on 7 January 2011 for WDI:[646]

[643] Plaintiff subs at [1220].
[644] Id.
[645] January FER at .0395.
[646] MSC.010.354.0001 at .0038; circled lines added.

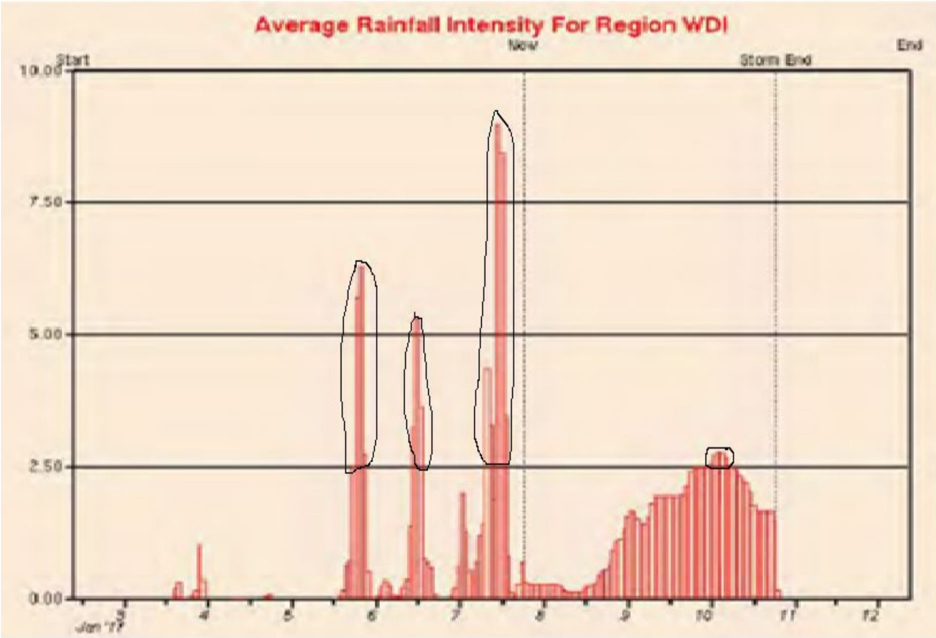

Figure 6-2: RTFM screenshot of rainfall intensity in WDI

301 The vertical red lines to the left of the black dotted line titled "Now" are the rainfall bursts received during the January 2011 Flood Event up to the point in time that the modelling was undertaken. All of the (circled) rain above the horizontal black line marked "2.50" represents rain that became run-off. The total catchment average rainfall prior to time *"Now"* was approximately 80mm.[647]

302 As noted, the continuing loss rate that was applied for WDI was 2.5mm per hour and the modelled rainfall was 100mm. This loss rate is represented by the horizontal line adjacent to "2.50". The modelled (or predicted rainfall) is represented by the vertical red lines to the right of time "Now". The temporal distribution of that rain has been allocated in accordance with "PMP-144hours (c)" and, as explained, that assumes rainfall over continuous periods. It bears almost no resemblance to the sharp bursts of rain experienced prior to time 'Now'. Mr Giles agreed that no reasonable engineer would assume that rain would fall in the continuous patterns assumed by the type of distributions

[647] RTFM Screenshots for 201101072200_72hr run; MSC.010.304.0001 at .0039. Refer to the black cumulative rainfall line.

provided by the RTFM, albeit the RTFM forces their use.[648] The result is that the only rain that represents runoff for that 100mm of predicted rain in WDI after time "Now" is the tiny amount above the horizontal line marked "2.50", which occurs early on the morning of 10 January 2011 (circled). The rest of the rain received that falls after time 'Now' is modelled as being absorbed by the catchment.[649] Thus, with this modelling, past rainfall of 80mm generated substantial runoff but forecast rainfall of 100mm produced almost no runoff. In the circumstances facing the flood engineers on the evening of 7 January 2011 that result was completely absurd. Mr Malone agreed that this was an unrealistic result.[650]

303 Mr Giles also agreed the above showed an "*unreasonable modelling outcome*" for the WDI catchment taken *"in isolation*".[651] However, in re-examination, Mr Giles was taken to part of one of Mr Ayre's affidavits that stated that the "overall modelled results" showed a "good calibration" for the rate of 2.5mm per hour at Wivenhoe Dam.[652] Mr Giles stated that "given that outcome, again it symbolises that the runoff from that sub-catchment, for that forecast was reasonable".[653] This answer exacerbated my misgivings about Mr Giles' evidence because it did not appear to come to grips with the logic that drove his early concession about the "unreasonable modelling outcome", namely that the combination of the RTFM's temporal distribution for future rainfall and past calibrated loss rates produced low and, in some case, unreasonable future inflow estimates. When pressed on his answer in re-examination, Mr Giles clarified that he took Mr Ayre's evidence as confirmation that the continuous loss rate of 2.5mm per hour was a "reasonable value to be using" which it might be for rain on the claground

[648] T 8835.30; T 8822.12 to T 8823.7.
[649] T 5215.31 (Malone).
[650] T 5216.5.
[651] T 8861.30.
[652] Ayre 3, LAY.SUN.007.0001 at [53].
[653] T 8938.23.

modelling,[654] but not for deriving estimates for forecast rainfall over a period of days.

304 This error was clearly material given that WDI comprises 20% of the area of all the catchments above the dam.

305 For Cooyar (COO), which comprised 14% of the catchment area above the dam, the equivalent screenshot was as follows:[655]

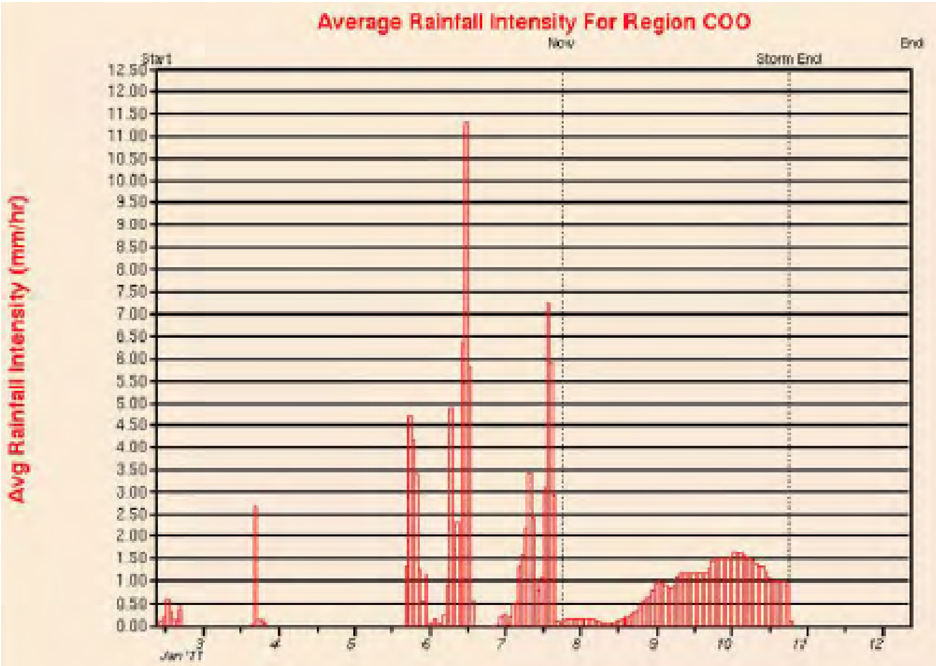

Figure 6-3: RTFM screenshot of rainfall intensity in COO

306 The selected continuing loss rate at COO was 0.50mm so that only rainfall amounts above the horizontal line marked "0.50" yielded runoff. The total catchment average rainfall experienced prior to time 'Now' was 90mm and the amount forecast after time now was 60mm. It is self-evident that the proportion of runoff from rain after time 'Now' will be significantly less than received before time "Now". When pressed, Mr Giles described this result as

[654] See Chapter 9, section 9.5.
[655] MSC.010.354.0001 at .0028.

"at the lower boundary" of possible outcomes[656] (which can be taken as a reference to the lower boundary of reasonable outcomes).

307 The screenshot for Emu Creek (EMU),[657] which like COO used a continuing loss rate of 0.5mm per hour, predicted only a small amount of runoff from 60mm of forecast rain. It was virtually identical to the screenshot for COO. EMU comprises 13% of the total area of the catchments above the dam.

308 For Cressbrook (CRE), which comprises 5% of the catchment area above Wivenhoe Dam,[658] and for which a forecast of 80mm of rain with a continuing loss rate of 2.5mm was input into the RTFM, the equivalent screen shot to this produced no runoff for the forecast rain.[659] In cross-examination, Mr Giles agreed that was an "unreasonable modelling outcome" for that "catchment taken in isolation".[660]

309 However, in re-examination, Mr Giles was referred to evidence from Mr Ayre that the CRE sub-catchment contained two fixed crest spillway dams, the lower of which is the "outlet of the CRE region", with flows from that dam and then into WDI. According to Mr Ayre, the result is that flows will only emerge from CRE when both dams have reached their storage limits,[661] which did not occur until 10 January 2011 (the flood engineers were advised on this on 11 January 2011).[662] Mr Ayre also stated that the gauge for CRE had failed prior to 6 January 2011 so that in effect no proper calibration could be undertaken as there was no flow information from CRE in the period 6 January 2011 to 10 January 2011. Mr Ayre said that, at the time of his 8 Jan 15:00 72-hour run, he and the other flood operations engineers did not have any information regarding the outflow from Cressbrook Creek Dam and there was no basis to change the default continuing loss rate of 2.5mm/hr. Given

[656] T 8862.14.
[657] MSC.010.354.0001 at .0032.
[658] January FER at .0395.
[659] MSC.010.354.0001 at .0026; T 5213.19 (Malone).
[660] T 8861.42 (Giles).
[661] Ayre 3, LAY.SUN.007.0001 at [40].
[662] Ibid at [44].

that information, Mr Giles said that modelling no flow out of CRE was "entirely reasonable".[663]

310 I accept Mr Ayre's evidence in relation to CRE. However, the fact that subsequently information was received that justified one small part of Mr Ruffini's modelling does not address the methodological error that the plaintiff has identified and Mr Giles did not justify. That said, given Mr Ayre's evidence, at least with the benefit of hindsight, the prediction of no runoff for CRE in the Ruffini 7 Jan 22:00 72-hour run does not support the suggestion that overall the modelling was unreasonable.

311 The screenshots for the other upstream sub-catchments, being Linville (LIN),[664] Gregors Creek (GRE)[665] and Somerset Dam (SDI)[666] do not predict such a low amount of runoff compared to that experienced prior to time 'Now' as the screenshots for WDI or CRE or EMU although the same phenomenon is still at work. This is a product of the use of either higher rainfall amounts, lower continuing loss rates or both for those sub-catchments.

312 This feature of forecast modelling identified by the plaintiff has less of an effect the higher the forecast rainfall and the lower the continuing loss rate. Nevertheless, it still affects all of the sub-catchments because all of them use loss rates calibrated to past rainfall received in bursts and then apply to them a future temporal pattern that assumes periods of continuous rainfall. A comparison of the rain received before and after time 'Now' for all of the sub-catchments confirms that they each predict a lower proportion of runoff in the forecast period compared with the past. If anything, the position should have been the reverse given that the catchments were getting much wetter and given the substantial amount of rain being modelled. In answer to a question from Senior Counsel for Seqwater concerning whether the use of past calibrated loss rates with assumed patterns of (future) continuous rainfall

[663] T 8937.36; see SunWater subs at [2063].
[664] MSC.010.354.0001 at .0030.
[665] Ibid at .0034.
[666] Ibid at .0036.

"will *inevitably seriously underestimate* the amount of runoff from the forecast", Mr Giles stated that he did not "*necessarily* think that's the case because if you've got enough rainfall falling on the catchment …but once you get past the amount required for runoff to commence, it then doesn't matter whether there's another 10mm on top of it …it will still run off".[667] What appears implicit in this and what I am otherwise satisfied of, is that the use of past calibrated loss rates and continuous rain temporal distributions will always tend to underestimate the amount of future runoff. As illustrated by the above, whether it will "seriously underestimate" the amount of runoff will depend on the amount of rain, the loss rate chosen and the particular temporal pattern.

313 In the case of Mr Ruffini's 7 Jan 22:00 72-hour run, the chosen parameters for WDI led to a gross underestimation of the amount of runoff, a significant underestimation of the runoff with both COO and EMU and, leaving aside CRE, an underestimation with the other sub-catchments.

314 As noted in his evidence, Mr Giles accepted that considered "in isolation" the amount of runoff modelled for WDI was unreasonable. Later, he was reminded of his evidence that both WDI and CRE produced unreasonable forecast volumes[668] and that COO was low and was asked whether the overall result could be regarded as reasonable.[669] Mr Giles only accepted that it was low but not unreasonable.[670] When it was suggested that a reasonable engineer would never model no inflow from 25% of the relevant catchment, ie, WDI and CRE, he maintained that he would not have modelled any lower continuing loss rates than were used but in fact would have used higher rates: "somewhere between 0.5 and 1" being "as low as I would want to do to consider that to take into account the possibility of discrete rainfall".[671] I regret to state that I found Mr Giles' evidence on this issue unconvincing. He appeared to be attempting to doggedly maintain a defence of the logic of

[667] T 8774.39 - .44.
[668] Later retracted in relation to CRE.
[669] T 8862.41.
[670] T 8862.45.
[671] T 8863.1 to T 8864.45.

using past loss rates derived from spasmodic rainfall for predicting inflows from future temporal patterns that assumed continuous rainfalls. He did not display the level of detachment the Court expects of expert witnesses.

315 Putting aside the issue with CRE, I am satisfied that a cursory look at the screenshots of the RTFM modelling for the Ruffini 7 Jan 22:00 72-hour run would have revealed that the WDI inflows were absurd and, considering it was such a large contributor to the model, that it should have been revisited. A closer look would have revealed the difficulties with at least CRE, COO and EMU sub-catchments. The plaintiff's submissions included an analysis,[672] which I accept, that shows that the forecast component of this model run produced approximately the same inflow volume (421,866ML) as the rain on the ground model run undertaken at 6.00pm on 7 January 2011 (393,395ML)[673] in circumstances where the forecast average depth of rain (93mm) was approximately the same as the average rain received in the catchments (between 80mm and 90mm). The difficulty with that equivalence is that the modelling for the rain on the ground component allows for the absorption of initial losses of between 0mm and 40mm in all sub-catchments, all of which had been satisfied at the time of the modelling of future inflows.

316 The defendants' submissions variously sought to justify the loss rates used[674] and the temporal pattern selected,[675] but did not come to grips with either the problem created by their combined use or the fact that could be addressed by modelling future rainfall using lower loss rates and sharper temporal patterns to produce a proportion of runoff to rain comparable to that experienced previously.

317 Seqwater also contended that the modelling results were a consequence of the fact that in the past there had been "short, sharp bursts" of rain but the

[672] Plaintiff subs at [1233(d)(iii)].
[673] QLD.001.001.2409.
[674] Eg, State subs at [171] and [178]; Seqwater subs at [1456] to [1462] and [1470].
[675] Seqwater subs at [1453] to [1454].

"forecast being modelled is for more continuous rain over three days".[676] None of the forecasts purported to predict rain temporal patterns at the level of granularity necessary to support this submission; ie, whether it was in continuous streams over three hours or in bursts. As noted, Mr Giles agreed that no reasonable engineer would assume rainfall would fall in the continuous manner assumed by the temporal pattern he adopted in his modelling which in this respect is not relevantly different.[677] Seqwater contended that forecasts were indicating different patterns of rainfall "something more akin to *heavie*r, widespread rain, which was likely to approach continuous rainfall situation".[678] If the forecasts were indicating that, they were not the forecasts modelled by Mr Ruffini or Mr Ayre the following day. As the above analysis demonstrates, *their modelled rainfall*, at least in the Upper Brisbane and Middle Brisbane catchments, was greater than, but still of a similar magnitude to, what had been experienced to date.

318 The defendants also contended that the plaintiff's criticism does not allow for the fact that the RTFM does not accommodate different loss rates, so that in the one run different loss rates could not be used for modelling rain on the ground and then modelling rainfall for forecasts extending beyond one day.[679] That may the case, but separate modelling could be undertaken and otherwise it demonstrates that the flood engineers could not derive comfort from the 72-hour forecast modelling.

319 I am satisfied that the combination of loss rates and the selected temporal pattern used in the Ruffini 7 Jan 22:00 72-hour run was unreasonable.

Conclusion

320 I note three further matters raised by the defendants to justify the Ruffini 7 Jan 22:00 72-hour run.

[676] Ibid at [1466].
[677] T 8835.30.
[678] Seqwater subs at [1471].
[679] State subs at [172]; Seqwater subs at [1464]; SunWater subs at [2065(d)].

321 First, the State referred to a separate modelling exercise performed by Mr Giles who modelled the four and eight-day PME forecasts using a georeferencing of the PMEs to the catchment areas which was said not to be available to Mr Ruffini at the time.[680] Utilising the gate openings set out in the recreated GOS for the Ruffini 7 Jan 22:00 72-hour run, this modelling produced a Wivenhoe peak level of EL 71.94m AHD for the four-day PME forecast and EL 72.40m AHD for the eight-day forecast, with both peaks predicted to occur over a week after the model run time.[681] (However, they would appear to exceed EL 74.0m AHD on a no-release basis.)[682] Mr Giles concluded that this would not have necessitated any change in dam operations "from that in place following the 22:00 model run completed by Mr Ruffini", which he asserted was W3 and was otherwise not sufficient to trigger W4.[683]

322 However, Mr Giles' modelling has the same defective combination of calibrated past loss rates and predictions of future continuous rainfall as the Ruffini 7 Jan 22:00 72-hour run did.[684] Thus, for example, his modelling of 220mm of rain in WDI until 12 January 2011 produced 20% runoff from 77mm of predicted rain on 9 January 2011, a tiny proportion of runoff from a prediction of 60mm rain on 10 January 2011 and no runoff from the 83mm of rain on the other days, despite 90mm of rain having fallen in the previous days thus saturating the catchment[685] with further forecast rain likely to increase the proportion of runoff.[686] Further, his modelling produced a predicted peak inflow of around 2100m^3/s on 10 January 2011, which was only marginally higher than the observed peak inflow on 7 January 2011.[687] This was so despite modelling the effect of a much greater rainfall over a

[680] State subs at [149] to [154]; EXP.QLD.001.1359 at .1404.
[681] EXP.QLD.001.1359 at .1411.
[682] See MSC.010.462.0001.
[683] EXP.QLD.001.1359 at .1411.
[684] T 8822.30 (temporal pattern that assumes continuous rainfall); T 8823.37 to T 8824.11 (same loss rates as flood engineers: MSC.010.539.0001 at .0004, .0006; MSC.010.540.0001 at .0004, .0006.
[685] T 8827.46; MSC.010.540.0001 at .0008.
[686] T 8837.14.
[687] T 8833.37 to T 8834.19; "Inflow Chart" tab on MSC.010.462.0001.

smaller period in the future than was received in the past.[688] That outcome is a very strong indication that the combination of loss rates calibrated to the past and then applied to future rainfall patterns that assumed continuous rain predicted too little runoff.[689]

323 Mr Giles agreed that his estimates were at the "lower bound of reasonableness".[690] I am satisfied that they were well below it.

324 Otherwise, I note that Mr Giles' modelling was not undertaken on a no release basis and, contrary to Mr Giles' understanding, Mr Ruffini did not operate in W3 on the evening of Friday 7 January 2011. Flood operations consistent with W3 were not undertaken until around midnight on 10 January 2011. Further, I note that Mr Giles' modelling[691] produced relatively modest flows emanating from Bremer River on 8 January 2011 and then very large flows from midday on 9 January 2011 thus suggesting scope for an increase in releases on 8 January 2011.[692]

325 Second, there was a debate in the submissions as to object of calibrating past rainfall to inflow to determine loss rates.[693] It is unnecessary to address this in detail. It suffices to state that the objective of modelling future rainfall during a flood event is to estimate future inflows and not necessarily to create a model of the flood event to date. Mr Ruffini's 7 Jan 22:00 72-hour run did not do this.

326 Third, Seqwater and the State emphasised that the "real problem" was that the actual rainfall that fell was far in excess of the rainfall that was forecast as revealed by a comparison between the actual figures in Table 6.2.2 and the forecast figures (allowing for the possibility of error).[694] There is no doubt that generally the amount of rain that fell was in excess of the forecast amounts. However, the whole point of this exercise is to consider the position

[688] T 8834.
[689] See T 8834.35.
[690] T 8833.30.
[691] EXP.QLD.001.1359 at .1411.
[692] Input data tab, MSC.010.462.0001.
[693] Plaintiff subs at [1233(c)]; Seqwater subs at [1486].
[694] Seqwater subs at [1475] to [1477]; State subs at [182].

prospectively as part of the inquiry into whether there was a breach of duty. Further, one aspect of the flood engineers' functions was to consider the possibility of rainfall in excess of the relevant forecasts.

327 It follows from the above that I am satisfied that, on the information available at the time it was conducted, Mr Ruffini's 7 Jan 22:00 72-hour run yielded a severe underestimate of the likely inflows into Wivenhoe Dam from existing rainfall and the rain forecast to fall over the following 72 hours. It did not provide any support for the maintenance of the gate operations that were in place and did not otherwise produce a reasonable inflow estimate calculated by reference to the "best forecast rainfall … information available at the time".

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CHAPTER 7: THE JANUARY 2011 FLOOD EVENT FROM 8 JANUARY 2011

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CHAPTER 7: THE JANUARY 2011 FLOOD EVENT FROM 8 JANUARY 2011

7.1: Saturday, 8 January 2011

1 As noted in Chapter 6,[1] according to the plaintiff, the one-day PME made available at 6.00pm on 7 January 2011 predicted rain in the 10mm to 50mm range for the 24-hour period to 10.00pm on 8 January 2011,[2] whereas the State contended that it predicted 1 to 25mm of rain above the dam and 5mm to 50mm of rain below the dam.[3] The plaintiff contended that the four-day PME available from midnight on 8 January 2011 predicted rain in the 100mm to 300mm range for the period 10.00pm on 7 January 2011 to 10.00pm on 11 January 2011[4] whereas the State contended that it predicted rain in the 50mm to 300mm range above the dam and rain in the 100mm to 400mm range below the dam.[5] The plaintiff contended that the eight-day PME forecast predicted 100mm to 320mm of rain for the period 10.00pm on 7 January 2011 to 10.00pm on 15 January 2011,[6] whereas the State contended that it predicted 50 to 300mm of rain above the dam and between 150mm to 400mm of rain below the dam.[7]

2 The morning QPF issued shortly after 10.00am on 8 January 2011 predicted 30mm to 50mm rain for the 24 hours until 9.00am on 9 January 2011.[8] The 4.00pm QPF forecast had the same prediction for the 24 hour period to 3.00pm on 9 January 2011.[9]

3 Just after midnight on 8 January 2011, the BoM issued a flood warning for the Brisbane River above Wivenhoe Dam, advising of “[r]enewed rises and minor to moderate flooding … occurring in Gregor and Cressbrook Creeks” and “major flooding occurring along the Brisbane River between Linville and

[1] Chapter 6 at [239] to [241].
[2] AID.500.022.0001.
[3] SEQ.013.004.1304; AID.500.022.0001.
[4] AID.500.022.0001.
[5] SEQ.013.004.1314; AID.500.022.0001.
[6] AID.500.022.0001.
[7] SEQ.013.004.1315; AID.500.022.0001.
[8] SEQ.001.019.7014; QLD.001.001.2486.
[9] QLD.001.001.2546.

Devon Hills".[10] An update issued shortly after 9.00am on 8 January 2011 advised that "[m]inor to moderate flood levels [were] generally falling along Lockyer and Warrill Creeks and the Bremer River".[11] Severe weather warnings were issued for the Southeast Coast, Wide Bay and Burnett districts at 4.52am, 11.00am, 5.12pm and 10.18pm.[12]

4 Throughout 8 January 2011 until 3.00pm, the gates at Wivenhoe Dam were opened at the rate of one increment per hour.[13] By that stage, 24 increments were open. This was in accordance with the gate sequence modelled in the rain on the ground model runs undertaken at midday on 7 January 2011[14] and 6.00pm on 7 January 2011.[15]

5 At 6.32am on 8 January 2011, Mr Ruffini circulated his situation report.[16] He noted that since 9.00am the previous day there had been "widespread 20 to 40mm" of rainfall throughout the catchments upstream of Wivenhoe Dam "with isolated higher totals of 70mm in the upper reaches of the Brisbane [river]" but that "no significant rain ha[d] fallen in the past 12 hours". In relation to forecast rain the report stated:

> "Advice from BoM indicates that SE Qld can expect further high rainfall totals over the next 4 days.
>
> Saturday: Rain light at times 5-50mm with higher falls along the coast
> Sunday: Widespread rain with totals between 50-100mm
> Monday: Widespread rain again with totals between 50-100mm
> Tuesday: Rain easing with totals between 25-50mm
>
> Given the saturated conditions of the catchments, significant inflows to Seqwater dams will be generated, especially following the forecast rainfall on Sunday/Monday."

6 The daily rainfall totals in this extract amount to between 130mm and 300mm of rain over four days, and 125mm to 250mm in the three-day period beginning Sunday, 9 January 2011.

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[10] QLD.002.002.1856.
[11] QLD.002.002.1845.
[12] QLD.002.002.1850; QLD.002.002.1839; QLD.002.002.1833; QLD.002.002.1827.
[13] January FER at .0450.
[14] QLD.001.001.2357.
[15] QLD.001.001.2409.
[16] QLD.001.001.2456.

7 This situation report uses the phrase "significant inflows to Seqwater dams," which was also used by Mr Malone in his situation reports. SunWater submitted that there was nothing to suggest that either Mr Malone or Mr Ruffini "expected significant inflows into Wivenhoe Dam and Somerset Dam *specifically*".[17] There were only three dams referred to in Mr Ruffini's situation report: Wivenhoe, Somerset and North Pine Dams. As a matter of grammar, the reference to "dams" must have included at least one of Wivenhoe or Somerset Dam. Considered in context, the reference to Seqwater dams in this situation report was a reference to all of Seqwater's dams as referred to in previous reports.

8 Mr Ruffini's report noted that at 5.00am Somerset Dam was at EL 100.42m AHD and rising and that at 6.00am Wivenhoe Dam was at EL 68.45m AHD and "rising steadily with all five gates open". The report then stated that "[i]t is intended to ramp up the releases from Wivenhoe to 1,200m^3/s by midday Saturday 08/01/2011". The report stated that "[f]urther assessments will be undertaken to determine increases above this level" but that "given the high likelihood of significant inflows in the next week, this may be increased".

9 Under the heading "Impacts downstream of Wivenhoe" the report stated: [18]

> "The projected Wivenhoe release of 1,200m^3/s combined with Lockyer flows and local runoff will mean that all crossings downstream of Wivenhoe (Twin Bridges, Savages Crossing, Burtons Bridge, Kholo Bridge and Colleges Crossing) will be adversely impacted for several days. At this stage Fernvale and Mt Crosby Weir Bridge are not expected to be affected but they could potentially be affected if the predicted rainfall totals eventuate.
>
> The current available assessments indicate that the combined flow in the lower Brisbane R[iver] would only add 50mm to an upper limit of 100mm to the recorded water levels in the City Reach of the Brisbane Rive[r]. However, it is noted that tides in the lower Brisbane R[iver] will be 0.4 to 0.5 metres higher than predicted tides.
>
> Somerset Regional, Ipswich City and Brisbane City Councils have been advised of the Wivenhoe operating strategy."

[17] SunWater subs at [2086(a)(2)].
[18] QLD.001.001.2456 at .2457.

10 Other than the potential increase in river levels "in the City Reach," the situation report did not advert to any potential adverse effect on urban areas. The above statement was repeated in a catchment update issued at 9.00am.[19]

Conclusion Regarding Mr Ruffini's Shift

11 The plaintiff noted the heights referred to in the above report, the progression of observed lake levels throughout the early hours of the morning of 8 January 2011, the references to Wivenhoe Dam "rising steadily" and "significant inflows," and submitted that Mr Ruffini "must have expected that Wivenhoe Dam would exceed 68.5m before his shift ended at 6.00am" such that he was required to implement W3.[20] I treat this submission as suggesting that Mr Ruffini must have formed that expectation before he finished his shift. I accept that he must have known that from the commencement of his shift the previous evening.[21] Nothing that occurred that morning would have or should have disabused him from that knowledge (even though there had been no significant rain in the previous twelve hours). The plaintiff also contended that, despite this knowledge, Mr Ruffini adhered to the gate release program previously formulated which was directed towards the objectives of W1 and did not seek to address the objectives of W3.[22] I agree that the gate release program was directed to, and only consistent with, the objectives of W1.

12 One further matter should be noted in relation to Mr Ruffini. The pleaded breaches in respect of Mr Ruffini on 7 and 8 January 2011 are addressed in Chapter 12. One of the pleaded breaches is that he was obliged to operate in Strategy W4.[23] As noted by the State,[24] the plaintiff's submissions did not address that suggestion. In Simulation F, which commences at midnight on 8 January 2011 and utilises four-and eight-day forecasts, Dr Christensen determined that the state of Wivenhoe Dam and prevailing forecasts as at

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[19] QLD.002.001.4757 at .4758.
[20] Plaintiff subs at [1247] and [1249].
[21] See Chapter 6 at [244], [251].
[22] Plaintiff subs at [1250] to [1252].
[23] 5ASOC, [288(b)]; PLE.010.001.0001 at .0138.
[24] State subs at [233] to [234].

midnight on 8 January 2011 was such that a selection of W4 was required.[25] However, in Simulation H which also commences at midnight on 8 January 2011 but only operates on the basis of 24-hour QPFs, he determined that the selection of W3 was required.[26]

Mr Ayre's Shift

13 Mr Ayre signed on as the DFOE at 6.30am and Mr Ruffini signed off an hour and fifteen minutes later.[27]

14 At 8.00am, the level at Wivenhoe Dam was recorded as EL 68.52m AHD[28] and Somerset Dam was at EL 100.46m AHD.[29] On any view of the Manual, the conditions for invoking Strategy W3 had now been exceeded. The January FER records that there was a transition from Strategy W1 to W3 at this time.[30] However, as explained below, I reject any suggestion that the flood engineers conducted flood operations on 8 January 2011 as though they were in Strategy W3 or believed they were so acting.[31]

15 At 8.15am, Mr Ayre issued "Wivenhoe Directive 4"[32] which directed six gate openings of one increment each between 9.00am and 2.00pm, taking the total increments open to 24 increments. His directive indicated that at the completion of the opening, the dam would be releasing 1247m^3/s. These openings accorded exactly with the gate openings in the 7 Jan 12:00 ROG run and the 7 Jan 18:00 ROG run. Mr Ayre's 6 Jan 21:00 ROG run modelled gate openings to 24 increments at 10.00pm on 8 January 2011. All of them were directed to establishing an outflow of around 1200m^3/s.

25 Simulation Analysis, EXP.ROD.015.0461 at .0846.
26 Ibid at .0931.
27 SUN.002.005.0002 at .0003.
28 QLD.001.001.2469.
29 QLD.001.001.2470; Simulation Analysis, EXP.ROD.015.0461 at .0479.
30 January FER at .0307.
31 Chapter 7 at [458].
32 QLD.001.001.2471.

Mr Ayre's Buffer

16 Mr Ayre accepted that, in giving that gate directive, he was "following on from the gate operations spreadsheet" handed to him by Mr Ruffini, being the product of the 7 Jan 18:00 ROG run.[33] However, Mr Ayre also asserted that "on that Saturday … the minimum release rate I would have needed to make was 660 [m^3/s], but we put in play a gate release sequence that took releases up to 1250 [m^3/s]".[34] This was clearly a reference to the gate directive as that was the only instruction given by Mr Ayre on that day to open Wivenhoe Dam gates.

17 Mr Ayre said that, in setting releases on that day (and throughout the flood event), he considered forecasts in making release decisions by shortening the period to evacuate water currently retained above FSL.[35] Mr Ayre said that he adopted an approach whereby he determined the amount of water that was above FSL, which at this time was 430,000 ML, and determined the minimum release rate to evacuate that water in the seven-day period referred to in the Manual,[36] namely, 660m^3/s. He says that "we compressed that into a four to five-day drainage sequence by adopting 1250 cumecs as the release rate" and "[i]n that way, we were making room for the potential for forecast rainfall upstream of the dams".[37] He explained that this approach involved identifying the maximum rate of release by reference to the relevant strategy (determined by actual lake levels and the statement that peak outflow should not exceed peak inflow to date) and the minimum rate of release, being the rate necessary to evacuate the water above FSL in seven days.[38] Within those constraints, he said that he considered forecast rain in determining whether to shorten the period of evacuation by increasing the release rate.[39]

[33] T 7650.289.
[34] T 7632.2 -.5.
[35] T 7632.9; T 7694.37 to T 7695.11; T 7723.20 - .33.
[36] Manual at 1.
[37] T 7632.7; (Ayre); T 7625.15.
[38] T 7693.19 - .33.
[39] T 7693.39.

18 The plaintiff attacked this evidence and submitted that it was "demonstrably false",[40] a proposition that SunWater contended was never put to him in cross-examination[41] but which I will treat as no more than a submission that something can be demonstrated to be incorrect. In a supplementary submission, the plaintiff submitted that it was a "recent invention",[42] a proposition that SunWater also submitted was never put.[43] In any event, it was never put to Mr Ayre that he was lying in his evidence on this point. However, it was plainly suggested that he was wrong in asserting that he adopted the above approach[44] and I will address the submission on that basis. In addressing that submission, it is necessary to outline how Mr Ayre's evidence of this approach emerged and whether it is supported by the contemporaneous materials.

19 The plaintiff submitted that the adoption of the approach "was not mentioned in Mr Ayre's voluminous affidavit evidence".[45] In his oral evidence, Mr Ayre agreed that a discussion of this approach was not "captured" in his affidavits. That concession is substantially correct although, as I will explain, Mr Ayre did himself a slight disservice.

20 Mr Ayre swore three affidavits in the proceedings.[46] Just the text of the three affidavits total 1076 pages. His first affidavit[47] addressed, inter alia, his general approach to flood operations, the Manual and provides a detailed hourly chronology of the course of the flood event.

21 In its submissions, SunWater contended that section 22 of the affidavit included a reference to this approach. Section 22 is entitled "Use of the model runs and GOS in operational strategy".[48] In that section Mr Ayre describes the setting of a release rate and noted that the "minimum release

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[40] Plaintiff subs at [1260].
[41] SunWater subs at [2104]; as did Seqwater: Seqwater subs at [1023].
[42] SBM.010.009.0001 at .0008, [6].
[43] T 9917.19 to T 9920.1.
[44] T 7636.41; cf Seqwater subs at [1155].
[45] Plaintiff subs at [1264].
[46] Ayre 1, LAY.SUN.001.0001; Ayre 2, LAY.SUN.006.0001; and Ayre 3, LAY.SUN.007.0001.
[47] Ayre 1, LAY.SUN.001.0001.
[48] LAY.SUN.001.0001 at .0129; SunWater subs at [1824] to [1825].

rate" was "ordinarily dictated by estimates" of the rate necessary to empty the stored floodwaters within seven days.[49] The only reference in this section to the use of forecasts was the following statement:[50]

> "In the January 2011 Flood Event, there was little divergence in the predictions based on rain on the ground and the 24 hour QPFs until Sunday 9 January 2011. I did not operate on the basis of forecast rainfall, but as these divergences occurred, I took the 24 hour QPFs into account when selecting the timing of gate opening sequences and release rates."

22 Contrary to SunWater's submissions,[51] this passage is inconsistent with Mr Ayre's oral evidence about the deployment of a buffer. This passage suggests that rainfall forecasts did not play any role in the selection of release rates until 9 January 2011, when there was said to be a divergence between the QPFs and rain on the ground assessments.

23 Section 26 of Mr Ayre's first affidavit is entitled "Use of forecast rainfall in Flood Operations generally". Section 27 is entitled "Forecast rainfall in the context of the Flood Mitigation Manual" and section 28 is entitled "Use of rainfall forecasts in the January 2011 Flood Event".[52] The reduction of the evacuation period for water stored above FSL by reference to rainfall forecasts is not mentioned in any of section 27, section 28 or the vast number of pages outlining the course of the Flood Event. However, there is an oblique reference to it in section 26. In section 26 (and elsewhere), Mr Ayre reiterated his blanket opposition to the use of forecasts in making predictions about lake levels[53] and states that gate operations were set by reference to predictions over the ensuing 12 to 15 hours using rain on the ground modelling.[54] However, Mr Ayre also stated:[55]

[49] LAY.SUN.001.0001 at .0130, [521] to [522].
[50] LAY.SUN.001.0001 at .0131, [526]; In its submissions, Seqwater referred to two subsequent parts of Mr Ayre's first affidavit that cross refer to this statement: Seqwater subs at [1158] referring to Ayre 1, LAY.SUN.001.0001 at .0157, [642] and [648].
[51] SunWater subs at [1826].
[52] Ayre 1, LAY.SUN.001.0001 at .0005.
[53] T 7633.36; Ayre 1, LAY.SUN.001.0001 at [345], [624] and [627].
[54] Ayre 1, LAY.SUN.001.0001 at [624].
[55] Ayre 1, LAY.SUN.001.0001 at [626].

> "The use of forecast rainfall *can* provide an indication of the overall flood volume to be dealt with and this *assists* in setting the minimum required seven day drainage rate." (emphasis added)

24 The use or non-use of rainfall forecasts by the flood engineers during the January 2011 Flood Event has always been a critical issue in the proceedings. While this extract might be suggesting something similar to what Mr Ayre said in his oral evidence, it was not expanded upon. Further, this passage does not expressly suggest that the period of drainage below seven days should be reduced. Most importantly, although this extract refers to the possible use of forecasts to assist in setting drainage rates, nowhere in the affidavit is it suggested that this in fact happened during the January 2011 Flood Event or that it was discussed with the other flood engineers.

25 Mr Ayre first mentioned the adoption of this approach when he was being cross-examined in this case on a statement he made to the QFCI to the effect that gate operations were based on rain on the ground assessments in which he described the deleterious consequences of basing release decisions on forecast rain.[56] In explaining his evidence to the QFCI, Mr Ayre said that the "prospect of forecast rainfall" was considered if he decided to "adopt a release rate which is in excess of the minimum required to meet [the] seven-day drain down".[57] He said that the "prospect of rainfall" was determined by reference to QPF forecasts.[58] Shortly afterwards, he was asked if he ever "moderated" releases to take into account forecasts, ie, by increasing them.[59] Mr Ayre said that he did and nominated the morning of Saturday, 8 January 2011, saying "we put in play a gate release sequence that took releases up to 1,250m^3/s" and "[i]n that way, were making room for the potential for forecast rainfall upstream of the dams".[60]

26 This assertion has the obvious defect that the release sequence that Mr Ayre gave effect to on the morning of 8 January 2011 was not itself the product of any assessment of the forecasts but instead simply gave effect to the gate

[56] T 7617.31; T 7619.40.
[57] T 7625.17.
[58] T 7625.43.
[59] T 7631.42.
[60] T 7631.47 to T 7632.10.

operations set out in the 7 Jan 12:00 ROG run and 7 Jan 18:00 ROG run formulated by Mr Malone and the 6 Jan 21:00 ROG run formulated by Mr Ayre himself. The cross-examination of Mr Ayre on this point developed this inconsistency by tracing the origins of that release sequence and comparing it to the relevant forecasts.[61]

27 As noted in Chapter 6,[62] Mr Ayre agreed that the proposed gate operations sequences in 6 Jan 21:00 ROG run, which opened gates and increased releases to around 1200m^3/s, was formulated "before there were any with forecast RTFM runs" and was based on "rain on ground".[63] Further, in his affidavit, he noted that on the morning of 7 January 2011 "the four and five day forecasts showed estimates of rainfall between 100 to 200mm" which he said was the "first indication of an escalation of forecast rainfall, which had not been apparent in earlier forecasts".[64] However, the only relevant change in the gate opening sequences in the next gate operations spreadsheet (ie, the 7 Jan 12:00 ROG run) was to bring forward the time at which the gates would open from 11.00pm on 7 January 2011 to 3.00pm, which Mr Ayre said was because "we had a more reliable prediction for Lockyer" flows[65] ie, the change was not referable to the deterioration in the forecasts.

28 Similarly, Mr Ayre was taken to the forecasts available on the evening of 7 January 2011 which showed a further deterioration in the forecasts, yet the only response in the 7 Jan 18:00 ROG run was to *increase* the period of the releases of around 1200m^3/s to 5.00am on 12 January 2011.[66] The gate openings by Mr Ruffini on his shift and by Mr Ayre the following morning were made in accordance with the modelled sequence in the 7 Jan 18:00 ROG run.

29 Mr Ayre was pressed on the apparent inconsistency between, on the one hand, asserting he preserved a buffer for forecast rainfall by reducing the drain down period on account of forecasts and, on the other, the fact that the

[61] T 7701.8 to T 7705.38.
[62] Chapter 6 at [196].
[63] T 7703.12.
[64] LAY.SUN.001.0001 at [1906]; T 7703.24.
[65] T 7705.15.
[66] T 7709.19.

only material changes in planned gate operations between 9.00pm 6 January 2011 and the morning of 8 January 2011 was to increase the time in which releases took place despite a worsening of forecasts.[67] Mr Ayre responded that on 8 January 2011 there was no more "room to move" in relation to releases because the combined downstream flow rate was intended to be less than the rate that would inundate Fernvale and Mt Crosby Weir;[68] ie, in effect the 1200m^3/s was at that time a maximum rate whereas the "minimum release would have been 660 [m^3/s]".[69] This answer illustrates how the objective of Strategy W1 limited his approach. In any event, as noted, the evidence first emerged when Mr Ayre nominated the gate openings in the morning of 8 January 2011 as having given effect to a concern about forecasts. Mr Ayre then asserted that the modelled gate sequence from the evening of Thursday 6 January 2011 incorporated this buffer approach[70] bearing in mind the forecast of up to 100mm of rain which he said was with Mr Malone at the time of their handover that evening.[71]

30 Mr Ayre ultimately asserted that he spoke to Mr Malone about this approach on the evening of Thursday, 6 January 2011 ("Q. So you had discussed with him [Mr Malone] on the Thursday night increasing releases based on forecast rainfall; right? A. Yes".)[72] As noted, Mr Malone prepared the 7 Jan 12:00 ROG run so, if Mr Ayre's evidence is to be accepted, one would expect him to be aware of this approach to forecast rain.

31 As noted, Mr Ayre's lengthy first affidavit addresses each day of the January 2011 Flood Event in detail, including the discussion during the handover from Mr Malone on the evening of 6 January 2011.[73] Nowhere in this affidavit does it mention any discussion with Mr Malone on this topic. Mr Malone gave evidence prior to Mr Ayre. As noted, in his first (lengthy) affidavit Mr Malone specifically addressed the use made of rainfall forecasts during the January

[67] T 7721.15.
[68] T 7721.24.
[69] T 7722.42.
[70] T 7723.7 to T 7724.47.
[71] T 7725.43.
[72] T 7723.28; see also T 7729.18.
[73] LAY.SUN.001.0001 at .0431, [1865] and the handover back to Mr Malone on the morning of 7 January 2011; LAY.SUN.001.0001 at 0443, [1912].

2011 Flood Event. Neither in his affidavits nor in his oral evidence did he give any evidence suggesting there was such a discussion. No question was directed to him suggesting there was such a discussion. In one part of his first affidavit, when explaining his general approach to releases, Mr Malone stated that if "forecast rainfall was for areas upstream of the dam, a higher set of releases *might be* targeted, providing that they did not exacerbate downstream flooding and compromise dam safety".[74] This is not the same as stating that there was a reduction of the drain down period to accommodate rainfall forecasts. Moreover, nowhere in his affidavits or oral evidence did he assert that such an approach was put into effect. His detailed descriptions of the events of 6 and 7 January 2011 do not mention any such approach.[75]

32 SunWater sought to defend both the fact that Mr Ayre adopted this approach and its utility by calculating the time in which the gate releases in various operational spreadsheets would return the dams to FSL after their predicted peak inflows.[76] Table A to its submissions set out these calculations.[77] In the case of the rain on the ground runs from 9.00pm on 6 January 2011 to 2.00pm on 9 January 2011 and using a figure derived from the entire inflows for the flood event, the derived figures were between two days 23 hours and five days 15 hours, although the 7 Jan 2011 12:00 ROG run only returned Wivenhoe Dam to EL 69.44m AHD and not FSL. Table B of SunWater's submissions included similar calculations for the Appendix A "with QPF" and "without forecast" runs.[78] All the "with forecast" runs prior to 2.00pm on 9 January 2011 were returned to FSL in less than seven days.

33 SunWater contended that the difference between those times and seven days, the extra days of releases beyond seven days contemplated by the Manual, the allowance for the releases which had already occurred and the remaining flood storage capacity in Wivenhoe and Somerset Dams all

[74] Malone 1, LAY.SEQ.007.0001 at .0070, [214].
[75] Ibid at .0161 to .0187, [565] to [656]; cf SunWater subs at [391].
[76] SunWater subs at [399ff]; Seqwater made a similar submission: Seqwater subs at [1161].
[77] SBM.030.003.0001.
[78] Ibid at .0002.

constituted a "'buffer' for future rainfall".[79] However, SunWater's tables reveal that the so-called buffer started disappearing rapidly during the evening of 9 January 2011 as rain on the ground estimates started increasing rapidly. SunWater submitted that this was not the result of forecast rain falling but instead of very high catchment average rainfall on the day which was between two and three times what was forecast.[80]

34 In substance, the figures in Table A and Table B are just calculations that follow from an application of the modelled release rate to the rain on the ground inflows (and not vice versa). To speak of the "spare" days between the modelled return to FSL and the seven day period after the predicted peak as a "buffer" means no more than saying that compliance with clause 3.2 of the Manual might still be achieved if those releases are pushed back. However, it does not address the potential to reach EL 74.0m AHD, and thus the requirement to make potential damaging releases as a result of forecast rainfall and inflows in the meantime, especially if the existence of the buffer assumes that releases can be made at times that coincide with heavy rainfall downstream (ie, the "can release assumption").[81] This is illustrated by the events of 9 January 2011 which are addressed below. As noted, on that day, the so-called buffer disappeared. Accepting SunWater's figures and comparing the rain that fell compared to the QPF forecast, planning for rainfall that was double that forecast even over a 24-hour period was exactly the step contemplated by the FPM's reference to modelling 200% of forecast rainfall. Moreover, the steady stream of ever worsening PMEs over 7 and 8 January 2011 consistently pointed to very heavy rainfall on 9 and 10 January 2011.

35 The release rates throughout the period 7 January 2011 to the evening of 9 January 2011 were set by one reference to one criterion only, namely, what was the most that could be released to evacuate flood waters without it being said that an increase in releases caused the inundation of a downstream bridge? Thus, there were no releases made until Burtons Bridge was

[79] SunWater subs at [418].
[80] Ibid at [407] to [408].
[81] SBM.010.009.0001 at [14] and [18(d)].

inundated at around 3.00pm on 7 January 2011. Thereafter releases were increased to the level whereby the combination of existing releases and downstream flows would not cause the inundation of Fernvale Bridge and Mt Crosby Weir. In the end result, those bridges were inundated around midnight on 10 January 2011 but only by a combination of Wivenhoe releases that had been maintained at the same level for effectively 24 hours and an increase in natural flows.

36 While it may be that, against the contingency of further rainfall generally, the flood engineers decided to release at the highest amount below that which would cause the inundation of the next bridge, I do not accept that *beyond that* they were setting releases with a view to maintaining a "buffer" by planning to drain down in less than seven days or any other form of buffer. I reject Mr Ayre's evidence to the extent he said anything more than that. The use of forecasts was such a centrally important issue in this case such that, if they had been used in the manner suggested by Mr Ayre, then I expect that he would have discussed it in his voluminous affidavit in detail. Instead, there is a bare reference to some possible approach similar to the one he articulated but that is all. There is nothing in the contemporaneous material that even hints that forecasts were used in the suggested manner in setting releases. Mr Ayre's oral evidence on this topic, including his assertion that he spoke with Mr Malone about it on the evening of 6 January 2011, caused me to doubt the reliability of his evidence on any matter not corroborated by contemporaneous material.

37 As stated, the figures in Table A of SunWater's submission are merely the lengths of time that follow from the application of the "save the bridges" approach adopted by the flood engineers to the rainfall inflows that confronted them. If anything, they illustrate why a time frame of considering inflows over 24 hours is too small in that they do not address the likely inflows that were being predicted over a two to three-day period. Even allowing for the deficiencies in the 72-hour modelling, on SunWater's figures, the inflows from Mr Ayre's 8 Jan 15:00 72-hour run would not be evacuated until eight days

and five hours after the predicted peak.[82] The cross-examination of Mr Ayre yielded a similar figure for Mr Ruffini's 7 Jan 22:00 72-hour run.[83]

Narrative Resumed

38 At around 9.00am, the Director of Operations for SEQ Water Grid Manager, Mr Spiller, emailed Ministerial and police staff advising them that all five Wivenhoe gates were open and it was anticipated that the release rate would increase to 1200m^3/s by midday. He noted that the release rate was "less than peak release from October 2010" and added that the "[t]he release strategy will continue to be reviewed based on *actual rainfall* …[w]ith significant inflows, it may need to be increased".[84] Within an hour, he sent a further email explaining the strategy and identified the "key risk will be if the high rainfall eventuates (200mm over four days)". He stated Seqwater "will review as this occurs, but in the meantime, it is important that we get the flood storage compartment down to give ourselves some flexibility".[85]

39 An operational run spreadsheet prepared by Mr Ayre at around the same time using only rain on the ground has been preserved (the "8 Jan 09:00 ROG run").[86] This predicted Wivenhoe Dam reaching a peak height of 68.64m AHD at 9.00pm on 8 January 2011 with peak releases from the dam of 1472m^3/s at 1.00am on 10 January 2011. The run predicted or assumed that the natural peaks at Moggill and Lowood had already occurred. The GOS utilised a gate sequence that opened Wivenhoe Dam to 24 increments at 2.00pm on 8 January 2018 and continued to open gates such that 29 increments would be open at 1.00am on 10 January 2011, with gates being closed from around 5.00pm on 10 January 2011. In the 7 Jan 18:00 ROG run, gate openings were held at 24 increments throughout this period. These further openings must be considered with the predicted flows at Moggill. In the 7 Jan 18:00 ROG run, the predicted peak flow rate at Moggill was 1641m^3/s which resulted from the last gate openings being increased to 24 increments at 2.00pm. The

[82] Table A, SBM.030.003.00001.
[83] T 7717.25.
[84] SUN.002.001.0893 at .0894.
[85] SUN.002.001.0893.
[86] QLD.001.001.2476; SDWD-201101080900.xls.

downstream flows at Moggill were then predicted to recede as gate openings were maintained at 24 increments. Mr Ayre's 8 Jan 09:00 ROG run increased the releases from Wivenhoe during that recession so that overall the downstream flow at Moggill remained at around 1600m^3/s until well into 10 January 2011.[87] A flow rate of 1600m^3/s is sufficient to keep Mt Crosby Weir and Fernvale Bridges open.

40 The plaintiff made three related criticisms of this approach.[88] First, the plaintiff contended that it modelled or at least assumed making large releases on 9 and 10 January 2011 when at that stage significant amounts of rain were forecast to fall, including downstream. It contended that this demonstrated that the gate sequences were planned without regard to forecast rainfall. Second, the plaintiff contended that it was in effect an approach only consistent with W1 in that the object was to keep bridges open rather than reduce dam levels to optimise protection against urban inundation. Third, the plaintiff contended that it did not increase releases during 8 January 2011 when downstream flows were relatively low. I accept these points.

41 SunWater noted that these criticisms were not pleaded, but they did not have to be.[89] SunWater also submitted that this release plan preserved a "buffer" for forecast rainfall, generally being the difference between the seven-day drain down period and the four-day 15-hour drain down period that was modelled,[90] a proposition I have already rejected.

42 SunWater further submitted that the PMEs were too unreliable to conduct flood operations and pointed out that the rain that fell early on 11 January 2011 was not forecast in the PMEs.[91] This submission overlooks the fact that the flood engineers repeatedly asserted that they used predictions about the location of rain falling, including that set out in the PMEs, as a basis for *not*

[87] T 7731.5 (Ayre); QLD.001.001.2476.
[88] Plaintiff subs at [1269] to [1270].
[89] SunWater subs at [2113]; see Chapter 6 at [2] re breach pleading.
[90] SunWater subs at [2113] and [2115].
[91] Ibid at [2114].

releasing water,[92] but apparently rejected it as a basis for deciding to immediately release water to create storage space in anticipation of forecast rain. In doing so, and in particular in limiting releases on 8 January 2011, they did not put "chance on their side" because they effectively bet storage space against the chance that the forecasts had substantially overestimated rainfall. As for the absence of a PME forecast for the rain that fell on 11 January 2011, neither the plaintiff nor Dr Christensen advocated holding back water throughout 8 to 9 January 2011 on the chance that releases could be made on 11 January 2011. Throughout 8 January 2011 and much of 9 January 2011, there was sufficient information available about short term conditions downstream to ascertain that releases could be immediately increased without exceeding the Manual's thresholds for damaging flows downstream in order to create space to meet the contingency of forecast rain (or more rain than forecast) falling.

43 SunWater also contended that in Strategy W3 the flood engineers were entitled to consider lower level objectives and thus calibrate flows to maintain Fernvale and Mt Crosby Weir Bridges as open.[93] This can be accepted, but just because they were kept open does not mean that Strategy W3, or its primary consideration of protecting urban areas of inundation, was being given effect to.

44 As noted in Chapter 6, an interrogation of the RTFM reveals that another model run was performed at 9.00am with the case name "201101080900_72hr",[94] however, the GOS from this run was not saved (ie the 8 Jan 09:00 72-hour run).[95] Mr Ayre noted the run in his affidavit and asserted that it "utilised the 72 hour SILO forecast" and that both that run and the rain on the ground were "utilised for the purposes of devising the GOS".[96] During his cross-examination, Mr Ayre stated that it used the same rainfall depths, temporal patterns and initial loss rates as the Ruffini 7 Jan 22:00

[92] Ayre: LAY.SUN.001.0001 at [2287]; see Chapter 7 at [467]; Malone: see Chapter 6 at [183]; T 4736.24; LAY.SEQ.007.0001 at [214]; Tibaldi: LAY.SEQ.014.0001 at [16] and [90].
[93] SunWater subs at [2116].
[94] LAY.SEQ.007.0001 at [660]; EXP.ROD.002.0001 at [67].
[95] Ayre 1, LAY.SUN.001.0001 at .0465, [2014].
[96] Id.

72-hour run.[97] He used the same continuing loss rates for the upstream catchments but reduced some of the loss rates in the Lockyer sub-catchments.[98]

45 It follows that there are two potential issues with this forecast run, namely the combination of loss rates and rainfall distributions and the selected rainfall depths. SunWater contended that the complaints about this run were not pleaded.[99] However, the deficiencies in that forecast run did not have to be pleaded. Consistent with the analysis in Chapter 6,[100] the undertaking of a defective RTFM run is simply part of the decision-making process that leads to implementing a strategy and making or not making a gate release. It was the defendants who sought to rely on these runs as justifying the approach taken. The plaintiffs pleaded the strategy that *was* implemented and what *should have been* implemented. That is sufficient.

46 In relation to the former issue, Mr Ayre accepted that depending on the depth of the rainfall and the temporal pattern applied, there will always be a difficulty in estimating future inflows using continuous rainfall applied to loss rates calibrated to spasmodic past rainfall.[101] In any event, the reasoning and findings noted above in relation to the Ruffini 7 Jan 22:00 72-hour run apply with equal force to this forecast run. The position with respect to rainfall depths used in this run is addressed below in the context of the 8 Jan 15:00 72-hour run.

47 Just before 11.30am, Mr Ayre issued a directive to the Somerset Dam operators that required the opening of a sluice gate at Somerset to its full capacity.[102] The directive stated:

> "Somerset Dam is expected to peak at around mid-day at about EL 100.48 m. As we have exceeded EL 100.45 m (fixed crest level), *but Wivenhoe Dam is still rising we will need to implement Strategy S2.*

[97] T 7752.24; T 7752.41; T 7753.18 (Ayre).
[98] T 7763.24 - .36.
[99] SunWater subs at [2118].
[100] Chapter 6 at [2].
[101] T 7766.16.
[102] SEQ.001.018.4107; SEQ.001.018.4108; QLD.001.001.2489.

> This strategy is aimed at maximising the benefits of the mitigation storage in both Somerset and Wivenhoe dams. Consequently, we will endeavour to follow the target line as defined in the manual." (emphasis added)

48 The plaintiff submitted that, as both dams had been above FSL for some time, the conditions that engage S2 had occurred long before this point. It contended that this email reveals a fundamental lack of understanding of the Manual's strategies on the part of Mr Ayre. It noted that, when pressed on this, Mr Ayre said that he "probably should have said we were continuing to implement Strategy S2"[103] and submitted that this was not a credible explanation.[104] SunWater urged an acceptance of Mr Ayre's explanation.[105]

49 I do not accept either the plaintiff's contention or Mr Ayre's rationalisation. I consider it far more likely that this directive was meant to refer to the conditions that engage the second row of the "box" in Strategy S2, rather than the strategy itself.[106] The second box is applicable when Wivenhoe Dam is rising and Somerset Dam exceeds EL 100.45m AHD.[107] Once engaged, it states that the Operating Target Line is to "generally be followed". Mr Ayre's directive refers to the conditions for the second box in the first paragraph and then declares a goal of endeavouring to "follow" the Operating Target Line in the second paragraph. Another sluice gate was opened at midday.[108] (As the events of 9 and 10 January 2011 demonstrate, the approach of "follow[ing]" the Operating Target Line involved moving almost vertically from the duty point to the Operating Target Line and then operating for a period above the Operating Target Line. This is not what was required by the Manual.)[109]

50 At 12.15pm, Mr Ayre issued a Flood Operations Centre status report.[110] He circulated the same report as a situation report at 2.22pm.[111] He noted that no significant rain had fallen over the dam catchments in the previous

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[103] T 7902.41.
[104] Plaintiff subs at [1282] to [1283].
[105] SunWater subs at [2131].
[106] See Chapter 3 at [82] to [89].
[107] Manual at 40.
[108] January FER at .0465.
[109] See Chapter 3 at [88] to [89] and Chapter 9 at [362].
[110] QLD.002.002.2889; SEQ.001.011.4656.
[111] QLD.001.001.2516.

18 hours but repeated the four-day forecasts summarised by Mr Ruffini in his situation report issued that morning; ie, 5 to 50mm for Saturday, 50 to 100mm for the following day, 50 to 100mm for Monday 10 January 2011 and 25 to 50mm for Tuesday 11 January 2011. He noted that at midday Wivenhoe Dam was at EL 68.60m AHD and rising steadily with all five gates open, releasing 1150m^3/s which would increase to 1250m^3/s that afternoon. He stated that Somerset Dam had peaked at EL 100.47m AHD and was slowly falling. Consistent with earlier reports, he noted that it was "intended to increase the release(s) from Wivenhoe to 1250m^3/s by 14:00 on Saturday 08/01/2011" and that "[t]his will maintain flows of up to 1600m^3/s in the mid-Brisbane River throughout the afternoon." His discussion of downstream impacts was not materially different from Mr Ruffini's earlier report. He stated that it was not expected that Fernvale Bridge and Mt Crosby Weir Bridge would be affected.

51 The Event Log records that at 2.00pm a representative of Brisbane City Council contacted the FOC inquiring about combined flow levels in the Brisbane River and was "advised that at this stage flows would not exceed 1500m^3/sec".[112]

52 At around 3.00pm, Mr Malone emailed Mr Ayre referencing the rainfall estimates in the most recent situation report. He provided a link to the BoM website and stated that the "BoM estimates are now double these estimates for the next few days".[113] In his first affidavit, Mr Malone stated that these were PME forecasts.[114] Given the totals included in the situation report issued at midday, it suggests that 100 to 200mm of rain was forecast for Sunday, 100 to 200mm of rain forecast for Monday and (potentially) 50 to 100mm of rain for Tuesday.

[112] QLD.002.001.8660.
[113] SEQ.001.018.6305.
[114] LAY.SEQ.007.0001 at [663].

8 Jan 15:00 72-Hour Run

53 Two operational runs undertaken by Mr Ayre at around 3.00pm on 8 January 2011 have been preserved. One is a rain on the ground run[115] (the "8 Jan 15:00 ROG run") and the other is the 8 Jan 15:00 72-hour run.[116]

54 The 8 Jan 15:00 72-hour run predicted a substantial increase in the overall volume of inflows into Wivenhoe Dam compared to the rain on the ground model, being 788,378 ML compared to 423,274 ML. However, this did not yield an appreciable increase in the predicted height of the Wivenhoe Dam water level, in that it only predicted Wivenhoe Dam reaching a maximum height of 68.82m AHD at 3.00pm on 12 January 2011 as part of a twin peak hydrograph with the first peak of 68.66m AHD at 8.00pm on 8 January 2011. To achieve this, the gate operations spreadsheet commenced increasing gate openings late in the evening of 8 January 2011 and projected opening to 28 increments at 6.00pm on 9 January 2011. The spreadsheet projected starting to close gates again at 10.00pm that night, with gate closings occurring slowly until 11 January 2011 before openings resumed again.

55 Both of these runs predicted that the natural peaks at Lowood had already passed. The 8 Jan 15:00 72-hour run predicted that the natural peak of 887m^3/s at Moggill would occur at 4.00am on 11 January 2011.[117] It predicted very modest outflow from Lockyer Creek and Bremer River throughout Sunday 9 January 2011 and for most of Monday 10 January 2011.[118]

56 Again, the plaintiff subjected the 8 Jan 15:00 72-hour run to severe criticism.[119] Mr Ayre described how the RTFM run was undertaken in his third affidavit which includes the relevant RTFM's screenshot.[120] The run used the same rainfall depths and loss rates as the Ruffini 7 Jan 22:00 72-hour run for the upstream catchments and the same temporal pattern for all catchments.

[115] SDWD-201101081500.xls; QLD.001.001.2542.
[116] SDWD-201101081500-Forecast72hr.xls; QLD.001.001.2543.
[117] Ayre 1, LAY.SUN.001.0001 at [2039(c)]. A closer analysis of the gate operations data reveals the natural peak to actually be 886m^3/s on 11 Jan at 4.00am.
[118] QLD.001.001.2542; input data.
[119] Plaintiff subs at [1288ff].
[120] Ayre 3, LAY.SUN.007.0001 at [54] to [70].

The findings I made in Chapter 6 in relation to the combination of using continuing loss rates calibrated from past sporadic rain to future temporal patterns that assume continuous rain apply with equal force to this RTFM run.

57 The rainfall depths utilised in the 8 Jan 15:00 72-hour run were also scrutinised. In his first affidavit, Mr Ayre stated that the 8 Jan 09:00 72-hour run "utilised the 72 hour forecast". In his third affidavit, Mr Ayre stated that the rainfall depths in the 8 Jan 15:00 72-hour run were "based on a SILO Meteogram forecast obtained from the BoM's website".[121] However, as noted, both used the same rainfall depths as the Ruffini 7 Jan 22:00 72-hour run. Mr Ayre was cross-examined about this as follows:[122]

> "Q. Who obtained the SILO meteogram forecast from the Bureau's website?
> A. Well, I would have obtained that forecast.
>
> Q. Is it your recollection that you made an assessment of that forecast and then included the rainfall in that case run which is identified in the screenshot in paragraph 59 [of this third affidavit]?
> A. Well, I'm now aware, because I've reviewed all three 72-hour SILO meteograms, that, indeed, the rainfall incorporated in all three is similar.
>
> Q. It's not similar; it's identical, isn't it?
> A. It's identical, yes. But I have a recollection that I did review the SILO meteograms on that Saturday, and if I had observed a material difference in the rainfalls, then I would have changed them.
>
> Q. So is it your recollection that there was no relevant change in the SILO meteogram forecast between the evening of 7 January and the afternoon of 8 January?
> A. Yes. If there had been, I believe I would have changed those values.
>
> …
>
> Q. So Mr Ruffini's 72-hour forecast run, if it was based on a SILO meteogram forecast, would have been based on the 6pm, 7 January 2011 meteogram forecast?
> A. Yes, I believe so, yes.
>
> Q. You would have, if your recollection is correct, checked that, or checked his figures against the 6am, 8 January forecast; correct?
> A. Yes.

[121] Ayre 3, LAY.SUN.007.0001 at [58].
[122] T 7733.44 to T 7735.23.

Q. And did you take any other forecasts into account when you included rainfall in either your 9am RTFM 72-hour case runs or your 3pm 72-hour case runs?
A. No, I think they would have been solely on the basis of the SILO meteograms.

Q. Did you have any discussion with Mr Ruffini about what his case run was based on in terms of forecasts?
A. I don't have a recollection of a specific discussion with Mr Ruffini about that, no.

Q. But in any event, all you looked at was the SILO meteogram forecast issued at 6am on 8 January in order to decide whether to change the figures which Mr Ruffini had put into the earlier case run?
A. Yes."

58 It follows from the findings in Chapter 6,[123] that I do not accept that a comparison between a SILO updated at 6.00pm on Friday 7 January 2011 and a SILO updated at 6.00am on Saturday 8 January 2011 would have justified maintaining the same rainfall values across all three 72-hour RTFM runs. Although Mr Ayre stated that he had an actual recollection of comparing SILOs, I am not satisfied that occurred.

59 It further follows from the findings in Chapter 6[124] that a SILO updated at 6.00am on 8 January 2011 was based on a 7 January 1200UTC Access-G output that was available at 3.30am on 8 January 2011. It was one of the five Access models that contributed to the FEWS translated catchment forecasts for 1200UTC on 8 January 2011 in Table 6.2.2 of the January FER. The FEWS translation yielded catchment forecasts of 165mm for the Somerset catchment and 136mm for the Wivenhoe catchments.[125] The modelled figures utilised in the 8 Jan 09:00 72-hour run and the 8 Jan 15:00 72-hour run were 130mm for the Somerset catchment and a range of 60 to 100mm for the Wivenhoe catchments (ie, Middle Brisbane and Upper Brisbane).

60 I am sceptical of Mr Ayre's evidence of consulting a SILO in performing his 72-hour model runs. However, given that the Access-G forecast was only one of five outputs into the FEWS translation and what little is known about a

[123] Chapter 6 at [287].
[124] Ibid at [291].
[125] Ibid at [278].

FEWS translation, I cannot exclude the possibility that a SILO based on an Access-G output available at 3.30am on 8 January 2011 was capable of (just) supporting the rainfall depth figures in the two 72-hour forecast runs that Mr Ayre undertook that day.

61 Nevertheless, even allowing for this, I am still satisfied that the derived inflow figures were still unreasonably low given the combination of temporal pattern and loss rates. In cross-examination, Mr Ayre said that he assessed the reliability of the two forecast runs he undertook at around 3.00pm on 8 January 2011 by comparing the overall volume of runoff calculated upstream of the dams in the two runs.[126] He noted that the 8 Jan 15:00 72-hour run estimated an inflow volume of 788,378 ML while the 8 Jan 15:00 ROG run produced 423,274ML;[127] ie, 423,274ML of inflow was referable to rain that had fallen and a further 365,104ML was due to forecast rain. He noted that in the period from 2 January 2011 up to 3.00pm on 8 January 2011, approximately 80 to 90mm of rain had fallen and that the 8 Jan 15:00 72-hour run assumed a further 60mm to 80mm of rainfall in the Upper Brisbane catchment and 130mm of rainfall in the Somerset catchment. He regarded that a "reasonable validation".[128]

62 There are two interrelated problems with this analysis. First, Mr Ayre is comparing the runoff from approximately 80mm to 90mm of rain that fell in the six days from 2 to 8 January 2011 with a prediction of runoff based on the assumption that approximately the same amount of rain will fall in three days in a catchment that is progressively getting wetter. His modelling produced approximately 14% less runoff for the three-day period and not more (as would be expected). Second, as noted by the plaintiff,[129] this analysis overlooks the circumstance wherein, on the modelling undertaken by the flood engineers, a significant portion of the past rainfall was absorbed as initial losses, which would not apply to the forecast rain being modelled. The initial

[126] T 7768.3.
[127] T 7768.13 - .18.
[128] T 7768.37; T 7769.7 (Ayre), although he was modelling 100mm of rainfall in the middle Brisbane catchment.
[129] Plaintiff subs at [1294]; Seqwater complains that this was not taken up with Mr Ayre (Seqwater subs at [1474]) whereas SunWater does not (SunWater subs at [2148]).

loss figure was 15mm for the Somerset catchment and ranged between 0mm and 40mm for the Wivenhoe catchments.[130] This yields an overall weighted average of 21.5mm for initial losses.

63 Further, in relation to the 8 Jan 15:00 72-hour run, it must be remembered that, at the time it was performed, Mr Ayre's most recent assessment in the situation report was 125mm to 250mm in the subsequent three days and Mr Malone had just advised that the PME forecasts had doubled those figures. The 8 Jan 15:00 72-hour run used rainfall depths well below those amounts. Further, in the QPF forecast issued at 4.00pm, predicted average rainfall was 30mm to 50mm in both dam catchment zones for the 24 hours to 3.00pm on 9 January 2011.[131] This represented a substantial portion of the three-day forecast rainfall depths included in the 8 Jan 15:00 72-hour run. It utilised a forecast of 60mm of rain for two of the upper Brisbane sub-catchments, COO and EMU.

64 I am satisfied that, on the information available at or shortly after it was conducted, the 8 Jan 15:00 72-hour run yielded a serious underestimate of the likely inflows based on rain on the ground and rain forecast to fall over the following 72 hours.

65 As noted, in his first affidavit Mr Ayre stated that the outcome of 8 Jan 15:00 72-hour run "confirmed that the current releases would satisfy the primary consideration of Strategy W3 whilst allowing Fernvale Bridge and Mount Crosby Weir Bridge" to remain open.[132] Given the deficiencies in the modelling, the progression of the forecasts and that the modelled heights and releases assumed that releases could be made over a sustained period, I do not accept that. SunWater's submissions to the contrary are predicated on an

[130] 0mm – WDI; 40mm – GRE; 30mm – EMU; 30mm – LIN; 30mm – COO and 10mm – CRE: LAY.SUN.007.0001, [65].
[131] QLD.001.001.2546.
[132] Ayre 1, LAY.SUN.001.0001 at .0474, [2040]; T 7914.19.

acceptance of the reasonableness of the inflow volume generated by the 8 Jan 15:00 72-hour run,[133] a matter I do not accept.

8 Jan 15:00 ROG Run

66 The 8 Jan 15:00 ROG run[134] was not materially different from the RTFM rain on the ground run undertaken that morning. The commencement of the gate opening sequence that increased openings from 24 to 29 increments was pushed back to 2.00am on 9 January 2011 from 11.00pm on 8 January 2011 with consequential amendments to the gate closing sequence. It predicted Wivenhoe Dam reaching a maximum height of 68.66m AHD at 8.00pm on 8 January 2011. This run appears to have been used as the basis for gate operations as it contains gauge board readings up to and including 6.00am on 9 January 2011. The gate operations modelled by this run appear to be a continuation of the gate operations strategy foreshadowed as far back as the evening of 6 January 2011.

67 The plaintiff submitted that this was "remarkable" given the forecasts for the coming days, the fact that at a minimum Strategy W3 was required to be engaged and the fact that downstream conditions were then favourable to make releases. It submitted that "[a]ll indications were that releases could be increased from Wivenhoe Dam with minimal risk of causing downstream flooding",[135] especially having regard to the Manual's reference to flows below 4000m^3/s as "non-damaging".[136] SunWater contended that, no witness advocated making releases based on PMEs, the material available suggested that damage at flow rates between 2000m^3/s and 4000m^3/s would occur and that there was always a risk of unforecasted rain falling directly on the river and combining with releases.[137] However, as noted, the engineers advocated not releasing water based on rainfall forecasts[138] and the Manual dictated a threshold for non-damaging releases. The risks associated with releases

[133] SunWater subs at [2145] to [2151].
[134] QLD.001.001.2543; SDWD-201101081500.xls.
[135] Plaintiff subs at [1303].
[136] Ibid at [1304].
[137] SunWater subs at [2153] and [2155].
[138] See [467].

combining with unforecasted rain are addressed below (and in Chapters 8 and 9).

Evening Situation Report

68 The doubled estimates referred to by Mr Malone were not incorporated into Mr Ayre's situation report issued at 5.53pm.[139] In that report, he noted that some rain had fallen over the dam catchments in the preceding 12 hours and noted the QPF forecast of 30mm to 50mm of rain in the following 24 hours. He provided a breakdown of the PME-predicted rainfall for Sunday, Monday and Tuesday, this being between 50mm to 100mm, 50mm to 150mm and 25mm to 50mm respectively. They total between 125mm and 300mm over three days and are thus well in excess of the rainfall depths modelled in the 8 Jan 15:00 72-hour run. The situation reports issued at midday that day referred to predictions of between 125mm and 250mm over three days.

69 The plaintiff contended that these figures warranted revisiting the 8 January 15:00 72-hour run.[140] Mr Ayre agreed that the 8 Jan 15:00 72-hour run was not a "reasonable realisation of 300mm [of forecast rain] in that period",[141] this number representing the high range of forecasts. SunWater noted that the one-day PME forecast of 50mm to 100mm for 9 January 2011 was not consistent with the catchment specific QPF forecast of 30 to 50mm.[142] However, the one-day PME was for the 24-hour period to 10.00pm on 9 January 2011, whereas the QPF was only to the period to 4.00pm. They were not inconsistent.

70 Mr Ayre reported that Somerset Dam had peaked at EL 100.47m AHD at 10.00am and was slowly falling but Wivenhoe Dam was at EL 68.65m AHD, rising slowly and releasing 1250m^3/s. He stated that the "current gate operation strategy will [be to] maintain flows of up to 1600m^3/s in the mid Brisbane River throughout the evening". The section of the situation report

[139] SEQ.001.011.4651.
[140] Plaintiff subs at [1305].
[141] T 7770.4.
[142] SunWater subs at [2164] to [2165].

entitled "Impacts Downstream of Wivenhoe" was not materially different from the earlier report. It noted that:

> "The *current Wivenhoe release* of 1,250m^3/s combined with Lockyer flows and local runoff will mean that all low level crossings downstream of Wivenhoe (Twin Bridges, Savages Crossing, Burtons Bridge, Kholo Bridge and Colleges Crossing) will be adversely impacted for several days (until Wednesday 12 January). At this stage Fernvale and Mt Crosby Weir Bridge *are not expected to be affected* but they could potentially be affected if the predicted rainfall totals eventuate and higher releases from Wivenhoe Dam are considered necessary." (emphasis added)

71 However, the situation report also contained a section entitled "Forecast scenario". It stated:

> "**Forecast Scenario – Based upon mid-range rainfall forecasts**.
>
> Assessments have been undertaken to determine possible increases to releases given the high likelihood of significant inflows in the next few days. The interaction with runoff from the Bremer River and Warrill Creek catchment is an important consideration as the event magnitude *will require the application of Wivenhoe Dam flood operation strategy W2 (Transition strategy between minimizing downstream impacts and maximizing protection to urban areas*).
>
> Projections based upon the forecast rainfalls suggest flows of up to 1,200 m^3/s will emanate from the Bremer River catchment. If similar rainfall magnitudes occur in the Upper Brisbane and Stanley Rivers then increased releases may be required from both Somerset Dam and Wivenhoe Dam. Preliminary projections suggest that such a forecast will extend the release duration until next Saturday 15 January, but mid-Brisbane River flows will be kept to a maximum of 1,800 m^3/s. However, if falls are greater than those forecast releases from Wivenhoe Dam may need to adversely impact Mt Crosby Weir Bridge (1,900 m^3/s) and possibly Fernvale Bridge (2,100 m^3/s) *but will be maintained below 3,500 m^3/s*.
>
> The assessments will be updated as the event progresses." (emphasis added)

72 The above passage contains the first express reference to a Wivenhoe strategy in any of the situation reports (or other documents) issued by the flood engineers during the January 2011 Flood Event. On its face, the passage suggests that Mr Ayre was not acting on the basis that any transition out of Strategy W1 had yet occurred. Instead, it appears to contemplate a possible transition to Strategy W2 at some point in the future in the event of forecast rain falling, in which case releases would be increased but be

constrained to 3500m^3/s. Each of Mr Malone and Mr Ruffini received the situation report suggesting that a transition to W2 would occur in the future. There is no evidence that they sought to contradict or correct that suggestion.

73 Mr Ayre did not address this part of his situation report in his daily chronology in his first affidavit.[143] In cross-examination, he was taken to this part of the report and asked as follows:[144]

> "Q. You are speaking in the future then, because you are referring to forecasts; correct?
>
> A. So the projected gate sequence that I put in place would effectively take up from where we were at, which was a lake level of about 68.65, draw us down below 68.5, and the bring us back above the W1, W2/W3 threshold level peak at about 68.6.
>
> In the modelling, because I was focussed on predominantly downstream flows and the fact that I was trying to piggyback on hydrographs, I have referenced strategy W2, but I recognise now that the – in the gate operations spreadsheet, the maximum release rate that I selected in that scenario actually exceeds the naturally occurring peak flows downstream, so it should have been categorised as a W3 release.
>
> Q. Did you explain all of that to Mr Tibaldi later in January 2011 when he was preparing the flood event report?
>
> A. I believe we had a discussion about what was being looked at under that forecast scenario, yes."

74 In this answer, Mr Ayre appears to be suggesting that the situation report assumes that flood operations were already in W3 and he was advising recipients that the water level would drop below EL 68.5m AHD but, if forecast rain fell, the Wivenhoe Dam level would rise above EL 68.5m AHD (and that he mistakenly referred to W2 when he should have referred to W3). If that is what Mr Ayre intended to convey by his answer, then I do not accept that represents what is conveyed by the situation report or his state of mind at the time. The recipients of the situation report included Council representatives. None of the earlier communications had advised them that W3 was engaged and no other contemporaneous document had suggested that W3 was engaged. To the contrary, all of the communications to this point had been only concerned with the primary objective of W1, namely, avoiding disruption

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[143] See Ayre 1, LAY.SUN.001.0001 at [2045] to [2046].
[144] T 7914.37 to T 7915.11 (Ayre).

to downstream bridges and there had not been any reference to concerns about avoiding damage to urban areas. The conclusion that Mr Ayre (and the other flood engineers) understood they had been and were currently operating in W1 is only strengthened by considering the evidence concerning flood operations over the following 30 hours, especially the Event Log entry for 3.30pm on 9 January 2011[145] as well as the documents prepared in the immediate aftermath of the flood event (see below).

75 A sign on sheet records that Mr Ayre signed off duty at around 7.00pm.[146] Mr Tibaldi commenced his first shift around that time.[147]

State of Forecasts around Time of Handover

76 It is necessary to identify the state of the rainfall forecasts at the time of the handover from Mr Ayre to Mr Tibaldi.

77 As noted, the QPF issued at 4.00pm on 8 January 2011 had predicted 30 to 50mm of rain falling above the dams in the 24-hour period to 4.00pm on 9 January 2011. Mr Ayre's situation report passed on a forecast of between 125mm and 300mm over the following three days (an increase from the prediction of between 125mm to 250mm at 12.15pm and 2.22pm) but not the doubled estimate advised by Mr Malone at around 3.00pm.

78 The most current forecasts were the daily PMEs for the forecast periods commencing 10.00pm that evening that became available at 6.00pm that evening.[148] Mr Giles' assessment of those one-day PMEs for the following three days was that they predicted 218mm of rain for the middle Brisbane catchment, 202mm of rain for the Somerset catchment, between 100mm and 149mm of rain for each of the upper Brisbane sub-catchments, and much larger predictions (mostly in excess of 300mm) for each of the downstream sub-catchments, especially Bremer and the Lower Brisbane River

[145] See [190].
[146] SUN.002.005.0002 at .0003.
[147] January FER at .0328.
[148] SEQ.004.019.2495; SEQ.004.019.2497; and SEQ.004.019.2499.

catchments.[149] These figures are consistent with Professor Manton's assessment of the four-day PME available from midnight which was largely derived from the one-day PMEs. Professor Manton assessed the four-day PME as predicting 184mm in the catchments above the dams, 235mm in the Lockyer catchment, 315mm in the Bremer catchment and 392mm in the Lower Brisbane catchment.[150] These four-day figures effectively correspond with a three-day forecast, as less than 4mm of rain was predicted for the fourth day in every sub-catchment.[151]

79 Mr Giles and Professor Manton's assessments all predicted greater rain below the dams than above. Their analyses were not available to a flood engineer on the evening of 8 January 2011. However, a flood engineer considering the PME maps should be taken to be aware of the uncertainty associated with the precise location of predicted rainfall and caution would therefore warrant planning for higher amounts falling above (as well as below) the dams.

80 There was no suggestion that a SILO meteogram was obtained by Mr Tibaldi during his shift. Any SILO meteogram that was available *before* 6.00pm was based on an Access-G output that was one of five Access models that was translated via FEWS to a catchment forecast of 165mm for Somerset Dam and 136mm for Wivenhoe Dam. However, such a SILO meteogram was by that time well out of date and about to be updated at 6.00pm by an Access-G output that, when translated by FEWS with the other Access models, would produce a three-day catchment forecast of 230mm for Somerset Dam and 267mm for Wivenhoe Dam.[152]

81 In his second affidavit, Mr Tibaldi stated that at the time he commenced his shift, the eight-day PME forecast available to him was issued "on the morning" of 8 January 2011.[153] He noted that the plaintiff's assessment of the four and

[149] EXP.QLD.001.0611 at .0792.
[150] AID.500.026.0001.
[151] EXP.QLD.001.0611 at .0792.
[152] See Table 6.2.2 from the January FER in Chapter 6 at [278].
[153] Tibaldi 2, LAY.SEQ.014.0001 at [14].

eight-day forecasts was between 100mm and 300mm of rain and between 100mm and 320mm of rain respectively, but he contended that they only showed rain above the dams in the range 150mm to 200mm,[154] a view not shared by the State.[155] He said that it predicted heavier rain downstream of Wivenhoe Dam, suggesting one should be cautious about releases.[156]

82 It is not clear whether Mr Tibaldi was referring to the four-day and eight-day PMEs available from midnight on 8 January 2011 (ie, 00UTC PMEs) or 6.00am on 8 January 2011 (ie, 1200UTC PMEs). Professor Manton's analysis of the four-day and eight-day PMEs available from 6.00am is that they showed a significant deterioration in the predicted rainfall both above and below the dam from the PMEs available from midnight.[157] In any event, these PMEs were overtaken by the one day PMEs available from 6.00pm that night. Otherwise, given Mr Tibaldi's lack of recollection of the shift and my overall view of Mr Tibaldi's evidence, I am not satisfied he undertook the required level of analysis on the evening of 8 January 2011.[158]

Mr Tibaldi's Shift until Midnight

83 Mr Tibaldi was on leave during 2 to 7 January 2011 and returned to Brisbane on 8 January 2011.[159] The gate operations spreadsheet associated with the 8 Jan 15:00 72-hour run had indications that it was saved at around 7.42pm on the evening of 8 January 2011. Having regard to that, Mr Tibaldi states that he saved it and thereafter reviewed it.[160] Notwithstanding my doubts about his evidence, I accept that this is the most likely inference to be drawn.

84 Mr Tibaldi maintained the gate settings he inherited at the commencement of his shift until midnight on 8 January 2011 such that Wivenhoe Dam gates

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[154] Tibaldi 2, LAY.SEQ.014.0001 at [15].
[155] AID.500.035.0001 at .0003.
[156] Tibaldi 2, LAY.SEQ.014.0001 at [16].
[157] North: 156mm to 187mm; Lockyer: 163mm to 225mm; Bremer: 215mm to 317mm; Lower Brisbane: 339mm to 427mm; AID.500.026.0001.
[158] T 6294.30.
[159] Tibaldi 1, LAY.SEQ.004.0001 at [616]; T 6256.42.
[160] T 6261.27 (Tibaldi); LAY.SEQ.014.0001 at .0029, [43].

were open to a total of 24 increments.[161] This was consistent with the gate operations that were modelled in the 8 Jan 15:00 ROG run (which reflected the gate operations modelled as far back as the 7 Jan 12:00 ROG run and largely reflected the gate operations foreshadowed in the 6 Jan 21:00 ROG run). At midnight, Wivenhoe Dam was releasing 1241m^3/s. The reservoir level was EL 68.64m AHD, with the level falling as inflows were 926m^3/s.[162] Somerset Dam was releasing 412m^3/s through two sluice gates. The reservoir level at Somerset Dam was EL 100.32m AHD, which was also falling as inflows were 357m^3/s.[163] This reflected the effect of the recent cessation of rainfall and meant that Wivenhoe Dam was at or approaching the crest of the first peak in the hydrographs predicted by the recent operational runs. In Dr Christensen's Simulation A, by midnight on 8 January 2011, Wivenhoe Dam was at a lake level of EL 63.33m AHD and releasing 1387m^3/s.[164]

85 There is nothing to suggest that Mr Tibaldi undertook any modelling of his own that evening. I am satisfied that he simply continued the gate operations strategy that he inherited from Mr Ayre.

86 Mr Malone's "Observed Rainfall Analysis" report records catchment average rainfalls of 53mm, 22mm and 11mm for the 24 hours to 9.00am on Sunday, 9 January 2011 for the Somerset, Upper Brisbane and Middle Brisbane catchments respectively.[165] It also records catchment average rainfall in the 24 hours to 9.00am on 9 January 2011 in the Lockyer, Bremer and Lower Brisbane catchments of 5mm, 3mm and 9mm respectively. Dr Christensen assessed actual rainfall upstream of Wivenhoe Dam on 8 January 2011 as 28mm.[166]

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[161] January FER at .0451.
[162] Simulation Analysis, EXP.ROD.015.0461 at .0469.
[163] Ibid at .0479.
[164] Ibid at .0469.
[165] SEQ.004.046.0230 at .0273.
[166] EXP.ROD.001.0583 at .0680.

Mr Tibaldi and Strategy W3

87 In his affidavits, Mr Tibaldi outlines the course of the events on the evening of 8 January 2011 and his response to the various allegations of breach by the plaintiff in respect of his conduct on 8 January 2011.[167] At this stage, I note the evidence concerning what Mr Tibaldi asserts he can recall about that evening.

88 In his first affidavit, Mr Tibaldi stated that, during the evening of 8 January 2011, he "managed the operations of the Dams in accordance with the dam and river management approach determined by the Senior Flood Operations Engineer",[168] a proposition I generally accept and will return to address. However, he also stated that "Somerset Dam and Wivenhoe Dam were operated in accordance with Strategy S2 and Strategy W3 respectively during my shift on Saturday 8 January 2011".[169] In his second affidavit, he stated:[170]

> "It was appropriate *for me to use Strategy W3* at Wivenhoe Dam while on duty on 8 January 2011 because this was the *strategy set* by the Senior Flood Operations Engineer and was in force when I began my shift that day. I judged it to be correct for the following reasons…" (emphasis added)

89 In cross-examination, Mr Tibaldi said that "I don't recall the shift"[171] and that "I have no recollection of 8 or 9 January at all, unless I reconstruct something"[172] and that "…I've got no actual recollection of that shift or looking at the PMEs or any of that".[173]

90 When he was asked about what strategy he implemented that evening, the following exchange occurred:[174]

> "[SENIOR COUNSEL for the PLAINTIFF]: Q. A bit earlier you said, "We were in W3"?

[167] LAY.SEQ.004.0001 at [616] to [639]; Tibaldi 2, LAY.SEQ.014.0001 at [12] to [35].
[168] LAY.SEQ.004.0001_OBJ at [624].
[169] Ibid at [629(a)].
[170] Tibaldi 2, LAY.SEQ.014.0001_OBJ at [23].
[171] T 5545.11.
[172] T 6227.30.
[173] T 6280.26.
[174] T 6231.10.

A. Well, if I was there by myself, it was "I", if it was me and someone else, it was "we". As I say, I can't recall discussions with Mr Ayre about strategy, we've talked about that, but my view, as we've discussed also, was that in that shift *I was in W3 without question*; that's my view.

HIS HONOUR: Q. That's not a recollection, that's based on –

A. It's not a recollection, your Honour, no. Look, I just - as I've said many times, I can't remember that shift, even the first thing about it." (emphasis added)

91 Having observed this evidence being given, I can state that this passage illustrates one of the (many) reasons I have misgivings about Mr Tibaldi's evidence. In the first answer, he conveys a certitude that he operated in W3 that evening ("without question") followed by an immediate declaration that he had no recollection of that matter. As the evidence below demonstrates, any knowledge much less certitude that Mr Tibaldi had about the strategy that was supposedly invoked on 8 January 2011 was gained during the aftermath of the flood event when he worked on various briefings and the flood event report. As part of that process, he seized on W3 as being applicable on 8 January 2011 because Wivenhoe Dam was above EL 68.5m AHD from early that morning.

92 Seqwater sought to defend Mr Tibaldi's evidence that he operated in W3 as being "based on his practice",[175] although the passage of the evidence of Mr Tibaldi cited in support of this was simply him reiterating his understanding of the Manual.[176] Seqwater also submitted that Mr Tibaldi's evidence was "strong" on the fact that his understanding at the time was that as soon as he became aware that the level had exceeded EL 68.5, he would have understood he was not in Strategy W1 but, in W2 or W3.[177] This is impossible to reconcile with the various documents he drafted in the period immediately after the flood event, including a briefing note to the relevant Minister suggesting that the transition to W2 took place around 7.00pm on 9 January 2011 and the transition to W3 occurred at around 6.30am on 10 January

[175] Seqwater subs at [1531(b)].
[176] T 5934.32 to T 5935.22.
[177] Seqwater subs at [1533].

2011.[178] Having observed Mr Tibaldi give his evidence and after considering the contemporaneous documents, I do not accept that any aspect of Mr Tibaldi's evidence was "strong".

93 Save for admissions against interest, or unless it is otherwise corroborated by contemporaneous evidence, I do not afford any weight to Mr Tibaldi's affidavit and oral evidence concerning the events of that shift he performed on the evening of 8 January 2011 and the morning of 9 January 2011.

Effective Strategy Throughout 8 January 2011

94 I have already made reference to the fact that, on any view, the preconditions to invoking W3 had been reached at 8.00am on 8 January 2011 when the lake level of Wivenhoe Dam exceeded EL 68.5m AHD. It never returned below that level. Each of the 8 Jan 09:00 ROG Run, 8 Jan 15:00 ROG run and 8 Jan 15:00 72-hour run predicted the storage level remaining above EL 68.5m AHD well into 9 January 2011.

95 The plaintiff contended that the approach adopted throughout that day was an extension of that which had been formulated on the evening of 6 January 2011 of maintaining bridges open with the variance of increasing outflows to 1600m^3/s to account for the (temporary) reduction in downstream flows. The plaintiff submitted that the "focus remained keeping Mount Crosby Weir Bridge and Fernvale Bridge open, as the forecasts grew larger".[179] The plaintiff submitted that there was "no real doubt that the Flood Engineers were operating in W1 throughout 8 January" and not in W3, as suggested by Mr Ayre's situation report, as well as the Strategy Summary Log and Ministerial submission discussed below.[180]

96 So far as Mr Tibaldi is concerned, Seqwater denied that, during his shift, he maintained a sole focus on keeping bridges open and that he ignored the

[178] ROD.650.001.7326 at .7354; see section 7.10.
[179] Plaintiff subs at [1324].
[180] Plaintiff subs at [1325]; Chapter 7, sections 7.10 and 7.11.

potential for urban inundation.[181] It noted the further openings that occurred early in the morning of 9 January 2011 which increased the release rate,[182] which it submitted "increased the risk of inundation of the two remaining bridges".[183] However, those openings only reflected the gate openings included in Mr Ayre's 8 Jan 15:00 ROG run and only effected a marginal increase in outflows to accommodate what proved to be a temporary reduction in downstream flows.

97 Seqwater referred to Mr Tibaldi's evidence to the effect that, if releases had been increased, then the lake level would have reduced below EL 68.5m AHD, thus requiring a transition back to W1, a point also made in the January FER.[184] It also referred to his supposed knowledge that damage would be occasioned at flow rates above 2000m^3/s, which he ascertained from drafting the Manual and reviewing the 2007 study of damaging flow rates.[185] However, both of these points are predicated on a construction of the Manual that I reject.[186] More importantly, both points take the matter nowhere given Mr Tibaldi's lack of recollection of the evening shift and my findings about his evidence generally. As for the January FER, as explained below, it is a completely unreliable chronicle of the flood engineers' conduct of flood operations.

98 Mr Tibaldi's approach (and that of the other flood engineers on 8 January 2011) is encapsulated by a draft response to a media inquiry about the conduct of flood operations that he drafted on 16 January 2011.[187] In that report, he deleted all references to releases having been made based on rainfall forecasts and instead stated:

> "Why did Seqwater permit the flood storage capacity to build up so much over the weekend?

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[181] Seqwater subs at [1537] to [1543].
[182] See Chapter 7 at [145].
[183] Seqwater subs at [1538(b)].
[184] Seqwater subs at [1540] citing January FER at .0308; see also Seqwater subs at [1549].
[185] Seqwater subs at [1541] citing T 5546.4; see Chapter 4 at [117] to [118].
[186] Chapter 3 at [170] to [171] re actual levels and Chapter 3 at [285] re non-damaging flows.
[187] SUN.006.001.8909 and which is further explained in Chapter 7 at [429] to [434].

Releasing large volumes of water over the weekend would have had major impacts on the rural communities of the Brisbane Valley. Bridges would be cut and communities would be isolated with little notice. This is not an action that is undertaken unless there is **certainty** that inflows into the dam will result in flood releases that will cause impacts to urban areas. Over the weekend, neither rainfall forecasts nor the rain on the ground indicated with **certainty** that urban areas would be impacted, so the emphasis at that time was on protecting the rural communities of the Brisbane Valley." (emphasis added)

99 As this passage states, and as the events of 8 January 2011 demonstrate, Mr Tibaldi and the other flood engineers were not prepared to countenance inundating the remaining downstream bridges unless it was "certain" that inflows would necessitate releases that caused urban damage and that certainty was not forthcoming. This is the approach identified by Mr Fagot for a method A reservoir, which Wivenhoe Dam is not.[188] It involves an inversion of the priority of objectives of the Manual. At best it is only consistent with operating in a version of W1 that treats preventing inundation of rural bridges as the primary consideration. As I will explain, even this approach was abandoned on 9 January 2011 when the flood engineers persisted in maintaining releases at existing levels even though it was practically "certain" that the inflows into the dam would cause impacts to urban areas.

100 In relation to Mr Ayre, at one point he was asked:[189]

"Q. What I want to put to you is that on the 6th and the 7th and the 8th you were focussed *only* on working out what releases could be made from Wivenhoe dam without closing Mount Crosby and Fernvale Bridge; correct?

A. Well, *in keeping with strategy W1 that we started with, yes*, that was the original intention." (emphasis added)

101 There was a debate in the submissions about whether in giving this answer Mr Ayre agreed that he was in W1 throughout those three days.[190] I do not treat it as a concession going that far, but it was a concession that when he was operating in W1 he was *only* concerned about downstream bridges. However, for the reasons that follow, I am satisfied that he was operating in W1.

[188] See Chapter 3 at [346] to [347].
[189] T 7906.47.
[190] Plaintiff subs at [1286]; Seqwater subs at [1181].

102 Seqwater referred to Mr Ayre's evidence to the effect that, based on his 8 Jan 15:00 72-hour run, he was addressing the position of the downstream bridges and providing optimum protection against urban areas.[191] Seqwater contended that gate operations modelled in the 8 Jan 15:00 ROG run spreadsheet reflect an approach on the part of Mr Ayre that addressed both objectives in that it limited outflows to 1600m^3/s (which was below what was said to be a threshold of 2000m^3/s at which urban damage began) and which contained a 300m^3/s buffer and further dam storage space for forecast rain.[192]

103 The defects in the 8 Jan 15:00 72-hour run as a reliable estimate of the likely inflow of water have already been addressed. Further, the fact that the run was undertaken does not of itself indicate that Mr Ayre was either operating in W3 or not solely focused on preserving the downstream bridges. The gate operations in the relevant spreadsheet are all calibrated to produce outflow rates that keep those bridges open. There is no contemporaneous material suggesting that any consideration was given to closing the bridges to reduce dam levels quicker to guard against further rainfall that was greater than what was forecast. Instead, the indications are that Mr Ayre sought to model 72 hours of rain to see if he could keep the bridges open.

104 The reference to downstream flows of 2000m^3/s as the level at which urban damage occurs arises from an answer that Mr Ayre gave[193] where he referred to an entry from the Brisbane City Council 2007 study noted in Chapter 4,[194] which provided that with flow rates between 2000m^3/s and 3000m^3/s, 29 residential properties would suffer an average of $13,780 damage each.[195] However, Mr Ayre agreed that 4000m^3/s was adopted as the threshold for non-damaging downstream flows and asserted that on the morning of 10 January 2011, he reiterated the need to operate on that basis even though the Council was advising that the true threshold was 3500m^3/s.[196] In the end result, Mr Ayre's actions on 8 January 2011 were entirely consistent with him

[191] Seqwater subs at [1181]; see for example T 7558.32 (Ayre).
[192] Seqwater subs at [1181].
[193] T 7558.29.
[194] SUN.900.011.5068; see Chapter 4 at [117].
[195] SUN.900.011.5068 at 5078; see T 7541.11.
[196] T 7593.4 to T 7594.11.

operating in W1 and being solely focused on maintaining downstream bridges open. To the extent that his evidence was to the contrary I do not accept it.

105 In light of the reference to transitioning to W2 in the situation report issued by Mr Ayre in the evening, the entry in the Event Log for 3.30pm the next day,[197] the manner in which they conducted flood operations and some of the documents produced after the event,[198] I am satisfied that the Senior Flood Operations Engineer, that is, Mr Ayre, did not ‘set’ Strategy W3 at any time during 8 January 2011. I am also satisfied that none of the flood engineers conducted flood operations throughout 7, 8 and most of 9 January as though W3 was operative. Instead, flood operations were conducted in a manner consistent with W1, namely by being exclusively focused on avoiding the inundation of the remaining downstream bridges by limiting downstream flows to around 1600m^3/s. This represented the effective continuation of the gate operations strategy that had been modelled via the rain on the ground RTFM runs undertaken throughout 7 and 8 January 2011 and which had its genesis in the 6 Jan 21:00 ROG run undertaken by Mr Ayre on the evening of 6 January 2011. It remained in effect notwithstanding contemporaneous rainfall and forecasts of heavy rain.

What Strategy and Approach to Releases was Required?

106 In its written submissions, the plaintiff contended that, in failing to implement Strategy W3 on 8 January 2011, Mr Ayre and Mr Tibaldi breached section 8.4 of the Manual on any interpretation of the provision. It further submitted that, “when the magnitude of the forecasts on 8 January are considered, it is clear that a reasonable engineer would have expected Wivenhoe Dam to rise above 74m on 8 January, requiring the application of W4”.[199]

107 The contention that W4 was required to be implemented by an expectation that the expected height of Wivenhoe Dam would exceed EL 74.0m AHD needs to be considered in light of the conclusions in Chapter 3. It follows from

[197] See [190].
[198] See below at [405] to [410].
[199] Plaintiff subs at [1326].

Chapter 3 that, to engage Strategy W4, it is only necessary that the predicted height of Wivenhoe Dam, assessed on a “no release” basis, exceed EL 74.0m AHD. In Chapter 3, I also accepted that once the actual level of Wivenhoe Dam exceeds EL 74.0m AHD then there is a “general” requirement to keep opening gates “until the storage level of Wivenhoe Dam begins to fall” and that, while there was no minimum rate at which those openings had to occur, in making releases there was much reduced scope to consider lower level objectives.[200] It follows that, if possible, exceeding EL 74.0m AHD should be avoided because when that occurs and the dam level is rising, large releases have to be made and there is then little scope, if any, to consider downstream effects.

108 The present context concerns the position prior to Wivenhoe Dam reaching EL 74.0m AHD but when it is predicted to exceed that height. As explained in Chapter 3,[201] at that point, Strategy W4 is engaged but there is no requirement to keep opening gates to address the rising water levels and the requirement to consider lower level objectives, as well as dam safety, in their order of importance is fully engaged. The principal difference between that position and W3 is that the flood engineers are not subject to any limit on their maximum releases. It can be expected that, if a flood engineer transitions to Strategy W4 based on a predicted height of EL 74.0m AHD, that will not necessarily lead to an immediate increase in releases because he or she may decide to observe the upper limit of non-damaging flows downstream. Thus, in some, perhaps many, circumstances in which Strategy W4 is engaged by a predicted but not actual height of Wivenhoe Dam above EL 74.0m AHD, there will not necessarily be any immediate different approach to operations in Strategy W3, although in the former case the flood engineer has the capacity to increase releases above 4000m^3/s and cross the limit on non-damaging flows if, say, forecasts worsen. However, in this circumstance, the flood engineer would need to be mindful that if the actual level does exceed EL 74.0m AHD then their scope to avoid releases that cause damaging flows will be greatly reduced.

[200] Chapter 3 at [318]; see also Manual at 30.
[201] Chapter 3 at [314].

109 It also follows from the above findings that on 8 January 2011 Mr Ayre and Mr Tibaldi were at the very least obliged by the Manual to conduct flood operations in Strategy W3. From 8.30am, Wivenhoe Dam remained above EL 68.5m AHD throughout the day. All the rain on the ground and forecast modelling had Wivenhoe Dam above EL 68.5m AHD until well into 9 January 2011. The forecasts were worsening and the predictions about maximum storage levels only increased if the modelling was done on a “no release” basis as the Manual required.

110 The position of Mr Tibaldi, Strategy W4 and release rates is addressed below. In relation to Strategy W4 and Mr Ayre, his 8 Jan 15:00 72-hour run did not suggest that the storage level of Wivenhoe Dam would approach EL 74.0m AHD. However, as explained,[202] it was defective both in terms of forecast depths and the combination of temporal patterns and loss rates. As noted, in his 12.00pm situation report, Mr Ayre referred to rainfall predictions of between 125mm and 250mm and Mr Malone advised that at around 3.00pm they had doubled. In his 6.00pm situation report, Mr Ayre referred to rainfall predictions of between 125mm and 300mm in the area that included the dam catchments over the ensuing three days.[203] The one-day PMEs suggested higher figures for the next three days across the catchments above and below the dams.[204]

111 If Mr Ayre was obliged by the Manual to ascertain the maximum storage height by reference to actual rainfall and best forecast rainfall information, as I find he was, then his 8 Jan 15:00 72-hour run was not sufficient and had to be redone. If he was obliged to undertake that by reference to forecast rainfall for at least three days, a matter addressed later, then in rough terms it would at least involve a doubling of the rainfall estimates used in the 8 Jan 15:00 72-hour run. In fact, prudence would warrant the use of higher figures, especially bearing in mind the order of priorities in the Manual and the necessity to ascertain maximum storage levels. Using twice as much (or

[202] At [56ff].
[203] See above at [68].
[204] See [78].

more) rainfall would tend to reduce but not eliminate the problem occasioned by applying past loss rates calibrated to spasmodic rainfall to future continuous rainfall. However, lower loss rates would still be necessary, especially as the catchment would become more saturated.[205]

112 In preparing his second affidavit, Mr Tibaldi prepared a recreated version of the 8 Jan 15:00 72-hour run which doubled the forecast rainfall.[206] He included it as a response to a suggestion that he should have implemented Strategy W4. This spreadsheet predicted Wivenhoe Dam reaching a level of just under EL 73.0m AHD on 13 January 2011.[207] Four points should be noted about the spreadsheet.

113 First, there appears to be an error in the past inflow data used in the spreadsheet in that it suggests that at midday on 7 January 2011 there was an inflow into the dam of 3543m^3/s[208] whereas the actual inflow at that time was 1778m^3/s (and one hour before it was 2225m^3/s).[209]

114 Second, the gate operations in this spreadsheet are different from the 8 Jan 15:00 72-hour run. Mr Tibaldi's spreadsheet extends releases at rates over 1300m^3/s to 6.00am on 19 January 2011 when it proposed that Wivenhoe Dam returns to FSL,[210] whereas the 8 Jan 15:00 72-hour run reduced outflows below 120m^3/s at 11.00am on 14 January 2011 and proposed a return to FSL at 4.00pm on 15 January 2011. Mr Tibaldi's spreadsheet modelled peak inflow as having occurred at 12.00pm on 7 January 2011, which, as noted, is erroneous.[211] The modelled future peak inflow in Mr Tibaldi's spreadsheet is 2943m^3/s, occurring at 6.00pm on 11 January 2011.[212] These modelled gate operations take almost twelve days to return Wivenhoe Dam to FSL from the time of peak inflow recorded in the

205 T 7756.11 (Ayre); T 8775.28 (Giles); T 3792.12 (Nathan).
206 LAY.SEQ.014.0001 at [47(c)]; SEQ.004.051.0001.
207 LAY.SEQ.014.0001 at [47(c)].
208 Input data tab, row 131, column H.
209 Simulation Analysis, EXP.ROD.015.0461 at .0469.
210 Gate operations tab, row 409, column AE.
211 Input data tab, row 131, column H.
212 Input data tab, row 233, column H.

spreadsheet and, even ignoring that figure's inaccuracy, well in excess of the seven days from the modelled future peak.

115 Third, Mr Tibaldi's spreadsheet maintained the same loss rates as the 8 Jan 15:00 72-hour run, even though its assumed rainfall would involve the catchments being completely saturated. The difficulty with that and the use of loss rates calibrated to past spasmodic rainfall being applied to an assumption of future continuous rainfall is illustrated by noting that the (actual) peak inflow prior to the time the model commences was 2225m^3/s at 11.00am on 7 January 2011[213] and, as noted, the predicted future peak inflow was 2943m^3/s at 6.00pm on 11 January 2011. This relatively small difference is completely unrealistic when, on his modelling, the amount of rainfall that supposedly led to that peak inflow on 7 January 2011 was much less than that being modelled to fall in the next three days, the pre-7 January 2011 rain fell on a catchment that was drier, the rain was less concentrated and it had yet to satisfy initial losses. According to Mr Malone's "Observed Rainfall Analysis" report in the period from 9.00am on 2 January 2011 to 9.00am on 7 January 2011, the Somerset catchment received 67mm, the Upper Brisbane catchment received 72mm and the Middle Brisbane catchment received 53mm of rain.[214] In contrast, Mr Tibaldi was modelling rainfall of approximately 200mm falling over the following three days.

116 Fourth, the plaintiff contended that the effect of doubling the forecast should have been that all of the extra rainfall above that modelled in the 8 Jan 15:00 72-hour run would have been converted to runoff, as the initial forecast rainfall satisfied the continuing losses.[215] I am not convinced that this is so, especially as the FLOODOPS screenshots for the 8 Jan 15:00 72-hour run reveal a number of periods of rainfall when the forecast rainfall used by Mr Ayre did not exceed the continuing loss rates used.[216]

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213 Simulation Analysis, EXP.ROD.015.0461 at .0469.
214 See Chapter 6 at [3]; see also SEQ.004.046.0230 at .0267 - .0271.
215 Plaintiff subs at [1299].
216 See Chapter 6 at [296]; see also LAY.SUN.007.0001 at .0024 - .0036.

117 Nevertheless, the fact the combination of loss rates and temporal patterns is still producing an unrealistically low amount of inflows in Mr Tibaldi's spreadsheet suggests that, if that was corrected and the same releases were maintained, then it was extremely likely that the predicted level of Wivenhoe Dam would exceed EL 74.0m AHD. That outcome is inevitable if the modelling is undertaken on a "no release" basis.[217]

118 More significantly, the fact that in Mr Tibaldi's spreadsheet outflows in excess of 1300m^3/s are modelled from 8 January 2011 to 19 January 2011 reveals that, if rain fell in the amounts modelled and if its loss rates were appropriately adjusted, then at some point flows would have to have been increased to inundate downstream bridges. No possible application of the Manual could involve the extension of the drain down period at that level of releases for a period of that length.

119 It follows that I am satisfied that, had proper modelling been undertaken on forecast rain that either doubled the rainfall depths used in the 8 Jan 15:00 72-hour run or used a forecast that incorporated an approximate median of the rainfall figures in Mr Ayre's 6.00pm situation report or used Mr Giles' assessment of the PMEs available from 6.00pm on 8 January 2011, then it is overwhelmingly likely that either the predicted level of Wivenhoe Dam would have exceeded EL 74.0m AHD or the strategy of maintaining Fernvale and Mt Crosby Weir Bridges open would have had to have been abandoned. That becomes a matter of certainty if the modelling was done on the basis of the high-end of the range in Mr Ayre's situation report (ie, 300mm) or a no release basis.

120 The only question that would then arise was when releases inundating downstream bridges should have occurred. The longer that this was delayed, the more exposed flood operations became to the "can release" assumption being invalidated by downstream conditions. The obvious concern about an immediate increase in releases that would inundate the downstream bridges

[217] Which can be checked by changing all releases from 6.00pm on 8 January 2011 in Mr Tibaldi's spreadsheet to 0.

is the result of their combining with downstream flows. The plaintiff contended that the flood engineers' modelling on that day, and the following day, indicated that releases could be made with little risk of exceeding 4000m^3/s at Moggill.[218] An Appendix A "with forecast" rainfall run referable to 2.00pm on 8 January 2011[219] and another run referable to 1.00am on 9 January 2011 suggested scope for increased releases arriving at Moggill on 9 January 2011. The former predicted a peak natural flow of 940m^3/s at Moggill at 10.00am on 9 January 2011 and the latter of 840m^3/s at Moggill at midnight on 10 January 2011.

121 SunWater referred to the potential for damage at flow rates above 2000m^3/s at Moggill, a matter I have already addressed.[220] It also submitted that a reasonably competent flood engineer increasing releases around that time had to be cognisant of the risk of rain falling directly onto the tributaries as occurred on 11 January 2011, when rain fell on both Wivenhoe Dam and the river immediately below it.[221] The type of rainfall to which this concern is directed is unforecast rain. If rain of that kind is forecast then the flood engineer has sufficient time, or at least some time, to reduce releases to account for it. Nevertheless, it can be accepted that there is always a risk of releases combining with unforecast rain in an area directly above or around the river downstream of the dam to cause damage. Such a risk pertained throughout January 2011 and was present regardless of what release decisions were made having regard to inflows calculated by reference to rain on the ground or rainfall forecasts. However, as explained in Chapter 8[222] and Chapter 9,[223] in balancing the respective risks the flood engineer is in a better position to make judgments about likely downstream conditions in the next 16 hours than they are about downstream conditions beyond that time.

122 The ability to address downstream flows in this manner is demonstrated by the flood engineers' own conduct on 8 and 9 January 2011 when they

[218] Plaintiff subs at [1304].
[219] See January FER at .0527.
[220] SunWater subs at [2155(a)].
[221] Ibid at [2155(b)] and [2187] to [2189].
[222] Section 8.5.
[223] Section 9.10.

managed flows to avoid the inundating of downstream bridges. If downstream conditions can be monitored to avoid the inundation of bridges by keeping the combined flow rate below, say, 1800m^3/s, then they can manage to avoid inundating homes by keeping combined flow rates below 4000m^3/s, although there needs to be an allowance for the further distance for downstream water to travel to urban areas relative to the bridges (and forecast rain).[224]

123 Finally, SunWater also submitted that the Manual requires the flood engineers to consider lower level objectives, such as avoiding disruption to rural life, as a justification for not increasing releases.[225] However, the premise of the present discussion is that the level of rain forecast late on 8 January 2011 (and earlier that day) meant that the inundation of downstream bridges was inevitable. The only issue was whether releases should be increased much sooner, perhaps immediately, or delayed. This analysis suggests the former.

124 This discussion has sought to address whether in applying section 8.4 Mr Ayre was obliged to select Strategy W4. At this point it suffices to state that, if the application of section 8.4 required the use of forecasts over (at least) a three-day period, and if proper modelling was undertaken on a "no release" basis or by keeping releases below a level that kept Fernvale Bridge and Mt Crosby Weir Bridge open, then at least at some point on 8 January 2011 he was. Whether three days or more was the appropriate period for such an assessment is a matter I will return to in addressing Dr Christensen's evidence and simulations. However, even if Strategy W4 was engaged, as opposed to W3, then I do not accept that this would have led to any immediate substantial difference in gate operations compared to the proper implementation of Strategy W3. As discussed, the necessity to raise gates in Strategy W4 was not engaged until the Wivenhoe Dam storage level exceeded EL 74.0m AHD and prior to that, lower level objectives were fully engaged. Given the storage levels throughout 8 January 2011, the focus of dam operations should have been providing optimum protection to urbanised areas from inundation. As the above analysis shows, an appreciation of the

[224] T 6316.28 (Tibaldi).
[225] SunWater subs at [2155(c)].

developing rainfall forecasts over the ensuing three days meant that giving effect to that objective required the immediate inundation of the remaining bridges.

Mr Tibaldi, the General Strategy and W4

125 As noted, Mr Tibaldi stated that he operated in Strategy W3 during the evening of 8 January 2011 as that was the strategy set by Mr Ayre as SFOE. I have rejected both aspects of this contention. Nevertheless, I accept that he acted in accordance with a general strategy set by Mr Ayre of preserving downstream bridges as reflected in the gate settings set out in the 8 Jan 15:00 ROG run.[226] However, it follows from the analysis in Chapter 3 and Chapter 6[227] that the specification of a general strategy to that effect did not relieve Mr Tibaldi of his obligations under the Manual to consider the best rainfall forecast and streamflow information to determine the applicable strategy, to ascertain the primary consideration of the strategy and to make decisions on dam releases.

126 Assuming that Mr Tibaldi received the 8 Jan 15:00 72-hour run that he inherited from Mr Ayre, then it would follow that Mr Tibaldi was obliged to adopt Strategy W3 when, on my findings, he acted consistently with W1. However, how much beyond the assessment in that spreadsheet was he obliged to go? Seqwater submitted that, in effect, Mr Tibaldi was entitled to act on the 8 Jan 15:00 72-hour run bearing in mind the calibrated loss rates it used and, as he said, the fact that he was "not a hydrologist", and was entitled "to trust their modelling" and rely on Mr Ayre's expertise.[228]

127 The position of Mr Tibaldi in relation to that forecast modelling can be addressed by considering the modelled rainfall depths. As just noted, Mr

[226] Seqwater subs at [1107] and [1117].
[227] Chapter 3 at [323] and Chapter 6 at [262].
[228] Seqwater subs at [1479]; T 6231.31 (Tibaldi).

Tibaldi was obliged to consider the "best rainfall forecast" information. The most up to date rainfall information available to him is summarised above.[229]

128 In that regard, Mr Tibaldi said that he "expect[ed]" he would have "looked" at the RTFM to see what parameters Mr Ayre had used in his 15:00 72-hour run on 8 January.[230] I consider it likely that he did. If he had, he would have, or at least should have, realised that the rainfall forecast depths utilised were significantly less than that predicted by the one-day 00UTC PMEs available from 6.00pm and by the figures in Mr Ayre's situation report. Mr Tibaldi accepted that the 00UTC forecasts suggested that there was a chance that 300mm of rain could fall both above and below the dams in the next three days.[231] Seqwater's submissions in respect of those one-day PMEs emphasise that the location of the expected heaviest rainfall was below the dam.[232] However, at the risk of repetition, that overlooks the uncertainty associated with where rain would fall and thus the risk that it would fall above the dams, instead (or in addition to) falling below the dams.

129 Mr Tibaldi either knew, or ought to have known, that if forecast rain fell in accordance with those forecasts it would invalidate the 8 Jan 15:00 72-hour run and the current release strategy. He said that, on the night of 8 January, it was "*reasonable to expect*" that, if the 300mm high range of the forecasts in Mr Ayre's situation report fell in the dam catchments, that would result in releases being made that would generate "*a flow of in the order of 4,000 at Moggill*".[233] He also agreed that it was reasonable to assume that, if the high range forecast fell in the dam catchments, Wivenhoe Dam would reach EL 74.0m AHD unless releases were increased above the 1,250 m^3/s outflow release rate being released on the evening of 8 January.[234] It follows from the above analysis that this conclusion also follows if less than 300mm of rain fell in the catchments, namely, rain that was approximately double the estimates

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[229] At [77] to [82].
[230] T 6231.35.
[231] T 6281.39 to T 6282.7.
[232] Seqwater subs at [1505(e) to (g)] and [1521].
[233] T 6278.2.
[234] T 6278.16.

used in the 8 Jan 15:00 72-hour run. This could not be known with certainty unless a proper “with forecast” run was undertaken, but it was not.

130 In his second affidavit, Mr Tibaldi said that he thought the 8 Jan 15:00 72-hour Run “*remained current at 12:00 am on 9 January 2011*” because not much rain had fallen since 15:00 and it was still calibrating well to observed lake levels in Wivenhoe Dam[235] although it appeared to be under-predicting Somerset Dam. The difficulty with that reasoning is that a screenshot set out in the same affidavit reveals that the 8 Jan 15:00 ROG run which he was working from was also calibrating well to the same observed lake levels.[236] Those facts, along with the fact that not much rain had fallen since 3.00pm, meant that the calibration merely showed that at best for a short period the rain on the ground component of the 8 Jan 15:00 72-hour run was calibrating well to rain on the ground. It said nothing about the forecast rain component of the 8 Jan 15:00 72-hour run. The ominous trend of all the available forecasts invalidated the future rainfall assumptions on which it was built.

131 Mr Tibaldi did not undertake any “with forecast” modelling of his own on the evening of 8 January 2011. His conduct of flood operations is completely consistent with him operating exclusively on the basis of rain on the ground assessments. I am satisfied that from early on in his shift he was obliged (by section 8.4 of the Manual) to make an assessment based on the best rainfall forecast information and that this required him to revisit the rainfall depths in the 8 Jan 15:00 72-hour run. The likely results of such an analysis if conducted on the basis of three-day rainfall using either double the forecast depth in the 8 Jan 15:00 72-hour run, an approximate median of the mid-range of Mr Ayre’s situation report or Mr Giles’ assessment of the one-day PMEs, as well as the high end of Mr Ayre’s range of forecasts, are summarised above.[237] SunWater also referred to the difficulties in making

[235] Tibaldi 2, LAY.SEQ.014.0001_OBJ at [43(a)].
[236] Ibid at [46(a)].
[237] At [119]; cf Seqwater subs at [1505(i)].

downstream releases in the context of Mr Tibaldi's shift.[238] That has already been addressed.

132 The analysis and findings in [124] concerning Mr Ayre applies equally to Mr Tibaldi. In respect of both of them, the nature of the forecasts, current dam levels and releases rates were such that there was a significant risk that, if releases were not increased to the level necessary to inundate the remaining bridges, then uncontrolled releases above EL 74.0m AHD capable of causing urban damage would be required.

SunWater's Comparison with Dr Christensen

133 At this point it is necessary to address one aspect of SunWater's submissions concerning Dr Christensen's simulations. SunWater noted that in Dr Christensen's Simulation F, which commences at midnight on 8 January 2011, releases are made at a level of 2750m^3/s on 8 January 2011, which is well above the historical maximum release rate of 1800m^3/s, yet there is no explanation of why that is necessary and how it relates to the pleaded breaches.[239] The relationship between the simulations and the pleaded breaches is addressed in Chapter 12. However, it suffices to state that the making of releases at that level and the assumption that it does not create an unacceptable risk of breaching the limits of non-damaging flows downstream appears to be the logical consequence of basing release decisions on the three to four-day rainfall forecasts. As the above analysis demonstrates, once that approach is adopted, then it would follow that releases had to be increased to inundate the remaining bridges to avoid making damaging and mostly uncontrolled releases above EL 74.0m AHD.

134 SunWater also extracted part of Dr Christensen's oral evidence in which he explained his methodology as follows:[240]

> "…*The methodology is, 1st through January 8th, protect Fernvale Bridge, keep from inundating that, and Mount Crosby, and that's below the 2,000*

[238] SunWater subs at [2167].
[239] Ibid at [2179(e)].
[240] Ibid at [2180]; T 2144.41 to T 2145.7.

level. Then, it's not until January 9, on the afternoon of January 9, after it has rained a real lot, that then you start making decision on flows at Moggill. And then that time on, you've got heavy rainfall that has already occurred and you have forecasts within just a day or two, though, let's see, 9, 10, 11 – in the next three days, the 9th, 10th – two and a half days, 9th, 10th, 11th. So you are in the middle of the 10th, so the next two and a half days is what you are basing your releases on, and you are trying to keep it below 4,000." (emphasis in SunWater's submissions)

135 SunWater contended that on 8 January 2011 the flood engineers operated substantially in accordance with this "proposed methodology" of Dr Christensen.[241] However, as with most things, context is everything. Dr Christensen gave this answer in the context of his Simulation A,[242] which along with Simulation J, commenced on 2 January 2011 and embodied the totality of his methodology[243] including the making of releases below FSL on the basis that the dams could be refilled by the modelled level of the estimated inflow derived from the four-day PME.[244] Under Simulation A, Wivenhoe Dam on 8 January 2011 was between EL 63.0 AHD and EL 63.5 AHD, whereas the flood engineers were operating 5m higher on that day. In those circumstances, and even with substantial forecasts looming, Dr Christensen was in a position to address forecast inflows without inundating Fernvale Bridge. As noted, under his Simulation F (and H), which commenced at midnight on 8 January 2011, and which broadly approximates to at least the period Mr Ayre was on duty on that day, the level of forecast inflows meant that Fernvale Bridge and Mt Crosby Weir Bridge had to be inundated.

7.2: Midnight to 6.00pm on Sunday, 9 January 2011

136 Heavy rain was predicted and received above and below the dams on 9 January 2011. Significant rain commenced falling in the Somerset catchment from around 4.00am and its intensity and spread increased throughout the day.

137 I have already outlined the effect of the multiple one-day PME forecasts that were available from 6.00pm on 8 January 2011, as well as Mr Giles'

[241] Ibid at [2180].
[242] T 2144.5.
[243] See Chapter 8.
[244] Reply Report, EXP.ROD.004.0005 at .0067 to .0068.

assessment of those forecasts and what Mr Tibaldi's response to them should have been. According to the plaintiff, the one-day PME available to the flood engineers from 6.00pm on 8 January 2011 for the 24-hour period to 10.00pm on 9 January 2011 predicted 25mm to 150mm of rain,[245] whereas the State contended it predicted 25 to 100mm of rain above the dam and 25 to 150mm below the dam.[246] According to the plaintiff, the four-day PME available to the flood engineers from midnight on 9 January 2011[247] predicted 75mm to 300mm of rain for the period of 10.00pm on 8 January 2011 to 10.00pm on 12 January 2011,[248] whereas the State contended that it predicted 50mm to 300mm of rain above the dam and 100mm to 400mm of rain below the dam.[249] The plaintiff contended that the eight-day PME forecast available from midnight predicted 100mm to 320mm of rain for the period of 10.00pm on 8 January 2011 to 10.00pm on 16 January 2011,[250] whereas the State contended that it predicted rain in the range 50mm to 300mm above the dam and 100mm to 400mm below the dam.[251] Professor Manton's assessment of the four-day PMEs is noted above.[252]

138 The QPF issued at 10.00am on 9 January 2011 predicted 40mm to 60mm of rain in the 24 hours to 9.00am on 10 January 2011.[253] The QPF forecast issued at 4.00pm predicted 50mm to 80mm of rain in the 24 hours to 3.00pm on 10 January 2011.[254]

139 At 9.14am, the BoM issued a revised flood warning for Warrill Creek and the Lower Brisbane River below Wivenhoe Dam, advising that minor flood levels in the creek were falling but that releases from the dam would continue throughout the day.[255] Fourteen minutes later, the BoM issued a flood warning for the Stanley River advising that, "[h]eavy rainfall has returned to

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245 SEQ.013.004.1317; AID.500.022.0001.
246 AID.500.035.0001 at .0004.
247 Although largely reflective of the one day PMEs available from 6.00pm.
248 AID.500.022.0001.
249 SEQ.013.004.1327; AID.500.035.0001 at .0004.
250 AID.500.022.0001.
251 SEQ.013.004.1328; AID.500.035.0001 at .0004.
252 At [78].
253 SEQ.001.019.5593.
254 SEQ.001.019.5605.
255 QLD.002.002.1820.

the Brisbane River catchment overnight and will continue through today" resulting in minor, moderate and major flood levels at various locations.[256] At 2.13pm, the BoM flood warning for these areas advised that "[r]ainfall of up to 85 millimetres [had] been recorded in the catchments of the Upper Brisbane and Stanley Rivers" in the previous five hours, with further heavy rainfall expected to continue along with very fast rises in the Brisbane River at Linville.[257] A flood warning for the coastal streams was issued at 2.49pm.[258]

140 The severe weather warning for the Southeast Coast District, Wide Bay and Burnett issued just before midnight on 9 January 2011 was effectively reissued at 4.40am.[259] It warned of "heavy rainfall leading to localised flash flooding and potentially worsening the existing river flood situation". At 10.55am, it was extended to the eastern Darling Downs and Granite Belt District to the south west of the dams.[260] Another severe weather warning to similar effect was issued at 4.55pm.[261]

The Balance of Mr Tibaldi's Shift

141 In his second affidavit, Mr Tibaldi refers to the 00UTC four-day and eight-day PME forecasts available at midnight on 9 January and notes that the plaintiff contended that the four-day forecast predicted between 75mm and 300mm of rain[262] whereas on his interpretation they predicted between 150mm and 200mm above the dams generating an average of 175mm, with much greater rainfall predicted downstream.[263] Mr Tibaldi said that "[o]verall this PME forecast appeared to be about the same as the previous [four-day and eight-day] PME forecast(s)"[264] and Mr Ayre's situation report from 6.00pm the previous evening.[265]

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[256] QLD.002.002.1818.
[257] QLD.002.002.1804.
[258] QLD.002.002.1803.
[259] QLD.002.002.1824.
[260] QLD.002.002.1815; SEQ.001.018.8524.
[261] QLD.002.002.1800; SEQ.001.018.8538.
[262] See [137].
[263] LAY.SEQ.014.0001 at [39].
[264] Ibid at [39].
[265] Ibid at [42].

142 Three matters should be noted about this. First, if by the "previous PME forecast(s)" Mr Tibaldi meant the four-day and eight-day PME forecasts issued at 6.00am on 8 January 2011 then, save for one important respect, he is correct in concluding that the four-day and eight-day forecasts were "about the same" (see [137]). Professor Manton's assessment of the four-day PMEs revealed relatively little difference between the four-day PME issued at 6.00am on 8 January 2011 and the one issued at midnight on 9 January 2011.[266] (There was, however, a significant increase between the four-day PME issued at midnight on 8 January 2011 and midnight on 9 January 2011.)[267]

143 Second, the one significant difference between the four-day PME issued at 6.00am on 8 January 2011 and the four-day PME issued at midnight on 9 January 2011 was the timeframe over which the total rainfall amounts was predicted to fall. As Mr Giles' analysis demonstrates, the same four-day totals were now predicted to fall over only three days, namely, 9 January, 10 January and 11 January 2011.[268] The prospect of more intense rain carried with it the prospect of greater run-off. This would have been apparent from the one-day PMEs available at 6.00pm the night before.[269] Mr Tibaldi was able to ascertain that because, in his second affidavit, he observed that the one-day PME forecast for 12 January 2011 detected little rain from 10.00pm on Tuesday 11 January 2011.[270] That was the fourth day of the four-day PME.

144 Third, regardless of how these figures are analysed, they all invalidate the forecast rainfall depths used in the 8 Jan 15:00 72-hour run.

145 Mr Tibaldi opened the gates at Wivenhoe Dam by one increment between 1.00am and 2.00am and then another by an increment between 4.00am and

[266] North: 187mm to 184mm; Lockyer: 225mm to 235mm; Bremer: 317mm to 315mm; Lower Brisbane: 427mm to 392mm: AID.500.026.0001.
[267] See Chapter 6 at [209].
[268] Compare the totals for 9/01, 10/01 and 11/01 on EXP.QLD.001.0611 at .0791 with .0792.
[269] See [78].
[270] LAY.SEQ.014.0001 at [41].

5.00am on the morning of 9 January 2011.[271] The first of these openings was one hour later than what was modelled in the 8 Jan 15:00 ROG run and the second occurred at the same time as was modelled.[272]

146 At around 4.00am, rain started falling above the catchments.[273] At around 6.00am, the 1200UTC PMEs became available. The plaintiff contended that they predicted between 200mm and 650mm of rain during 9, 10 and 11 January 2011 in the area "around the dam catchments".[274] The extent to which the defendants disputed that assessment is not clear. SunWater appeared to address the wrong forecast.[275] In its submissions, Seqwater contended that the forecasts did not worsen but remained materially the same while still predicting very heavy rainfall downstream.[276]

147 However, on any view, the 1200UTC PMEs were showing a deteriorating forecast. Professor Manton's breakdown of the four-day 1200UTC PME available from 6.00am on 9 January 2011 shows increases in the predicted rainfall above and below the dam compared to the four-day 00UTC issued at midnight, although the heaviest rainfall is still predicted to occur below the dam. In his analysis, the predicted rainfall in the catchments above the dam increased from 184mm to 219mm, the predicted rainfall in the Lockyer catchment increased from 235mm to 288mm, the predicted rainfall in the Bremer catchment increased from 315mm to 385mm and the predicted rainfall in the Lower Brisbane catchment increased from 392mm to 463mm.[277]

148 At 6.15am, Mr Tibaldi distributed his situation report.[278] He noted that the Somerset Dam and Wivenhoe Dam catchments had received weighted average rainfall of 40mm and less than 10mm respectively in the previous

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[271] January FER at .0451.
[272] QLD.001.001.2543; "gate operations" tab.
[273] QLD.001.001.2588.
[274] SEQ.004.019.2508; SEQ.004.019.2510; SEQ.004.019.2512; Plaintiff subs at [1338].
[275] Plaintiff's submissions identified SEQ.004.019.2508 for the one day 1200UTC PME (Plaintiff subs at [1338]) whereas Seqwater referred to SEQ.013.005.0495 (see AID.500.026.0001); SunWater's subs at [2197] p 342 set out four-day and eight-day PMEs for periods commencing 10.00pm on 9 January 2011 which would not have been available until midnight on 10 January 2011 (SEQ.004.019.2531; SEQ.004.019.2532) – see Chapter 2.
[276] Seqwater subs at [1569(e)] and [1572].
[277] AID.500.026.0001.
[278] QLD.001.001.2588; SEQ.001.011.4631.

12 hours, with the bulk of that rain having fallen in the previous two hours. He advised that Somerset Dam was at EL 100.27m AHD and Wivenhoe Dam was at EL 68.58m AHD with both "falling slowly". The report did not provide quantitative forecast figures but instead indicated "[r]ain periods" for Sunday, Monday and Tuesday. The report stated that the "[d]am catchments are relatively saturated and significant inflows will be generated if the forecast rainfall eventuates". It noted that the "current gate operation strategy" would maintain downstream flows at around 1600m^3/s and that all downstream bridges other than Mt Crosby Weir Bridge and Fernvale Bridge were likely to remain inundated until 13 January 2011. The report made no reference to the possibility of urban inundation. It referred to the flood event as having commenced on 2 January 2011. Mr Tibaldi noted that "[s]ince the commencement of the event on 02/01/2011 approximately 150,000ML has been released from [Wivenhoe] dam, with a total of at least 450,000ML to be released based on the currently recorded rainfall". The Plaintiff noted that the total Wivenhoe inflows from the Late December Event was 505,000 ML.[279]

149 At 6.30am, Mr Malone signed on for duty.[280] There is no record of Mr Tibaldi signing off. In his affidavit, he stated that he finished his shift at around 7.00am.[281] At that time, Wivenhoe Dam was releasing 1334m^3/s.[282] Somerset Dam was releasing 412m^3/s through two sluice gates with inflows of 456m^3/s.[283]

150 In his second affidavit,[284] Mr Tibaldi noted that towards the end of his shift there was a deviation between the actual levels and predicted levels which warranted undertaking an updated RTFM rain on the ground run to take into account the further rain received in the Somerset Dam catchment.[285] Consistent with this, a rain on the ground operational run undertaken at

[279] Plaintiff subs at [1343].
[280] SUN.002.005.0002 at .0003.
[281] LAY.SEQ.004.0001 at [644].
[282] January FER at .0451.
[283] Ibid at .0465.
[284] LAY.SEQ.014.0001 at [46(b)].
[285] See also T 6290.3.

7.00am on 9 January 2011 was saved (the "9 Jan 07:00 ROG run")[286] which Mr Tibaldi undertook.[287]

151 The 9 Jan 07:00 ROG run predicted a total inflow volume of 555,000 ML compared to the 423,000 ML yielded by Mr Ayre's 8 Jan 15:00 ROG run. This run maintained the same operational strategy of making four gate openings during 9 January 2011 until gates were open by 29 increments at 1.00am on 10 January 2011. However, the period where the maximum gate opening was 29 increments was extended from 7.00pm on 10 January 2011 to midnight on 11 January 2011. The maximum predicted storage level for Wivenhoe Dam in this run was EL 68.66m AHD at 8.00pm on 8 January 2011 (ie, the night before). Consistent with Mr Tibaldi's situation report and the earlier operational runs, it maintained a downstream flow of approximately 1600m^3/s and extended that into the following three days.

152 Mr Tibaldi's modelling was predicated on predictions of very low downstream flows emanating out of Lockyer Creek and the Bremer River from 9 to 11 January 2011. In the 9 Jan 07:00 ROG run, the difference between the Wivenhoe outflows and the combined flow at Moggill ranged between around 300m^3/s on 9 January 2011 down to around 30m^3/s on 11 January 2011. Given that it was a rain on the ground run and in light of the deteriorating prevailing forecasts, those estimates were especially dubious for any period beyond the following 9 to 12 hours. However, they were suggesting that in the short term there was an opportunity to increase releases.

153 Seqwater contended that it was not the case that Mr Tibaldi simply gave effect to Mr Ayre's proposed gate openings, only that his evidence indicated that there was no reason to change them, as for most of his shift no rain fell.[288] However, even when rain did fall from 4.00am, Mr Tibaldi did not model gate openings that had the effect of increasing flows to inundate the remaining bridges but instead sought to extend flows for long periods to keep the bridges open.

[286] SDWD-201101090700.xls – QLD.001.001.2592.
[287] T 6290.3.
[288] T 6290.10 - .21; Seqwater subs at [1598].

Conclusions re Mr Tibaldi's Shift on 9 January 2011

154 Similar to the evening before, the plaintiff contended that Mr Tibaldi continued to conduct flood operations on the morning of 9 January 2011 in accordance with Mr Ayre's approach and was thus in effect operating solely on the basis of rain on the ground modelling[289] and giving effect to a W1 Strategy.[290] It submitted that he did not comply, but should have complied, with section 8.4 of the Manual by undertaking "with forecast" modelling during his shift on the morning of 9 January 2011 and, if he had, then consistent with his double forecast run it would have required the selection of W4.[291] It also submitted that he was obliged to make larger releases because of what the forecast modelling would have revealed and that his 9 Jan 07:00 ROG run (and presumably the "with forecast" run referable to 9 January 2011 at 1.00am noted above[292]) indicated that an increase in releases could be made without creating a "material risk of causing damaging combined flows downstream".[293] The plaintiff also contended that Mr Ayre should have received the forecasts that were received overnight and into the next morning, and should have directed Mr Tibaldi (and then Mr Malone) to conduct "with forecast" modelling but did not.[294]

155 The response of Mr Tibaldi to these contentions in his second affidavit has already been summarised in relation to the period prior to midnight on 8 January 2011, namely that he was following Strategy W3 as set by Mr Ayre,[295] that the 8 Jan 15:00 72-hour run was still "current" and calibrating well to observed data[296] and there was no basis for invoking Strategy W4.[297]

156 Seqwater submitted that "conditions continued to improve" during the morning portion of Mr Tibaldi's shift.[298] As noted, it contended that the forecasts

[289] Plaintiff subs at [1332].
[290] Ibid at [1348] and [1350].
[291] Ibid at [1349] to [1350].
[292] At [120].
[293] Plaintiff subs at [1344] to [1345] and [1351].
[294] Ibid at [1333] to [1334].
[295] LAY.SEQ.014.0001 at [46].
[296] Ibid at [43].
[297] Ibid at [47].
[298] Seqwater subs at [1569].

available that morning had not worsened since the previous evening,[299] a proposition I have already rejected.[300] It noted that at the end of Mr Tibaldi's shift the level of Lake Wivenhoe was still only EL 68.58m AHD and that it had fallen since midnight when it was EL 68.64m AHD and that significant rain in the catchments did not commence until around 4.00am.[301] It submitted that those matters, the 8 Jan 15:00 72-hour run (and the results of doubling the forecast amounts)[302] as well as the level of inflows and outflows meant that there was no risk of the temporary flood storage being exceeded[303] or that any circumstance warranted the selection of Strategy W4.[304] Seqwater also denied that Mr Tibaldi remained solely focused on maintaining the existing bridges as open[305] or that he operated in W1.[306]

157 All of these matters were addressed in relation to the period prior to midnight on 8 January 2011. The above analysis of those responses applies equally to the period covering the remainder of Mr Tibaldi's shift on the morning of 9 January 2011 and I make the same findings. There was no relevant change in circumstances, except for that of the 1200UTC PMEs, which made an even stronger case for a substantial increase in releases, and the 9 Jan 07:00 ROG run (as well as a 9 January 2011 01:00 "with forecast" run), which suggested that there was scope for an immediate increase before downstream flows worsened. The rainfall depths in the 8 Jan 15:00 72-hour run were invalidated by the forecast information received by Mr Tibaldi when he commenced his shift and that only strengthened overnight as forecasts worsened.

158 Seqwater also submitted that the "fact that there was no major change in overall strategy is demonstrative of the fact that the *actual conditions*, which the plaintiff studiously ignores, improved over the period of Mr Tibaldi's shift".[307] This submission only holds if the reference to "actual conditions"

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[299] Seqwater subs at [1569] and [1572].
[300] At [147].
[301] T 6289.20; Seqwater subs at [1569](a) to (c) and [1593].
[302] Seqwater subs at [1573] to [1576], [1590].
[303] Ibid at [1570] to [1572].
[304] Ibid at [1585] and [1590].
[305] Ibid at [1591].
[306] Ibid at [1594].
[307] Ibid at [1592].

excludes rainfall forecasts. Unless one completely disregarded the forecasts which, even allowing for their uncertainties and variations, all pointed to very large rainfall and runoff in the ensuing days, the absence of any rain and reduction in inflows simply meant that there was an opportunity to make larger releases immediately in advance of rainfall.

159 SunWater submitted that the plaintiff's analysis of Mr Tibaldi's shift also overlooked the outcome of the Access model analysis reflected in Table 6.2.2 of the January FER which was said to demonstrate that the forecasts for Somerset and Wivenhoe dropped from 230mm to 140mm and 267mm to 170mm respectively between "midnight, commencing 9 January 2011 and 09:00 on 9 January 2011".[308] SunWater effectively submitted that this level of change in nine hours was an indication that the rainfall forecasts were unsuitable for use in flood operations.[309]

160 However, contrary to SunWater's submissions, the relevant drop in the forecasts listed in Table 6.2.2 of the January FER was between midnight 9 January 2011 and midday on 9 January 2011 (ie, not 9.00am). Mr Tibaldi had ceased his shift at around 6.30am. Further, Table 6.2.2 only provides notional translations of BoM Access data obtained after the event. This drop in the forecasts between midnight and midday on 9 January 2011 in Table 6.2.2 appears to be a departure from the trend of the PMEs to this time and thus appears to be evidence of the questionable nature of this data, as submitted by SunWater.[310] In any event, there is no suggestion that a SILO meteogram was obtained during this period and no evidence that any forecast product reflective of these numbers was obtained by either Mr Tibaldi on this shift or by Mr Malone on the shift that followed.

161 The potential for volatility in rainfall forecasts can be acknowledged. However, from at least the evening of 7 January 2011 there was a strong unambiguous stream of PME predictions of very high rainfall for the period 9 January 2011 to 11 January 2011 and that was repeatedly stated in the situation reports.

[308] SunWater subs at [2201(a)].
[309] Ibid at [2202].
[310] See Chapter 6 at [290] to [291]; SunWater subs at [2202].

The rainfall depths used in the 8 Jan 15:00 72-hour run were very much outliers to those forecasts and the rainfall figures quoted in the reports. While I cannot exclude the possibility that at some point on 8 January 2011 there was a SILO that might have just justified them, I am not positively persuaded that there was.

162 Otherwise, SunWater, like Seqwater, made similar submissions to those considered and generally rejected in relation to Mr Tibaldi's conduct on the evening of 8 January 2011.[311]

163 In relation to Mr Ayre, it follows from the analysis in Chapter 6[312] that I accept that Mr Ayre had the authority to intervene and direct Mr Tibaldi in relation to flood operations overnight. However, Mr Ayre finished his shift at 7.00pm on 8 January 2011 and was clearly monitoring events during the daytime hours of 9 January 2011 (see below). However he was not cross-examined on whether he monitored Mr Tibaldi during that shift[313] and it is not known when he slept during that evening such that this cannot be taken further.

Mr Malone's Daytime Shift

164 At 7.00am, a Technical Situation Report was issued under the name of Mr Drury.[314] Against the topic "strategy" it stated "[c]ontinue the current releases of around 1350[m^3/s] … to maintain around 1600[m^3/s] in the mid Brisbane River" as "[t]his should keep Fernvale and Mt Crosby bridges clear however if further predicted rainfall occurs there may be impacts on these bridges too."

165 The Event Log records that around 8.40am Mr Malone telephoned the BoM and was advised that "widespread rain was expected to continue in the catchment areas over the next 24 - 48 hours".[315]

311 SunWater subs at [2205] to [2207].
312 Chapter 6 at [264].
313 T 7916.6 to T 7917.46.
314 SEQ.001.011.4598.
315 QLD.002.001.8660.

166 In his affidavit, Mr Malone stated that "not long after commencing my shift" on 9 January 2011 he noted that the forecasts for heavy rainfall over the next three days had persisted and he spoke to the BoM seeking an assessment. He then spoke to Mr Ayre about his concerns in relation to downstream flows and "never before seen Wivenhoe Dam releases" which would inundate Fernvale and Mt Crosby Weir Bridges. He says he suggested that there be a discussion with all four engineers to discuss "upcoming operations".[316] Just before 10.00am, Mr Ayre emailed the other flood engineers requesting they attend a meeting in the FOC at 3.00pm "to discuss [the] developing flood event situation".[317] There was a debate in the submissions about whether Mr Ayre's reasons for convening the meeting were a concern about forecast rain or just rain on the ground developments and whether he was justified in waiting for five hours before the meeting was held.[318] It is not necessary to resolve that dispute.

167 A rain on the ground operational run undertaken by Mr Malone at 9.00am on 9 January 2011 was saved (the "9 Jan 09:00 ROG run").[319] It was not materially different from the 9 Jan 07:00 ROG run undertaken by Mr Tibaldi at 7.00am. It predicted a total inflow volume of 563,000 ML. It also predicted that the Lockyer and Bremer downstream flows would recede from their current levels. It utilised the same gate openings as the 9 Jan 07:00 ROG run and thus sought to limit combined downstream flows to 1600m^3/s.

168 At around 9.00am, one more sluice gate was opened at Somerset Dam. By this time, Somerset Dam was releasing 618m^3/s into Wivenhoe Dam and inflows to Somerset Dam were 600m^3/s.[320] At this time, Wivenhoe Dam levels were not rising and Somerset Dam levels were at EL 100.28m AHD such that the second box in Strategy S2 which states that the Operating Target Line was "generally [to] be followed" was not engaged.[321] Even with

[316] LAY.SEQ.007.0001 at .0193, [674].
[317] QLD.001.001.2744.
[318] Plaintiff subs at [1358] to [1360]; SunWater subs at [2225] to [2228].
[319] SDWD-201101090900.xls – QLD.001.001.2741.
[320] January FER at .0465.
[321] Ibid at .0465; Manual at 40.

the increase in Somerset Dam outflows there was no increase in Wivenhoe Dam releases.[322]

169 As noted, at 10.00am the QPF forecast was released which predicted between 40mm and 60mm of rain above the catchments.[323] At 10.30am, Mr Malone issued a directive to open one gate a further increment at 11.00am.[324] This opening was based on the 9 Jan 09:00 ROG run he conducted at 9.00am and had been modelled as far back as Mr Ayre's 8 Jan 15:00 ROG run. This opening maintained a flow of around 1,600m^3/s downstream.[325]

170 Just before 11.00am, the BoM issued the severe weather warning noted above at [140] and a dam operator at Somerset Dam advised that it was "Raining Buckets full".[326] At around 11.00am, Mr Malone sent an email to the flood engineers entitled "Forecast Rainfall and possible run off"[327] (the "Malone memo"). He noted that the "forecast for the next few days [was] for heavy rainfall, particularly for [the] period [from] 10pm Sunday to 10pm Monday with totals between 200-300mm" and that "[t]he areas most heavily impacted will be the North Pine, Somerset and Leslie Harrison catchments". He noted that the BoM website indicated that the heaviest falls were likely to be overnight on 9 to 10 January 2011 and then overnight on 10 to 11 January 2011. Mr Malone advised that recorded inflows into the dams since 2 January 2011 were 120,000 ML into Somerset and 380,000 ML into Wivenhoe Dam. He noted that "presently" the conversion rate of rain to runoff was "about 0.45 for Wivenhoe, 0.60 for North Pine and 0.75 for Somerset". His email continued as follows:

> "**Expected Runoff**
>
> Based on the approximate runoff conversion rates and the forecast rainfall, estimated runoff volumes (ML) generated could be of the order of:

Catchment	Monday	Tuesday	Wednesday	Three Day Total

[322] January FER at .0452.
[323] SUN.002.003.6261.
[324] Wivenhoe Directive 7, QLD.001.001.2748.
[325] SDWD-201101090900.xls - QLD.001.001.2741 (Gate Operations tab).
[326] SEQ.001.019.4383.
[327] QLD.001.001.2750; SEQ.001.018.4073.

North Pine	10,000-20,000	35,000-55,000	25,000-35,000	70,000-110,000
Somerset	50,000-100,000	200,000-300,000	75,000-150,000	325,000-550,000
Wivenhoe	125,000-250,000	250,000-500,00	125,000-250,000	500,000-1,000,000

The lower limit of the inflow to Somerset and Wivenhoe will be similar to the October 2010 flood while the upper limit is similar to the February 1999 floods. However, the starting level of the dams is much higher than in these historical events.

This points to continued flood operations for Somerset and Wivenhoe until at least the weekend of 15/16 Jan and maybe a shorter time for North Pine.

It should be noted that these estimates are based upon forecast rainfall which may or may not eventuate." (emphasis in original)

171 In his affidavit, Mr Malone stated that these calculations were based on "Interactive Weather and Wave Forecast Maps" issued by the BoM which are based on the BoM's Access models and which he considered provided a better indication of the temporal pattern of rainfall.[328] He said they contradicted the QPFs by suggesting heavier rainfall in the dam catchments for 9 and 10 January 2011.[329] He said that the above figures used a proportion of runoff to rainfall of 45% for the Wivenhoe Dam catchments and 75% in the Somerset Dam catchment which he calculated using "catchment average rainfall and inflow volumes up to that time".[330]

172 The plaintiff noted that as at 11.00am Wivenhoe Dam was at a water level of EL 68.54m AHD and that its storage capacity between that level and EL 74.0m AHD was 742,000 ML, which was approximately half of Mr Malone's high range of the combined projected inflows into Somerset Dam and Wivenhoe Dam of 1,550,000 ML. It also contended that Mr Malone's use of past proportions of runoff was conservative in that it can be expected that the proportion will increase if forecast rain of that level fell, a proposition that

[328] LAY.SEQ.007.0001 at [142] and [681].
[329] Ibid at [681].
[330] Ibid at [682].

Mr Ayre accepted[331] (and which was not premised on an assumption that around 300mm of rainfall fell in one day).[332] Given those circumstances, the plaintiff submitted that the "only reasonable prediction that a flood engineer could make was that Wivenhoe Dam was ("likely") to exceed [EL] 74m" AHD so as to engage W4.[333]

173 Three matters should be noted about this analysis. The first is that the runoff percentages utilised are far less than the catchment response during the Late December Flood Event, including Mr Malone's own analysis of that response.[334] The second is that this analysis ignores the storage capacity of Somerset Dam. As at 11.00am on 9 January 2011, Somerset Dam was at EL 100.34m AHD.[335] On the Operating Target Line, the equivalent to EL 74.0m AHD for Wivenhoe Dam is approximately EL 104.25m AHD for Somerset Dam. The storage capacity of Somerset Dam between EL 100.34m AHD and EL 104.25m AHD is approximately 220,000 ML.[336] However, even allowing for that storage capacity, EL 74.0m AHD is still well exceeded at Wivenhoe Dam with the high range of inflows referred to in the runoff volume table in the Malone memo.

174 Third, in his oral evidence, Mr Malone stated that his expectation was that only "about a third" of the above volumes would enter the dams during those three days if forecast rain fell.[337] Mr Ayre stated that "as a very approximate *rule of thumb, hydrologists use the assessment of one-third on the rising limb and two-thirds on the falling limb*". The plaintiff noted that he added that this was "*a very rough approximation*".[338] Seqwater countered by pointing out that the cross-examination of Mr Ayre on the Malone memo, including that which elicited the qualification that the one third/two thirds approach was a rough approximation, proceeded on the false premise that rainfall of around 300mm

331 T 7762.35 (Ayre).
332 Cf SunWater subs at [2236(c)(1)].
333 Plaintiff subs at [1366].
334 See Chapter 9 at [122].
335 Simulation Analysis, EXP.ROD.015.0461 at .0480.
336 See Manual at 59 (QLD.001.001.0146 at .0209).
337 T 5258.25 (Malone).
338 Plaintiff subs at [1367]; T 7841.2.

or higher was predicted for one day.[339] That may be so, but the one third/two thirds rule is nevertheless self-evidently a “rough approximation”. Mr Tibaldi said that “*the longest time that… rainfall on the outer boundary takes to get to the dam*” is 24 hours which represents a far quicker rate of inflows than a one third/two thirds “rule of thumb”.[340]

175 I am doubtful that this “rule of thumb” referred to by Mr Ayre is of much assistance to an assessment of the likely inflow of three-day rainfall. On any view of the time taken to receive the inflows, the peak of that portion of inflow referable to the first day’s rain will flow into the dam well within the three days so that the three-day total inflow will also include the bulk of the inflows on the falling limb of any theoretical hydrograph in respect of that first day’s rain only. To an extent, the same position applies for some of the rain that falls on the second day. In any event, I do not accept that the serious implications of the volumes suggested by the Malone memo could be put aside on the basis of a quick impression that only one-third of that forecast runoff would be received as inflows in the next three days

176 Seqwater submitted that the Malone memo was only concerned with possible runoff volumes and only indicated Mr Malone’s appreciation of the possibility of particular inflows based on the forecasts which were being prepared in anticipation of the flood engineers’ meeting at 3.30pm that afternoon.[341] However, even the mid-range of the forecast amounts for Somerset and Wivenhoe Dams over three days exceeded 1.15 million ML. Seqwater accepted that, from the time of that email, it can be accepted that a risk of EL 74.0m AHD being exceeded was “not insignificant” but submitted that a submission to the effect that the Malone memo reveals a likelihood of Wivenhoe Dam exceeding EL 74.0 AHD should not be entertained in the absence of that being expressly put to Mr Malone.[342] However, the cross-examination of Mr Malone on this topic was directed to the prospects of

[339] SunWater subs at [2236(a), (c) and (d)]; see T 7840.47 to T 7841.14.
[340] T 6041.25 (Tibaldi).
[341] Seqwater subs at [1604(b) and (f)].
[342] Ibid at [1604(d) and (g)].

Wivenhoe Dam exceeding EL 74.0m AHD[343] and I address it in the context of maintaining the existing releases in an endeavour to keep the remaining bridges open.

177 When the inflow volumes in the Malone memo are considered with the heavy rainfall predictions for downstream areas, and even adopting its low ratio of runoff to rain, I am satisfied that the inflow ranges set out in the Malone memo were suggesting that there was a (very) strong likelihood that either Wivenhoe Dam would exceed EL 74.0m AHD or that the combination of releases and downstream flows would exceed the threshold for non-damaging flows, and that there was a significant risk of both. This conclusion is overwhelming when a more realistic conversion rate that approximates to the Late December Flood Event is used. Most significantly, it warranted the undertaking of "with forecast" modelling, although it appears that this did not occur until 7.00pm on 9 January 2011.[344] Mr Ayre said that he received the email and telephoned Mr Malone to discuss it.[345] He did not suggest that forecast modelling be undertaken.

178 Leaving aside any debate about the amount of runoff expected in the following days, Mr Malone agreed that, despite his email, there was no increase in releases on 9 January 2011 and further gate openings only occurred on the morning of 10 January 2011.[346] The cross-examination continued as follows:[347]

> "Q. The position by 11 o'clock on the 9th was that Mr Ayre had called a meeting for all the flood engineers to get together at the one place at the one time; correct?
> A. Yes.
>
> Q. That had never happened before during a flood event, had it?
> A. No.
>
> Q. You were sufficiently concerned to write this email which was not a sit rep but was setting out your concerns; correct?

[343] See for example T 5258.2.
[344] T 7924.25; see LAY.SUN.001.0001 at .0772 (annexure C4, line 27).
[345] LAY.SUN.001.0001_OBJ at [2126] to [2127].
[346] T 5259.47 to T 5259.6.
[347] T 5260.8 to T 5260.45.

A. Correct.

Q. And the forecasts at the time were indicating still that there could be considerable further rain in the next few days; correct?
A. Correct.

Q. And the dam was above 68.5; correct?
A. Yes.

Q. There was limited space compared to the difference between FSL and 74 metres; correct?
A. We still had about - the majority of that space available - about 75 per cent of that space available.

Q. And you knew that you needed, in order to achieve optimum flood mitigation protection of urban areas, to maximise the space available in the flood compartment of the dam in order to achieve that objective, didn't you?
A. That was desirable.

Q. *By this point, the only reasonable decision was to increase the releases from Wivenhoe Dam above the level of about 1,200 or 1,300 cumecs at which releases had been made since the afternoon of 7 January?*
A. *That's reasonable*." (emphasis added)

179 The manner in which the last answer was given made it clear that Mr Malone fully accepted all of the propositions put to him in that question.[348]

180 Seqwater submitted that this answer was only an expression of an opinion in hindsight and did not involve a concession by Mr Malone that *at the time* he recognised that an increase in releases was the only reasonable decision.[349] Having heard the answer and observed Mr Malone's evidence, I regard this answer as a concession that, based on what he knew at the time, releases should have been increased. Seqwater and SunWater also noted that there was no concession as to what the increase in outflows should have been.[350] As at 11.00am on 9 January 2011, releases were kept at around 1200 to 1300m^3/s to maintain Lowood flows at around 1600m^3/s so as to avoid inundating bridges.[351] In context, the only relevant increase that could be countenanced was one that inundated the remaining downstream bridges but

[348] Cf SunWater subs at [2239(d)].
[349] Seqwater subs at [1605(a) to (d)].
[350] Ibid subs at [1605]; SunWater subs at [2239(e)].
[351] See 9 Jan 12:00 ROG run: SDWD-201101091200.xls - QLD.001.001.2757, gate operations tab, row 174.

did not cause flows downstream to exceed the threshold for non-damaging flows. Seqwater also submitted that this concession was overtaken by events that afternoon, including the 3.30pm meeting with the SFOE. Subject to considering the extent to which they might have been bound by some general strategy that emerged from that meeting (see below), the unfolding events, including the intense rainfall and ever worsening rain on the ground assessments, only reinforced the necessity to increase outflows.

181 Rain on the ground operational runs that were conducted by Mr Malone at around midday and 2.00pm were saved.[352] The estimate of the total volume of inflows in the midday run (the "9 Jan 12:00 ROG run") was 679,815 ML, an increase above the 9.00am run of 116,000 ML. By the time of the 2.00pm run (the "9 Jan 14:00 ROG run"), this figure had increased to 910,288 ML, which was higher than the 8 Jan 15:00 72-hour run undertaken by Mr Ayre at 3.00pm on 8 January 2011. The maximum predicted height of Wivenhoe Dam in the 9 Jan 12:00 ROG run was EL 69.21m AHD and in the 2.00pm run it was EL 69.93m AHD. Both model runs continued to estimate that the naturally occurring peaks at Lowood and Moggill had already occurred on 7 January 2011.

182 The 9 Jan 12:00 ROG run modelled a peak discharge of 1594m^3/s and the 9 Jan 14:00 ROG run modelled a peak discharge of 1483m^3/s. Both runs modelled peaks at Lowood and Moggill that enabled Mt Crosby Weir Bridge and Fernvale Bridge to (just) remain open, including on 9 January 2011,[353] by keeping releases to a maximum of around 1450m^3/s. In the case of the 9 Jan 12:00 ROG run, this result came about from modelling a modest increase in the number of gate increments at Wivenhoe Dam from the present 27 to 30 by 7.00pm on 10 January 2011 and then maintaining 30 increments until 2.00am on 13 January 2011. In the case of the 9 Jan 14:00 ROG run, this result came about from maintaining 27 increments until 3.00am on 15 January 2011;[354] ie, cancelling the planned openings by three increments and stretching out

[352] SDWD-201101091200.xls - QLD.001.001.2757; SDWD-201101091400.xls - QLD.001.001.2763.
[353] LAY.SUN.001.0001 at .0772 (Annexure C4, lines 21 and 22).
[354] See "gate operations" tab on QLD.001.001.2757; QLD.001.011.2763.

releases just below the inundation level for the remaining bridges over a longer period. If the 30 increments modelled in the 9 Jan 12:00 ROG run had been maintained in the 9 Jan 14:00 ROG run, then the bridges would have been inundated. In other words, the 9 Jan 14:00 ROG run was beginning to show the rise in downstream flows that had been threatened for some time.

183 SunWater contended that both runs still maintained a "buffer" for future rainfall, being the period of days between the modelled return of Wivenhoe Dam to FSL and the seven day period referred to in the Manual.[355] I have already addressed whether the buffer was any part of the approach to determining releases.[356] It had no role on 9 January 2011 when releases were simply set by one criterion, namely not increasing existing releases which would combine with downstream flows to inundate the two bridges that remained open. Further, in circumstances where very heavy rain was forecast above and below the dam for the present day and the two days that followed, that "buffer" was meaningless. No further stretching out of the proposed releases to seven days would avoid the dam rising, nor would it avoid the combination of releases and downstream flows combining to inundate bridges and then approach the threshold for non-damaging flows.

184 Both the 9 Jan 12:00 ROG run and the 9 Jan 14:00 ROG run modelled relatively modest downstream flows over the following 24 hours at Lowood and Moggill as part of the strategy of maintaining the bridges open. The plaintiff noted that the 9 Jan 12:00 ROG run "showed that, at 12.00 on 9 January, the flows from Lockyer would be 141m^3/s and flows from Bremer would be 88m^3/s" and "[b]oth were receding" such that "there remained an opportunity to significantly increase Wivenhoe releases at the time".[357] SunWater contended that this was inconsistent with the premise of the plaintiff's case, namely, that forecasts should be taken into account, and noted that a "with forecast" Appendix A run referable to 2.00pm showed a naturally occurring peak flow at Lowood of 690m^3/s at 2.00am 11 January

[355] SunWater subs at [2245(b) and [2249(g)].
[356] See above at [36].
[357] Plaintiff subs at [1373].

2011 and 1210m^3/s at Moggill at midday on 10 January 2011.[358] It made a similar submission about the 9 Jan 14:00 ROG run.[359]

185 Two points should be noted about that contention. First, the submission proves too much because it only demonstrates that the rain on the ground modelling that sought to maintain downstream bridges open was not sustainable as combined peak flows in these runs all exceeded the inundation levels for both bridges. Thus, it only begged the question why were those bridges being kept open given that the rising storage levels and the prevailing ominous forecasts meant that they would have to close in any event? Second, the naturally occurring peak levels and the delay in time until they were reached modelled in the "with forecast" run still allowed considerable leeway to immediately increase releases and not to exceed the downstream threshold for non-damaging flows set out in the Manual.

186 As noted above, as an indication of the intense rain that was falling in the catchments, a flood warning for the Stanley River and Brisbane River above Wivenhoe Dam was issued at 2.13pm.[360] It noted that "up to 85 millimetres" of rain had been recorded in the Upper Brisbane and Somerset catchments over the five hours since 9.00am that morning, with heavy rain expected to continue during the remainder of Sunday and into Monday. As noted, these warnings only reflected what was apparent to the flood engineers from their rainfall gauge and stream flow information.

187 At midday on 9 January 2011, one gate increment at Wivenhoe Dam was opened increasing outflows from 1332m^3/s to 1384m^3/s.[361] Between 12.00 and 1.00pm one more sluice gate was opened at Somerset Dam such that outflows increased to 826m^3/s with inflows at 1673m^3/s.[362] At this time, Somerset Dam was still below EL 100.45m AHD. Between 1.00pm and 2.00pm, another sluice gate was opened at Somerset Dam increasing

[358] AID.500.021.0002; SunWater subs at [2243].
[359] SunWater subs at [2251].
[360] QLD.002.002.1804.
[361] January FER at .0451.
[362] Ibid at .0466.

releases to 1034m^3/s with inflows now at 2744m^3/s.[363] Despite this, there were no increases in outflows from Wivenhoe Dam such that, of the outflow from Wivenhoe Dam of 1386m^3/s at 2.00pm on 9 January 2011, all bar 352m^3/s, represented inflows from Somerset Dam. By 2.00pm, Somerset Dam levels were above EL 100.45m AHD such that uncontrolled spillage occurred above that level. The five sluice gates remained open throughout the rest of 9 January 2011. By midnight, Somerset Dam was releasing 1359m^3/s[364] whereas Wivenhoe Dam was only releasing 1462m^3/s.[365]

188 Another flood warning issued at 2.49pm warned of a “rainband that stretches from Gympie to the northern suburbs of Brisbane and inland to Dalby” which was “expected to move south during this afternoon and during Sunday night”.[366] Mr Malone agreed that this referred to a movement through the Somerset catchment to reach the Lockyer Valley.[367] Mr Ayre described this as information concerning “a heavy rainband, [which] was going to be contracting to the south, ie, downstream of the dams overnight”.[368] This is addressed below.

189 At around 3.00pm, Wivenhoe Dam was recorded at EL 68.61m AHD.[369] An email from a duty officer was distributed to state and local officials advising that “[r]ainfall predictions from the BoM website indicate that SE QLD” could receive between 50mm and 100mm of rain that day, 150mm to 200mm on 10 January 2011 and 100mm to 150mm on 11 January 2011.[370] It also stated that the “current gate operation strategy will maintain flows of around 1,600m^3/s in the mid-Brisbane River” and that “[a]t this stage Fernvale and Mt Crosby Weir Bridge are not expected to be affected, but this may be

[363] Ibid at .0466.
[364] Id.
[365] Ibid at .0452.
[366] QLD.002.001.1803.
[367] T 5263.42 to T 5264.2.
[368] T 7697.40.
[369] QLD.001.001.2766.
[370] QLD.002.001.4799.

revised if the predicted rainfall totals eventuate and higher releases from Wivenhoe Dam are considered necessary".[371]

190 The Event Log contains the following entry for the meeting of the flood engineers at 3.30pm on 9 January 2011:[372]

> "Duty Engineer Conference held at the FOC: Attended by RA, JR, TM with JT on conf phone. *At this stage operating at the top end of W1 and the bottom end of W2*. Storing approx. 300,000 ML at present (above Wivenhoe) with an additional 500,000 ML expected to flow into the dams from rainfall on the ground. *The rainfall system is currently in the N-E part of the catchment and expected to travel south over the next 24-36 hours according to the BOM forecasts.* This has the potential to significantly increase flows in Lockyer Ck & the Bremer River which potentially could close Fernvale Bridge and Mt Crosby Bridge and increase the risk of flooding in the Lower Brisbane. Releases from Wivenhoe Dam will be maintained at the current level of ~ 1,400 cumecs. If required, releases from Wivenhoe Dam will be reduced to contain the flow in the Mid-Brisbane to 1,600 cumecs and 3,000 cumecs in the Lower Brisbane. At this stage it is anticipated that levels below 102.5 in Somerset and 72.5 in Wivenhoe can be attained." (emphasis added)

191 The Event Log records the author of this entry as "NGA" which is a reference to a staff member of the FOC, Neville Ablitt.[373] Mr Ablitt was not called to give evidence.

192 Mr Malone referred to this meeting in his first affidavit but did not address that part of the Event Log that discusses the applicable strategy. He recalled that it was agreed that, at least until the cessation of heavy rainfall, two flood engineers would be on duty for each shift.[374] In his affidavit, he claimed that he was operating in Strategy W3 throughout 9 January 2011.[375] In cross-examination, Mr Malone said that he had no recollection of the meeting[376] but contended that the reference to "*operating at the top end of W1 and the bottom end of W2*" was "*erroneously*" recorded[377] because he

371 QLD.002.001.4799 at .4802 to .4803.
372 SEQ.004.033.1007.
373 T 5272.44 (Malone).
374 LAY.SEQ.007.0001 at .0194, [687].
375 Ibid at .0202, [708].
376 T 5265.38.
377 T 5264.25.

understand during his shift that they were "in W3 ... because the dam level was above 68.5".[378]

193 In his first affidavit, Mr Ayre stated that "[m]ost of the entries in the Event Log were made by the Flood Officers who were on shift in the FOC during the January 2011 Flood Event", although he added that it was not a "complete contemporaneous record".[379] He extracted the entirety of this entry from the Event Log in his affidavit but he did not address the reference "operating at the top end of W1 and the bottom end of W2".[380] He was not taken to it in cross-examination either. He stated in reference to the meeting that "at that stage the lake level in Wivenhoe was about 68.6, so we're just above the W1 to W2/W3 threshold level".[381] SunWater contended that it was not open to the plaintiff to submit this, in the absence of it being put to Mr Ayre that the Event Log recorded what was stated during the meeting about the strategy being applied.[382] I do not accept that. Mr Ayre was the SFOE. He chose to extract the entire entry from the Event Log referable to this meeting in his affidavit and did not suggest that it was not an accurate record of the meeting. In those circumstances, the plaintiff was entitled to proceed on the basis that the document speaks for itself. It did not carry some burden of extracting Mr Ayre's explanation for it.[383] It was repeatedly put to Mr Ayre that throughout the weekend of 8 and 9 January 2011 he was operating in W1 because he was solely concerned with maintaining downstream bridges open.[384]

194 In cross-examination, Mr Ayre was taken to the reference to reducing mid-Brisbane flow to 1600m^3/s and it was suggested that this was connected to maintaining Mt Crosby Weir Bridge and Fernvale Bridge open. Mr Ayre stated that "I guess the intention at that time was, if we could, we would try and keep the bridges open …".[385] At that time, Wivenhoe Dam had been above the actual lake level of EL 68.5m AHD since early on the morning of 8 January

[378] T 5264.33 - .38.
[379] LAY.SUN.001.0001 at [164].
[380] Ibid at [2149] to [2150].
[381] T 7932.28.
[382] SunWater subs at [2266] to [2267].
[383] See *Whites Industries (Qld) Pty Ltd v Flower & Hart (a firm)* [1998] FCA 806.
[384] See [100].
[385] T 7932.28.

2011. Every possible permutation of modelling that took into account forecast rain would keep its predicted height above that level. Otherwise, Mr Ayre accepted that there was no discussion at the 3.30pm meeting regarding the possibility of increasing releases from Wivenhoe in light of the risk that the forecast rain would result.[386] He said that was because the flood engineers knew they could store the 500,000 ML referred to in the Event Log entry. That volume, however, was only the inflow volume based on rain on the ground. Mr Ayre accepted that, at this point in time, the inflow volume calculated with forecast rainfall could total 1.5 million megalitres.[387]

195 The Event Log records that Mr Tibaldi participated in the meeting by telephone. Mr Tibaldi referred to this meeting in his affidavit but did not address this part of the Event Log.[388] In cross-examination, he said he could not remember what was said at this meeting.[389] Seqwater submitted that this "may readily be believed" given that after this shift in the FOC overnight, Mr Tibaldi returned home to sleep and was not in a position to assess the written information being considered by the other flood engineers as he was not present in the FOC during the meeting.[390] It was not submitted that Mr Tibaldi feigned his lack of recollection of the meeting and I do not find that he did. However, even though he participated by telephone, he was in a position at the meeting to reject any suggestion that the flood engineers were operating in Strategy W1 if it did not accord with his understanding.

196 The reference in the Event Log to operating at the top end of W1 and the bottom end of W2 was completely consistent with the situation report issued on the evening of 8 January 2011, the approach to flood operations of keeping downstream bridges open that had been pursued by the flood engineers to that point (and afterwards), the absence of contemporaneous material adverting to the need to optimise protection against urban inundation and some of the material produced in the immediate aftermath of the January

[386] T 7933.2.
[387] T 7933.13.
[388] LAY.SEQ.004.0001 at [648].
[389] T 6331.36.
[390] Seqwater subs at [1600].

2011 Flood Event. The Event Log was kept in real time by data collectors and they were required to maintain accurate records.[391] I am satisfied that the Event Log accurately records what was discussed between the flood engineers at the meeting and that it reflects their understanding of the Wivenhoe Dam strategy that they had been and were applying. I reject their evidence to the contrary.

197 The entry in the Event Log concerning the meeting at 3.30pm also refers to the movement of the rainfall system in the north east of the catchment and its movement south. In his first affidavit[392] and oral evidence,[393] Mr Ayre said that this was discussed in the meeting.

198 Either during or just after this meeting concluded, the 4.00pm QPF was issued which, as noted, predicted 50mm to 80mm in the 24 hours to 3.00pm on 10 January 2011.[394] SunWater contended that this forecast was only incrementally greater than the morning QPF of 40mm to 60mm.[395] However, considerable rain had fallen in the meantime. The plaintiff contended that it was an indication that the rainband in the north east of the catchments would deposit rain in the dam catchments as it moved south,[396] whereas SunWater contended that most of the rain was still forecast to fall downstream.[397] I accept both contentions.

199 Further, a rain on the ground model run conducted at around 4.00pm was saved (the "9 Jan 16:00 ROG run").[398] With this run, the predicted volume of inflows had increased to approximately 1.3 million ML from the 910,888 ML estimate in the 9 Jan 14:00 ROG run. Once again, the modelling endeavoured to manage these inflows and keep downstream flows below the threshold to just maintain Mt Crosby Weir and Fernvale Bridges open. To do this, the modelling allowed for the predicted maximum storage level of Wivenhoe Dam

391 T 7873.43 (Ayre); T 5272.44 to T 5273.24 (Malone).
392 LAY.SUN.001.0001 at [2142].
393 T 7460.18.
394 QLD.001.001.2773.
395 SunWater subs at [2270].
396 Plaintiff subs at [1388].
397 SunWater subs at [2270].
398 SDWD-201101091600.xls; QLD.001.001.2772.

to rise to EL 72.15m AHD and maintained the modelled gate settings in the 9 Jan 14:00 ROG run. This run ended gate operations at 6.00am on 16 January 2011, which was six days and three hours after the peak inflow.[399] At that time, Wivenhoe Dam would still have been at EL 69.397m AHD and rising thereafter. Thus, there was no "buffer" of the kind asserted by Mr Ayre in this run. In cross-examination, Mr Ayre stated that at the time of this spreadsheet "we were still of the belief ... we could satisfy the objectives of maintaining a flow of between 1,600 and 1,800 [m^3/s] downstream and maintain the bridges open …".[400] I do not accept that the 9 Jan 16:00 ROG run provided any support for such a belief. To the contrary the fact that it was not even close to evacuating just the rain on the ground within seven days of the peak pointed to the necessity to increase releases.

200 The Event Log records that between 4.15pm and 4.27pm Mr Malone spoke with representatives of three local Councils and advised them that the "current strategy was to maintain a flow in the Brisbane River such that the Fernvale Bridge and the Mt Crosby [Weir] Bridge could be kept open".[401] The Event Log also records that, in the last of those calls and further calls to Council officers at 5.18pm and 5.25pm, Mr Malone adverted to further rainfall causing flow in the Lower Brisbane River, and not releases from Wivenhoe Dam, as likely to force the closure of those remaining bridges on 12 or 13 January 2011.[402] An entry in the Event Log at 5.58pm refers to the "Major bridge open strategy".

201 The situation report distributed by Mr Malone just before 6.00pm was consistent with this.[403] It advised that the catchment average rainfall in the previous 12 hours for Somerset Dam and Wivenhoe Dam was 150mm and 80mm respectively (and North Pine was 60mm). It noted that the BoM had forecast "[v]ery heavy rain periods with totals up to 300mm centred around North Pine" for 10 January 2011, "[r]ain periods with totals up to 150mm

399 See SBM.003.003.0001.
400 T 7943.5.
401 QLD.002.001.8660.
402 Ibid.
403 SUN.001.001.0771; QLD.001.001.2780.

centred around North Pine" for 11 January 2011, and little rain in the ensuing four days. He recorded that Somerset Dam was at EL 100.75m AHD "and rising quickly" with an estimated rate of peak inflow of "about 3000m^3/s". The report stated that Wivenhoe Dam was at EL 68.7m AHD, "rising again" and estimated to "reach at least 72.5m AHD during Wednesday morning".

202 The report stated that "the current gate operations strategy will maintain flows of around 1,600m^3/s in the mid-Brisbane River for the next 24 hours". Under the heading "impacts downstream of Wivenhoe Dam", Mr Malone stated that both Fernvale and Mt Crosby Weir Bridges "will not be affected for the next 24 hours" but there was a "strong possibility" that, if the predicted rainfall eventuated in the following 12 to 24 hours, higher releases from Wivenhoe Dam would be necessary, which could adversely impact those bridges.

203 Mr Malone agreed that the references to rainfall amounts centred around North Pine were "clearly relevant" to Wivenhoe and Somerset Dams.[404] He said that inflow rates and height predictions in the situation report were based on rain on the ground assessments.[405] He also accepted that there was an "increasing likelihood" by this time that Wivenhoe Dam would reach EL 74.0m AHD.[406] Mr Ayre agreed that the rainfall centred on North Pine "would in all likelihood extend across into the adjacent areas of Stanley River and mid-Brisbane"[407] but contended that bridges could be still be maintained (but would have to be closed if forecast rainfall eventuated).[408]

204 A rain on the ground model was conducted at around 6.00pm on 9 January 2011 and was saved (the "9 Jan 18:00 ROG run").[409] This run modelled the same gate release strategy as the 9 Jan 16:00 ROG run but with a slightly higher volume of inflows, being 1,346,488 ML compared to 1,306,419 ML. This yielded a higher predicted maximum storage level at Wivenhoe Dam of

[404] T 5274.13.
[405] T 5275.13 - .25.
[406] T 5275.47.
[407] T 7941.26.
[408] T 7944.23.
[409] SDWD-201101091800.xls; QLD.001.001.2792.

EL 72.69m AHD and slightly higher predicted combined downstream flows, although they were still calibrated to keep the remaining bridges open.

The Rainband Moving South

205 Mr Ayre was cross-examined by Senior Counsel for Seqwater first. During that cross-examination he was taken to that part of his affidavit which referred to the flood warning issued at 2.48pm on 9 January 2011[410] which referred to a rainband that was "expected to move south during this afternoon and during Sunday night".[411] Mr Ayre stated that the "southerly movement" referred to in that storm warning "meant that it was likely the heavy rainfall would be occurring in the downstream catchments below Wivenhoe [Dam] in the next 24 to 36 hours" and "[s]o if we were to start making increases to the releases from Wivenhoe Dam, we'd be potentially releasing into a situation which could exacerbate flooding in the Lower Brisbane [River]".[412] The following exchange then occurred:[413]

> "HIS HONOUR: Q. Do I understand you held off making releases based upon a prediction as to where forecast rain would fall.
> A. Yes.
>
> Q. To that extent, you were making operational decisions based on forecasts?
> A. To that extent, we were taking forecast rainfall into consideration, yes."

206 The plaintiff noted that Mr Ayre repeated this contention in cross-examination.[414] It contended this evidence should be rejected for three reasons, which I accept.[415] First, the plaintiff noted that it was not referred to in Mr Ayre's voluminous affidavits. As stated, his first affidavit provides an hour by hour breakdown of the flood event and there is nothing in that part of the discussion concerning 9 January 2011 which suggests that this approach

[410] See above at [188].
[411] LAY.SUN.001.0001 at [2137].
[412] T 7463.6.
[413] T 7463.14.
[414] See T 7935.37 to T 7936.34.
[415] Plaintiff subs at [1399].

was adopted *at that time*.[416] As noted, Mr Ayre's evidence contains a detailed discussion of the use and non-use of forecasts during the flood event. In that discussion he repeatedly warns about the risk inherent in ascertaining where forecast rain will fall (ie, either above or below the dam)[417] and otherwise asserts that "forecasts by themselves did not provide a sufficiently reliable basis upon which to make operational decisions on releasing floodwaters from the Dams during flood events".[418] However, in the above passage, he advocates using forecast location of rain as a basis upon which to make an operational decision.

207 Second, the plaintiff contended that Mr Ayre's assertion that forecasts were used in this way on the afternoon was inconsistent with the "contemporaneous documents". The plaintiff asserted that the material demonstrates that the only reason that releases were held back was a concern about inundating the remaining bridges. I regard that as having been overwhelmingly demonstrated. There is a not skerrick of material suggesting that concern about forecast rain downstream drove those decisions. There was no material difference in the modelled gate operations before and after the flood warning.[419] In fact, the modelling still assumed a reduction in naturally occurring downstream flows on the following day.

208 The third reason noted by the plaintiff was that Mr Ayre's contention was not supported by Mr Malone's evidence and he was the flood engineer on duty during the afternoon of 9 January 2011 and did not cease until around 9.00pm.[420] In neither his affidavit evidence[421] nor oral evidence did Mr Malone suggest any decision to release or not release water was based on the direction of this rainband.

[416] Although he stated a similar approach was taken at around 6.30am the following morning: Ayre 1, LAY.SUN.001.0001 at [2287]; cf SunWater subs at [1570].
[417] LAY.SUN.001.0001 at [627] and [640].
[418] Ibid at [639].
[419] Difference in naturally occurring Lockyer flows between 9 Jan 14:00 ROG run and 9 Jan 16:00 ROG run never exceeds 70m^3/s for 10 Jan 2011.
[420] Plaintiff subs at [1399].
[421] See LAY.SEQ.007.0001 at [673] to [705].

209 SunWater's submissions refer to passages from the contemporaneous documents, Mr Ayre's affidavit and other affidavits which refer to the southern movement of this rainband.[422] However, it is not the fact that the rainband was identified that is controversial; it was Mr Ayre's assertion that an increase in releases on 9 January 2011 was suspended because of it. None of the sources cited by SunWater in its submissions assert that. I do not accept Mr Ayre's evidence on this topic. It is another matter that has caused me to doubt the reliability of his evidence on any matter not corroborated by contemporaneous material.

Conclusion about Period up to 6.00pm on 9 January 2011

210 As at 6.00pm on 9 January 2011, sustained and intense rainfall had been experienced across the dam catchments throughout the day, so much so that between 9.00am and 6.00pm the rain on the ground modelling of the inflow volume for the flood event had increased from 563,513 ML to 1,346,488 ML. As at 6.00pm, Wivenhoe Dam was at EL 68.86m AHD and Somerset Dam was at EL 101.29m AHD.[423] At midnight of 8 January 2011, all bridges other than Fernvale and Mt Crosby Weir were closed and that position had not changed by 6.00pm. This was not by accident but by design. From midnight on 9 January 2011 to 6.00pm on 9 January 2011 the gates at Wivenhoe Dam had only been opened by three increments[424] and the rate of releases from Wivenhoe Dam had only increased from 1241m^3/s to 1404m^3/s.[425] All of the rain of ground modelling reflected the maintenance of those flows and sought to accommodate the increasing volume estimates by extending that rate of flows further into the future and in some models by allowing the dam to rise higher. They did not contemplate raising the rate of releases so as to inundate the bridges. This reflects the adoption by the flood engineers of a "save the major bridges strategy"; that is, the flood engineers were not prepared to increase releases to inundate those bridges and even as late as 3.30pm contemplated reducing releases to keep those bridges open. They did not

[422] SunWater subs at [2255] to [2257], [2262] and [2303]; [1574].
[423] Simulation Analysis, EXP.ROD.015.0461 at .0470 and .0480.
[424] January FER at .0451 to .0452.
[425] Simulation Analysis, EXP.ROD.015.0461 at .0469 to .0470.

contemplate urban flooding and continued operations throughout the weekend until 6.00pm, actions that in context were consistent with giving effect to a W1 Strategy. The situation report prepared on the evening of 8 January 2011 and the entry from the Event Log for 3.30pm on 9 January 2011 confirm as much.

7.3: 6.00pm Sunday, 9 January 2011 to Midnight on Monday, 10 January 2011

211 At the meeting of the flood engineers on the afternoon of 9 January 2011 it was agreed that two flood engineers would work together on each 12-hour shift. As it turned out, Mr Malone was on duty during the daytime of 9 January 2011 and he did not sign off or leave the FOC until 9.30pm that evening.[426] Mr Ruffini signed on at 7.00pm and Mr Ayre at 7.30pm.[427] During Mr Malone's shift to 6.00pm, the radial gates at Wivenhoe Dam had been opened by one increment (at 12.00pm)[428] and three sluice gates at Somerset Dam were opened.[429]

212 Model runs with no forecast rain[430] (the "9 Jan 19:00 ROG run") and 24 hours of forecast rain[431] (the "9 Jan 19:00 Forecast run") that were undertaken by Mr Ruffini at around 7.00pm on 9 January 2011 have been saved. The 9 Jan 19:00 ROG run predicted a lower volume of inflows than the 9 Jan 18:00 ROG run, being 1.21 million ML compared to 1.346 million ML. However, the 9 Jan 19:00 Forecast run estimated the volume of inflow as 1.578 million ML.

213 The 9 Jan 19:00 ROG run predicted a maximum height of Wivenhoe Dam of EL 71.69m AHD and predicted a peak flow rate at Lowood and Moggill of around 2550m^3/s at 9.00am on 12 January 2011. The 9 Jan 19:00 Forecast run predicted a maximum height of Wivenhoe Dam of EL 73.16m AHD at around 4.00pm on 11 January 2011 and peak flow rates (including releases)

[426] LAY.SEQ.007.0001 at [695].
[427] SUN.002.005.0002 at .0003.
[428] January FER at .0451.
[429] Ibid at .0465 to .0466.
[430] SDWD-201101091900norain.xls – QLD.001.001.2798; there is another rain spreadsheet entitled SDWD-201101091900withrain.xls – QLD.001.001.2796, however that is misnamed and it is a copy of the no rain run (T 7945.17 - .25 (Ayre); LAY.SUN.001.0001 at [2165] (Ayre).
[431] SDWD-201101091900.xls; QLD.001.001.2797.

at Lowood and Moggill of around 3300m^3/s at 8.00am on 11 January 2011. Of particular relevance are the gate operations strategies that underlay these predictions. With the 9 Jan 19:00 ROG run, the existing level of increments that the gates were open to, namely 27, was maintained up to and including 11.00am on 10 January 2011 when the amount released at that time would cause Lowood to reach flows of 1865m^3/s. When that water worked its way downstream, Mt Crosby Weir Bridge would effectively be inundated. The spreadsheet assumed one gate increment was opened in the following hour which would cause Lowood to reach flows of 1931m^3/s and then a further gate increment in the following hour resulting in the flow at Lowood reaching 1997m^3/s, which would effectively inundate Fernvale Bridge one hour downstream. In this model run, gates were then progressively opened at a rate of one increment an hour to 34 increments by 6.00pm on 10 January 2011 and then increased to 43 increments at 9.00am on 12 January 2011, by which time the dam would be releasing over 2400m^3/s. Thus, this release plan does not support the suggestion that releases were being held back because of a supposed concern about downstream flows based on forecasts. Instead, it suggests that releases were being held back until a combination of existing releases and downstream flows inundated Mt Crosby Weir Bridge.[432] This position is borne out by subsequent events.

214 In the 9 Jan 19:00 Forecast run, the existing level of gate increments was also maintained until 11.00am on 10 January 2011 and was then increased by one increment an hour until they reached 50 increments at 8.00am on 11 January 2011, by which time Wivenhoe Dam would be releasing almost 3000m^3/s. The flow rates at Lowood throughout 10 January 2011 in the 9 Jan 19:00 Forecast run are not materially different from the 9 Jan 19:00 ROG run. Thus, one feature common to both runs is that the modelled gate operations strategy does not contemplate any more than one gate opening until Mt Crosby Weir Bridge was inundated by a combination of downstream flows and the existing level of releases.

[432] Cf SunWater subs at [2294].

215 As noted, the peak height predicted by the 9 Jan 19:00 Forecast run was EL 73.16m AHD late in the afternoon of 11 January 2011, notwithstanding the significant increase in releases modelled by that run from midday on 10 January 2011. The plaintiff submitted that, given two days of heavy rain were still forecast, but only one day's rain was modelled, it should have been "obvious to each of Mr Ruffini, Mr Ayre and Mr Malone that there was a likelihood of Wivenhoe Dam exceeding 74m," so as to require the invocation of W4. It also submits that "a reasonable engineer would have recognised the need urgently to increase releases from Wivenhoe" and not wait for natural flows to inundate Mt Crosby Weir Bridge and Fernvale Bridge.[433]

216 I accept those contentions. According to Mr Ayre, the 9 Jan 19:00 Forecast run used a "12 hour QPF",[434] that is, it assumed the rain forecasted in the QPF forecast would fall in the first 12 hours of the 24-hour forecast period.[435] Even allowing for that, Mr Malone's situation report raised a possibility of greater rain falling in that period and most importantly the strong likelihood of significant rain on the day following the expiry of the QPF forecast period at 3.00pm on Monday 10 January 2011.

217 At 7.06pm, a flood warning for the coastal streams was issued.[436] The Event Log records that around this time senior Seqwater and Council staff were contacted by the FOC and advised that higher releases in the order of 3000m^3/s were expected to be necessary in view of the heavy rain over the preceding three hours and that releases from Wivenhoe "causing damaging flooding are likely to be necessary".[437] These statements were consistent with the 9 Jan 19:00 Forecast run. One of the entries records that Mr Allen, the Director of Dam Safety at DERM, was contacted and advised that the flood engineers would "have to ramp up releases to around 3000 [m^3/s] as by as early as midnight which is likely to have flooding impacts on low-lying levels of Brisbane". This is not consistent with the rain on the ground modelling but is

433 Plaintiff subs at [1403].
434 LAY.SUN.001.0001 at [2165].
435 Ibid at [538].
436 QLD.002.002.1792.
437 QLD.002.001.8660.

consistent with the forecast rain modelling undertaken at 7.00pm. In terms of gate operations, it is not what in fact occurred.

218 As noted, Mr Ayre signed on for duty at 7.30pm. In his first affidavit, Mr Ayre said that there was a handover meeting at around this time.[438] He said that, amongst other matters, they affirmed that the "current gate operational strategy would be to maintain flows of around 1,600m^3/s in the mid-Brisbane River for the next 24 hours in order to allow the peak of the flow in Lockyer Creek to pass through the Brisbane River without having to close Fernvale Bridge and Mt Crosby Weir Bridge".[439]

219 A rain on the ground model run undertaken by Mr Ruffini and Mr Ayre at around 8.00pm on 9 January 2011 was saved[440] (the "9 Jan 20:00 ROG run"). This run predicted a total volume of inflows of 1.533 million ML which was more than 300,000 ML greater than the volume of inflows predicted in the 9 Jan 19:00 ROG run. The model run assumed the same gate openings as the 7.00pm ROG model run and yielded a maximum storage level of EL 73.06m AHD in Wivenhoe Dam. The model run again assumed gate operations that effectively did not increase gate increments at Wivenhoe Dam until the combination of existing flows and Lockyer flows inundated Mt Crosby Weir.

220 The plaintiff submitted that, at this stage, it should have been obvious to each of Messrs Ruffini, Ayre and Malone that there was an extremely high likelihood of Wivenhoe Dam exceeding EL 74.0m AHD.[441] I agree. Given the difference between the inflows predicted by the 9 Jan 19:00 ROG run and 9 Jan 19:00 Forecast run and the state of the forecasts, if an up-to-date RTFM run based solely on rain on the ground data was predicting EL 73.06m AHD, then the likelihood that forecast rain would push it over EL 74.0m AHD was overwhelming. The "with forecast" Appendix A model run of 8.00pm on

[438] LAY.SUN.001.0001 at [2175].
[439] Ibid at [2175(f)].
[440] SDWD-201101092000withnorain.xls; QLD.001.001.2804.
[441] Plaintiff subs at [1405].

9 January 2011 predicted Wivenhoe Dam exceeding EL 74.1m AHD on 11 January 2011.[442]

221 SunWater submitted, inter alia, that if Strategy W4 had been invoked at this point then it would have required releases greater than the modelled inflows of between 4398m^3/s and 6731m^3/s, which would have been especially damaging downstream.[443] However, that contention is predicated on the assumption that once W4 is invoked then gates had to be raised until the water level stopped rising. In Chapter 3, I found that W4 can be invoked by a predicted level greater than EL 74.0m AHD rather than an actual level and that before the actual level exceeds that amount the gates do not have to be raised to arrest the rising lake level.[444]

222 The Event Log records that at around 8.30pm Mr Ruffini spoke to an Ipswich Council representative and advised them of the likelihood of high releases the following day causing flood damage.[445] An entry at 8.50pm records that Mr Ayre requested Mr Morris from Brisbane City Council to provide a copy of a "flood damages curve".

223 Just after 9.00pm, a situation report was issued,[446] under Mr Malone's name.[447] The report noted that "[v]ery heavy rainfall [had] been recorded in the upper reaches of the Brisbane and Stanley in the last 6 hours with totals up 100 to 140mm" and that "[t]otals for the last 24 hours range from 100 to 300mm" with "[r]ainfall of similar magnitudes … expected in the next 12 to 24 hours, especially around the Bremer/Warrill catchments as the system tracks south." The report stated that Somerset Dam was at EL 101.68m AHD and "rising quickly" with five sluice gates open that were releasing about 1100m^3/s, while Wivenhoe Dam was at EL 69.1m AHD and releasing 1400m^3/s. It was anticipated that the dam "will reach at least 73.0m AHD

[442] QLD.001.001.2802.
[443] SunWater subs at [2317(d)].
[444] Chapter 3 at [313] to [314]; see above at [107] to [108].
[445] QLD.002.001.8660.
[446] SUN.001.001.0783.
[447] LAY.SEQ.007.0001 at [698].

during Tuesday morning". This assessment was based on the rain on the ground modelling.[448] The report continued:

> "… Given the rapid increase in inflow volumes, it will be necessary to increase the release from Wivenhoe Monday morning.
>
> *The objective for dam operations will be to minimise the impact of urban flooding* in areas downstream of the dam and, at this stage, releases will be kept below 3,500m^3/s and the combined flows is the lower Brisbane will be limited to 4,000m^3/s. This is below the limit of urban damages in the City reaches.
>
> The current release rate from Wivenhoe Dam is 1,400m^3/s (120,000 ML/day). Gate opening will start to be increased from noon Monday and the release is expected increase to at least 2,600m^3/s during Tuesday morning." (emphasis added)

224 This is the earliest objective evidence to suggest that the flood engineers acknowledged the objectives of W3. However, it still only addresses those objectives in the future, specifically the following morning. Instead, the report maintains the approach of resisting further gate openings at Wivenhoe Dam well into 10 January 2011 and that was only at the time when Mt Crosby Weir Bridge was predicted to be inundated by the existing level of releases and an increase in natural downstream flows. A technical situation report issued at the same time described the strategy as being to "[c]ontinue the current releases until tomorrow noon when [releases] will be increased to impact Mt Crosby and Fernvale Bridges".[449]

225 In his affidavit, Mr Malone said that dam operations over the following 24 hours were very much dependent on where forecast rainfall occurred, that is, upstream or downstream of Wivenhoe Dam. He added that, even if it fell upstream, "it was not expected that the lake level in Wivenhoe Dam would reach dam safety trigger level and that operations would still be limited to Strategy W3".[450] I have already found to the contrary. Mr Malone also said that the "strategy" was to "seek a balance between temporary storage flood water and limiting releases, and increasing releases to limit the peak water

[448] T 5280.25 (Malone).
[449] SEQ.001.011.5033.
[450] LAY.SEQ.007.0001 at [693].

level in the dam".[451] In cross-examination, Mr Malone suggested that the delay in increasing releases might have been the result of "*practical issues with regard to getting people out to close the bridges*",[452] but said he could not remember if that was the case.[453] The material set out below does not support this. As noted by the plaintiff,[454] the police were onsite to close the bridges in less than two hours once it became clear the bridges would close.[455]

226 In its submissions, SunWater quoted Mr Fagot's commentary on this situation report as follows:[456]

> "Situation Report 12 by Mr. Malone (January 9, 2011 at 21:04) offers some insight into these decisions. He states that very heavy rainfall has occurred in the controlled areas (upstream of the dams). However, he also states that rainfall of similar magnitude is expected to occur in the next 12 to 24-hours around the Bremer / Warrill catchments as the system tracks south. At this point, Mr. Malone is indicating that significant rainfall is likely to occur in the uncontrolled areas (downstream of the dams). Based on my experience, it is reasonable and prudent for a reservoir engineer *to avoid significant increases in releases with heavy rainfall forecasted downstream of the controlled areas. The flood mitigation manual also specifies that the flow should be minimized prior to the naturally occurring peak at Moggill*. My analysis of the actual operations indicates that the reservoir engineers were unable to decrease releases due to rising pool elevations, *but were constrained from significantly increasing releases due to heavy rainfall forecasted downstream of the dams*. In my opinion the operations adopted by the reservoir engineers in those circumstances were reasonable." (emphasis added)

227 There are two difficulties with this analysis. First, nothing in Mr Malone's situation report indicates that releases were being held back by reason of forecast conditions downstream suggesting urban flooding might occur. As noted, the releases were not being increased to avoid inundating downstream bridges and once that occurred the releases were increased. Second, I have already rejected the proposition that Strategy W3 generally required the minimisation of releases prior to the naturally occurring peak at Moggill. Instead, that is only applicable when the downstream flow rates exceed the

[451] LAY.SEQ.007.0001 at [699].
[452] T 5282.8.
[453] T 5282.14 - .17.
[454] Plaintiff subs at [1411].
[455] QLD.002.001.8660 (21:10-21:20; 22:45 entry); QLD.002.001.3121.
[456] EXP.QLD.001.0524_2 at [22]; SunWater subs at [2324].

threshold for non-damaging flows.[457] Further, at that point, the flood engineers' most recent rain on the ground model, namely the 9 Jan 20:00 ROG run, was still advising them that the naturally occurring peaks at Lowood and Moggill had already occurred.[458]

228 At 9.08pm, an email was sent with an hourly breakdown of the projected release rates of water from Wivenhoe Dam over the ensuing days.[459] The changes in the projected rates during the course of 10 January 2011 are consistent with the gate operations modelled in the 9 Jan 20:00 ROG run. In particular, they appear to assume no further gate openings at Wivenhoe Dam until after 11.00am on 10 January 2011.[460]

229 The Event Log records that at 9.10pm, Mr Ayre advised Mr Drury that "releases will need to be ramped up from current 1400[m^3/s] to 2500[m^3/s] which will cause flooding in low lying areas of Brisbane" and that "volumes [were] getting close to 1974 levels".[461] In his affidavit, Mr Ayre stated that he referred to a flow rate of 2600m^3/s and not 2500m^3/s and also discussed arrangements for the closure of Fernvale Bridge.[462]

230 At 9.18pm, Mr Drury emailed Mr Spiller and others the Technical Situation Report.[463] Mr Spiller forwarded it to a wider group, including Mr Barry Dennien and Ms Debra-Lee Best in anticipation of a teleconference at 9.30pm.[464] Mr Drury said he could not recall the teleconference other than it being arranged to obtain information for the Premier and the relevant Minister.[465]

231 Model runs that were undertaken at around 10.00pm on 9 January 2011 with no forecast rain (the "9 Jan 22:00 ROG run")[466] and with forecast rain based

[457] Chapter 3 at [289].
[458] LAY.SUN.001.0001 at .0772 (Annexure C, line 28).
[459] QLD.001.001.2815.
[460] When the discharge rate increased from 1581m^3/s to 1646m^3/s.
[461] QLD.002.001.8660.
[462] LAY.SUN.001.0001 at [2187] and [2191].
[463] QLD.002.002.3012.
[464] QLD.002.002.2601.
[465] T 6701.31.
[466] SDWD-201101092200norain.xls– QLD.001.001.2826.

on the QPF over a 24-hour period[467] (the "9 Jan 22:00 Forecast run") were saved. The 9 Jan 22:00 ROG run predicted a volume of inflows very similar to the 9 Jan 20:00 ROG run, namely, 1.539 million ML compared with 1.533 million ML. However, there were three material differences between the two runs.

232 First, like the 9 Jan 20:00 ROG run, the 9 Jan 22:00 ROG run maintained the existing gate increments (ie, 27) until midday on 10 January 2011, but then modelled gate openings increasing by one increment an hour until gates were open to 45 increments at 5.00am on 11 January 2011, which was maintained until 12.00pm on 15 January 2011. As a consequence, under the 9 Jan 22:00 ROG run, the predicted peak release from Wivenhoe Dam was higher than the 9 Jan 20:00 ROG run, namely, 2729m^3/s compared to 2586m^3/s, and was reached earlier, being 5.00am on 11 January 2011 compared to 9.00am on 12 January 2011. The predicted maximum height of Wivenhoe Dam in the run was EL 73.29m AHD.

233 Second, unlike all the modelling conducted over the previous three days, the 9 Jan 22:00 ROG run estimated that the natural peaks at Lowood and Moggill were yet to occur. Specifically, the model run predicted a natural peak flow rate of 613m^3/s at Lowood at 7.00am on 10 January 2011 and a natural peak flow rate of 830m^3/s at Moggill at 6.00am on 10 January 2011.

234 Third, the 9 Jan 22:00 ROG run indicated that the time at which the remaining bridges would close was approaching much quicker than had previously been anticipated. This model run predicted that Lowood would reach the threshold for the inundation of Mt Crosby Weir Bridge of 1900m^3/s just after midnight (although the bridge is ten hours downstream) and that Lowood would reach the 2000m^3/s threshold to close Fernvale Bridge shortly after 1.00am on 10 January 2011.

235 With the 9 Jan 22:00 Forecast run, the estimate of the volume of inflows on this model run increased to 2.099 million ML compared with 1.539 million ML

[467] SDWD-201101092200-Forecast24hr.xls; QLD.001.001.2825; LAY.SUN.001.0001 at [2197].

in the 9 Jan 22:00 ROG run. The model predicted significant increases in the flows from Lockyer Creek and the Bremer River with the natural peak at Lowood now predicted to occur at 2.00am on 11 January 2011 and at Moggill at 3.00pm on 10 January 2011. This model run included gate openings commencing at around 1.00am on 10 January such that by 10.00am they would be open to 46 increments. This resulted in a maximum release rate of just under 3000m^3/s and a predicted maximum flow rate at Moggill of over 5000m^3/s, which would inundate homes. The maximum predicted height of Wivenhoe Dam was EL 75.11m AHD.

236 In his first affidavit, Mr Ayre recounted a conversation he had with Mr Drury at around 10.20pm in which he said he stated that "we have been attempting to optimise protection to downstream areas by keeping flows to around 1600m^3/s [but] we can no longer keep the low level bridges open and so we will need to increase releases from Wivenhoe Dam".[468] In his oral evidence, Mr Ayre said this was reflected in bringing forward the planned increase in releases from around 11.00am to around 2.00am.[469] There was a debate in the submissions as to whether the increase in releases was planned based on the 9 Jan 22:00 Forecast run or opted for only when the bridges were washed out. The plaintiff noted that the GOS for the 9 Jan 22:00 Forecast run spreadsheet includes gauge board readings from up to 2.00am on 11 January 2011 and contended that this spreadsheet was most likely altered to reflect the gate openings that in fact occurred.[470] It also noted that the relevant gate directive for the opening at 2.00am was not issued until after a further rain on the ground run was undertaken at 1.00am on 10 January 2011.[471] SunWater disputed this.[472] However, in cross-examination, Mr Ayre agreed that no directives were issued based on the 9 Jan 22:00 Forecast run.[473] I accept that evidence.

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[468] LAY.SUN.001.0001 at [2202].
[469] T 7466.34 - .44.
[470] Plaintiff subs at [1418].
[471] Ibid at [1419].
[472] SunWater subs at [2334] to [2336].
[473] T 7953.20.

237 In any event, what is significant is that the releases were only planned to occur and only did occur after the downstream bridges were inundated by existing flows and increases in naturally occurring downstream flows. There were no increases in gate openings at Wivenhoe Dam from midday on 9 January 2011 until 2.00am on 10 January 2011.[474]

238 In its submissions, SunWater relied on the following statement by Mr Fagot about increasing releases based on the 9 Jan 22:00 Forecast run:[475]

> "Significant increases based on the January 9, 2011 with rain forecast at 22:00 hours would have dropped the pool elevation, but it would have also increased impacts downstream. Had the rainfall that occurred late on January 10 and throughout January 11 not developed or had shifted slightly downstream, the reservoir engineers would have been *open to criticism* for creating additional downstream impacts with flood storage remaining." (emphasis added)

239 It is not necessary to dwell upon whom the flood engineers would have faced criticism from or why the fact that they could be criticised is of any relevance at all. Instead, it suffices to note that this opinion, like much of his critique, is premised on Mr Fagot's mistaken opinion that Wivenhoe and Somerset Dam are method A reservoirs in which releases are not made from flood storage unless it is certain that it will fill.[476] In this answer, he asserts that it was not certain that it would fill, despite the rain on the ground and forecast assessments, because of the possibility that predicted rainfall would not develop or might "shift ... slightly downstream". As explained in Chapter 3, that approach inverts the priority of the objectives in the Manual.

240 It appears that the remaining bridges were closed even faster than the latest rain on the ground modelling predicted. The Event Log records that a visual inspection was undertaken at Fernvale Bridge around 10.40pm which revealed that "[w]ater is lapping the bridge girders".[477] Around the same time, discussions took place concerning the removal of the guardrails at Mt Crosby Weir Bridge "in view of increasing flow expectations overnight". Events

[474] January FER at .0452.
[475] EXP.QLD.001.0524_2 at [20]; SunWater subs at [2315].
[476] Chapter 3 at [345] to [347].
[477] QLD.002.001.8660.

moved rapidly from that point. By 10.45pm, the police were on site at Mt Crosby Weir Bridge.[478] Mr Ayre sent an email at 11.30pm advising that the police were on site at Fernvale Bridge and were "considering closing the road" and that Mt Crosby Weir Bridge had closed "due to local runoff from residual catchments and Lockyer Creek".[479] At 12.15am, a call was made to the FOC confirming that Mt Crosby Weir Bridge was closed.[480]

241 Mr Ayre was asked as follows in relation to the position as at around 10.30pm:[481]

> "Q. By this point it was apparent that this was a rainfall event where the focus had to be on minimising flooding downstream rather than avoiding urban flooding downstream; correct?
> A. Yes.
>
> Q. This type of information made it very likely that the dam could - and by "the dam", I mean Wivenhoe Dam - reach the level of 74 metres?
> A. Yes, it was indicating this was now a very large flood in the Upper Brisbane.
>
> HIS HONOUR: Q. Can I just ask, when you accepted that by this point the focus was on minimising flooding downstream, rather than avoiding urban flooding downstream, are you taking the threshold for urban flooding as the 4,000?
> A. *Yes*, trying to maintain flows below 4,000, effectively." (emphasis added)

242 SunWater contended that Mr Ayre did not concede that the focus was to prevent downstream flows from exceeding 4000m^3/s because Mr Ayre knew that damage would result from combined flows over 2000m^3/s and had that "in mind" when answering the question about the threshold for urban damage.[482] I do not accept that. From observing Mr Ayre give this evidence, I understood him to accept the proposition that he took the threshold for urban flooding as a flow rate of 4000m^3/s at Moggill ("yes"). Mr Ayre accepted that downstream flooding at rates above 4000m^3/s would occur, although he would try to maintain flows below that. Otherwise, he accepted that it was likely that the level of Wivenhoe Dam would exceed EL 74m AHD and the focus had to be

[478] QLD.002.001.8660.
[479] QLD.002.001.3121.
[480] QLD.002.001.8660.
[481] T 7954.3 – .21.
[482] SunWater subs at [2339].

on minimising downstream flooding, not avoiding it. The plaintiff contended that this required W4 to be implemented and the "Flood Engineers breached the Manual by not implementing W4".[483] I agree, although I reiterate the discussion in Chapter 3[484] and above[485] about what implementing W4 prior to actual levels exceeding EL 74.0m AHD means.

243 Four flood warnings were issued between 10.39pm and 12.36am. The flood warning at 10.39pm concerned the Stanley River and Brisbane River above Wivenhoe Dam and noted that between 100mm and 250mm of rain had fallen causing major flooding.[486] The flood warnings issued at 10.56pm and 12.36am concerned the lower Brisbane River below Wivenhoe Dam and warned of stream rises causing minor to moderate flooding in the Lockyer Creek and Bremer River, as well as minor flooding in the middle and lower Brisbane River.[487] A flood warning for the coastal streams was issued just after 11.00pm.[488] At 10:58pm, the BoM issued a severe weather warning for the Southeast Coast District, southern parts of the Wide Bay and Burnett districts and the eastern parts of the Darling Downs and Granite Belt district. Two rain causing systems were said to be moving "*slowly west*".[489]

244 At 11.07pm, Mr Spiller emailed the Minister, Ms Best and others,[490] attaching the Technical Situation Report noted above.[491] Mr Spiller wrote:

> "To date, the primary objective for this event has been managing to prevent inundation of the Mt Crosby Weir and Fernvale Bridges.
>
> With the forecast volumes, this primary objective is being **changed** to minimizing the risk of urban inundation. This involves larger releases now, minimizing the risk of even larger releases later (were the flood compartment to reach high levels)."

483 Plaintiff subs at [1423].
484 Chapter 3 at [317].
485 See above at [108ff].
486 SEQ.001.018.8528.
487 QLD.002.002.1781; QLD.002.002.1770.
488 QLD.002.002.1776.
489 QLD.002.002.1778.
490 QLD.002.002.2596.
491 At [224].

245 The plaintiff noted that Mr Drury accepted that he received this email and did not seek to contradict it.[492] In those circumstances, the plaintiff contended that the Court should infer that this email accurately reflects what Mr Drury told Mr Spiller[493] and in turn what Mr Ayre told Mr Drury in a conversation at 9.10pm.[494] Mr Malone accepted that Mr Spiller's account was "*largely consistent*" with what his understanding was on 9 January 2011.[495]

246 To similar effect, at 11.44pm, Mr Keegan emailed the Seqwater employees responsible for the Mt Crosby Water Treatment Plant. Mr Drury was copied in on the email. Mr Keegan wrote:[496]

> "The FOC has introduced a *new strategy* to drain Wivenhoe Dam and minimize flooding impacts in urban areas. From midday tomorrow the releases rate will be increased gradually to a peak rate of approx 3500cumecs." (emphasis added)

Mr Drury did not respond or seek to correct this email at the time.

247 Sunwater disputed that the contents of these emails could be traced to anything stated to the authors by the flood engineers, particularly Mr Ayre.[497] I do not consider it necessary to undertake that exercise. Mr Spiller's and Mr Keegan's statements could well have been surmised on their behalf but if this was so, then they surmised correctly. Up until at least around 9.30pm the "*primary objective*" of flood operations was to keep Mt Crosby Weir and Fernvale Bridges open, and it was only after the bridges had closed that their "*primary objective*" changed to providing optimum protection of urban areas from inundation. The plaintiff contended that this approach involved a breach of section 8.4 of the Manual both on 9 January and in the days before 9 January, in that it constituted a failure to consider the hierarchy of objectives

[492] T 6702.20.
[493] See [230].
[494] See [229]; Plaintiff subs at [1426].
[495] T 5285.12.
[496] SEQ.016.017.5231.
[497] SunWater subs at [2344] to [2345].

in order in all strategies when making dam releases.[498] I agree that this contention encapsulates one aspect of the flood engineers' overall conduct.

248 Mr Malone's "Observed Rainfall Analysis" report recorded catchment average rainfall in the 24-hour period to 9.00am on 10 January 2011 of 210mm in the Somerset catchment, 124mm in the Upper Brisbane River catchment and 126mm in the Middle Brisbane River catchment above Wivenhoe Dam.[499] It recorded catchment average rainfall of 66mm, 44mm and 90mm in the Lockyer, Bremer and Lower Brisbane catchments in the same period respectively. Dr Christensen determined actual rainfall upstream of Wivenhoe Dam on 9 January 2011 to be 149mm.[500]

249 As at midnight on 10 January 2011, Wivenhoe Dam was at EL 69.80m AHD and releasing 1462m^3/s.[501] Somerset Dam was at EL 102.38m AHD and releasing 1359m^3/s.[502] As noted, the gates at Wivenhoe Dam were only opened by three increments in the period from midnight on 8 January 2011 to 6.00pm on 9 January 2011. There were no further gate openings at Wivenhoe Dam between 6.00pm and midnight on 10 January 2011.[503] In contrast, during 9 January 2011, three sluice gates were opened at Somerset Dam. By midnight, five sluice gates were open and 1238m^3/s was flowing from Somerset Dam into Wivenhoe Dam.[504]

General Strategies and Mr Ruffini

250 Seqwater submitted that throughout his shift on 9 January 2011, Mr Malone acted in accordance with the general strategy set by Mr Ayre. In particular, it contended that his gate operations prior to 3.30pm were in accordance with Mr Ayre's general approach of maintaining downstream flows below 1600m^3/s[505] and after 3.30pm, he "continue[d] the existing release strategy for

[498] Plaintiff subs at [1428].
[499] SEQ.004.046.0230 at .0274.
[500] EXP.ROD.001.0583 at .0680.
[501] Simulation Analysis, EXP.ROD.015.0461 at .0470.
[502] Ibid at .0480.
[503] January FER at .0452.
[504] Ibid at .0466.
[505] Seqwater subs at [1121].

the time being".[506] I accept this as a relatively accurate statement of the flood engineers' approach and that it was "set" by Mr Ayre, but it was also agreed to by the other flood engineers. However, as previously found,[507] the specification of a general strategy to that effect did not relieve Mr Malone and, subject to what follows, Mr Ruffini of their obligations under the Manual to consider the best rainfall forecast and streamflow information to determine the applicable strategy, ascertain the primary consideration of the strategy and make decisions on dam releases.

251 The State made the same submission as Seqwater in respect of Mr Ruffini but took it further. The State contended that, while Mr Ruffini was on duty during the evening of 9 January 2011 and the morning of 10 January 2011, Mr Ruffini, at the direction of Mr Ayre, "assumed responsibility for flood operations at North Pine Dam and Mr Ayre assumed responsibility for operations at Wivenhoe and Somerset Dams".[508]

252 During his cross-examination by Senior Counsel for the State, Mr Ayre agreed that on the evening of 9 January 2011 a "dangerous or significant situation" arose at North Pine Dam.[509] Mr Ayre said that "John [Ruffini] was looking after [North] Pine" including undertaking modelling, preparing operation spreadsheets and directives.[510] Mr Ayre was then asked if he, Mr Ayre, was "looking after Wivenhoe and Somerset" and replied "Yes...[b]ut we would both check each other during the course of the event, as a means of a sanity check".[511] Mr Ayre also confirmed[512] the correctness of a statement he made during an investigation after the flood event into Mr Ruffini's licensing status in which Mr Ayre stated that, during the period 9 January 2011 to 12 January 2011, he "maintained direct supervision of Mr Ruffini … including, for

[506] Seqwater subs at [1123].
[507] Chapter 3 at [323], Chapter 6 at [262] and Chapter 7 at [125].
[508] State subs at [116] and [252] to [253].
[509] T 7501.27.
[510] T 7504.19.
[511] T 7504.25.
[512] T 7504.41.

example, reviewing the directives and hydrological modelling conducted by Mr Ruffini for the purpose of flood operations".[513]

253 I accept that Mr Ruffini was undertaking the management of flood operations at North Pine Dam on the evening of 8 January 2011 and morning of 9 January 2011 and that, overall, he was supervised by Mr Ayre. However, I do not accept that Mr Ruffini had no direct involvement in the management of flood operations at Wivenhoe Dam and Somerset Dam throughout that period. To the contrary, the contemporaneous documents and balance of Mr Ayre's testimony suggested that he was directly involved and I so find. Mr Ruffini undertook the 9 Jan 19:00 ROG run,[514] the 9 Jan 20:00 ROG run,[515] participated in compiling the situation report issued at around 9.00pm on 9 January 2011,[516] made a number of telephone calls on the evening of 9 January 2011 concerning the closure of bridges[517] and made further calls the following morning about damaging flow levels,[518] jointly prepared the situation reports issued at 1.15am and 6.30am on 10 January 2011,[519] issued a gate directive at 2.00am[520] and generally prepared gate operations spreadsheets.[521]

Findings about Flood Operations on 9 January 2011

254 As noted, the contemporaneous material suggests that throughout 9 January 2011 the focus of the flood engineers' attention was on maintaining both Fernvale Bridge and Mt Crosby Weir Bridge open, this being their "Major bridge open strategy". They conducted flood operations as though they were subject to Strategy W1. They acted in accordance with their understanding of its constraints. They did so even though, on any view, they had exceeded its relevant storage height of Wivenhoe Dam at EL 68.5m AHD.

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513 QLD.017.006.0010 at [16].
514 T 7945.15 (Ayre).
515 T 7946.37.
516 QLD.001.001.2812; T 7948.14.
517 QLD.002.001.8660 (see 8.55pm, 10.00pm, 11.30pm, 11.35pm, 11.38pm, 11.40pm).
518 QLD.002.001.8660 (see 12.45am, 4.10am).
519 QLD.001.001.2858; T 7961.19; QLD.001.001.2901; T 7969.12.
520 QLD.001.001.2878; T 7964.45.
521 T 7968.46.

255 During the evening of 9 January 2011, the flood engineers came to accept that there was a necessity to transition out of W1 at some point but they still planned and conducted flood operations on the basis that the major bridges would be kept open for as long as possible. By early evening, the material suggests that there was a realisation of the possibility, growing in likelihood over time, that urban flooding would occur and then that Wivenhoe Dam would exceed EL 74.0m AHD. Nevertheless, the flood engineers still maintained a "Major bridge open strategy". In particular, they modelled gate openings on the basis that there would be no (or very minimal) further gate openings at Wivenhoe Dam until the combination of downstream flows and existing releases closed one or both of the remaining bridges. This approach was reflected in their communications, the gate strategies in their modelled runs and the projected outflows emailed to affected parties, all of which did not contemplate further openings until around 11.00am on 10 January 2011. It was also reflected in the flood engineers' failure to open any gates at Wivenhoe Dam between midday on 9 January 2011 and 2.00am on 10 January 2011, notwithstanding an avalanche of evidence that the flood event was rapidly worsening with a growing expectation that homes would be flooded. It was confirmed by an email sent at around 3.31am the next morning.[522] Eventually, the anticipated time at which those bridges would close moved rapidly forward so that they were closed by or shortly after midnight to 1.00am on 10 January 2011. As the following demonstrates, it was then and only then that the flood engineers undertook further gate openings at Wivenhoe Dam.

256 SunWater submitted that it was necessary to address the flood engineers' conduct from a perspective that considered the rapidly changing nature of the flood event on 9 January 2011. It noted that releases had never been made that closed Fernvale Bridge, that the damages curve reflecting the 2007 report noted in Chapter 4[523] contemplated some urban damage above 2000m^3/s and that the intense rain that fell on 9 January 2011 resulted in a large escalation in inflow volumes as evidenced by the rapidly changing rain on the ground

[522] See [281] and SUN.002.001.6651.
[523] Chapter 4at [117].

assessments.[524] In relation to the first matter, on any view of the Manual, the flood engineers should have been operating in W3 since Saturday morning, yet it is clear they were not. The question of inundating the remaining bridges in anticipation of further rain should have been at the very forefront of their deliberations, yet consistent with their sensitivity to criticism noted in Chapter 4[525] they chose to keep them open even when their rain on the ground modelling advised them that the flood storage component would fill. The second matter has already been addressed. In relation to the third matter, the rain that fell on 9 January 2011 certainly exceeded the prevailing QPF forecasts but it was also clearly foreseeable that rain of that magnitude might fall. Since at least the previous Thursday, the PME forecasts had been predicting very heavy rain for 9 and 10 January 2011.[526] The FPM drafted by the flood engineers had directed them to model 200% of forecast rainfall.

257 SunWater also cited Mr Fagot's analysis of the flood engineers' conduct on 9 January 2011.[527] His approach has already been addressed. As noted, Mr Fagot advocated letting the flood storage component fill to address lesser floods at the risk of worsening more severe floods. This is what the flood engineers did but it was completely contrary to the Manual's priority of objectives.[528] SunWater also cited Dr Christensen's explanation of his methodology as supportive of the flood engineers' approach.[529] The observations at [135] apply with equal force at this point.

258 The plaintiff's primary contention was that the flood engineers' conduct in remaining focused "solely on keeping Mt Crosby Weir Bridge and Fernvale Bridge open for as long as possible and until closed by increasing natural downstream flows" was "unreasonable and not in accordance with the Manual".[530] The plaintiff contended that each of the flood engineers on duty throughout 9 January 2011 was obliged to but failed to implement

[524] SunWater subs at [2352] to [2362].
[525] Chapter 4 at [219]-[221].
[526] Chapter 6 at [3], [152] and [217].
[527] SunWater subs at [2364].
[528] See also SunWater subs at [2409].
[529] SunWater subs at [2366].
[530] Plaintiff subs at [1431] and [1432].

Strategies W4 and S3 and otherwise should not have increased outflows from Somerset Dam[531] without a corresponding increase in Wivenhoe Dam outflows.[532]

259 It follows from the above that I am satisfied that in fact the flood engineers operated in W1 throughout 9 January 2011 and remained solely focused on keeping the remaining bridges open. In light of the prevailing rainfall, rainfall forecasts, and given that, at the very minimum they should have been operating in W3, or more correctly having regard to W3 objectives while in W4, then the flood engineers' approach of not increasing releases until existing releases and natural downstream flows inundated the bridges was completely unreasonable. None of the concerns about downstream flows, the time it would take to safely close the bridges or even the possibility of downstream damage at flow rates above 2000m^3/s warranted gambling away storage space to keep bridges open for that long.

260 It also follows from the above that I am satisfied that the flood engineers were obliged to operate in W4 throughout the day, although not by raising gates on the basis that the storage level had exceeded EL 74.0m AHD. I have explained that operating in W4 does not necessarily mean an immediate increase in releases from Strategy W3 but the flood engineers were not operating in that either. Although the outflows should have been increased to inundate the remaining bridges, the plaintiff did not suggest, and I do not accept, that they should have been increased to a level that by themselves exceeded the upper limit of non-damaging flows downstream. How they should have addressed the risk of releases combining with downstream flows to exceed that limit is addressed in Chapter 10, especially in relation to SIM F and SIM G.

261 Whether S3 should haven engaged in part depends on the required approach to modelling inflows, a matter addressed in Chapters 8 to10.

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[531] See [249].
[532] Plaintiff subs at [1432] to [1433].

262 Somerset Dam operations on 9 January 2011 involved a significant increase in releases through the sluice gates into Wivenhoe Dam. Those operations are best analysed by considering the following table.[533]

Time 9 Jan	Somerset Levels (m AHD) (Sluice Gates open)	Somerset Inflows (m^3/s)	Somerset Outflows (m^3/s)	Wivenhoe Inflows (m^3/s)[534]	Wivenhoe Outflows (m^3/s)	Wivenhoe Levels (m AHD)
07:00	100.27 (2)	456	412	1046	1334	68.57
08:00	100.28 (2)	600	412	773	1334	68.56
09:00	100.28 (3)	1027	618	1182	1333	68.55
10:00	100.31 (3)	1159	618	1536	1332	68.53
11:00	100.34 (3)	1237	619	1646	1332	68.54
12:00	100.39 (3)	1070	619	2080	1384	68.54
13:00	100.43 (4)	1673	826	2054	1385	68.56
14:00	100.47 (5)	2744	1034	3448	1386	68.58
15:00	100.57 (5)	5352	1038	4136	1388	68.61
16:00	100.75 (5)	5108	1052	3946	1394	68.70
17:00	101.14 (5)	2768	1098	4733	1398	68.77
18:00	101.29 (5)	4011	1121	5454	1404	68.86
19:00	101.43 (5)	4750	1145	5848	1411	68.97
20:00	101.68 (5)	4037	1193	7338	1419	69.10
21:00	101.89 (5)	3725	1238	7659	1428	69.24
22:00	102.06 (5)	3768	1277	7646	1440	69.44
23:00	102.22 (5)	3962	1317	7935	1450	69.60
00:00	102.38 (5)	3283	1359	7936	1462	69.80

Table 7-1: Somerset Dam operations on 9 January 2011

263 Five matters should be noted about these figures. First, there was a significant spike in inflows to Somerset Dam between around midday and 7.00pm but they stabilised and then reduced. Second, there was also a significant increase in inflows to Wivenhoe Dam from midday which unlike Somerset Dam inflows continued to increase until midnight. Third, the opening of five sluice gates at Somerset Dam caused a large increase in outflows from Somerset Dam into Wivenhoe Dam but there was no corresponding increase in releases from Wivenhoe Dam. Instead they were maintained at the level necessary to keep downstream bridges open. This meant that by midnight releases from Wivenhoe Dam represented all but $97m^3/s$ of Somerset Dam

[533] Taken from January FER at .0451 to .0452; and .0465 to .0466.
[534] Including Somerset Dam inflows.

outflows[535] even though inflows into Wivenhoe Dam from the upper and middle Brisbane catchments represented 6577m^3/s of inflows into Wivenhoe Dam.[536] Fourth, the level of Somerset Dam did not exceed EL 100.45m AHD until between 1.00pm and 2.00pm so that the statement in the Manual that the Operating Target Line "is to be generally followed" was not engaged until then. Instead, just prior to that point the Manual's statement that the "sluices are generally kept closed" was operative.[537] Fifth, a graphic representation of tandem dam operations on this day is set out below.[538]

7.4: Midnight on 10 January to 5.00pm on Monday 10 January 2011

264 The plaintiff contended that the one-day PME made available at 6.00pm on 9 January 2011 for the 24-hour period to 10.00pm on 10 January 2011 predicted 25mm to 150mm of rain,[539] whereas the State contended that it predicted 25mm to 100mm above the dams and 50mm to 150mm of rain below.[540] The plaintiff contended that the four-day PME for the period 10.00pm on 9 January 2011 to 10.00pm on 13 January 2011, predicted 75mm to 225mm of rain,[541] whereas the State contended it predicted 50mm to 200mm above the dams and 100mm to 300mm of rain below.[542] Both parties contended that the eight-day PME for the period 10.00pm on 9 January 2011 to 10.00pm on 17 January 2011 depicted the same amount of rain as their respective four day assessments.[543] Dr Christensen took the PMEs as predicting rain on 10, 11 and 12 January 2011 but little rain thereafter.[544]

265 The QPF issued at 10.03am predicted 50mm to 100mm of rain in the 24 hours to 10.00am on 11 January 2011.[545] The QPF issued at 4.00pm forecast 25mm to 50mm of rain in the Somerset and Wivenhoe catchments,

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[535] 1462m^3/s – 1359m^3/s.
[536] 7936m^3/s – 1359m^3/s.
[537] Manual at 40, Wivenhoe Dam levels were rising from midday.
[538] At [382].
[539] AID.500.022.0001.
[540] SEQ.013.004.1330; AID.500.035.0001.
[541] AID.500.022.0001.
[542] AID.500.035.0001; SEQ.013.004.1340.
[543] SEQ.013.004.1341; AID.500.022.0001; AID.500.035.0001.
[544] EXP.ROD.001.0583 at .0680.
[545] SEQ.001.018.8509; QLD.002.002.1756.

with isolated falls of up to 100mm, in the 24 hours to 4.00pm on 11 January 2011.[546]

266 I have already noted the flood warnings issued by the BoM at 10.56pm on 9 January 2011 and 12.36am on 10 January 2011 for the Lower Brisbane River including the Lockyer Valley. Further flood warnings for the Lockyer Valley were issued in the period up until 5.00pm, although they did not convey the size of the impending disaster that was about to sweep down from Toowoomba through the towns of the Lockyer Valley, including Grantham and Hellidon, late in the afternoon. A further flood warning for the Lockyer and Warrill Creeks, as well as the Bremer and Lower Brisbane Rivers, was issued at 10.29am.[547] It referred to "[s]tream level rises causing moderate to major flooding [that were] being recorded in Lockyer Creek and along the Bremer River" and that "[r]ises to around 14.5 metres [were] expected at Lyons Bridge later [that Monday]".

267 Flood warnings for the Stanley and Brisbane Rivers above Wivenhoe Dam[548] as well as for the coastal streams from Maryborough to the New South Wales border[549] were issued at around 9.20am. The former referred to rainfall of up to 300mm as having been recorded in the catchments of the Upper Brisbane and Stanley Rivers during the 24 hours to 9.00am on 10 January 2011.

268 A severe weather warning was issued just prior to 5.00am on 10 January 2011 for the Southeast Coast District, Wide Bay and Burnett and the eastern parts of the Darling Downs and Granite Belt. It predicted heavy rains and thunderstorms.[550] The warning was repeated just after 11.00am.[551] The BoM warned of "heavy rainfall leading to localised flash flooding." This was again repeated at 5.06pm.[552]

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546 QLD.002.002.1737.
547 QLD.002.002.1753.
548 QLD.002.002.1759.
549 QLD.002.002.1757.
550 QLD.002.002.1767; SEQ.001.018.8517.
551 QLD.002.002.1750.
552 QLD.002.002.1729.

269 As noted, sometime around midnight, Mt Crosby Weir Bridge was closed and the police were in attendance at Fernvale Bridge. It is not clear exactly when Fernvale Bridge was closed but based on the email sent at 3.31am on the morning of 10 January 2011[553] it appears to have been around this time.

270 The Event Log records that around 12.45am Mr Ruffini received a telephone call from Mr Ken Morris from the Brisbane City Council. Mr Morris advised him that 3500m^3/s "is the damaging flow for Brisbane urban areas", despite the Manual referring to 4000m^3/s as "the damaging level". The Event Log records that "John [Ruffini] undertook to take this into consideration when preparing the current situation report, and would not refer to damage levels".[554] In one of his affidavits, Mr Ayre stated that he spoke to Mr Ruffini after this call and he agreed with a proposal from Mr Ruffini to not include a specified flow rate for urban damage in the situation reports but to instead state "that we would be operating at the value specified in the Manual".[555]

271 The Event Log records that at 12.55am Mr Ruffini called Mr Drury to discuss Mr Morris' call and during the call "John [Ruffini] confirmed that if flows were kept below 3500[m^3/s] the fuse plug would be triggered" and that it was agreed that the situation reports would not "allude to damage levels" as that would be a matter for the Councils.

272 SunWater noted that the suggestion that a fuse plug would breach was "patently incorrect having regard to the 9 January 22:00 Run and the 10 January 01:00 Run". This was said to demonstrate the unreliability of the Event Log which it submitted contained entries "recorded by persons other than the Flood Engineers who may not fully understand the matters being discussed".[556] Two matters should be noted about that submission.

273 First, SunWater's submission does not make it clear whether the reference to the "9 January 22:00 run" was to the 9 Jan 22:00 ROG run or the 9 Jan 22:00

[553] See [281].
[554] QLD.002.001.8660.
[555] LAY.SUN.001.0001 at .0526 to .0527, [2250].
[556] SunWater subs at [2389].

Forecast run. The statement attributed to Mr Ruffini was patently correct if regard was had to the latter. It predicted Wivenhoe Dam reaching EL 75.11m AHD and Moggill reaching a peak flow of 5652m^3/s even with Wivenhoe releases being kept under 3000m^3/s. If Wivenhoe Dam outflows were reduced to such an extent to keep Moggill at 3500m^3/s then it was overwhelmingly likely that the height of Wivenhoe Dam would increase from EL 75.11m AHD to above EL 75.5m AHD. On this approach, which includes accounting for releases, W4B and S3 would be engaged. As at the time of Mr Ruffini's call with Mr Drury, the most recent QPF forecast was issued at 4.00pm on 9 January 2011, which predicted 50mm to 80mm of rain in the 24-hours to 3.00pm.[557] As noted, the PME forecasts also predicted substantial rain for Monday and Tuesday.

274 Second, in his evidence, Mr Drury agreed that a conversation to the effect stated in the Event Log occurred:[558]

> "Q. What he [Mr Ruffini] was telling you was that if combined flows were kept below 3,500 at Moggill by limiting releases from Wivenhoe Dam, then the Wivenhoe Dam level would increase to 75.7 metres and trigger a fuse plug; correct?
> A. That's what I believe, yes, that's what it says and I believe that's what - he mentioned something like that, yes."

275 Notwithstanding my concerns about Mr Drury's evidence, I accept this answer given that it conforms with the Event Log. I am satisfied that Mr Ruffini advised Mr Drury in the terms stated in the Event Log and that this advice was based on an assessment that had regard to forecast rain which only made sense given that (substantial) rain was forecast.

276 A gate operations spreadsheet from a rain on the ground model run undertaken at around 1.00am on 10 January 2011 was saved (the "10 Jan 01:00 ROG run").[559] The results of the model run were not much different from the 9 Jan 22:00 ROG run. It predicted an overall volume of inflows of 1.605 million ML with a predicted maximum lake level of EL 73.32m AHD

[557] SEQ.001.019.5605.
[558] T 6703.17.
[559] SDWD-201101100100withnorain.xls; QLD.002.001.8886.

compared to 1.539 million ML and EL 73.29m AHD predicted by the 9 Jan 22:00 ROG run. However, unlike the 9 Jan 22:00 ROG run, which delayed further gate openings at Wivenhoe Dam until midday on 10 January 2011, this run assumed or modelled gate operations commencing at 2.00am on 10 January 2011 and opening at a rate of one increment per hour until gates were open to 45 increments at 7.00pm on 10 January 2011 by which time Wivenhoe Dam would be releasing around 2700m^3/s.

277 As noted, Mr Ayre agreed that the flood directives issued that morning were based on this rain on the ground run and a further rain on the ground run conducted at 3.00am and thus the increases in increments were not based on forecast rain.[560] SunWater noted Mr Ayre's evidence to the effect that the difference between the predicted height "just above EL 73" and EL 74m AHD was "held in reserve to be able to deal with future rainfall".[561] However, the 9 Jan 22:00 Forecast run suggested that this supposed buffer was very inadequate and, in any event, it disappeared later in the morning when the gate openings were suspended.

278 At 1.14am, Mr Ruffini distributed a situation report.[562] It stated that there had been "[v]ery heavy rainfall" in the Upper Brisbane River and Stanley River with totals of 100mm to 240mm of rain in the previous 12 hours and up to 300mm in the previous 24 hours and that "rainfall of similar magnitudes is expected in the 12 to 24 hours around the downstream catchments as the system tracks south". The report noted that Wivenhoe Dam was at EL 69.60m AHD, "rising quickly" and would reach "at least 73.3m AHD during Tuesday morning". The stated objective for dam operations was described as "minimis[ing] the impact of urban flooding in areas downstream of the dam" and "at this stage, releases will be kept below 3,500m^3/s and the combined flows in the lower Brisbane will be limited to 4000m^3/s if possible". However, the report added that if "predicted rainfall eventuates in the downstream tributary catchments" then the "lower Brisbane may exceed the threshold of damaging discharge in

[560] T 7955.22 - .34 (Ayre).
[561] T 7975.24; SunWater subs at [2392].
[562] QLD.001.001.2858.

the urban areas within the next 24 to 48 hours". The prediction that Wivenhoe Dam might reach EL 73.3m AHD reflects the assessment made in the 10 Jan 01:00 ROG run, as does the attempt to keep releases below 3,500m^3/s. The only forecast rainfall addressed in the situation report was rain that might fall below the dams. The report noted that the "approaches" to Fernvale Bridge and Mt Crosby Weir Bridge had been inundated "and both bridges are now closed or in the process of being closed".

279 At 2.00am, Mr Ruffini issued Wivenhoe Directive 8 which directed the gates be opened by one increment an hour up to and including 6.00am.[563] This was consistent with the gate operations modelled in the 10 Jan 01:00 ROG run. As a consequence of the directive, at 2.00am the first gate opening occurred at Wivenhoe Dam since midday on 9 January 2011.[564] Thereafter, the gates were opened at the rate of one increment per hour until 9.00am by which time Wivenhoe Dam was releasing 2015m^3/s.[565] However, contrary to what was contemplated by the 10 Jan 01:00 ROG run, there were no further gate openings until 4.00pm on 10 January 2011.[566] An email recounting actual releases and outlining projected releases for the next week sent at 1.56am contained flow rates identical to the modelling in that run.[567] Releases from five sluice gates at Somerset Dam continued even though inflows to Somerset Dam had reduced from the previous day.[568] The level of releases from Somerset Dam continued to increase with uncontrolled spillage above EL 100.45m AHD.[569] By 9.00am, releases from Wivenhoe Dam were 2015m^3/s against total inflows of 9731m^3/s.[570] Outflows from Somerset Dam into Wivenhoe Dam were 1567m^3/s against total inflows of 2128m^3/s.[571]

[563] QLD.001.001.2878.
[564] January FER at .0452.
[565] Ibid at .0452.
[566] Ibid at .0452 to .0453.
[567] QLD.001.001.2867.
[568] January FER at .0466.
[569] See [326].
[570] January FER at .0452.
[571] Ibid at .0466.

280 A gate operations spreadsheet from an RTFM run that was undertaken at 3.00am was saved (the "10 Jan 03:00 ROG run").[572] The results of the modelling were not materially different from the 10 Jan 01:00 ROG run. There was a slight reduction in estimated volume of inflows, from 1.605 million ML to 1.583 million ML, with a consequential slight reduction in the predicted maximum storage level, from EL 73.32m AHD to EL 73.22m AHD. The modelling maintained the same gate increments as the 10 Jan 01:00 ROG run.

281 At 3.31am, Mr Malone emailed the duty engineer inquiring whether he should attend the FOC. A few minutes later he received the following response:[573]

> "No you can sleep in! Rain has eased for the time being = last three hours is < 7mm
>
> *Have commenced opening Wivenhoe gates as local catchment flows took Fernvale and Mt Crosby out just after mid-night.*
>
> *Forecast suggests heavy rain will be downstream of dams this morning."* (emphasis added)

282 In one of his affidavits, Mr Ayre states that Fernvale Bridge was "inundated" at about 4.00am.[574] It is not clear whether this is different from the bridge being "[taken] out" as referred to in this email. In any event, this email confirms the above finding that the flood engineers avoided further gate openings at Fernvale and Mt Crosby Weir Bridge until "local catchment flows" combined with the existing level of releases to close the bridges.

283 Mr Malone replied to the email noting that the "radar doesn't look good" and requesting that he be sent the actual and projected releases.[575]

284 At 3.45am, a reply was sent from the "Duty Flood Engineer" to Mr Malone providing the releases. They corresponded with the releases produced by the 10 Jan 03:00 ROG run.[576] Nine minutes later, Mr Malone emailed his

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[572] SDWD-201101100300withnorain.xls; QLD.001.001.2883.
[573] SUN.002.001.6651.
[574] LAY.SUN.001.0001 at .0534, [2273].
[575] QLD.002.001.4893.
[576] QLD.002.001.3105.

assessment of the flows at Savages Crossing he prepared using those releases and an assessment of downstream rainfall which he prepared at home using "Enviromon URBS models".[577]

285 At 5.00am, the BoM issued a severe weather warning "[f]or people in the Southeast Coast district, southern parts of the Wide Bay and Burnett district and eastern parts of the Darling Downs and Granite Belt district".[578] The warning noted that "an upper level low was located over the Southeast Coast district" and that "a surface trough was located near the Fraser coast". It added that "[b]oth of these systems are moving slowly west". The plaintiff emphasised its westward movement over the dam catchments.[579]

286 Mr Ayre acknowledged that this warning had that effect,[580] but stated that "*from the other information* we had available, it still appeared to be that the heavy rainfall was predominantly on the coastal fringe and affecting metropolitan Brisbane and the Bremer and Warrill".[581] In his affidavit, he explained that "the best information (from the BoM's Access models and the WATL website) that was available at [around 6.30am] indicated that the rainfall producing system was moving south" and "that was another reason why we did not want to greatly increase the rate of releases considering that downstream Brisbane may well have significant flows from rainfall".[582] This appears to be another asserted instance of using the PME forecasts to identify the location of forecast rainfall as a basis for not making releases. In any event, it was no justification for adopting a gate release strategy that risked a fuse plug breach as occurred after Mr Ayre's shift ended.

287 A gate operations spreadsheet from a rain on the ground model run that was undertaken at around 5.00am was saved (the "10 Jan 05:00 ROG run").[583] Again, the results of the modelling were not materially different from the

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577 LAY.SEQ.007.0001 at .0208, [729] to [730].
578 SEQ.001.018.8517.
579 Plaintiff subs at [1443] and [1444].
580 T 7967.25 - .34.
581 T 7967.44.
582 LAY.SUN.001.0001_OBJ at [2287].
583 SDWD-201101100500withnorain.xls; QLD.002.001.8888.

10 Jan 01:00 ROG run and the 10 Jan 03:00 ROG run, save that this run assumed or modelled that there would be no further gate openings beyond the 35 increments due to be reached at 9.00am that morning until 3.00pm on 10 January 2011. It predicted a maximum water level for Wivenhoe Dam of EL 73.16m AHD. In his first affidavit, Mr Ayre states that at around 5.00am he advised a dam operator that there "are no planned gate movements for at least the next 12 hours".[584]

288 A situation report was issued at around 6.30am on 10 January 2011.[585] It advised that there had been "[m]oderate to heavy rainfall … recorded in the Upper Brisbane and Stanley Rivers in the last 12 hours with totals up to 90mm" and warned that "[r]ainfall of similar magnitudes is expected in the 12 to 24 hours around the downstream catchments as the system tracks south." The report added that a "severe weather warning remains current for heavy rainfall in the dam catchment areas". It advised that Somerset Dam was at EL 102.84m AHD and Wivenhoe Dam was at EL 70.77m AHD with both rising. They were releasing 1,100m^3/s and 1,753m^3/s respectively. The balance of the report was in similar terms to the situation report issued at 1.14am. It referred to a predicted peak height of Wivenhoe Dam of EL 73.3m AHD on the morning of 11 January 2011 and an expected peak release of 2600m^3/s in the ensuing 12 to 24 hours. It repeated the statement that "[t]he objective for dam operations will be to minimise the impact of urban flooding in areas downstream of the dam and, at this stage, releases will be kept below 3,500m^3/s and the combined flows in the lower Brisbane will be limited to 4,000m^3/s if possible." It also included the warning that "[i]f the predicted rainfall eventuates in the downstream tributary catchments the resultant combined flows in the lower Brisbane may exceed the threshold of damaging discharge in the urban areas within the next 24 to 48 hours."

289 At the same time as this situation report was issued, Flood Directive No 9 was issued in the name of Mr Malone to the dam operators, requiring the opening of gates at a rate of one increment an hour at Wivenhoe Dam from 7.00am to

[584] LAY.SUN.001.0001 at .0535, [2278].
[585] SEQ.001.011.4629.

11.00am.[586] Two minutes later, an email was sent from the duty engineer which outlined the actual and projected Wivenhoe releases, including proposed release rates that assumed continuous gate openings at Wivenhoe Dam from 7.00am to 7.00pm, by which time the release rate would be 2690m^3/s.[587] This was consistent with the gate operations modelled in the 10 Jan 01:00 ROG run and 10 Jan 03:00 ROG run, but not the 10 Jan 05:00 ROG run. At 6.42am, a dam operator sent an email stating, inter alia, that the "initial target" for releases was "2600 cumecs in the next 12 to 24 hours".[588]

290 Mr Ayre signed off duty at 6.45am and Mr Ruffini did so at 7.00am. Both Mr Malone and Mr Tibaldi signed on at 7.00am.[589]

291 An issue arose as to the content of the discussions during the handover about the relevant downstream flow limit.[590] Seqwater contended that it should be found that Mr Ayre set a "general strategy" to increase Wivenhoe releases by opening gates to 45 increments but with the "aim [of] keep[ing] the combined flows at Moggill below 3,500m^3/s, if possible", but failing that, aiming to manage operations to keep the flows at 4000m^3/s. Seqwater contended that this was conveyed at the handover.[591]

292 Both the 1.00am and 6.00am situation reports referred to limiting downstream flows to below 4000m^3/s, not 3500m^3/s, which was consistent with the stipulated limit of "non-damaging flows" in the Manual. According to his affidavit, Mr Ayre recalled Mr Ruffini stating that "we will continue to operate under the Manual strategy target flow level of 4,000m^3/s".[592] Under cross-examination by Senior Counsel for Seqwater, Mr Ayre said that during the handover he mentioned to Mr Malone and Mr Tibaldi the Council's assertion that the "threshold for over floor flooding" was 3500m^3/s.[593] It was suggested to Mr Ayre that he told them they should not exceed that threshold,

586 QLD.001.001.2914.
587 QLD.001.001.2904.
588 SEQ.001.023.7245.
589 SUN.002.005.0002 at .0003.
590 Seqwater subs at [1135] to [1137].
591 Ibid at [1137].
592 LAY.SUN.001.0001 at [2296].
593 T 7474.37 to T 7475.2.

ie, 3500m^3/s, “unless they were forced to go to W4 during their shift”. Mr Ayre only agreed that “may have been said” although he did accept that he said they should contact the Councils “should that eventually arise”.[594] However, in cross-examination by Senior Counsel for the plaintiff, Mr Ayre stated that he and Mr Ruffini prepared gate openings that had regard to the limit of non-damaging flows at 4000m^3/s,[595] that when he went off shift he expected that Mr Malone and Mr Ruffini would implement those planned openings,[596] and that it was only around 1.00pm when he awoke from sleep and learnt that they had suspended the gate openings.[597] Mr Ayre said that his approach had been changed to an attempt to maintain flows below 3500m^3/s.[598]

293 Mr Malone did not refer to any conversation with Mr Ayre during the handover in his affidavits.[599] In his first affidavit, Mr Tibaldi only referred to being advised by Mr Ayre about the Council’s view that the limit of non-damaging flows was 3500m^3/s.[600] In his second affidavit, he stated that it was agreed that during the handover he and Mr Malone should contact the Council if they needed to increase downstream flows to 4000m^3/s.[601] In cross-examination, he said that Mr Ruffini may have said, although he did not recall, that “we will continue to operate under the Manual strategy target flow level of 4,000” m^3/s.[602] In re-examination, Mr Tibaldi stated that he understood the instruction from Mr Ayre[603] was “don’t exceed the urban damage threshold unless you’ve got to transition to W4”.[604] However, despite being pressed, he could not recall whether that figure was 3500m^3/s or 4000m^3/s.[605]

294 I accept that Mr Ayre may have advised Mr Malone and Mr Tibaldi to give the Council advance notice if downstream flows would exceed 3500m^3/s.

[594] T 7475.4 - .24.
[595] T 7968.40.
[596] T 7971.26.
[597] T 7971.32 -. 35.
[598] T 7971.47.
[599] See Malone 1, LAY.SEQ.007.0001 at [733].
[600] LAY.SEQ.004.0001 at [676].
[601] LAY.SEQ.014.0001 at [59(b)].
[602] T 6348.29 - .39.
[603] T 6494.21.
[604] T 6493.42; T 6494.28.
[605] T 6494.42.

However, in light of the situation reports at 1.00am and 6.00am and the subsequent exchanges with Mr Drury, I am not satisfied that Mr Ayre set any strategy or approach of seeking to maintain downstream flows below 3500m^3/s as contended for by Seqwater. Instead, that approach and the suspension of some of Mr Ayre and Mr Ruffini's planned gate operations (as noted below[606]) were made by Mr Malone and Mr Tibaldi and were discussed with Mr Drury.

295 After the event, Mr Malone prepared three Appendix A "with forecast" rain runs (ie, using QPF forecasts) utilising the RTFM data available as at 1.00am,[607] at 4.00am,[608] and at 9.00am[609] on 10 January 2011. All three of those runs predicted Wivenhoe Dam exceeding EL 74.0m AHD. Both the 4.00am and 9.00am runs resulted in predicted maximum heights of Wivenhoe Dam of EL 74.5m AHD. The 4.00am run used Mr Ayre and Mr Ruffini's proposed gate opening sequences from the 10 Jan 01:00 ROG run. Mr Malone accepted that, as Mr Ruffini's 6.30am situation report had predicted Wivenhoe Dam rising to EL 73.3m AHD based on rain on the ground, then it was a "reasonably strong possibility" that Wivenhoe Dam would exceed EL 74.0m AHD.[610] The plaintiff contended that this meant that W4 was clearly required by the Manual to be engaged by this time.[611]

296 Seqwater noted that Mr Giles' inquiry of the RTFM indicated that a "with 24-hour forecast rain" RTFM run was undertaken at 5.00am that morning but not saved.[612] Given that the 24-hour QPF forecast at 5.00am was no different from the 4.00am forecast, and that Mr Ayre's proposed gate opening sequences were still in play at 5.00am, there is no reason to believe that it produced any materially different outcome from the Appendix A "with forecast" run referable to 4.00am. Seqwater also noted that Mr Giles located evidence that suggested two "with 24-hour forecast" RTFM runs might have been

606 At [322]
607 January FER at 0527.
608 QLD.001.001.2889.
609 QLD.001.001.2941.
610 T 5313.40.
611 Plaintiff subs at [1452].
612 Seqwater subs at [1649]; Giles 3, EXP.QLD.001.1359 at .1490.

undertaken around 10.00am but not saved.[613] As noted, the morning QPF issued at 10.03am on 10 January 2011 predicted 50mm to 100mm of rain and that was worse than the QPF from the previous afternoon. Further, as at 10.00am, Mr Malone had already suspended the further gate opening sequences suggested by Mr Ayre. This suggests that any forecast run undertaken at 10.00am would have predicted an even greater maximum height of Wivenhoe Dam than the maximum height predicted by Appendix A "with forecast" run referable to 9.00am, namely EL 74.5m AHD.

297 At around 8.22am, Mr Spiller and Mr Drury had an email exchange in which Mr Spiller queried whether Wivenhoe Dam was being operated under Strategy W2 or W3. Mr Drury advised that it was W2.[614]

298 At 8.30am, Mr Spiller, Mr Drury and other representatives of Seqwater and the Grid manager met.[615] A note of the meeting indicates that one of the topics was "3.5 and 4", which I infer was a discussion about the possibility of urban flooding resulting from an outflow rate of 3,500m^3/s or 4000m^3/s. The meeting notes indicate that it was again stated that Strategy W2 was engaged but also that the objective was to "minimise urban impacts". The note also stated that releases were currently at 2000m^3/s but that they would increase to "2500m^3/s in the next 12-24 hours".

299 The plaintiff contended that the references to W2 reflect what the flood engineers told Mr Drury was their strategy. It noted that, although Mr Drury denied it was based on what he had been told by the flood engineers,[616] it is unlikely that he would have provided his own assessment.[617] Mr Malone denied that he advised him that.[618] I am not prepared to find that anyone at the meeting passed on any specific advice they received from the flood engineers about the prevailing strategy. That said, the note appears to reflect the misconception reflected in Mr Ayre's situation report from the previous

[613] Seqwater subs at [1649]; Giles 3, EXP.QLD.001.1359 at .1490.
[614] SEQ.001.022.0085.
[615] SEQ.005.003.0830.
[616] T 6706.1 - .7.
[617] Plaintiff subs at [1453].
[618] T 5301.8.

Saturday evening that the point of distinction between W2 and W3 is whether to limit releases to the point where downstream flows were 3500m^3/s or 4000m^3/s.[619]

300 At around this time, the flood directives in place were being altered. At 8.30am, Flood Directive No 10 was issued in the name of Mr Malone. It replaced Flood Directive No 9 issued by Mr Ruffini at 6.30am and only directed gate openings to increase by one increment an hour until 9.00am. It stated that "[f]ollowing the gate movement at 09.00 10/01/2011 gate [openings] will be held [at existing levels] until further advised".[620]

301 The Event Log records that at 8.38am Mr Baddiley from the BoM was advised that the "planned strategy" was to "maintain gate openings for the next 24 hrs".[621] I am satisfied that Mr Malone conveyed that.[622] As events transpired, there were no further gate openings between 9.00am and 4.00pm on 10 January 2011.

302 As noted, Mr Ayre stated that he was not aware of the change in gate openings until around 1.00pm after he woke up from sleeping after his shift ended and realised that they had attempted to limit downstream flows to 3500m^3/s.[623]

303 In his affidavit, Mr Malone stated that upon reading Mr Ruffini's situation report that morning he noted that the predicted lake level was EL 73.3m AHD and the heaviest forecast rainfall was for catchments downstream of the dams. He said the latter suggested to him that any increase in releases could coincide with downstream run-off should the forecast rainfall have eventuated.[624]

304 The approach of maintaining downstream flows to 3500m^3/s was discussed in

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[619] See above at [71] to [73].
[620] QLD.001.001.2938.
[621] QLD.002.001.8660.
[622] T 5301.20.
[623] T 7971.32.
[624] LAY.SEQ.007.0001 at [732].

an email exchange between Messrs Malone, Tibaldi and Drury. At 9:37am, Mr Drury emailed Mr Malone and Mr Tibaldi as follows:[625]

> "As discussed.
>
> It is expected that we would require around 50 to 100mm of rain across our catchments to go beyond the 3500cumecs strategy however this depends on the spatial distribution, intensity and duration of the rainfall.
>
> The current intention of the FOC is to aim for a total flow of 3,500cumecs in the lower Brisbane River, to that end they are holding off ramping up for several hours today while flows downstream pass through the system. However there may be a need to go to 4,000cumecs or above if necessary.
>
> If there is a need to go beyond 3,500cumecs in the lower Brisbane we should be able to provide around 24 hours notice to BCC."

305 At 9.55am,[626] an email was sent from the duty engineer (being either Mr Malone or Mr Tibaldi) to Mr Drury, recording the outcome of their discussions as follows:

> "The current operational strategy is to aim for a flow of no greater than 3,500cumecs in the lower Brisbane River. *Accordingly, the current outflow from Wivenhoe Dam will be held at its current level of 2000 cumecs for the next 12 to 24 hours to allow for potential high flows from the Lockyer, Bremer* and local area catchments to pass downstream. However, this strategy may need to be revised at short notice if further significant rainfall occurs.
>
> It would require in the order of 50mm of rain across the Brisbane River Basin (this includes the Brisbane, Stanley, Lockyer and Bremer catchments) to go beyond the current operational strategy, however this depends on the spatial distribution, intensity and duration of the rainfall. This amount of rain is possible under current BOM forecasts.
>
> If there is a need to go beyond 3,500cumecs in the lower Brisbane around 24 hours notice should be able to be provided to BOM and BCC." (emphasis added)

306 The Event Log records the following as having occurred at 9.38am:[627]

> "Conference call with Ken Morris (BCC) - informed them that release from Wivenhoe *will be maintained at 2000m^3/s for the next 24 hrs*. This will be revised in 24 hrs. The strategy is to limit the flows to 3000 - 3500m^3/s. At 3500m^3/s about 322 (the whole property) will be submerged and about 7000 properties will be affected somehow damage bill $7mil). If the rainfall in the Bremmer and Lockyer increases substantially - it is likely the flows from these

[625] SEQ.001.018.6413.
[626] QLD.002.001.3103.
[627] QLD.002.001.8660.

catchments can peak at 1000m^3/s (on top of Wivenhoe release)." (emphasis added)

307 In his affidavits, Mr Tibaldi agreed that he participated in this telephone conference call.[628] In cross-examination, he denied stating that gate openings would be maintained for the following 24 hours ("…geez, I wouldn't be making any commitments for the next 24 hours on that day"[629]). Given that the same commitment was repeated in the emails with Mr Drury that summarised their discussions, I do not accept Mr Tibaldi's denials.

308 The additional rain of 50mm necessary to invalidate or "go beyond" the operational strategy was forecast in the 10.00am QPF, which predicted 50mm to 100mm of rain in the Wivenhoe and Somerset dam catchments.[630] However, in his affidavit, Mr Malone stated that "[a]t that stage, given the rate at which we were releasing and the expectation of increasing the release rate, I considered that we could manage this catchment average and the possible inflows".[631]

309 Mr Malone stated that at around 10.10am he emailed model results illustrating the potential effects downstream of Wivenhoe releases allowing for 50mm rainfall in the Lockyer Creek and 100mm of rainfall in the Bremer River.[632] He stated that to "the best of my recollection, this model run was prepared in URBS" (ie, not the RTFM). It showed peak discharges at Moggill, Jindalee and Brisbane of 4,513m^3/s, 4,524m^3/s and 4,520m^3/s respectively.[633] These figures used projected releases from Wivenhoe Dam as an input. Thus, they do not show the revised projected height of Wivenhoe based on the 10.00am QPF forecast.

[628] Tibaldi 1, LAY.SEQ.004.0001 at [678]; Tibaldi 2, LAY.SEQ.014.0001 at [63].
[629] T 6352.26.
[630] QLD.001.001.3057.
[631] LAY.SEQ.007.0001 at [735].
[632] SEQ.001.018.3981; LAY.SEQ.007.0001 at [737].
[633] SEQ.001.018.3981.

310 At 10.28am, a flood warning was issued for the Lockyer, Bremer, Warrill and Brisbane River below Wivenhoe.[634]

311 An Appendix A "with forecast" run referable to midday on 10 January 2011 predicted a maximum height for Wivenhoe Dam of EL 75.6m AHD at 10.00am on 12 January 2011.[635] That height is sufficient to trigger a fuse plug breach.

312 Mr Malone issued a situation report at 12.16pm.[636] The report noted that there had been rainfall in the dam catchments over the previous six hours with "an approximate catchment average" of 20mm for Wivenhoe and 40mm for Somerset, that a severe weather warning remained current for the dam catchments and summarised the QPF forecast. The report also noted that Wivenhoe Dam was at EL 71.95m AHD, it was releasing 2000m^3/s and that the predicted maximum height was EL 73.5m AHD the following morning. That statement was most likely based on a rain on the ground estimate. The report describes the objective for dam operations as being to "minimise the impact of urban flooding in areas downstream of the dam" with the "current aim to keep river flows in the lower Brisbane River below 3,500m^3/s if possible".

313 In his report, Mr Collins identified a significant unprecedented rainfall event as having occurred between 9.00am and 12.00am on 10 January 2011 when heavy rainfall was concentrated over the southern half of the upper catchments.[637]

314 The amount of rain falling in the catchments appears to have caused the abandonment of the attempt to constrain flows from Wivenhoe Dam in order to limit lower Brisbane River flows to 3500m^3/s.[638] The Event Log records that by 12.36pm Mr Trace from Ipswich City Council was being advised that the strategy was "moving ... from urban damage control to dam safety priority".[639]

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634 SEQ.001.018.8507.
635 QLD.001.001.3064.
636 QLD.001.001.3068.
637 EXP.QLD.001.0881 at .0882; State subs at [268].
638 Tibaldi 2, LAY.SEQ.014.0001 at [64].
639 QLD.002.001.8660.

Of course, dam safety is the priority of Strategy W4. Mr Tibaldi contended that the "note is wrong" and they were in Strategy W3.[640] I do not accept Mr Tibaldi's recollection as reliable.

315 Mr Tibaldi noted that there were a number of attempts to contact the Brisbane City Council.[641] The Event Log records that at 2.30pm, the Brisbane City Council was also informed that the "latest strategy …[was] changing from "Flood Mitigation" to "Dam Safety"" and that Wivenhoe gates would commence opening at 3.00pm.[642] Mr Tibaldi also denied that "we were in dam safety strategy at that point".[643]

316 A gate operations spreadsheet from a rain on the ground model run that was undertaken at around 1.00pm on 10 January 2011 was saved (the "10 Jan 13:00 ROG run").[644] This run estimated the total inflow volume from the flood event to be 1.749 million ML. The 10 Jan 05:00 ROG run estimated the volume to be 1.574 million ML. The predicted maximum storage level in the 10 Jan 13:00 ROG run of Wivenhoe Dam was now EL 73.73m AHD (compared to EL 73.16m AHD in the 10 Jan 05:00 ROG run). This was achieved with revised gate settings that opened the Wivenhoe gates by ten increments between 4.00pm and 9.00pm, resulting in a maximum flow rate at Moggill of just over 4000m^3/s.

317 Another situation report was issued at 2.52pm.[645] It warned of significant rain having fallen over the Wivenhoe Dam catchment in the last three hours with falls exceeding 100mm. It referred to the severe weather warning for the dam catchment areas and that the radar evinced "[p]otentially significant rain moving towards the dam catchments". Somerset Dam was at EL 103.41m AHD and Wivenhoe Dam was at EL 72.41m AHD. The situation report warned that the "*rainfall experienced over the last 2 to 3 hours will result in significant further inflows into the dam and releases from the dam will need to be*

640 T 6399.45.
641 Tibaldi 2, LAY.SEQ.014.0001 at [64].
642 QLD.002.001.8660.
643 T 6400.13.
644 SDWD-201101101500withnorain.xls; QLD.001.001.3075.
645 QLD.002.001.4941; SEQ.001.011.4359.

increased to protect the structural safety of the dam and ensure that a fuse plug is not initiated." It confirmed that the "[t]he objective for dam operations is currently to minimise the impact of urban flooding in areas downstream of the dam and to keep river flows in the lower Brisbane River below 4,000m^3/s if possible" but added that further rainfall could cause lower Brisbane River flows to reach 5,000m^3/s.

318 Consistent with this report, at 3.00pm Mr Malone issued a directive requiring the opening of Wivenhoe Dam gates by one increment from every half an hour from 3.00pm until 7.30pm, this being a total of ten increments.[646] A technical issue delayed the implementation of that release.[647] However, by 4.00pm one gate had been opened by one increment, and the gates were opened by a further nine increments by 8.00pm (making a total of 45 increments).[648]

319 As noted, at around 4.00pm the QPF predicted 25mm to 50mm of rain with isolated falls of 100mm.[649]

320 In his second affidavit, Mr Tibaldi stated that at around 4.00pm and "whilst it was looking tight" he regarded a transition to Strategy W4 as "looking less likely to what it had earlier in the day".[650] He identified the basis for this belief as the most recent operational run being the 10 Jan 13:00 ROG run, the just-issued QPF (which displayed a reduction from the morning QPF that predicted 50 to 100mm of rain), the PMEs issued that morning which predicted rain clearing "the following day on 11 January 2011" and two later BoM warnings issued at 5.06pm and 6.29pm "indicating that conditions would ease the following day".

321 In cross-examination, it emerged that Mr Tibaldi's understanding of Strategy W4 was that once engaged, "you would have to increase the release

[646] QLD.002.001.3091.
[647] SUN.006.003.7302.
[648] January FER at .0453.
[649] QLD.002.002.1737.
[650] Tibaldi 2, LAY.SEQ.014.0001 at [65].

so that you've got more than 4,000 at Moggill".[651] The operation of Strategy W4 prior to the actual level exceeding EL 74.0m AHD is addressed above. Otherwise, as at 4.00pm the actual level of Lake Wivenhoe was EL 72.70m AHD.[652] The 10 Jan 01:00 ROG run predicted a maximum height of 73.73m AHD. The most recent situation report issued at 2.52pm noted heavy rain in the previous three hours. The next ROG run, the 10 Jan 17:00 ROG run predicted a maximum height of EL 73.83m AHD. The QPF forecast issued at 4.00pm continued to predict significant rain in the dam catchments. The PME forecasts that Mr Tibaldi referred to only suggested the rain would clear late in the evening on Tuesday 11 January 2011 after further rain fell (as it did).[653] As the Appendix A runs demonstrated, any RTFM run conducted with any amount of not insubstantial rain would have predicted a maximum height above EL 74.0m AHD. The RTFM 24-hour forecast run conducted at 5.00pm that evening predicted a maximum height of Wivenhoe Dam of EL 74.95m AHD.[654]

322 The only matter that relevantly changed during the course of 10 January 2011 was that, despite the fact that the rain that was forecast to fall during the day actually fell, Mr Malone and Mr Tibaldi chose to suspend gate openings. Any reasonably competent flood engineer would have had a strong expectation, bordering on a certainty, that throughout the day, based on Mr Ayre's proposed releases, the predicted maximum height of Lake Wivenhoe would have exceeded EL 74.0m AHD. In Mr Tibaldi's case, I am not satisfied that he actually considered the position to have improved during the course of the day as he asserted in his affidavit.[655] As was put to him in cross-examination, if that was his expectation, then he and Mr Malone would not have abandoned their approach of keeping downstream flows below 3500m^3/s.[656]

323 Two gate operations spreadsheets from model runs that were undertaken at or around 5.00pm on 10 January 2011 have been saved, one based on rain

[651] T 6405.9.
[652] Simulation Analysis, EXP.ROD.015.0461 at .0470.
[653] See LAY.SEQ.014.0001 at [68].
[654] See [323].
[655] Tibaldi 2, LAY.SEQ.014.0001 at [65].
[656] T 6410.3.

on the ground (the "10 Jan 17:00 ROG run")[657] and the other based on 50mm of rainfall falling over a 24-hour period (the "10 Jan 17:00 forecast run").[658] The 10 Jan 17:00 ROG run was not materially different from the 10 Jan 13:00 ROG run. There was a modest increase in the estimate of the total inflow volume from 1.749 million ML to 1.768 million ML and the 5.00pm model run assumed that Wivenhoe Dam would be open to a level of 45 increments by 8.00pm instead of 9.00pm. The 10 Jan 17:00 ROG run predicted a peak flow rate at Moggill of 4068m^3/s and a maximum height for Wivenhoe Dam of EL 73.83m AHD.

324 The 10 Jan 17:00 forecast run predicted a total inflow volume of 2.08 million ML. This run modelled the same gate operations as the 10 Jan 17:00 ROG run, except that the Wivenhoe Dam gates were open to a level of 45 increments by 9.00pm on 10 January 2011 (instead of 8.00pm). As noted, the 10 Jan 17:00 forecast run predicted Wivenhoe Dam reaching EL 74.95m AHD early in the morning of 12 January 2011 and a peak flow rate at Moggill of 5076m^3/s.

325 As at 5.00pm on Monday 10 January 2011, Wivenhoe Dam was at EL 72.84m AHD, with gates open to a level of 38 increments. It was releasing 2277m^3/s. Under Dr Christensen's Simulation A, Wivenhoe Dam was at EL 67.73m AHD and releasing 1466m^3/s.[659] In his affidavit, Mr Malone stated that the Lockyer Creek flows around this time "were just under 1000m^3/s, which I considered to be relatively low".[660]

Conclusion

326 The following table compares the inflows and outflows for each of Wivenhoe and Somerset Dams for the period up to 7.00pm on 10 January 2011:

657 SDWD-201101101700withnorain.xls; QLD.001.001.3137; SEQ.001.011.0085.
658 SDWD-201101101700with50mmrain.xls; QLD.001.001.3136.
659 EXP.ROD.015.04.
660 LAY.SEQ.007.0001 at [751].

Time 10 Jan	Wivenhoe Dam Levels (m AHD)[661]	Wivenhoe Inflows (m^3/s)[662]	Wivenhoe Outflows (m^3/s)[663]	Somerset Dam Levels (m AHD)[664]	Somerset Dam Outflows (m^3/s)[665]	Somerset Inflows (m^3/s)[666]
01:00	69.97	8449	1473	102.54	1403	2593
02:00	70.17	8732	1539	102.62	1426	2752
03:00	70.36	9133	1605	102.70	1449	2557
04:00	70.57	8759	1672	102.78	1473	2741
05:00	70.77	8933	1740	102.84	1491	2703
06:00	70.96	9312	1806	102.93	1519	2182
07:00	71.16	9351	1875	102.98	1535	2403
08:00	71.36	10095	1944	103.02	1548	2306
09:00	71.56	9731	2015	103.08	1567	2128
10:00	71.78	7267	2031	103.11	1577	2868
11:00	71.95	8059	2044	103.16	1593	3468
12:00	72.07	9026	2053	103.26	1627	2732
13:00	72.26	7384	2067	103.36	1661	2191
14:00	72.41	7856	2077	103.39	1672	2230
15:00	72.54	8411	2087	103.43	1686	1829
16:00	72.70	6568	2155	103.45	1693	1664
17:00	72.84	5116	2277	103.45	1693	1693
18:00	72.92	5286	2399	103.45	1693	1707
19:00	72.99	4946	2517	103.45	1693	1650

Table 7-2: Wivenhoe and Somerset Dam operations on 10 January 2011

327 There are two related features of flood operations on 10 January 2011 that should be noted. The first is the maintenance of the high level of outflows from Somerset Dam into Wivenhoe Dam. All five sluice gates were open at Somerset Dam throughout 10 January 2011 and there was uncontrolled spillage above EL 100.45m AHD. As the above table indicates this meant that the rate of outflow from Somerset Dam into Wivenhoe Dam was between 1359m^3/s at 1.00am and 1693m^3/s at 4.00pm. Those flow rates were between 92% and 79% of Wivenhoe outflows even though the rate of inflows into Wivenhoe Dam were far in excess of Somerset Dam inflows. The effect was that Somerset Dam levels effectively stabilised while Wivenhoe Dam levels

[661] January FER at .0453
[662] Ibid at .0453; including Somerset Dam inflows.
[663] Ibid at .0453
[664] Ibid at .0466
[665] Ibid at .0466
[666] Ibid at .0466

escalated rapidly. This is evident from the tandem dam operations line set out below[667] which was effectively vertical on this day.

328 The second feature was the suspension imposed on further gate openings at Wivenhoe Dam from 9.00am to 4.00pm. This arose because, from around the time of the commencement of Mr Malone and Mr Tibaldi's shift, there was an attempt to implement a strategy to maintain flows at Moggill at or below 3500m^3/s because of a concern that this figure represented a rate at which flooding of properties and homes would commence. The strategy was abandoned when rain persisted throughout the day such that after midday it was accepted that the flows at Moggill could not be held below 3500m^3/s.

329 Seqwater contended that Mr Malone and Mr Tibaldis' approach of not making any further gate openings between 9.00am and 4.00pm gave effect to a general strategy, or at least was consistent with a general strategy, set by Mr Ayre.[668] Mr Malone's evidence did not support this submission. He stated that the gate openings were suspended to provide a buffer for forecast rainfall downstream.[669] In relation to Mr Tibaldi, Seqwater contended that he had a "distinct recollection" that this derived from a statement made by Mr Ayre at the handover early on the morning of 10 January 2011.[670] I have addressed Mr Tibaldi's evidence and the other evidence on this topic above and rejected it. In any event, Mr Tibaldi agreed that he and Mr Malone "exercised professional judgment to modify the releases from the dams" but asserted that this was done "within the guidelines" set by Mr Ayre.[671] It follows that, in suspending the further gate openings between 9.00am and 4.00pm that were suggested by Mr Ayre and Mr Ruffini's spreadsheets prepared early on the morning of 10 January 2011, they were not giving effect to any general strategy set by Mr Ayre.

[667] At [383]
[668] Seqwater subs at [1143] to [1145].
[669] T 5301.45 to T 5302.4; T 5398.18 - .37.
[670] Seqwater subs at [1142].
[671] T 5481.34.

330 The plaintiff made three further submissions in respect of this aspect of the approach to gate openings on 10 January 2011.

331 First, the plaintiff submitted that the strategy of maintaining flows below 3500m^3/s arose out of discussions "between Mr Borrows, Mr Drury and representatives of the Water Grid Manager at 8:30[am]".[672] It submitted that the course of those meetings "demonstrate[s] that Mr Borrows and Mr Drury felt perfectly entitled to give Mr Malone and Mr Tibaldi directions in relation to the operation of the dams during a Flood Event",[673] a matter Seqwater strongly disputed.[674] I agree that at least Mr Drury was consulted and agreed to the approach but ultimately it was Messrs Malone and Tibaldi's decision. The first step in giving effect to that approach was Flood Directive No 10 (issued at 8.30am) which must have been prepared before any of the relevant meetings or communications relied on started.

332 Secondly, the plaintiff contended that the approach they adopted was "precisely that which Mr Ruffini had said at 00:55 [on 10 January 2011][675] would cause a fuse plug to trigger".[676] Seqwater noted that no fuse plug was triggered and the submission ignores the evidence of their considerations during 10 January 2011.[677] I have already found that early on the morning of 10 January 2011 Mr Ruffini advised the BCC that any attempt to limit downstream flows to 3500m^3/s was likely to trigger a fuse plug and that statement was amply justified by the "with 24-hour" forecast modelling undertaken at 22:00 on 9 January 2011. It also follows that Mr Malone and Mr Tibaldi did exactly that and initially planned to do it for 12-24 hours (see 305). The approach was abandoned and thus, for that reason, no fuse plug was initiated. Subject to what is addressed next, all the Appendix A "with forecast" modelling suggested that if there was a sustained attempt to limit downstream flows to less than 3500m^3/s then there would have been a strong likelihood of a fuse plug initiation. The Appendix A "with forecast" modelling noted above

672 Plaintiff subs at [1461].
673 Ibid at [1462].
674 Seqwater subs at [1668] to [1673].
675 On 10 January 2011.
676 Plaintiff subs at [1462].
677 Seqwater subs at [1658].

utilises release rates that yield much higher downstream flows, indeed, higher than 4400m^3/s. In those circumstances, the attempt to maintain downstream flows to less than 3500m^3/s was reckless.

333 Thirdly, the plaintiff submitted that the approach adopted "was made without any '*with forecast'* modelling being performed and in circumstances where any such modelling would have shown Wivenhoe Dam exceeding 74 m."[678] As noted above, the indications are that some "with forecast" modelling runs may have been undertaken around 10.00am. However, I am satisfied that any such modelling would have shown Wivenhoe well exceeding EL 74.0m AHD.

334 The plaintiff further contended that the circumstances faced by the flood engineers on 10 January 2011 in terms of dam levels were the product of their unreasonable past conduct of flood operations. Putting that aside, the plaintiff submitted that the only reasonable course of action for the flood engineers was to implement W4, commence storing water in Somerset Dam and not delay making increased releases from Wivenhoe Dam.[679] The plaintiff pointed to Dr Christensen's Simulation G as exemplifying the type of releases that were necessary.[680] In Simulation G, releases were quickly increased at midnight on 10 January 2011 from 1462m^3/s to 3117m^3/s at 7.00am on 10 January 2011 and remained around that level until 3.00pm.[681]

335 Seqwater submitted that, in the circumstances that faced Mr Tibaldi and Mr Malone, it was not "certain" that EL 74.0m AHD would be reached, as opposed to it "merely being possible".[682] Its submissions contended that the necessity for "certainty" arose because of the "seriousness of implementing W4", which appears to be based on the misconception that simply invoking Strategy W4 carried with it the necessity to raise gates to meet the rising water level (even if below EL 74.0m AHD).[683] That was addressed in

678 Plaintiff subs at [1462].
679 Ibid at [1466] to [1467].
680 Plaintiff subs at [1467].
681 Simulation Analysis, EXP.ROD.015.0461 at .0915.
682 Seqwater subs at [1652].
683 Ibid at [1647].

Chapter 3 (and above[684]). It follows from that discussion that a transition to Strategy W4 does not depend on a determination that it is certain that EL 74.0m AHD will be exceeded. Seqwater pointed to the various matters addressed by Mr Tibaldi in his affidavit as supporting a belief that EL 74.0m AHD would not be exceeded, namely the available storage,[685] the suggested threshold of 3500m^3/s for urban damage,[686] the RTFM runs,[687] and the suggestion that the forecasts were showing less rain and that it would fall away from the catchment areas.[688] All those matters are addressed above. Similarly, SunWater contended that the plaintiff's contention "smacks of hindsight". It contended that, as at 4.00pm on 10 January 2011, the QPF forecast was for "very little rain in the catchments" above the dam and, given that, it was not unreasonable for the flood engineers to limit downstream flows.[689]

336 It follows from the above that I accept that throughout 10 January 2011 any reasonably competent flood engineer should have formed the expectation that Wivenhoe Dam would exceed EL 74.0m AHD and that Strategy W4 was required by the Manual to be engaged. As explained, the engagement of W4 on a prediction did not necessarily require the making of releases that caused downstream flows to exceed the threshold for non-damaging flows. However, given the storage levels of both dams,[690] the prevailing conditions were no justification for Mr Malone and Mr Tibaldi's decision to attempt to maintain downstream flows at 3500m^3/s by holding releases to 2000m^3/s when the Manual specifies that 4000m^3/s was the limit of non-damaging downstream flows. I accept that Mr Malone and Mr Tibaldi's decision to delay the increase in openings suggested by Mr Ayre was unreasonable. Whether or not it was necessary to increase releases well above Mr Ayres's proposed release strategy as per Simulation G and hold releases in Somerset Dam is addressed in Chapter 10 (and Chapter 12). Whether the flood engineers'

[684] At [107] to [108]
[685] Seqwater subs at [1631].
[686] Ibid at [1632], [1640] and [1642].
[687] Ibid at [1646] to [1648].
[688] Ibid at [1635] to [1638].
[689] SunWater subs at [2375].
[690] Cf those simulated by Dr Christensen in simulations A to F and H to I.

actions amounted to a (pleaded) breach of their duty of care is addressed in Chapter 12.

7.5: 5.00pm Monday, 10 January 2011 to Midnight Tuesday, 11 January 2011

337 The gate openings at Wivenhoe Dam that commenced at 4.00pm continued until 8.00pm, by which time gate openings were at a level of 45 increments and the dam was releasing 2695m^3/s. There were no further gate openings from that point until 9.00am on 11 January 2011.[691]

338 The most significant feature of the contemporaneous material produced on the evening of 10 January 2011 is the growing realisation that extreme flash flooding was occurring in the upper parts of the Lockyer Valley. Mr Collins described this as having commenced with intense rainfall at the Toowoomba Range at around midday as the rain event described at [313] came from the north west above the catchments.[692] There were difficulties in detecting the extent of this rainfall and consequential flooding as the rain gauge network was sparse and a number of gauges failed under the weight of water.[693]

339 At 5.01pm, the BoM issued a "TOP PRIORITY" release about the flash flooding which stated that "[v]ery heavy rainfalls have been recorded in the Toowoomba area and caused extreme flash flooding".[694] At 5.32pm, Mr Baddiley sent an email to, inter alia, the flood engineers which attached the BoM warning and that stated that there had been a "[r]apid rise in Lockyer Creek at Helidon between 2pm to 3pm" with the "auto gauge indicat[ing] it rose about 8 metres …[a]ccuracy unknown" and the flash flooding had arrived in Gatton where water levels had risen two metres in an hour.[695] Mr Malone responded to that email at 5.39pm,[696] stating that he "suspect[ed] that it will be routed out by the time it gets to the Brisbane [River] and should have little impact upon current estimates and strategy for the lower Brisbane [River]".

[691] January FER at .0453.
[692] EXP.QLD.001.0881 at 0884; State subs at [271].
[693] EXP.QLD.001.0881 at 1098; State subs at [272].
[694] QLD.002.002.1732.
[695] QLD.002.001.4953.
[696] QLD.002.001.3081.

340 Not surprisingly, just after 5.00pm the BoM issued flood warnings for all the catchments above[697] and then below Wivenhoe Dam.[698] The former referred to rainfall between 50mm to 75mm having been recorded in the Cressbrook Creek sub-catchment with localised flood totals in excess of 125mm. The BoM issued severe weather warnings for the catchments as well as the districts to the north and west of the dams at 5.06pm,[699] 6.30pm[700] and 7.51pm.[701] They warned of heavy rain areas and thunderstorms during that evening and most of Tuesday but noted that they would be "gradually eas[ing] later in the day". The Event Log records that contact was made with the BoM just after 6.00pm, who advised that the "forecast now is – still more of the same of what we had today".[702]

341 As noted, two operational spreadsheets prepared around 5.00pm on 10 January 2011 were saved. The outcome of those runs is described in [323].

342 A situation report was issued at 6.43pm just prior to Mr Malone and Mr Tibaldi completing their shift.[703] The report noted that "significant rain" had fallen in the Wivenhoe catchments over the preceding six hours "with isolated falls exceeding 100mm" and it summarised the effect of the recent QPF. It also noted that Wivenhoe Dam was at EL 72.92m AHD and "rising quickly" with releases increased over the preceding three hours to avoid a fuse plug initiation. However, the report stated that the flash flooding in the upper areas of Lockyer Creek was not "expected to significantly increase Brisbane River flows above the current projection of 4000m^3/s at Moggill". The objective for dam operations was still said to be keeping flows in the lower Brisbane River below 4000m^3/s but "[i]f further rainfall occurs" releases might have to be increased.

[697] SEQ.001.018.8490.
[698] QLD.001.001.3144.
[699] QLD.002.002.1729.
[700] QLD.002.002.1717.
[701] QLD.002.002.1714.
[702] QLD.002.001.8660.
[703] SEQ.001.011.4649.

343 In his affidavit, Mr Malone stated that he considered the possibility of a fuse plug initiation to be "highly unlikely" but it was referred to in the report "to reassure recipients of the unlikelihood of this event".[704]

344 After issuing this report, Messrs Malone and Tibaldi signed off duty and Messrs Ayre and Ruffini signed on.[705] The Event Log records that at 8.00pm Mr Baddiley telephoned the FOC to "advise of [the] situation regarding flows in Lockyer" and, in particular, that "very heavy localised rainfall (eg, 600mm in [a] few hours) on [the] Toowoomba escarpment [is going] to cause observed ... flooding".[706] This concern about the Lockyer flows is reflected in three operational spreadsheets based on rain on the ground model runs undertaken at around 8.00pm which have been preserved. One of them maintained the then current level of gate openings (45 increments) to early on 16 January 2011, yielding a maximum predicted height of EL 73.72m AHD and predicted maximum flow at Moggill of 4058m^3/s.[707] Another spreadsheet modelled maintaining gate openings to a level of 45 increments until 4.00am on 11 January 2011 and then reducing gate openings to a level of 24 increments by 7.00am and then increasing gate openings back to 45 increments by 1.00pm on 11 January 2011.[708] This yielded a maximum storage level of EL 74.04m AHD. The third run was a variation on the second.[709] An Appendix A spreadsheet undertaken with forecast rain referable to this time modelled gate openings to a level of 45 increments with forecast rain to yield a maximum predicted height of EL 74.27m AHD and a peak flow rate at Moggill of 4467m^3/s.[710]

345 As noted, further gate openings ceased at 8.00pm. Another top priority flood warning for Lockyer Creek was issued at 8.38pm. It warned of "[v]ery fast and dangerous rises ... occurring downstream of Gatton to Glenore Grove [which]

[704] LAY.SEQ.007.0001 at [756].
[705] SUN.002.005.0002 at .0003.
[706] QLD.002.001.8660.
[707] SDWD-201101102000withnorain.xls; QLD.001.001.3169.
[708] SDWD-201101102000-Lockyer.xls; QLD.001.001.3170.
[709] SDWD-2011010200-TMinflows.xls; QLD.001.001.3171.
[710] SUN.002.002.2690.

will extend downstream to Lyons Bridge and O'Reilly[s] Weir" during that night and the following morning.[711]

346 In his first affidavit, Mr Ayre stated that at around 8.00pm on 10 January 2011 he and Mr Ruffini participated in a conference call with BoM representatives about the flash flooding in the Lockyer Valley which caused him to become concerned that the combination of Lockyer flows and existing releases would cause downstream flows to exceed 4000m^3/s.[712]

347 An Event Log entry for 9.00pm records that Mr Ayre spoke to Mr Allen of DERM who "endorsed [a] variation to [the] manual to operate at minimum gate settings to create [a] gap to allow [the] peak of flash flood[ing] to pass" and who also "endorsed [a] concept allowing Wivenhoe ... to rise above 74m AHD briefly".[713] An Event Log entry for 11.20pm records that Mr Drury was contacted and he agreed that, if it was possible, flow from Wivenhoe Dam should be reduced "to accommodate [the] Lockyer flash flood peak".

348 A detailed flood warning for the downstream areas was released at 9.45pm[714] and a severe weather warning for the Southeast coast and the areas to the north and west of the catchments was again issued at 10.57pm,[715] which again referred to the rain conditions only easing late on Tuesday 11 January 2011.[716]

349 A gate operations spreadsheet for a no rain model run undertaken at midnight on 10 January 2011 was saved.[717] This was not materially different from the 8.00pm rain on the ground runs noted above, save that it modelled maintaining gate openings to a level of 45 increments until 10.00am on 12 January 2011 and opening gates by a further 3 increments at the time.

[711] QLD.002.002.1710.
[712] Ayre 1, LAY.SUN.001.0001 at [2370] to [2371].
[713] QLD.002.001.8660; Ayre 1, LAY.SUN.0001.0001 at [2373] to [2376].
[714] QLD.002.002.1706.
[715] QLD.002.002.1703.
[716] QLD.002.002.1703.
[717] SDWD-201101110000withnorain.xls; QLD.001.001.3191.

350 An updated situation report was issued at 11.56pm by Mr Ayre.[718] It stated that Somerset Dam was at EL 103.40m AHD and "falling slowly" while it was discharging 1700m^3/s into Wivenhoe Dam. Wivenhoe Dam was at EL 73.22m AHD "and rising at about 50mm/hour" with releases held at 2750m^3/s since 7.30pm. The report noted that the BoM had advised that the rainfall responsible for the flash flooding in the Lockyer Valley was "not observed at any rainfall station". The report also stated that it was anticipated that Wivenhoe Dam would "reach about 73.8m AHD" on the following afternoon and that the dam operations objective was to keep river flows below 4000m^3/s if possible. Heavy rainfall was said to be continuing "and the situation could deteriorate over the next 24 hours".

351 In Dr Christensen's Simulation A, at midnight on 11 January 2011 Wivenhoe Dam would have been at EL 68.25m AHD and releasing 1882m^3/s.[719]

352 Mr Malone's "Observed Rainfall Analysis" report noted catchment average rainfall in the 24-hour period to 9.00am on 11 January 2011 of 103mm in the Somerset catchment, 103mm in the Upper Brisbane River catchment and 150mm in the Middle Brisbane River catchment above Wivenhoe Dam.[720] It also recorded catchment average rainfall of 103mm, 73mm and 73mm in the Lockyer, Bremer and Lower Brisbane catchments respectively. Dr Christensen assessed actual rainfall upstream of Wivenhoe Dam on 10 January 2011 as 116mm.[721]

353 The plaintiff did not make any submissions in support of any alleged breach by the flood engineers in respect of the period after 5.00pm on 10 January 2011.

7.6: Tuesday, 11 January 2011

354 According to the plaintiff, the one-day PME forecast for the 24-hour period to 10.00pm on 11 January 2011 which was available from 6.00pm on

[718] QLD.001.001.3185; SEQ.001.011.4619.
[719] Simulation Analysis, EXP.ROD.015.0461 at .0470.
[720] SEQ.004.046.0230 at .0275.
[721] EXP.ROD.001.0583 at .0680.

10 January 2011 predicted 25mm to 100mm of rain,[722] whereas the State contended that it predicted 15mm to 100mm of rain above the dam and 25mm to 150mm below the dam.[723] According to the plaintiff, the four-day PME for the period from 10.00pm on 10 January 2011 to 10.00pm on 14 January 2011 predicted between 40mm and 120mm of rain,[724] whereas the State contented that it predicted 25mm to 100mm of rain above the dam and 50mm to 150mm below the dam. [725] Both parties contended that the eight-day PME for the period 10.00pm on 10 January 2011 to 10.00pm on 18 January 2011 predicted the same amounts as their respective assessments of the four-day PME.[726]

355 The QPF issued at 10.14am on 11 January 2011 predicted "[f]alls in excess of 100mm" for the 24-hour period to 10.00am on 12 January 2011.[727] The QPF issued at 4.13pm forecast "50 to 100mm this evening and overnight, easing to less than 30mm during" the following day.[728]

356 Flash flood warnings for Lockyer Creek were issued at 12.19am,[729] 4.11am[730] and 7.28am.[731] They stated that the main flood waters arrived at Lyons Bridge from around 4.00am onwards. Flood warnings for all of the downstream catchments were issued at 12.07am,[732] 4.07am,[733] 9.29am,[734] 3.25pm[735] and 8.06pm.[736] The latter two advised of water level increases of between 3m and 4.5m at the city gauges, with the predicted elevated levels continuing until 13 January 2011 and at levels higher than the levels experienced in the 1974 Flood Event. These warnings reflected the reality that substantial urban flooding had by this time become inevitable.

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722 AID.500.022.0001.
723 SEQ.013.004.1343; AID.500.035.0001 at .0005.
724 AID.500.022.0001.
725 SEQ.004.019.2557; SEQ.013.004.1353; AID.500.035.0001 at .0005.
726 SEQ.004.019.2558; SEQ.013.004.1354; AID.500.035.0001 at 0005; AID.500.022.0001.
727 QLD.002.002.1670.
728 SUN.002.003.6266.
729 QLD.002.002.1696.
730 QLD.002.002.1691.
731 QLD.002.002.1680.
732 QLD.002.002.1698.
733 QLD.002.002.1693.
734 QLD.002.002.1674.
735 QLD.002.002.1650.
736 QLD.002.002.1635.

357 The rain continued to fall upstream of the dams throughout the early hours of 11 January 2011 and the morning. Flood warnings for the upstream catchments were issued at 6.57am,[737] 1.03pm,[738] 4.53pm[739] and 11.19pm.[740] The first of these advised that 30mm to 60mm of rain had been recorded in the previous six hours across the Upper Brisbane catchment. The warning issued at 1.03pm recorded that rainfall totals of between 100mm to 150mm had been recorded in the previous three hours across the Somerset Dam catchment, although only 20mm of rain had been recorded in that period in the Upper Brisbane River above Wivenhoe Dam. The warning issued at 4.52pm advised that rain in the catchments above both dams had "eased to around 20-30 millimetres in the last three hours". The warning issued at 11.19pm advised that rainfall above the dams had continued to ease with totals in the preceding three hours recorded as being "generally less than 10 millimetres".

358 Severe weather warnings for the Southeast coast and the districts to the north and west of the dams were issued at 5.04am,[741] 7.59am,[742] 10.59am,[743] 1.59pm,[744] and 5.00pm,[745] all of which warned of heavy rain and thunderstorms leading to "localised flash flooding". The warning was cancelled by an alert issued at 9.59pm which noted that heavy rains had eased and further flash flooding was no longer expected.[746]

359 Thus, these reports demonstrate that the rain continued throughout the early hours and the morning of 11 January 2011. This prevented the flood engineers from reducing flows to account for the passage of the flash flood waters from the Lockyer Creek. Instead, they had to brace for substantial urban flooding with an increasing concern about the possibility of fuse plug breaches.

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[737] QLD.002.002.1681.
[738] QLD.002.002.1659.
[739] QLD.002.002.1644.
[740] QLD.002.002.1627.
[741] QLD.002.002.1688.
[742] QLD.002.002.1677.
[743] QLD.002.002.1667.
[744] QLD.002.002.1656.
[745] QLD.002.002.1641.
[746] QLD.002.002.1632.

360 The Event Log records that at 1.30am the FOC was advised that Somerset Regional Council's offices were inundated.[747] At 2.25am, the flood information centre advised that approximately 1200 "properties" (not necessarily houses), were inundated.[748]

361 In his first affidavit, Mr Ayre said that between midnight and 2.00am he continued to conduct modelling to assess the viability of reducing releases from Wivenhoe Dam.[749] Operational spreadsheets for three variations on rain on the ground model runs undertaken at around 3.00am were saved.[750] By now, the rain on the ground estimate of total inflows for the event was just under 2 million ML. One of the model runs maintained the existing gate openings of 45 increments and predicted EL 74.0m AHD being exceeded at 10.00pm that evening and the peak rising slightly higher than that (the "11 Jan 03:00 ROG run").[751] Another assumed a closing of Wivenhoe gates to a level of 30 increments for part of 11 January 2011, presumably to allow for the peak from Lockyer Creek to pass, however it only resulted in an increase in the maximum estimate of the flow at Moggill once gate openings returned to a level of 45 increments when the dam height exceeded EL 74.0m AHD.[752]

362 In his first affidavit, Mr Ayre also said that "[l]ocalised, intense rainfall around the Lake Wivenhoe area" commenced at around 4.00am.[753] At 4.30am, Mr Ayre issued a directive to close three sluice gates at Somerset Dam to "equalise the relative volumes in flood storage" in the two dams, in an attempt to avoid Wivenhoe Dam "exceeding the trigger level for implementation of Strategy W4 (EL 74.00m AHD)".[754]

363 The Event Log records that at 5.15am there was a discussion with Mr Baddiley and the "[c]onsensus was that reducing releases from Wivenhoe

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747 QLD.002.001.8660.
748 QLD.002.001.4983.
749 LAY.SUN.001.0001 at [2428].
750 SDWD-201101110300withnorain.xls; QLD.001.001.3203; SDWD-201101110300-BoMLockyer.xls; QLD.001.001.3202; SDWD-201101110300_lockyer.XLS; QLD.001.001.3201.
751 SDWD-201101110300withnorain.xls; QLD.001.001.3203.
752 SDWD-201101110300_lockyer.XLS; QLD.001.001.3201.
753 LAY.SUN.001.0001 at [2429].
754 QLD.001.001.3210; SEQ.001.018.3936; SEQ.001.018.3937; SEQ.004.024.0202.

would no longer be feasible due to attenuation of [the] Lockyer peak and significant additional rainfall in upper Brisbane during the night”.[755]

364 The morning situation report was issued just after 6.00am.[756] At that time Somerset Dam was at EL 103.27m AHD “and falling slowly” while Wivenhoe Dam was at EL 73.51m AHD and “rising at about 25mm/hour”. The report noted that around 2750m^3/s was being released from Wivenhoe Dam and that the dam was predicted to “reach just over 74.0m AHD during Tuesday evening”. The latter prediction was consistent with the operational spreadsheet for the 11 Jan 03:00 ROG run.[757] The situation report confirmed that “[c]onsideration was given to modifying the releases from Wivenhoe Dam to try to moderate the peak flows emanating from Lockyer Creek but the rainfall in the past 12 hours in the catchment above the dam makes this option not possible”. The report stated that, instead, “the strategy will endeavour to maintain the current releases until Lockyer Creek peaks”. Consistent with this, an email from the FOC advising of actual and projected releases sent at 6.14am specified a maximum projected release of around 3200m^3/s.[758]

365 A technical situation report issued at 6.30am described the “current objectives” of flood operations in different terms, namely to “[m]aintain releases to keep Wivenhoe below [EL 74.0m AHD] at which significant releases need to be made to ensure the dam security and minimise flood impacts downstream if possible”.[759] Both of these approaches were invalidated within a few hours as further rain fell.

366 In his first affidavit, Mr Malone stated that “[d]ata received in the FOC” around this time advised that Mt Mee had recorded 55mm of rain and Mt Glorious had received 171mm of rain in the previous three hours. He stated that given their

[755] QLD.002.001.8660.
[756] QLD.001.001.3214.
[757] SDWD-201101110300withnorain.xls; QLD.001.001.3203.
[758] SEQ.001.018.3926.
[759] SEQ.001.011.5047.

proximity to Wivenhoe Dam it would be expected that most of the rain "would more or less fall directly on the reservoir surface".[760]

367 At 6.45am, both Mr Ruffini and Mr Ayre signed off.[761] Mr Malone and Mr Tibaldi commenced on duty at around 7.00am.[762] The January FER records that all four flood engineers remained at the FOC and participated in flood operation decisions that were made every half an hour following receipt of gauge board readings.[763] However, in his first affidavit, Mr Malone stated that Mr Ayre and Mr Ruffini assisted in the FOC from around 1.00pm.[764] Mr Ayre stated that he returned to the FOC "at about 12.30pm".[765] Mr Malone stated that he worked at the FOC until around 11.00pm and Mr Tibaldi until 9.00pm.[766]

368 An operational spreadsheet from a rain on the ground run that was undertaken at or around 7.00am on 11 January 2011 was saved (the "11 Jan 07:00 ROG run").[767] By this time, the estimate of the total event inflow volume had increased to 2.23 million ML and the modelled gate operations involved an increase in gate openings at Wivenhoe Dam to 60 increments by midday although releases remained under 4000m^3/s. The predicted maximum height was EL 74.59m AHD and the peak flow at Moggill was 5663m^3/s, well above the threshold for urban damage. With this run, the gate openings remained at 60 increments for 15 hours while the dam was above EL 74.00m AHD and rising. In his affidavit, Mr Malone stated that based on this model run, he and Mr Tibaldi invoked Strategy W4.[768] To that end, at around 8.30am, Mr Malone gave directives to close the sluice gates at Somerset Dam by 10.00am.[769]

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[760] LAY.SEQ.007.0001 at [771].
[761] SEQ.004.024.0014.
[762] LAY.SEQ.007.0001 at [773].
[763] January FER at 0318 to .0320.
[764] LAY.SEQ.007.0001 at [797].
[765] LAY.SUN.001.0001 at [2505].
[766] LAY.SEQ.007.0001 at [822] and [826].
[767] SDWD-201101110700withnorain.xls; QLD.001.001.3242.
[768] LAY.SEQ.007.0001 at [779].
[769] SEQ.001.018.3901; SEQ.001.018.3902.

369 The rest of 11 January 2011 involved the flood engineers dealing with a rapidly moving flood event as rain continued to fall, especially within the area near or on Wivenhoe Dam. They progressively and then rapidly opened the Wivenhoe Dam gates. Operational spreadsheets for rain on the ground runs undertaken at or around 11.00am,[770] 2.00pm,[771] 5.00pm,[772] 6.00pm[773] and 10.00pm[774] have been saved. By the evening, the total estimate of the inflow volume from the event had increased to over 2.6 million ML.

370 At 10.00am, Mr Malone emailed Mr Borrows to explain that "[o]ur strategy [now] revolves around trying to prevent initiation of the first fuse plug at EL 75.6m".[775] He advised that the sluice gates at Somerset had been closed. He warned that with no further rainfall Wivenhoe Dam would still rise to EL 74.7m AHD with outflow limited to "about 3,700 to 4,500m^3/s", but with "50mm rainfall in the Stanley and Upper Brisbane in the next 12 to 24 hours" releases would have to increase "to as much as 7,500 to 9,000m^3/s to prevent fuse plug initiation". This objective was repeated in a technical situation report issued at midday[776] and an update emailed by Mr Malone at 2.19pm.[777] The technical situation report described the then current strategy as "[m]aintain[ing] current release of 3970 cumecs as long as possible" while keeping the sluice gates at Somerset Dam closed to "store more water".[778]

371 As the table set out below demonstrates, that strategy could not be maintained. The technical situation report issued at 4.00pm described the then current strategy as "maintain[ing] current release [of] 5700cumecs as long as possible" but reviewing this strategy "every 30 minutes and … adjust[ing] accordingly".[779] In his affidavit, Mr Malone stated that at around

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770 QLD.001.001.3288.
771 QLD.001.001.3350.
772 QLD.001.001.3389.
773 QLD.001.001.3392.
774 QLD.001.001.3455.
775 SEQ.001.018.3892; LAY.SEQ.007.0001 at [787].
776 SEQ.001.011.5051.
777 QLD.001.001.3353.
778 SEQ.001.011.5051.
779 SEQ.001.011.5054.

3.00pm the rainfall ceased, although at 4.13pm a QPF predicting 50mm to 100mm of rainfall that evening and overnight was issued.[780]

372 At 6.00pm, Mr Malone issued a situation report which stated, inter alia:[781]

> "In the last twelve hours totals of up to 370mm have fallen in the area around Wivenhoe Dam. In the last hour, rainfalls between 15 and 30mm have been recorded in the same area. *At 1600, the BoM advised that falls between 50 to 100mm are still forecast for the 24hrs to 1600 Wednesday 12 January 2011 for the North Pine and Somerset/Wivenhoe catchments.*
>
> At 1730 Wivenhoe Dam was 74.92m AHD and rising slowly and releasing about 6,700m^3/s.
>
> The current expectation is that the dam will reach a steady state (outflow equals inflow) within the next three hours without further significant rainfall. At this time, release from the dam will be about 8,000m^3/s.
>
> If there is no further rainfall, it may be possible to then slowly reduce this release overnight.
>
> The dam is expected to peak below 75.5m AHD which is 100mm below the first fuse plug initiation level." (emphasis added)

373 Between 7.00pm and 8.00pm on 11 January 2011, Wivenhoe Dam peaked at EL 74.97m AHD and released a peak outflow of 7464m^3/s.[782] By 10.00pm, gate closures had been undertaken after the dam peak in circumstances where the flood warnings for the upper catchments advised that rain was easing and the severe weather warning for the southeast coast was cancelled.[783] Sometime late on 11 January 2011, the combination of downstream flows and large releases from Wivenhoe Dam first arrived in the lower Brisbane River and the large-scale inundation of homes and businesses commenced.

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[780] LAY.SEQ.007.0001 at .0227, [810] to [811].
[781] QLD.002.002.2856.
[782] January FER at .0454.
[783] As noted in [357] to [358].

374 The events of 11 January 2011 and the actions taken by the flood engineers in response are best told through two sets of numbers. The first is a table of the rainfall stations around Wivenhoe Dam set out in Mr Ayre's affidavit:[784]

Hourly rainfall stations around Wivenhoe Dam reservoir

Hour ending

	Lowood	Savages Crossing	Wivenhoe Dam	Mt Glorious	Kluvers Lookout	Mt Mee	Somerset Dam	Caboonbah	Toogoolawah	Rosentretters	Cressbrook Dam
	6646	**6559**	**6636**	**6680**	**6610**	**6690**	**6590**	**6574**	**6604**	**6553**	**6523**
	mm	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**
05:00 11 Jan	3	1	3	14	12	14	37	32	23	19	13
06:00 11 Jan	16	16	20	27	26	24	40	24	3	4	18
07:00 11 Jan	43	31	32	28	46	29	4	6	2	1	0
08:00 11 Jan	53	86	35	57	7	9	3	10	0	0	0
09:00 11 Jan	56	93	38	71	40	15	0	4	0	0	0
10:00 11 Jan	19	18	32	51	36	16	0	0	0	2	0
11:00 11 Jan	51	36	31	50	50	24	8	2	3	0	1
12:00 11 Jan	34	18	36	39	33	33	3	4	5	5	3
13:00 11 Jan	39	33	52	28	33	59	24	11	2	0	1
14:00 11 Jan	56	33	39	28	20	9	19	24	3	0	2

Table 7-3: Hourly rainfall on 11 January 2011

375 These figures, especially the third column, give an indication of the quantum of hourly rainfall that was falling directly on and around Lake Wivenhoe throughout 11 January 2011. Both Mr Ayre and Mr Malone explained that from around 12.00pm until 7.30pm on 11 January 2011 the RTFM hydrological models were "not able to accurately replicate the rate rise of Wivenhoe Dam" and inflows were calculated by using "reverse routing"; ie calculating back from increases in observed heights.[785] This was because

[784] LAY.SUN.001.0001 at [2431].
[785] LAY.SUN.001.0001 at [2500]; LAY.SEQ.007.0001 at [791].

there was no rainfall gauge on the lake and thus the rainfall directly on the lake was not being recorded.[786]

376 In its submissions, the State quoted the following statement from Mr Collins' second report prepared in March 2017:[787]

> "There is sufficient evidence from the extreme rainfall bursts in the upper Brisbane River and Lockyer Creek catchments and in the adjacent north-west part of the Upper Bremer River catchment to show that the event was unprecedented, highly unusual, and an event that we have not seen anything similar to since records began."

377 In his first report, dated June 2016, Mr Collins undertook an analysis of the relative frequency of the storm event that occurred on late 10 January 2011 and 11 January 2011. He concluded, inter alia, that the storm events in the Wivenhoe and Upper Brisbane catchments "exceeded an ARI 100 year event" and in the Somerset Dam catchment had "a peak ARI between 50 and 100 years".[788] An "ARI" is an "average rainfall recurrence" such that an ARI of 50 means that there is a 2 per cent chance of rainfall of that magnitude occurring. The 2 per cent is referred to as the "annual exceedance probability".[789] An event with an ARI of 50 has a 75.3% probability of occurring at least once in 70 years.[790] However, just prior to giving evidence, Mr Collins produced a supplementary report correcting these figures such that the ARI for Wivenhoe Dam was 50 and for Upper Brisbane and Somerset Dam it was in the range of 20 to 50 (as it was for the Lockyer Creek).[791] These figures were not materially different from Dr Christensen's assessments. Dr Christensen described the flood frequency of the January 2011 Flood Event above and below Wivenhoe Dam in the "order of a 40-year to 50-year flood".[792] In the context of a flood mitigation dam designed to address, inter alia, large floods, these probabilities cannot be dismissed as

786 Ibid at [2512].
787 State subs at [320] quoting EXP.QLD.001.1191 at .1201.
788 EXP.QLD.001.0881 at .0937.
789 T 8616.15 (Collins).
790 T 8617.2.
791 EXP.QLD.002.0081 at .0083.
792 February 2015 Report, EXP.ROD.001.0016 at .0522, [2197]; EXP.ROD.001.0583 at .1220; T 8606.37.

remote. Nevertheless, Mr Collins maintained that the results at particular gauges were "extreme".[793]

378 The second set of figures is a table of the inflows, outflows and gate openings taken from the January FER:[794]

Date/Time	**Wivenhoe Dam Level (m AHD)**	**Wivenhoe Gate increments open**	**Wivenhoe Inflow (m^3/s)[795]**	**Wivenhoe Outflow (m^3/s)**	**Somerset Dam level (m AHD)[796] (sluices open)**	**Somerset Dam Outflow (m^3/s)[797]**	**Somerset Dam Inflow (m^3/s)**
10 January							
20:00	73.06	42	4920	2695	103.45 (5)	1693	1206
21:00	73.11	45	5026	2699	103.44 (5)	1689	1231
22:00	73.17	45	4488	2705	103.40 (5)	1675	1446
23:00	73.22	45	4574	2709	103.39 (5)	167.2	1457
11 January							
00:00	73.26	45	4654	2713	103.37 (5)	1665	1149
01:00	73.31	45	4175	2717	103.36 (5)	1661	830
02:00	73.35	45	3594	2721	103.31 (5)	1644	847
03:00	73.38	45	4388	2724	103.27 (5)	1630	1702
04:00	73.40	45	4974	2726	103.23 (5)	1617	2686
05:00	73.46	45	5866	2731	103.28 (4)	1417	2463
06:00	73.51	45	6817	2736	103.34 (3)	1220	2280
07:00	73.61	45	6802	2745	103.40 (2)	1023	1881
08:00	73.70	45	8060	2753	103.46 (1)	826	1448
09:00	73.81	49	9165	2991	103.50 (0)	622	1588
10:00	73.95	55	10376	3347	103.54 (0)	636	1788
11:00	74.10	58	9606	3533	103.61 (0)	660	2631
12:00	74.27	60 **(63)**	10120	3667	103.68 (0)	684	3249
13:00	74.39	70 **(66)**	11561	4250	103.83 (0)	738	3278
14:00	74.57	75 **(75)**	9739	4562	103.96 (0)	786	4167
15:00	74.71	85	9055	5167	104.12 (0)	846	3569
16:00	74.81	95	8947	5786	104.31 (0)	921	2659
17:00	74.89	105	8196	6432	104.41 (0)	961	2729
18:00	74.95	110	7141	6774	104.51 (0)	1001	2818
19:00	74.97	120	6876	7464	104.60 (0)	1039	2779
20:00	74.97	120	7060	7464	104.70 (0)	1081	2519
21:00	74.95	120	6797	7458	104.78 (0)	1115	2208
22:00	74.95	115	6229	7111	104.85 (0)	1145	2462
23:00	74.92	115	5964	7103	104.90 (0)	1167	2145
00:00	74.91	100	5052	6118	104.98 (0)	1202	1707

[793] T 8617.37; T 8620.43.
[794] January FER at .0453 to .0454.
[795] Including Somerset outflows.
[796] See January FER at .0467.
[797] Id.

Table 7-4: Wivenhoe and Somerset Dam inflows, outflows and gate operations on 11 January 2011

379 Three matters should be noted about the flood operations shown in this table.

380 First, the flood engineers did not increase gate openings as Wivenhoe Dam level rose through EL 73m. There were no gate openings between 9.00pm on 10 January 2011 and 9.00am on 11 January 2011.

381 Second, the flood engineers then opened the gates rapidly throughout the day as Wivenhoe Dam approached and then exceeded EL 74.0m AHD. However, the above table does not accurately set out all the gate openings during 11 January 2011. The parties provided an agreed schedule of the gate directives that were issued during the above period.[798] There are two relevant differences between that table and the above table. The first is reflected in the figures in bold, which are the openings indicated by the agreed table of gate directives. That table indicates that gates were opened by five increments between (just after) 11.00am and (just after) 12.00pm, by three between (just after) 12.00pm and (just after) 1.00pm and then by nine between (just after) 1.00pm and (just after) 2.00pm. Taking the agreed table of gate directives as correct means that, during the period when the level of Wivenhoe Dam was above EL 74.0m AHD and rising, the number of gate increments per hour were 3, 5, 3, 9, 10, 10, 10, 5, and 10. The first three of those numbers concerned the period when outflows were less than 4000m^3/s. All are less than 6.[799] The second difference is that between 9.00pm and 9.15pm gates were opened by five increments at 9.15pm and then closed by those five increments at 9.45pm, meaning no change is visible in the hourly record of the January FER.

382 Third, the flood engineers maintained a very high level of releases from Somerset Dam via five sluice gates and uncontrolled discharge until around 8.00am on 11 January 2011. This was so even though Somerset Dam levels

[798] AID.020.021.0001.
[799] see Chapter 3 at [297ff]

were dropping while Wivenhoe Dam inflows were high and increasing with water levels approaching EL 74.0m AHD. The relatively modest output from Somerset Dam after 8.00am reflects the effect of the closing of all five sluice gates which led to the rise in Somerset Dam levels of more than a metre as inflows then increased[800]. Even with all of the sluice gates closed, unregulated outflow still took place from the water level above the crest level at Somerset Dam. By midnight on 12 January 2011, the rate of inflows to Somerset Dam had decreased and they continued to decrease throughout 12 January 2011. Somerset Dam levels peaked at EL 105.11m AHD at 6.00am on 12 January 2011.

383 The following is the tandem dam operations line for both dams across the course of the event:[801]

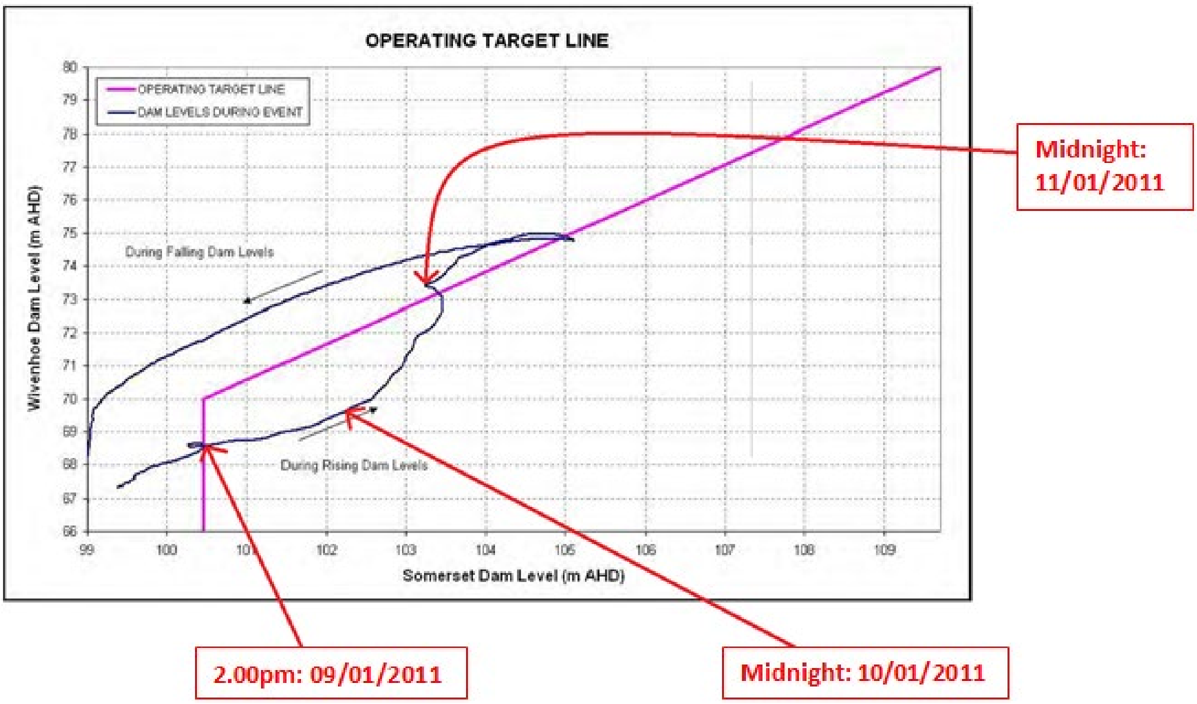

Figure 7-1: Tandem gate operations line for January 2011 Flood Event

384 The sharp rise in the tandem operations line on 10 January 2011 has already been noted. As a result, the tandem flood operations line rose above the Operating Target Line during the evening of 10 January 2011. Even though

[800] See January FER at .0466 to .0467.
[801] January FER at .0498.

sluice gates were closed on the morning of 11 January 2011, flood operations thereafter continued above that line. This was so even though inflows into Wivenhoe Dam were far in excess of inflows into Somerset Dam on (10 and) 11 January 2011. As explained in Chapters 9 and 10, if the sluice gates had been closed at a much earlier time as per Dr Christensen's simulations, then the tandem dam operations line would have been below the Operating Target Line but still headed towards it because of the uncontrolled spillage as Somerset Dam levels rose above EL 100.45m AHD. That form of flood operations would have reduced outflows from Somerset Dam into Wivenhoe Dam and allowed greater scope to either store water in Wivenhoe Dam or make releases that addressed the inflows from the Upper and middle Brisbane catchments. The differences between the two approaches largely reflect the differences in the approach to Strategy S2 in that the flood engineers appeared to act on the basis that the line had to be followed whereas Dr Christensen emphasised that operations need only progress towards it and that it would "not necessarily be possible to adjust the duty point directly towards the target line in a single operation".[802] For the reasons already given, the flood engineers' approach resulted in flood operations being stuck above the Operating Target Line and not being able to utilise storage space in Somerset Dam. Dr Christensen's approach represents the correct approach.

385 By midnight on 12 January 2011, Wivenhoe Dam was at EL 74.91m AHD, with gates open to 100 increments and 6109m^3/s being released.

386 Mr Malone's "Observed Rainfall Analysis" report notes catchment average rainfall in the 24-hour period to 9.00am on 12 January 2011 of 122mm in the Somerset catchment, 14mm in the Upper Brisbane catchment and 121mm in the Middle Brisbane catchment.[803] It also records 82mm, 82mm and 83mm in the Lockyer, Bremer and Lower Brisbane catchments respectively. Dr

[802] Manual at 42.
[803] SEQ.004.046.0230 at .0276.

Christensen assessed actual rainfall upstream of Wivenhoe Dam on 11 January 2011 as 55mm.[804]

7.7: Wednesday, 12 January 2011

387 The plaintiff contended that the one-day PME available from 6.00pm on 11 January 2011 for the 24-hour period to 10.00pm on 12 January 2011 predicted rainfall in the range of 10mm to 40mm,[805] whereas the State contended it was in the range of 5 to 25mm above the dam and 10mm to 50mm below the dam.[806] Both parties contended that the four-day PME for the period 10.00pm on 11 January 2011 to 10.00pm on 15 January 2011 available from midnight predicted the same amount of rain as their respective interpretations of the one-day PME.[807] Both the plaintiff and the State contended that the eight-day PME for the period from 10.00pm on 11 January 2011 to 10.00pm on 19 January 2011 placed the dams and their catchments in bands predicting between 25mm and 50mm of rain.[808]

388 The QPF issued at just after 10.00am for the 24-hour period to 10.00am on 13 January 2011 predicted 10mm of rain.[809] The QPF issued at 4.00pm for the 24-hour period to 4.00pm on 13 January 2011 predicted 5mm of rain.[810]

389 As would be expected, detailed flood warnings were issued throughout 12 January 2011 for the downstream catchments as floodwaters travelled down Lockyer Creek and the Brisbane and Bremer Rivers.[811] By 11.45am, the Brisbane city gauge was at 3.75m and rising. That level reached 4.2m on the high tide at 3.00pm and was predicted to peak at 5.2m at 4.00am on 13 January 2011.[812] Whether it did so was not the subject of evidence.

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[804] EXP.ROD.001.0583 at .0680.
[805] AID.500.022.0001.
[806] SEQ.013.004.1356; AID.500.035.0001 at .0005.
[807] SEQ.013.004.1366; AID.500.022.0001; AID.500.035.0001 at .0005.
[808] SEQ.013.004.1367; AID.500.022.0001; AID.500.035.0001 at .0005.
[809] QLD.002.002.1602.
[810] QLD.002.002.1571.
[811] 4.03am – QLD.002.002.1619; 11.57am – QLD.002.002.1572; 4.30pm – QLD.002.002.1577; 8.12pm – QLD.002.002.1587.
[812] QLD.002.002.1587.

390 In contrast, at 8.55am[813] and 5.46pm, the BoM advised that rainfall had eased over the catchments above the dam and that the upstream flooding was also reducing.[814] This was reflected in the situation reports issued at 5.49am[815] and just before 8.00am,[816] which advised that no significant rain had fallen in the previous 12 hours and less than 10mm to 15mm of rain was expected in the following 24 hours. A situation report issued just before 6.00pm stated that rainfall in the previous 12 hours was "generally below 5mm" and that "no significant rain [was] expected [in] the next 4 days".[817] The reports stated that releases from Wivenhoe Dam were reduced to around 2500m^3/s early in the morning to allow the peak flow from Lockyer Creek to pass but that they would be increased to 3500m^3/s after the downstream peak in the Lower Brisbane River had passed.

391 This was reflected in the gate operations undertaken at Wivenhoe Dam on 12 January 2011. As noted, at midnight on 12 January 2011, the gates were open to 100 increments, releasing 6118m^3/s with Wivenhoe Dam at EL 74.91m AHD. By 8.00am, the gate was only open to 40 increments with 2547m^3/s being released. The dam was then at EL 74.78m AHD. The gates remained open to that level for the rest of the day which resulted in a slight rise in the dam level to EL 74.82m AHD at 7.00pm.

392 By midnight on 13 January 2011, Wivenhoe Dam was at EL 74.79m AHD and releasing 2547m^3/s.[818] Somerset Dam released flows at a rate of approximately 1250m^3/s into Wivenhoe Dam throughout 12 January 2011. It peaked at 105.11m AHD at around 6.00am on 12 January 2011. By midnight it was at EL 104.53m AHD.

[813] QLD.002.002.1605.
[814] QLD.002.002.1569; QLD.002.002.1605.
[815] QLD.001.001.3536.
[816] QLD.001.001.3564.
[817] QLD.001.001.3636.
[818] January FER at .0455.

393 In Dr Christensen's Simulation A, at midnight on 13 January 2011 Wivenhoe Dam would have been at EL 73.60m AHD and releasing 1245m^3/s.[819]

394 Mr Malone's "Observed Rainfall Analysis" report recorded catchment average rainfall in the 24-hour period to 9.00am on 13 January 2011 of 5mm in the Somerset catchment and 2mm in each of the Upper Brisbane and Middle Brisbane catchments.[820] It also recorded 2mm of rain in each of the Lockyer Creek and Bremer River catchments and no rain in the Lower Brisbane catchment. Dr Christensen assessed actual rainfall upstream of Wivenhoe Dam on 12 January 2011 as 3mm.[821]

7.8: Flood Operations from 13 January 2011 to 19 January 2011

395 Both the plaintiff and the State contended that the one-day PME available from 6.00pm on 12 January 2011 predicted no rain for the 24-hour period to 10.00pm on 13 January 2011, the four-day PME available from midnight predicted 1mm to 5mm of rain for the four-day period up to 10.00pm on 16 January 2011 and the eight-day PME predicted 1mm to 5mm of rain for the eight-day period to 10.00pm on 20 January 2011.[822]

396 The situation report issued at 6.30am on 13 January 2011 stated that there had been "no significant rainfall in the last 12 hours and none is expected for the next 5 days".[823] The last situation report was issued at 1.45pm on 19 January 2011.[824] The only rainfall noted in the interim was 20mm to 30mm of rain in "isolated locations" upstream of the dams.[825]

397 Gate openings to 40 increments were maintained at Wivenhoe Dam until 1.00pm on 13 January 2011 and then steadily increased to 58 increments by 3.00am on 14 January 2011, at which time the dam was releasing 3543m^3/s with the water level at EL 74.18m AHD. Releases remained above 3000m^3/s

[819] Simulation Analysis, EXP.ROD.015.0461 at .0471.
[820] SEQ.004.046.0230 at .0277.
[821] EXP.ROD.001.0583 at .0680.
[822] AID.500.022.0001; AID.500.035.0001 at .0005 - .0006.
[823] January FER at .0774.
[824] Ibid at .0787.
[825] Ibid at .0785.

until 4.00pm on 17 January 2011 by which time Wivenhoe dam was at EL 68.66m AHD.[826] From then, the gates were progressively closed. All the regulators at Somerset had closed by 8.00pm on 18 January 2011.[827]

398 The last situation report confirms that the last gate at Wivenhoe Dam was closed at midday on 19 January 2011 and at 1.00pm the dam was at EL 66.89m AHD.[828] By that time, Fernvale and Mt Crosby Weir Bridges were clear of water and it was anticipated that Burtons Bridge, Kholo Bridge and Savages Crossing would be clear of water later than evening. The report added that:

> "Following fish recovery and inspections, minor ongoing releases will be made ... through the centre gate to account for ongoing small inflows. It is intended to drain down to 95%, approximately 66.5m AHD."

399 In his first affidavit, Mr Malone stated that the drain down below FSL occurred to maintain a higher rate of flow than normal to allow temporary pumps to operate at the Lowood pumping station for water supply purposes.[829]

7.9: Impact of Releases

400 A rough assessment of the overall contribution of Wivenhoe releases to urban flooding can be discerned by considering the flow rates at Moggill with and without the contribution of Wivenhoe Dam outflows. The Manual effectively treats Moggill as the reference point for impacts on the urban areas of the lower Brisbane River.

401 At least at one point in the proceedings there was disagreement between the parties about the appropriate figures to adopt both as to the actual peak rate of flow at Moggill during the January 2011 Flood Event and as to what that peak rate of flow at Moggill would have been absent any outflows from Wivenhoe Dam.

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[826] Ibid at .0459.
[827] Ibid at .0785.
[828] Ibid at .0787.
[829] LAY.SEQ.007.0001 at [900].

402 The defendants referred to a graph provided by an expert hydraulic and water resources engineer, Mr Collins, which depicted the rates of flow at Moggill with and without outflows from Wivenhoe Dam.[830] Mr Collins' graph was derived from the Brisbane River Catchment Flood Study ("BRCFS") which he described as a comprehensive analysis of the lower catchments undertaken as a consequence of the QFCI. The BRCFS itself, and the modelling that was prepared, was not tendered but the underlying output figures were.[831] Those figures indicated that the peak rate of flow at Moggill was at around 11.30am on 12 January 2011 of 10478m^3/s, of which 6303m^3/s was due to sources other than Wivenhoe Dam. Both figures remained within 100m^3/s of those rates until 2.00pm.

403 The plaintiff provided a graph extracted from Dr Altinakar's modelling which estimated that the peak flow at Moggill was at around 1.00pm to 2.00pm on 12 January 2011, was approximately 10700m^3/s[832] and that the flow without releases at around the same time was approximately 5400m^3/s.[833]

404 On these figures, outflows from Wivenhoe Dam contributed somewhere between 4200m^3/s and 5300m^3/s to a peak flow at Moggill on 12 January 2011 of between 10420m^3/s and 10700m^3/s. As stated, the peak rate of outflow from Wivenhoe Dam was 7464m^3/s and that occurred between 7.00pm and 8.00pm on the evening of 11 January 2011. In ordinary conditions it can be expected that water released from Wivenhoe Dam will take approximately 16 hours to arrive at Moggill.[834] However, in extreme conditions that estimate frays as the river becomes a flood plain and the water flow attenuates. However, even allowing for those considerations, it is clear that very large releases made from the early evening of 11 January 2011 into the later evening unfortunately coincided with the naturally occurring peaks at Moggill the next day, maximising the inundation of urban areas. This is confirmed by the figures and graphs provided by the parties. The BRCFS

[830] EXP.QLD.001.1285 at .1296 (Figure 3-2).
[831] AID.500.036.0001.
[832] AID.500.009.0001.
[833] AID.500.009.0001. The without Wivenhoe figures were based on the "WMA" report described in Mr Malone's third affidavit, LAY.SEQ.013.0001 at [13].
[834] SUN.001.007.0085.

figures reveal that the largest contribution of each of the Wivenhoe outflows and naturally occurring flows to the total flow figures coincided during the period from 11.30am to 2.00pm on 12 January 2011.[835]

7.10: The Ministerial Submission

405 As would be expected in the immediate aftermath of the flooding of Brisbane there were calls for a full inquiry which, to the knowledge of Seqwater staff, could extend to the conduct of flood operations.[836] For example, on 14 January 2011, one commentator's opinion piece was headed "Bligh's[837] 'tough people' owed a tough inquiry".[838] The article included the following statement:

> "There must be an investigation into the policies and strategies deployed in the operation of the Wivenhoe Dam… There must be hard-headed analysis of the decisions of the dam's operators to let the dam fill to levels close to maximum capacity, forcing a critical release of huge volumes of water before the Brisbane flood occurred."

406 During the afternoon of 14 January 2011, Mr Ayre circulated an email to the other flood engineers and Mr Drury requesting that "[i]n light of the impending review of our performance during this flood event", all the duty engineers be sent information relating to any forensic analysis of the flood data prior to its distribution as "[w]e need to ensure we have a consolidated view on things before information is distributed".[839]

407 At around 1.00pm on 15 January 2011, Mr Malone circulated a two-page summary of the Manual to the flood engineers for their comment before he provided it to Mr Borrows.[840] The report stated that W1 was "exceeded" at

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[835] AID.500.036.0001.
[836] T4089.12 - .23 (Borrows), T 5323.23 to T 5324.26 (Malone), T 6717.21 (Drury), T 7976.37 to T 7977.25 (Ayre).
[837] Ms Anna Bligh AC was the then Premier of Queensland.
[838] SEQ.001.023.3281 at .3287.
[839] SUN.002.001.1364.
[840] QLD.001.001.3887; QLD.001.001.3888.

8.00am on Saturday, 8 January 2011[841] and W2 was "exceeded [at] approximately 6.00pm Saturday, 8 January 2011".

408 During that afternoon, Mr Drury briefed the flood engineers on a request to provide the relevant Minister with a briefing paper on flood operations in anticipation of a cabinet meeting the following day[842] and that one of the objectives of the briefing was "[t]o answer the State's questions on the performance of Wivenhoe Dam operations".[843]

409 Mr Tibaldi started providing material for the briefing note from around 4.00pm.[844] At around 9.00pm, an email was circulated from Mr Tibaldi's email address to his own email address and the email addresses of Messrs Borrows, Drury, Ruffini, Malone and the duty engineer.[845] The email stated, inter alia, "I can't do any more tonight because I have run out of coke and can no longer focus on the screen". It attached a document entitled "JT draft – 02.doc", which included a discussion of whether drain downs should have occurred prior to the January 2011 Flood Event and the Early December Flood Event.[846] It stated:[847]

> "During [the December Flood Events], *pressure was experienced from residents* impacted by bridge closures downstream of the dam to curtail releases as soon and as quickly as possible. Additionally, the end date of the [Late December Flood Event; ie 2/1/2011] meant that significant drain down of the dam prior to the onset of the current event that commenced on 6 January 2011, was not possible without major bridge inundation downstream of the dam and without exceeding minor flood levels in the lower Brisbane River.
>
> Additionally, a flood event was also experienced in October 2010 that resulted in a release of 750,000 ML from the dam. Accordingly drain down below the dam full supply level prior to the start of the first December event would not have been possible without significant bridge inundation and without exceeding minor flood levels in the lower Brisbane River.
>
> Regardless, significant drain down, prior to the current event would have had little impact on final flood levels as shown in the graph below. This is

[841] Mistakenly described as Saturday 6 January 2011.
[842] SEQ.001.011.4359 (at 12:12pm entry).
[843] ROD.650.012.0001 at .0002.
[844] SEQ.001.021.9723.
[845] SEQ.001.018.7227.
[846] SEQ.001.018.7228.
[847] SEQ.001.018.7228 at .7232.

reinforced by an engineering report completed by Sunwater in 2011 entitled "Feasibility of Making Pre-releases from SEQWC Reservoirs." (emphasis added)

410 This draft also included a chronology of dam operations which included the following:[848]

Event Decision Making

The following table contains a summary of the key decisions points associated with the current event. As at 16 January 2011, the event remains in progress.

DATE AND TIME	FLOOD EVENT MILESTONE
07:00 06/01/2011 (Thursday)	Rainfall is experienced in the dam catchments that will result in flood releases, however Wivenhoe releases are delayed for 24 hours to allow Lockyer Creek flood flows to pass downstream and prevent the isolation of the community dependant on Burtons Bridge. The forecast is for 150mm over the next 24 hours.
15:00 07/01/2011 (Friday)	Wivenhoe releases commence, with operational strategy W1 in use. Rainfall for the next four days is estimated to be between 140mm and 300mm, with a forecast for rain easing on Tuesday 11 January 2011. All bridges downstream of the dam with the exception of Fernvale Bridge and Mt Crosby Weir Bridge are expected to be inundated for a number of days.
06:00 09/01/2011 (Sunday)	Rain periods forecast until Tuesday, but both Wivenhoe and Somerset dam levels were falling slowly, with Somerset at 1.27 metres above FSL and Wivenhoe 1.58 metres above FSL.
15:30 09/01/2011 (Sunday)	Following significant rain during the day a meeting with Duty Engineers is held. The QPF issued at 16:00 indicates 50mm to 80mm over the next 24 hours. Based on this forecast it is anticipated that dam levels can be held to a maximum of 3.50 metres above FSL in Somerset and 5.5 metres above FSL in Wivenhoe. However by 19:00 it was apparent that both Fernvale Bridge and Mr Crosby Weir Bridge would be inundated by dam releases *and that the operational strategy had progressed to W2*.
06:30 10/01/2011 (Monday)	Rainfall continued during the night and based on rainfall on the ground *it was apparent the operational strategy had progressed to W3*.
06:30 10/01/2011 (Monday)	Rainfall continued during the day but based on rainfall on the ground, operational strategy W3 remained in use. However it was apparent that any further heavy rain would result in progression of the operational

[848] SEQ.001.018.7228 at .7233.

	strategy to W4.

Save for the suggestion that W2 was being put into effect on the afternoon of 9 January 2011, this is a reasonable approximation of the flood engineers' conduct of flood operations as suggested by the contemporaneous material.

411 Further drafts that repeated the above statements were circulated from Mr Tibaldi's email address to Messrs Ayre's and Ruffini's email addresses at 6.41am,[849] to Mr Drury's email address at 8.15am[850] and to another Seqwater employee's email address at 12.11pm on 16 January 2011.[851] They were included in the final form of the briefing note provided to the Minister later that day,[852] save that the reference to "pressure experienced from residents" was changed to "requests were received from Councils and residents".[853] The amended version of the extract in [409] was included in the Ministerial briefing under the heading "Why weren't pre-emptive releases undertaken prior to the start of the flood event?".[854] The briefing included a table which purported to show the maximum height that Wivenhoe Dam would have reached had it been at various levels below FSL when the flood event commenced.[855] Thus, for example, according to the table, if Wivenhoe Dam had been at 50% of FSL, being a height of EL 60.00m AHD, then it would have reached a peak height of EL 74.11m AHD.

412 In cross-examination, Mr Tibaldi was at first not prepared to accept, but then did not deny, that he sent the email at around 9.00pm on 15 January 2011 even though it was from his email address, it attached a draft bearing his initials and it was sent to the other flood engineers ("Well, I just can't accept it.")[856] and then was not prepared to accept that he was the drafter of the document ("...I'm not prepared on that evidence to say that draft is something

[849] SEQ.001.022.1394; SEQ.001.022.1395.
[850] SEQ.001.022.1382; SEQ.001.022.1383.
[851] SEQ.001.035.4459; SEQ.001.035.4460.
[852] ROD.650.001.7326 at .7334, .7352 and .7354.
[853] Ibid at .7352.
[854] Ibid at .7334.
[855] Ibid at .7335.
[856] T 5574.37.

that I prepared alone…").[857] Later in his evidence, Mr Tibaldi accepted that he was co-ordinating the drafting of the briefing note.[858] I found Mr Tibaldi's evidence in this regard evasive and unsatisfactory. It was absolutely clear that he was the author and distributor of the document.

413 Four matters should be noted about these drafts at this point.

414 First, I am satisfied that the drafts prepared by Mr Tibaldi of material for inclusion in the briefing note were sent to and read by Messrs Malone[859] and Ruffini. Neither of them suggested any concern with their contents. Mr Tibaldi could not recall "any adverse comment on the table" showing the strategies being utilised from time to time in his drafts.[860] In light of Mr Ayre's email of 14 January 2011, it is to be expected they were reviewing this material. I am satisfied they were. I am satisfied they were content with its description of the flood engineers' strategies and understanding through the January 2011 Flood Event, which had occurred only one week previously.

415 Second, in relation to Mr Ayre, Sunwater submitted that he did not have the "opportunity to review the draft Ministerial briefing note during the short period it was prepared, [so therefore] no inferences can be made that his silence on receipt of the various drafts constituted an implicit approval of [its] contents".[861] For the reasons that follow I reject that submission.

416 In his affidavit, Mr Ayre stated that on the evening of 15 January 2011 he was at the FOC and assisted in preparing sections of the briefing note before leaving at 7.00pm.[862] The email sent by Mr Tibaldi later that evening attaching the first draft was not sent to Mr Ayre's personal or work email address. Instead, it was sent to the duty engineer's email address, that being an account that Mr Ayre did not have access to when he was not in the FOC. However, as noted, an email attaching a draft was sent to Mr Ayre's email

[857] T 5575.24.
[858] T 5593.43.
[859] See T 5329.42 to T 5332.14.
[860] T 5649.13.
[861] SunWater subs at [1620].
[862] LAY.SUN.001.0001_OBJ at [2924].

address at 6.41am the following morning. Mr Ayre commenced on duty in the FOC that day at around 7.00am.[863] In his first affidavit, Mr Ayre states that he sent an email to Mr Tibaldi at 9.00am attaching rainfall data for inclusion in the briefing note.[864] At around 2.40pm, Mr Malone telephoned Mr Ayre and requested a summary of flood volumes and peak discharges "for the preparation of the Ministerial Briefing Note". Mr Ayre said that he knew that Messrs Malone, Tibaldi and Drury were at Seqwater's offices finalising the report. He emailed the requested data to Mr Malone at 4.22pm.[865]

417 In cross-examination, Mr Ayre said that he did not see the draft that was circulated on the evening of Saturday 15 January 2011[866] and did not recall reviewing the email sent early the following morning.[867] He said that on 16 January 2011, while working in the FOC, he was distracted as communication with Somerset Dam had been lost that morning.[868] He accepted that he knew a briefing note for the Minister was being prepared and that it was for use in an emergency cabinet meeting. He agreed that, if he had noticed anything incorrect in any draft of such a note, he would have drawn Mr Tibaldi's attention to it.[869]

418 Given Mr Ayre's email of 14 January 2011 stressing the importance of a "consolidated view", his appreciation of the importance of the note and that he actively assisted in providing material for inclusion in the note on 16 January 2011, I am satisfied that Mr Ayre would have and did review the draft sent to him that morning. Like Mr Malone and Mr Ruffini, he was satisfied with its description of the flood engineers' strategies and understanding through the January 2011 Flood Event. The contrast between that description on the one hand, and his affidavit and oral evidence on the other, is a matter that has caused me to doubt the reliability of the latter.

863 Ibid at [2944].
864 Ibid at [2949].
865 LAY.SUN.001.0001_OBJ at [2971].
866 T 7980.14.
867 T 7980.42.
868 T 7981.4.
869 T 7981.24 - .38.

419 Third, the reference to a "significant draw down" after the end date for the Late December Flood Event must have been a reference to a draw down below FSL. Contrary to that note, a draw down to FSL could have been undertaken after 2 January 2011 "without major bridge inundation".[870]

420 Fourth, Mr Tibaldi accepted that it was incorrect to state that a draw down below the dam full supply level prior to the start of the Early December Flood Event would not have been possible without significant bridge inundation and without exceeding minor flood levels in the lower Brisbane River.[871] Mr Tibaldi could not provide any sensible explanation for why such a statement was included in the briefing to the Minister.[872] This was yet another matter that caused me to doubt the reliability of his evidence.

7.11: Strategy Summary Log

421 At 6:57pm on 15 January 2011, during the period when the Ministerial briefing note was being prepared, an email was sent from the "dutyseq" email address to Mr Tibaldi. It stated: "John, Excel spreadsheet of strategies and directives for Wivenhoe, Rob".[873] It attached an excel spreadsheet entitled "*Strategy Summary Log*".[874]

422 The Strategy Summary Log contained a series of chronological entries that were extracts from various situation reports and the Event Log as well as listing the gate directives. One of the columns assigned a strategy to each Wivenhoe Dam gate directive and various rows appeared to highlight a transition between strategies.[875] Thus, all the gate directives issued up to and including 12.30pm on 8 January 2011 are stated as referable to W1 sub-strategies. There is then a yellow highlighted row providing for "W2".[876] All the situation reports issued between 12.30pm on 8 January 2011 and up to but not including the 9.04pm situation report issued on 9 January 2011 are

[870] T 5578.38 to T 5579.13 (Tibaldi).
[871] T 5579.36 - .45 (Tibaldi); T 5614.11.
[872] T 5609.46.
[873] SEQ.001.019.2013.
[874] Strategy Summary Log, SEQ.001.019.2014.
[875] Column D.
[876] Row 107.

designated Strategy W2. There is then a highlighted yellow row specifying W3, which is applicable for all the entries until 9.00am on the morning of 11 January 2011.

423 The Strategy Summary Log is generally consistent with the chronology prepared by Mr Tibaldi as part of the preparation of the Ministerial briefing note save that the latter arguably attributes W3 as having become operative at 6.30am on 10 January 2011. As noted above,[877] the situation report issued at 9.04pm on 9 January 2011 was the first report to advert to the objective of minimising urban flooding, although no action was taken to increase releases until the combination of existing releases and increases in downstream flows inundated the remaining bridges.

424 Mr Tibaldi said he could not recall the document.[878] He on-sent the Summary Log to the duty engineer's email address at 7.50pm that evening.[879] The material was then emailed from the duty engineer's email account to Messrs Allen and Drury at 1.03pm on Monday 17 January 2011,[880] when Mr Ruffini was on duty.[881] I infer that both Mr Tibaldi and Mr Ruffini reviewed the document and were sufficiently content with its contents, including its attribution of strategies, so not to comment upon or dispute its contents. As stated, it is largely consistent with the briefing note save for confusion about whether a transition to Strategy W3 occurred late on 9 January 2011 or early on 10 January 2011.

425 It is not clear whether the "Rob" who sent the original document was Rob Drury or Rob Ayre as both were working in the FOC on the Saturday evening. Mr Drury did not recall sending the email from the duty engineer account or preparing that document.[882] Mr Ayre was cross-examined about it briefly. He was asked whether he was the author.[883] He stated that when he was

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[877] At [224].
[878] T 5572.37 to T 5573.34.
[879] QLD.002.001.5331.
[880] QLD.002.001.2679.
[881] SUN.002.005.0002.
[882] T 6720.34 - .46.
[883] T 7982.10.

"originally asked that question" at the QFCI he said "yes, it must have been me because I was usually the only 'Rob' in the flood operations centre" but said that later as he learnt there were two "it would have been either myself or Mr Drury" as he did not recall sending it.[884]

426 The plaintiff submitted it was most likely that Mr Ayre prepared and sent the Strategy Summary Log as Mr Drury was not a flood engineer, was not involved in strategy selection during the event and Mr Drury sent an email from a different email account, "*NQWater Duty Engineer*", less than 15 minutes later, suggesting that he was working from a different computer.[885]

427 SunWater contended that the basis for inferring that it was Mr Ayre was not put to him in cross-examination and the plaintiff's submission should be rejected for a failure to comply with *Browne v Dunn*.[886] *Browne v Dunn* does not require that every aspect of the reasoning in support of a suggested inference be put to the witness. Mr Ayre was given the opportunity to address whether or not he was the author of the document.

428 SunWater otherwise submitted that there was no basis for inferring that Mr Ayre prepared the document. It contended that just because either Mr Drury or Mr Ayre sent it by email does not mean they prepared it and that it could have been Mr Tibaldi who prepared it (but presumably one of them then sent it).[887]

429 I am satisfied that it was Mr Ayre who sent the email, that he either drafted or at least perused the log and that he sent it to Mr Tibaldi to assist in the preparation of the Ministerial briefing note. Mr Ayre was the SFOE. It was he who on 14 January 2011 emphasised the necessity for a "consolidated view on things before information is distributed".[888] As between himself and Mr Drury I expect that he would have taken the closest interest in statements being made around that time concerning the conduct of flood operations.

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[884] T 7982.16.
[885] SEQ.001.021.8691; Plaintiff subs at [321].
[886] (1893) 6 R 67 (HL); SunWater subs at [1606].
[887] SunWater subs at [1607].
[888] SUN.002.001.1364.

7.12: Mr Tibaldi's Approach to Forecasts and Response to Media Inquiries

430 On 16 January 2011, Mr Borrows forwarded to Mr Tibaldi an email from Mr Spiller.[889] Mr Spiller's email attached a draft response to a series of questions posed to Seqwater by a journalist to the effect that insufficient water was released on 8 and 9 January 2011 given the rainfall forecasts.[890] In his draft response, Mr Spiller twice suggested that dam releases were made based on rainfall forecasts but the actual rainfall exceeded what was forecast. Shortly after this was sent, at 7.05pm, Mr Drury emailed Mr Borrows and Mr Tibaldi stating "[t]alking to John …Will look at this one after the briefing Paper and report".[891]

431 At 7.40pm, an email was sent from the duty engineer email address to Mr Drury and the email addresses of Messrs Ayre, Malone and Ruffini.[892] The email attached[893] a revised set of responses. Part of the response has already been extracted above but at this point it is necessary to set out more:

> **1. Why did Seqwater permit the flood storage capacity to build up so much over the weekend?**
>
> Releasing large volumes of water over the weekend would have had major impacts on the rural communities of the Brisbane Valley. Bridges would be cut and communities would be isolated with little notice. This is not an action that is undertaken unless there is certainty that inflows into the dam will result in flood releases that will cause impacts to urban areas. Over the weekend, neither rainfall forecasts nor the rain on the ground indicated with certainty that urban areas would be impacted, so the emphasis at that time was on protecting the rural communities of the Brisbane Valley.
>
> ~~Releases were made based on the approved Operational Procedures and rainfall forecasts provided by the Bureau of Meteorology.~~
>
> ~~Based on the forecasts provided to us, higher release rates were not required. For example, the forecasts provided to us on the morning of Saturday 8 January 2011 were:~~
>
> ~~Saturday:Rain light at times 5-50mm with higher falls along the coast~~
> ~~Sunday:Widespread rain with totals between 50-100mm~~
> ~~Monday:Widespread rain again with totals between 50-100mm~~

889 QLD.002.001.5462.
890 QLD.002.001.5463.
891 SEQ.001.022.0027.
892 SUN.006.001.8908.
893 SUN.006.001.8909.

~~Tuesday:Rain easing with totals between 25-50mm.~~

~~The dam has managed events of this type on multiple occasions without flooding houses.~~

~~Unfortunately, the rainfall that occurred during this event was greater than anticipated - both over the event as a whole and from day to day. Actual rainfall on each of these days was significantly higher, with daily rainfall of up to 300 mm in some areas.~~

~~From late Sunday, combined flows at Moggill were about 4000 cubic metres per second, including dam releases and other flows. This is the limit above which houses begin to be flooded.~~

~~There was no reason to cause inundation of houses at that time, based on the forecasts that continued to be provided over the weekend.~~

432 At the time this email was sent, Mr Tibaldi was on duty at the FOC.[894] Mr Tibaldi was cross-examined about this email for some time.[895] One of the many unsatisfactory aspects of his evidence was his refusal to accept that he sent this email, although he would not outright deny it either ("Yes I was in the flood centre, but did one of the others send it; didn't send it to me because I was there anyway and had access to that email account, I'm not sure…"[896]). Given that Mr Tibaldi was on duty at the time, that the email with the attachment was sent to the email addresses of the other three flood engineers and in light of the contents of Mr Drury's email sent at 7.05pm, I am satisfied that it was sent by Mr Tibaldi and that he composed it. Its language is consistent with how he presented in giving oral evidence.

433 At this point it is appropriate to note Mr Tibaldi's evidence about the use of rainfall forecasts generally. In his first affidavit, Mr Tibaldi stated that, "[b]ecause of the unreliable nature of the rainfall forecasts and the serious consequences of poor decisions which include worsened urban flood mitigation outcomes and the potential failures of the Dams, I considered that those results were too uncertain to provide a basis for making such

[894] SUN.002.005.0002; T 5535.18 (Tibaldi).
[895] T 5535.20 to T 5545.7.
[896] T 5535.42.

decisions".[897] However, in his third affidavit sworn 4 May 2018 just prior to giving evidence, Mr Tibaldi stated:[898]

> "*My practice in January 2011 was to give consideration to rainfall forecasts when determining dam release plans.* The factors relevant to these considerations include the reliability of the forecast, the quantity of rain forecast, the forecast location and movement of the impacting rainfall system and the forecast timing of the clearance of the rainfall system. Because I used a methodology that reviewed and updated dam release strategies hour to hour throughout the flood event and not set once every 24 hours as contained in Dr Christensen's methodology, in my view I never assumed that a rainfall forecast "to be zero", particularly given the 24 to 48 hour time lag between when rain fall on the ground above Wivenhoe Dam and when dam releases resulting from the impact of that rainfall might impact Brisbane City." (emphasis added)

434 In cross-examination, the inconsistency between these two statements was pointed out to Mr Tibaldi. He stated that he "*considered forecasts*" in making decisions about dam releases in January 2011, but, upon consideration, he gave those forecasts "*no weight*" in each case.[899] I referred to this evidence in Chapter 3.[900] This inconsistency, and his explanation for it, is yet another matter that has caused me to doubt Mr Tibaldi's evidence.

435 Mr Tibaldi's actual approach to rainfall forecasts is best gauged by considering his amendments to the above response and his actions during the flood event. He did not undertake "with forecast" modelling on the evening of 8 January 2011 or the morning of 9 January 2011. His approach to gate operations was based purely on rain on the ground assessments. Mr Tibaldi's actions in deleting the reference to forecasts and substituting the above passage in response to the journalist's question confirms what was suggested by the contemporaneous material created on 8 and 9 January 2011, namely that: releases were not "based" on rainfall forecasts; the exclusive focus on the weekend of 8 and 9 January 2011 was on the protection of downstream bridges consistent with a Strategy W1 and that there was no consideration of the possibility of urban flooding unless it was certain that it would occur. Otherwise, his actions on 10 January 2011 in suspending gate openings were

[897] Tibaldi 1, LAY.SEQ.004.0001_OBJ, [117].
[898] Tibaldi 3, LAY.SEQ.017.0001_OBJ, [59(a)].
[899] T 5508.8 - .29, T 5510.26, T 5512.23, T 5514.25, T 5521.41 to T 5522.39, T 5525.5 - .42.
[900] At [191].

undertaken in defiance of assessments based on forecasts that suggested that that approach would lead to the necessity to make damaging releases above EL 74.0m AHD or risk a fuse plug breach or both.

7.13: The Strategy Descriptions in the Flood Event Report

436 As noted, the January FER was published in March 2011. Section 2 of the Report contained a "Flood Event Summary" which broke down the flood event into 20 "periods" and for each period included a discussion on the background, dam conditions, rainfall, model results and strategy said to be employed.[901] The first period was said to have commenced at 7.42am on 6 January 2011 which coincided with the mobilisation of the FOC. The discussion of the first three periods, which concern the period up to 3.00pm on 7 January 2011, refer to Strategy W1 and its various sub-strategies. It clearly treats their invocation as solely dependent on actual lake levels.[902]

437 The January FER identifies the fourth period as commencing at 3.00pm on 7 January 2011 and concluding at 2.00pm on 8 January 2011. Under the heading "background" it includes the following:[903]

> "**Transition from Strategy W1D to W1E to W3; and Strategy S2 Wivenhoe Directives #1 to #4.**
> **Somerset Directives #1 to #3.**
>
> Gates opened continuously at Wivenhoe Dam for 23 hours, in accordance with standard gate opening sequence at a rate of 0.5m of individual gate opening per hour.
>
> Transitioned from Strategy W1D to W1E when the Wivenhoe Dam level exceeded 68.25m (22:00 on 7 Jan 2011).
>
> *Transitioned from Strategy W1E to W3 as it became apparent Wivenhoe Dam level would exceed 68.50m (08:00 on 8 Jan 2011*). *Strategy W2 was by-passed as it was not possible to achieve this strategy by limiting the flow* in the Brisbane River to less than the naturally occurring peaks at Lowood and Moggill. This is because the calculated naturally occurring peaks at Lowood and Moggill were 530m^3/s and 770m^3/s respectively, whereas the release rate from the Dam was already 940m^3/s. Limiting releases to these naturally occurring peak flows would also have compromised the Dam drain down requirements." (emphasis added) (bold emphasis in original)

[901] January FER at .0303 to .0323.
[902] Ibid at .0304 to .0307.
[903] Id.

438 Under the heading “strategy”, the January FER included the following:[904]

> “**Strategy W3 and Strategy S2**
>
> **(Lake level greater than 68.50m, maximum release 4,000m^3/s)**
>
> Inflows from Lockyer Creek into the Brisbane River had inundated all bridges downstream of the Dam, with the exception of the Mt Crosby Weir Bridge and Fernvale Bridge.
>
> The strategy transitioned from W1 to W3 as it became apparent Wivenhoe Dam level *was likely to exceed 68.5m* and Strategy W2 couldn’t be applied.
>
> Strategy W3 required the flow at Moggill to be lowered to 4,000m^3/s as soon as possible after the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases). This was already achieved.
>
> Strategy W3 also required lower level Manual objectives to be considered. Therefore, consideration was given to minimising disruption to downstream rural life and endeavouring to keep Mt Crosby Weir Bridge and Fernvale Bridge trafficable. There was also [an] awareness Wivenhoe Dam outflows were already more than doubling the natural peak flow at Moggill.
>
> *Due to rainfall on the ground*, it was apparent the Somerset Dam level would exceed 100.45m. Accordingly, two sluice gates were opened during this period to allow Dam levels to move towards the Operating Target Line in accordance with Strategy S2……” (emphasis added) (bold emphasis in original)

439 The next eight periods discussed in the January FER spanned from 2.00pm on 8 January 2011 to 4.00am on 11 January 2011.[905] In both the background and strategy section, the January FER described the relevant strategy in force during these periods as W3 and S2.

440 This material, and the balance of the discussion for the period up to late on 9 January 2011, suggests that the flood engineers consciously operated the dam in Strategy W3. It also conveys that, to the extent that during the weekend of 8 to 9 January 2011 consideration was being given to maintaining downstream bridges, this was part of considering lower level objectives while operating within W3. However, the suggestion that the flood engineers were endeavouring to conduct flood operations during that weekend within W3 is inconsistent with the contemporaneous material, specifically the situation

[904] Id.
[905] Ibid at .0308 to .0316.

report issued by Mr Ayre on Saturday evening and the Event Log for the meeting at 3.30pm on 9 January 2011. It is also inconsistent with the briefing note provided to the Minister on 16 January 2011. Moreover, the suggestion that maintaining Fernvale and Mt Crosby Weir Bridges open was done as part of a consideration of W3's lower level objectives is also inconsistent with the contemporaneous material that I have addressed above. That material suggests that no consideration was given to the possibility of urban inundation until late on 9 January 2011 and instead the only matter being considered was the effect of inundating downstream bridges because the flood engineers were seeking to operate within W1, even though Wivenhoe Dam was above EL 68.5m AHD.

441 The fourteenth period identified in the January FER was said to have commenced at 4.00am on 11 January 2011 and concluded at 8.00am on the same day.[906] For this period, the background section notes that "[e]xtreme intense rainfall (estimated after the Event to possibly exceed 1 in 2000-year intensities) commenced on and close to the Wivenhoe Dam lake area". This period is said to be a transition from Strategy W3 to Strategy W4. The fifteenth period is described as commencing at 8.00am on 11 January 2011 and concluding at 1.00pm on the same day and it is stated that strategies W4 and S2 were being implemented. In respect of gate openings in this period the January FER stated:[907]

> "Once Strategy W4 is invoked, the Manual requires the opening of gates in accordance with standard sequences until the storage level of Wivenhoe Dam begins to fall. Accordingly, gates were opened continuously at Wivenhoe Dam for five hours in accordance with the standard gate opening sequence at an average rate of 2.0m of opening per hour. This increased the Dam discharge from 2,753m^3/s to 4,250m^3/s. The threshold limit for urban damage had been exceeded and the lake level continued to rise."

[906] Ibid at .0317.
[907] Ibid at .0318.

442 The sixteenth period described in the January FER spanned 1.00pm to 7.00pm on 11 January 2011. In relation to gate operations during that time, the January FER stated that:[908]

> "Gates were opened continuously at Wivenhoe Dam for six hours, in accordance with Strategy W4 and the standard gate opening sequence at an average rate of 4.5m of individual gate opening per hour."

443 The gate operations during both of these time periods are set out at [368] to [373] above and the gate opening sequences in section 8.6 of the Manual are summarised in Chapter 3.[909] A consideration of that material reveals that the above statement only addresses the period when the EL was above 74.0m AHD and the rate of outflows was above 4000m^3/s. For the five hours from 8.00am to 1.00pm on 11 January 2011, the gates at Wivenhoe Dam were opened by 21 increments or a total of 10.5m across all five gates which yields an average of 4.2 increments per hour (=2.1m per hour). For the three hours from just after 10.00am to 1.00pm when the lake level was above EL 74.00m and flows were below 4,000m^3/s, the gates were opened by eleven increments or less than four per hour.[910]. In respect of the six hours from just after 1.00pm to 7.00pm, the gates were opened by a further 55 increments which corresponds to an average of just over 9 increments an hour (or just over 4.5 m per hour as stated in the January FER above).

7.14: Mr Malone and Mr Tibaldi's Evidence on the Strategies in the Flood Event Report

444 At this point it is convenient to note parts of the cross-examination of Mr Malone and Mr Tibaldi on this part of the Flood Event Report and earlier drafts of this section of the January FER.[911] Mr Malone and Mr Tibaldi undertook most of the drafting of the report.[912]

[908] Ibid at .0319.
[909] Chapter 3 at [62] to [65].
[910] See [381].
[911] T 5651.45 to T 5660.6 (Tibaldi); T 5336.1 to T 5339.46 (Malone).
[912] T 5652.11 (Tibaldi).

Mr Tibaldi

445 On 24 January 2011 at 2.17pm, Mr Tibaldi emailed himself a draft of the above section of the January FER[913] (the "FER First Draft"). This draft stated that a transition from Strategy W1E to W2 took place at 3.00pm on 7 January 2011 and was completed by 2.00pm on 8 January 2011,[914] that dam operations remained in Strategy W2 until 7.00pm on 9 January 2011[915] and that a transition to W3 was completed at 1.00am on 10 January 2011.[916] Another draft prepared on or around 25 January 2011 suggested that the transition from W2 to W3 commenced at 2.00pm on 9 January 2011[917] (the "FER Second Draft").

446 On 31 January 2011 at 4.21pm, Mr Tibaldi emailed another draft to himself which indicated that as at 8.00am on 8 January 2011 Strategy W2 was invoked but as the conditions for that strategy could not be met, W3 was operative from that time until 8.00am on 11 January 2011[918] (the "FER Third Draft"). A minute later, Mr Tibaldi emailed himself another version which was in the same terms as the final version of the January FER.[919]

447 When he was asked in cross-examination why the description of the strategy changed to remove any transition through W2 from W1 to W3, Mr Tibaldi stated that his starting point in "drafting, [was] assuming the manual is correct, and assuming that that's what we should have done"[920] and added that:[921]

> "I think the manual – in my view, the manual is clear and unambiguous that once you leave strategy W1, you must go strategy W2 … Then very quickly I realised, well, for starters when I was there I wasn't operating under a - my understanding of W2, even though if you look at the conditions under W2 you would argue I was operating under W2 at that time, that wasn't my recollection. So then I started to test the manual. Like, how should I write this? The manual is saying clearly and unambiguously you should do this.

[913] ROD.650.002.4672.
[914] Ibid at .4676.
[915] Ibid at .4680.
[916] Ibid at .4681 to .4682. This was repeated in another draft sent at 4.35pm on 24 January 2011: ROD.650.002.4672 at .4683 to .4699.
[917] T 5653.40 (Tibaldi); The FER Second Draft can be found at ROD.650.002.4672 at .4741, .4750.
[918] ROD.650.002.4901 at .4913.
[919] Ibid at .4914 and .4919.
[920] T 5656.40 (Tibaldi).
[921] T 5656.23 to T 5657.2.

> *Well, we didn't do that. Well, my view was, at least when I was there, I didn't do it.* I thought about it for some period, tested in my mind different ways to approach the dilemma." (emphasis added)

448 Mr Tibaldi recounted how during the drafting of the January FER, he rang Mr Allen, even though he knew that it was "obviously inappropriate" for advice about how to draft the January FER because he "was in a dilemma about well, the manual is saying, completely unambiguous, you've got to be in W2 and we weren't, in my view".[922] He says that Mr Allen told him to "just give us the facts, John, and we'll sort it out from there",[923] and hence he only included a reference to W3.

449 In short, Mr Tibaldi defended the last change in the description of the strategies invoked by effectively saying that he realised there should have been a transition through W2 but so far as he was aware no transition occurred. Even though he knew it was inappropriate, he rang Mr Allen who told him "just give us the facts". This evidence was disingenuous to say the least because he had already prepared a submission for the Minister on the same topic, the facts of which were very different from those he had set out in the January FER (and which were far more consistent with what had transpired).

450 In cross-examination, Mr Tibaldi agreed that after 12 January 2011 he had no "clear idea" about what decisions were made to move from Strategy W1 to either W2 or W3, that he had no recollection of being informed when on duty of any decision to change strategy and that he wrote the FER attributing strategies W1 to W3 to various time periods based on actual lake levels.[924] However, he asserted that during flood operations, when he became aware that the actual lake level at Wivenhoe Dam exceeded EL 68.5m AHD, they "were no longer in Strategy W1" and "as required by the manual, I would have understood that we'd shifted to Strategy W2 or W3".[925] It was suggested to him that if that was true then he would not have let a Ministerial submission go

[922] T 5656.39 to 5657.39.
[923] T 5657.21 (Tibaldi); Transcript corrected to substitute "the facts" for "a fax".
[924] T 5657.43 to T 5658.23.
[925] T 5659.23 to .26.

forward suggesting that the progression to W3 occurred at 6.30am on 10 January 2011 or prepared the various drafts of the FER with differing versions of when a transition from W1 to W3, via W2 or not, occurred. Mr Tibaldi stated that it was only the drafts that were incorrect so far as he knew because he "may have let it go forward in a draft, but if we get to the final and there's something in there that I think is incorrect, I would have spoken up".[926]

451 Mr Tibaldi prepared both that part of the draft of the Ministerial briefing note and the January FER which described the strategies utilised at Wivenhoe Dam during the January 2011 Flood Event. His drafts on that topic ended up in the final version of those documents. As the table below demonstrates they are mutually inconsistent. In drafting the January FER, Mr Tibaldi retrofitted the description of the strategies invoked in an attempt to align them with the Manual, although that analysis relied on the transition to W2/W3 being dependent on actual and not predicted dam levels. All of the material in evidence, as well as Mr Tibaldi's explanation, only serves to reinforce the conclusion that Mr Tibaldi's evidence was completely unreliable, as is the January FER to the extent that it contains descriptions of the strategy said to be operative from time to time.

Mr Malone

452 Mr Malone was cross-examined at some length on the above documents (ie, the documents recording the strategies supposedly adopted by the flood engineers during the course of flood operations).[927] At the commencement of this part of the cross-examination Mr Malone agreed that before the January FER was issued, he was satisfied that Strategy W3 "commenced to be used ... at 8am on 8 January [2011]" ("I'm happy with that").[928] When referred to the fact that three RTFM runs undertaken on 7 January 2011 with forecast rainfall from the QPF predicted Wivenhoe Dam exceeding EL 68.5m AHD, thus invoking W3, Mr Malone stated that they only "indicated [exceeding EL 68.5m

[926] T 5659.34 - .43.
[927] T 5323 to T 5338.42.
[928] T 5322.25.

AHD] was a possibility, but not a certainty".[929] He agreed forecasts were not being used to make decisions about strategy and that instead decisions were based on actual lake levels.[930] However, he later asserted that the transition to W4 on 11 January 2011 was based on predicted levels,[931] although it was a prediction based on rain on the ground that yielded certainty that the level would be realised.[932]

453 Having been taken through the various changes as to when strategies were invoked, the basis for their invocation and the review of the flood engineers' conduct by the USACE after the QFCI report, Mr Malone was asked as follows:[933]

> "Q. Isn't it now the position that you can't remember what your views were about the manual prior to January 2011 because of all of the discussions and contemplation and statements and questions that you've been asked about the manual since January 2011?
> A. I think that's a fair statement. Certainly my opinion now is - must be changed.
>
> Q. And you can't now remember during the 2011 flood event precisely how you applied the manual because you were too busy at the time just dealing with the events as they unfolded; is that correct?
> A. That's a fair statement.
>
> Q. You didn't have the manual open in front of you in the flood operations centre, did you?
> A. Yes.
>
> Q. Did you look at it at all?
> A. Often.
>
> Q. Often?
> A. Often.
>
> Q. But you still can't remember how you interpreted and applied it at any particular point of time during the 2011 flood?
> A. No."

[929] T 5322.35 - .40.
[930] T 5323.5.
[931] T 5339.11.
[932] T 5339.40; T 5342.9.
[933] T 5353.9.

454 Having regard to these concessions, I do not place any weight on Mr Malone's evidence so far as he describes his understanding of the Manual prior to and during the January 2011 Flood Event.

7.15: Conclusion on Flood Engineers' Strategies

455 The following table summarises the strategies supposedly employed by the flood engineers during the January 2011 Flood Event as stated in the various documents produced in its immediate aftermath:

Strategy	Strategy Summary Log[934]	Ministerial Submission[935]	Tibaldi First Draft FER[936]	Tibaldi Second Draft FER[937]	Tibaldi Third Draft FER[938]	Seqwater January FER[939]
W1A	Not specified	Not specified	6/1/11 7:42	6/1/11 7:42	6/1/11 7:42	6/1/11 7:42
W1B	Not specified	Not specified	Transition commenced 7/1/11 2:00 and completed 7/1/11 07.00	Transition commenced 7/1/11 2:00 and completed 7/1/11 07.00	7/1/11 2:00	7/1/11 2:00
W1C	7/1/11 12:34	Not specified	Commenced 7/1/11 7:00	Commenced 7/1/11 7:00	7/1/11 9:00	7/1/11 9:00
W1D	7/1/11 21:53	Not specified	Not implemented	Not implemented	7/1/11 15:00	7/1/11 15:00
W1E	9/1/2011 1:00	Not specified	Commenced 7/1/11 8:30	Commenced 7/1/11 9.00	7/1/11 22:00	7/1/11 22:00
W2	9/1/11 15:30	9/1/11 19:00	Transition from W1E commenced 7/1/11 15:00 and completed at 8/1/11 14:00	Transition from W1E commenced 7/1/11 15:00 and completed at 8/1/11 14:00	Not implemented	Attempted but not implemented[940]
W3	9/1/11 21:00	10/1/11 6:30	Transition from W2 commenced at 9/1/11 19:00 and completed at 1.00am on 10/1/2011	Transition from W2 commenced at 9/1/11 14:00 and completed at 17.00 on 9/1/2011	8/1/11 8:00	8/1/11 8:00
W4	11/1/11 12:00	11/1/11 11:00	Transition	Transition	11/1/11 8:00	11/1/11 8:00

934 Strategy Summary Log (15 January 2011), SEQ.001.019.2014.
935 Seqwater Report to the Minister (16 January 2011), ROD.650.001.7326 at .7353 to .7355.
936 Draft Flood Event Report (24 January 2011), ROD.650.002.4672 at .4673 to .4681.
937 Draft Flood Event Report (25 January 2011), ROD.650.002.4672 at .4741 to .4762.
938 Draft Flood Event Report (31 January 2011), ROD.650.002.4901 at .4910 to .4935.
939 January FER, SUN.016.001.0280 at .0304 to .0323 .0482 to .0490.
940 Ibid at .0485.

Strategy	Strategy Summary Log[934]	Ministerial Submission[935]	Tibaldi First Draft FER[936]	Tibaldi Second Draft FER[937]	Tibaldi Third Draft FER[938]	Seqwater January FER[939]
			commenced at 4.00am on 11 January 2011 and completed at 10.00am on 11 January 2011[941]	commenced at 4.00am on 11 January 2011 and completed at 8.00am on 11 January 2011		

Table 7-5: Table of strategies in documents prepared by flood engineers

456 Ultimately, in making findings as to what strategies the flood engineers were cognisant of and deploying from time to time, I am only prepared to accept that which is suggested by the contemporaneous documents generated throughout the January 2011 Flood Event, specifically, Mr Ayre's situation report issued on the evening of 8 January 2011, the entry in the Event Log for the afternoon of 9 January 2011, the notes concerning the meeting held on the morning of 10 January 2011, as well as what can be ascertained from the steps the flood engineers undertook in managing the flood. To some extent, my conclusions are supported by the Ministerial submission and the Strategy Summary Log. However, I derive no support from the January FER, which I consider unreliable in this respect. I also place no weight on the statements in the affidavits of Messrs Malone, Tibaldi and Ayre concerning the strategy they contended they were applying or was being applied from time to time unless it is corroborated by the contemporaneous material I have identified.

457 The material suggests that throughout the January 2011 Flood Event, by reference to rain on the ground modelling and observed lake levels, the flood engineers conducted flood operations by seeking to avoid or minimise a particular adverse consequence. Thus, for example, throughout 6 January 2011 and the first half of 7 January 2011, they avoided making releases to inundate any bridge and did not commence releases until Burtons Bridge was inundated by natural downstream flows. From then until late on 9 January 2011, the flood engineers were exclusively focussed on avoiding or

[941] This entry is included in the version emailed at 4.35pm on 24 January 2011: ROD.650.002.001.4672 at .4698.

minimising the disruption to rural life that would follow from the inundation of the remaining bridges notwithstanding that, on any view of the Manual, from early on the morning of 8 January 2011 they were required to focus on optimising protection against urban inundation and the avoidance of inundating rural bridges was a lesser consideration. While on the evening of 9 January 2011 there was a realisation that it was necessary to conduct flood operations to protect urban areas from inundation, no release decisions were made to give effect to that reality until early on 10 January 2011, after the remaining bridges were inundated. An increase in releases was planned from that time but that was suspended by Messrs Malone and Tibaldi who in effect substituted 3500m^3/s as the threshold for non-damaging flows (whereas the Manual stipulated it was 4000m^3/s).

458 To the extent that the flood engineers' conduct, including that of Mr Ayre, was consistent with any strategy throughout the time flood operations commenced on 6 January 2011, it was consistent with operating in W1 until midnight on 10 January 2011. Thereafter they might have perceived they were operating in W2[942] or W3 until the morning of 11 January 2011, when Wivenhoe Dam levels exceeded EL 74.0m AHD and for the balance of that day they acted as though they were in W4. I do not accept that at any time during 8 January 2011 and up to and including the evening of 9 January 2011, Mr Tibaldi or any other flood engineer understood or acted on the basis that flood operations at Wivenhoe Dam were being conducted in accordance with Strategy W3.

7.16: The Flood Engineers' Evidence

459 It is appropriate to record my overall assessment of the flood engineers' evidence at this point.

460 I have already outlined the evidence given by Mr Malone concerning his recollection of how he interpreted the Manual[943] and made a finding as to the

[942] See [298]
[943] At [453].

weight to be given to that recollection.[944] Findings to similar effect have been made in earlier Chapters.[945]

461 I have also made reference to Mr Tibaldi's absence of recollection of his shift on the evening of 8 January 2011[946] and made findings as to his complete unreliability as a witness in this Chapter[947] and earlier chapters.[948] As a consequence, this means that I did not accept any contested aspect of Mr Tibaldi's evidence unless it was corroborated by independent evidence.

462 In relation to Mr Ayre I have at a number of points expressed doubts or scepticism about the reliability of his evidence.[949] Again, I did not accept his evidence on any contested matter unless it was corroborated by independent evidence.

463 For the avoidance of doubt I confirm that, in making these findings, I have considered all of this material in its totality before addressing each particular topic.

464 In its submissions, Seqwater contended that aspects of the plaintiff's submissions concerning the flood engineers' evidence sought to "impeach" their testimony without the contrary being put to them.[950] They instanced aspects of the plaintiff's submissions which referred to Mr Ayre's evidence as "demonstrably untrue"[951] and aspects of Mr Tibaldi's affidavit addressed above[952] as "misleadingly drafted".[953] It is not necessary to address this further beyond noting that I have not made any finding adverse to the honesty of the evidence given by the flood engineers as opposed to its reliability[954]

[944] At [454].
[945] Chapter 5 at [137ff] and see also Chapter 4 at [157] re lack of recollection.
[946] At [89ff].
[947] At [91] to [93], [412], [420], [432], [434] and [451].
[948] Chapter 4 at [158]; Chapter 5 at [142] to [158]; Chapter 3 at [152], [190].
[949] Chapter 4 at [105] and [159]; Chapter 5 at [159] to [166]; Chapter 7 at [36], [206] to [209], [417].
[950] Seqwater subs at [1023] and [1026] to [1028].
[951] Ibid at [1023(a)(i),] citing Plaintiff subs at [1001].
[952] At [88].
[953] Seqwater subs at [1023(a)(iii)] citing Plaintiff subs at (a)(iii).
[954] See [18])

and, to the extent it concerns the latter, it is based on matters raised with them in evidence.

7.17: How Were Forecasts Used by the Flood Engineers?

465 I have already addressed the evidence given by each of the flood engineers as to how they utilised rainfall forecasts during the January 2011 Flood Event.[955] Based on the contemporaneous materials, it can be accepted that the flood engineers monitored QPF and PME forecasts, made assessments in the situation reports of the likely amount of rainfall from PME forecasts for a number of days, undertook some RTFM model runs using forecast rainfall[956] and at times assessed inflow volumes based on forecasts.[957] These activities, and others of the kind described by Mr Malone in his first affidavit as set out in Chapter 6[958] were said to rebut the suggestion that rainfall forecasts were ignored.[959] Instead, it was submitted that the rainfall forecasts were used to create "situational awareness" on the part of the flood engineers.[960]

466 Further, in their evidence, the flood engineers asserted that in two respects rainfall forecasts were used to make what could only be described as "operational decisions".

467 First, each of Mr Ayre,[961] Mr Malone[962] and Mr Tibaldi[963] asserted that they decided to *not* release water based on an assessment of where forecast rainfall would, or might, fall. In its submissions, the State referred to an opinion of Mr Fagot's to the effect that a "reservoir engineer can use rainfall forecasts to make a determination to hold reservoir releases steady or avoid significant increases if rainfall is forecasted to occur in the uncontrolled areas

[955] Mr Malone: Chapter 6 at [181] to [194]; Mr Ayre: Chapter 6 at [194] to [200]; Chapter 7 at [13] to [37]; Mr Tibaldi: Chapter 7 at [429] to [435].
[956] Eg, SUN.002.002.3632; SUN.002.002.3626.
[957] See Mr Malone's email sent around 11.00am on 9 January 2011: QLD.001.001.2750.
[958] Chapter 6 at [181],
[959] See State subs at [432] to [434].
[960] T 5382.5 (Malone); Seqwater subs at [745], [776], [1777], [1975(a)] and [2050]; SunWater subs at [476], [510], [520] and [1746]; State subs at [228(f)] and [650].
[961] Chapter 7 at [203]; eg LAY.SUN.001.0001 at [2287]; T 7506.34 to T 7507.14.
[962] T 4736.24; eg LAY.SEQ.007.0001 at [214] and Chapter 6 at [181] to [186].
[963] LAY.SEQ.014.0001 at [90] and [16], although note T 5485.35 to T 5486.7 and T 5521.

downstream of the dams".[964] To the extent that that in fact happened, the flood engineers made an "operational decision" based on forecast rainfall. However, as already noted, that approach involved reliance on what was one of the most unreliable aspects of rainfall forecasts, namely an assessment that rain will fall below as opposed to above Wivenhoe Dam.[965] Otherwise, their approach was asymmetric because no decisions were made, or even considered, to immediately release water because of a concern that rainfall forecasts indicated that downstream conditions would worsen later and nor were decisions made, or even considered, to increase releases because of an assessment based on forecasts that rain would, or might, fall above the dams.

468 Second, as noted, in his oral evidence Mr Ayre asserted that he made an operational decision based on rainfall forecasts in so far as he adopted his "buffer" approach. I rejected his evidence in that respect save that I accepted that a concern about forecast rainfall generally, but not any particular forecast, may have influenced so much of the approach to releases in the period 7 to 10 January 2011 that led to releases below the point at which the next bridge was inundated.[966]

469 Otherwise, the flood engineers never determined the applicable strategy based on a predicted height level (much less a predicted height level based on a rainfall forecast), never determined to release water because rainfall was forecast to fall in catchments above the dams or in an area that included the catchments above the dams, never determined a volume of water to be evacuated based on a rainfall forecast, never determined to increase releases because of a concern that forecast rain might fall later downstream and impede releases then and did not use an RTFM model run that used forecast rainfall as the basis for flood operations. It follows that the relevant flood objectives governing the flood engineers' actions were, at best, only determined by rain on the ground assessments and the amount of water they determined to evacuate was always only based on a rain on the ground

[964] State subs at [568] citing Fagot, EXP.QLD.001.0524 at .0598
[965] See Chapter 9, section 9.2.
[966] See above at [36].

assessment which was directed to a planning horizon of 12 to 15 hours ahead.[967] At most, in the period from 3.00pm on 7 January 2011 to early 9 January 2011, the time in which the rain on the ground assessed volume of water was evacuated was reduced by a small degree because of a concern about forecast rain generally[968] but that was only done by taking releases up to a level that was near but still below the inundation level for the remaining bridges. That approach was still only an instance of making an operational decision to release an amount of water determined by a rain on the ground assessment only. It still ignored forecasts affecting the period over which those releases could occur and was still a decision made by reference to a flood objective that was determined by a rain on the ground assessment, in that case being the priority of maintaining downstream bridges.

470 Although they may have remained cognisant of the rainfall forecasts, the flood engineers were always effectively assuming that no forecast rain would fall above the dams while at the same time assuming that forecast rain would or might fall below the dams (but only during their short planning horizon of 12 to 15 hours with no rain to fall thereafter). It was an approach that would always tend to underestimate the amount of water to be evacuated and overestimate the capacity to release water beyond that 12 to 15-hour period. It follows from Chapter 3 that this approach was fundamentally contrary to the Manual. It ignored the Manual's method of strategy selection and meant that "within any strategy" consideration was not given to the flood objectives in their order of priority in making decisions on dam releases.[969]

7.18: Breaches of the Manual

471 The above analysis suggests that throughout a flood event the relevant release and downstream flow limits in the Manual, together with the circumstances of the catchment, combine to present a flood engineer with an escalating set of thresholds that they had to elect whether or not to exceed by making or not making releases. Thus, the flood engineers had to determine

[967] See Chapter 6 at [197].
[968] See Chapter 6 at [214], [218], [223] to [224] and Chapter 7 at [71] to [73], [148].
[969] Manual at 1 and 23.

whether or not to declare a flood event, then had to consider whether to raise releases to inundate each bridge in turn and, when the last bridge was inundated, had to consider whether to make releases at such a level that would exceed the upper limit of non-damaging flows. With the January 2011 Flood Event, the various sequential threshold decisions that confronted the flood engineers were (i) whether to declare a flood event and commence releases; (ii) whether or not to inundate Burtons Bridge; (iii) whether or not to inundate Fernvale Bridge and Mt Crosby Weir Bridge; and (iv) whether or not to exceed the upper limit of non-damaging flows (although there was an attempt to substitute 3500m^3/s for 4000m^3/s as that limit). The fact that those decisions presented themselves does not of itself reveal an approach that was contrary to the Manual. As I will explain, aspects of Dr Christensen's simulations reflect the same approach of confronting each threshold in turn.[970]

472 In confronting those thresholds in the period up to 5.00pm on 10 January 2011, the flood engineers chose (i) not to declare a flood event until far too late, (ii) not to commence releases until Burtons Bridge was inundated, (iii) not to increase releases until Mt Crosby Weir Bridge and Fernvale Bridge were inundated by existing flows and (iv) not to make releases on 10 January 2011 that could lead to combined flows at Moggill exceeding 3500m^3/s downstream. What is especially noteworthy is that throughout the entire January 2011 Flood Event not a single bridge was inundated by a decision to increase releases. If rainfall forecasts of whatever duration had been considered in choosing strategies, much less releases, then it is overwhelmingly likely that they would have been.

473 It follows from the above that in the period from 2 to 10 January 2011 the flood engineers did not act in accordance with the Manual in a number of respects including:

(i) Wrongly determining to end the Late December Flood Event;

(ii) Failing to declare a flood event;

[970] See Supplemental Report, EXP.ROD.002.0080 at [289] to [292].

(iii) Wrongly treating the reference to peak outflow not exceeding peak inflow as a reference to past peak inflow;

(iv) Failing to correctly determine the applicable strategy from time to time in accordance with section 8.4 of the Manual, especially having regard to rainfall forecasts (and on a "no release" basis);

(v) Failing to make release decisions in accordance with the applicable strategy;

(vi) Failing to release water by reference to, or even because of, rainfall forecasts;

(vii) Failing to have regard to the Manual's objectives and their priority; and

(viii) During 10 January 2011, wrongly treating 3500m^3/s instead of 4000m^3/s as the upper limit of non-damaging flows.

Otherwise, the flood engineers treated Strategy S2 as requiring tandem flood operations be conducted along the Operating Target Line.

474 The first three of these failures were clearly material to the first of the decisions noted in [472], the third to seventh failures were clearly material to the second and third of those decisions and the fourth to the eighth failures were material to the fourth decision.

7.19: Other Reports

475 Out of deference to the parties' submissions, I note that two reports into the flood engineers' conduct were tendered in evidence.

476 The first was a short preliminary report prepared by a consulting engineer, Mr Cooper, on 12 January 2011.[971] It included the following statement:

> "Until the last day or so, Wivenhoe Dam has been below EL74.0 *and accordingly, would be operating under Strategy W1* i.e. make releases such that bridges downstream of the dam do not have to be closed prematurely. At

[971] SEQ.001.040.4541.

various times during the Flood Event some of the downstream bridges have been closed. However, it is evident that action has been taken to vary dam releases such that various bridges could be re-opened as soon as possible. This appears to have been done in accordance with the flood operating strategies." (emphasis added)

477 It is self-evident that the report proceeds on a fundamental misunderstanding of the Manual.

478 The second was a report by the USACE prepared in September 2012 following a recommendation by the QFCI that there be an independent review of the January FER.[972] Seqwater sought to rely on its conclusion that the "release decisions selected by the flood engineers were those that would best meet the objectives stated" in the Manual.[973] The State sought to rely on it as demonstrating the flood engineers acted in accordance with peer professional opinion.[974] The USACE also concluded that the January FER was prepared "exceptionally well".[975] The plaintiff attacked the USACE report on the basis of the limitations imposed by the terms of reference for the report, the limited time that was made available for the report to be undertaken and what it contended was the lack of independence of the author from Seqwater.[976]

479 I do not consider it necessary to address all of the plaintiff's complaints about the USACE report. It suffices to state that I have already addressed the reliability of the January FER and the conduct of the flood engineers based on the contemporaneous materials. The terms of reference for the USACE specifically excluded from the scope of its review the issues that arise from the findings made by the QFCI that the flood engineers:[977] (a) did not properly take into account forecast rainfall to determine the appropriate release strategy; (b) did not, and were required to under the Manual, actively and consciously choose one of the release strategies in the Manual; and (c) did not actively and consciously choose a strategy beyond W1 from 8.00am

[972] QLD.017.001.2024.
[973] Ibid at .2047; Seqwater subs at [1701].
[974] State subs at [634] to [635].
[975] QLD.017.001.2024 at .2026.
[976] Plaintiff subs at [350] to [380].
[977] QLD.017.001.0958 at [17] to [20].

Saturday, 8 January 2011 until release rates were increased during the evening of Sunday, 9 January 2011.

480 In contrast to the task undertaken by the USACE, the issues that relate to these findings must be determined in these proceedings. Leaving aside the rest of the plaintiff's complaints, those restrictions also meant that no assistance was gained from the USACE report.

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CHAPTER 8: DR CHRISTENSEN'S EVIDENCE AND METHODOLOGY

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CHAPTER 8: DR CHRISTENSEN'S EVIDENCE AND METHODOLOGY

1 Four sets of reports were prepared by Dr Christensen for use in the proceedings, namely a report dated 19 February 2015 (the "February 2015 Report"), a report dated 3 July 2016 (the "Supplemental Report"), a report prepared in reply to the defendants' evidence dated 22 December 2016 (the "Reply Report") and a report dated 1 July 2017 (the "Response Report"). In their unredacted form the combined length of the reports exceeds 2300 pages and includes more than 150 spreadsheets. The tender of parts of those reports was rejected following judgment in *Rodriguez (No 10).*[1] Even allowing for that, the amount of material that was tendered was substantial. Dr Christensen was cross-examined for 22 days.

2 In broad terms, Dr Christensen's evidence addressed what the plaintiff contended was the negligent operation of Wivenhoe and Somerset Dams by the defendants during the period December 2010 to January 2011 and sets out alternative simulations of the flood operations for the January 2011 Flood Event.[2] As explained below, those simulations involve the adoption of different starting dates and operating assumptions. Much, but not all, of Dr Christensen's critique of flood operations and alternative approach to flood operations flows from his construction of the Manual.[3] Dr Christensen's construction of the disputed parts of the Manual are outlined in Chapter 3 and have generally been accepted. Further, much of the analysis of the flood engineers' conduct of flood operations in Chapters 6 and 7 involve an acceptance of the plaintiff's criticisms which, in turn, were generally consistent with Dr Christensen's critique and his construction of the Manual. What remains to be addressed is his evidence as to how a reasonably competent flood engineer would have conducted flood operations during the January 2011 Flood Event in accordance with the Manual.

[1] *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 10)* [2018] NSWSC 149 ("Rodriguez (No 10)").
[2] Dr Christensen also undertook a flood frequency analysis which is discussed in Chapter 7 at [377].
[3] February 2015 Report, EXP.ROD.001.0016 at .0022 to .0023, [4] to [5].

3 This Chapter addresses the various challenges to the reliability and honesty of Dr Christensen's evidence. It also outlines his methodology and his simulated dam operations. Chapter 9 addresses the defendants' criticisms of his approach. Chapter 10 addresses his simulations in light of the findings in Chapter 9.

8.1: General Observations, Qualifications and Credit

4 Before outlining Dr Christensen's simulations and addressing the numerous criticisms of Dr Christensen's approach, evidence and character, it is appropriate to set out the impression I formed from observing him as a witness which has been confirmed by my subsequent consideration of his evidence. One of the sustained attacks made on Dr Christensen was that he either consciously or unconsciously used the benefit of hindsight to formulate a flood operations strategy that assisted the plaintiff's case.[4] In relation to the former, I accept Dr Christensen's denial that he deliberately constructed an approach to flood operations that was destined to recreate dam outflows that were lower during 11 and 12 January 2011 than what in fact occurred.[5] However, in relation to the latter suggestion, given that Dr Christensen was briefed with all the material concerning what was forecast and what happened and that to a large extent his methodology was prepared for use in this case, I approached his evidence with a very significant amount of scepticism that it was affected by hindsight. In particular, in preparing his reports Dr Christensen was obviously aware that the flooding occurred in circumstances where, from at least around 5 January 2011 (and earlier), there were forecasts of large amounts of rain in the various catchments in the forthcoming days and that even larger amounts of rain fell. He also could not help be aware that from late on 11 January 2011 rainfall over the catchments began to ease and was relatively negligible from the evening of 12 January 2011.

[4] Eg, State subs at [436] to [438].
[5] T 1668.37.

5 Nevertheless, my scepticism slowly dissipated as Dr Christensen responded to a skilled forensic grilling over weeks in the witness box. At times Dr Christensen was inarticulate and prone to ramble as he verbalised his mental processes before answering the question. At other times he struggled to keep cognisant of the differences between the governing assumptions for different simulations when he was being asked to compare and contrast them. However, over time I formed a strongly favourable view of his evidence. In particular, I became satisfied that the approach he outlined in most respects flowed from his interpretation of the Manual's requirements, an interpretation I largely accept. It was also clear that Dr Christensen had closely studied the Manual. He had sought to engage with its underlying rationale as well as its limits. In contrast to all of the relevant witnesses called by the defendants, Dr Christensen reconciled the Manual's ambiguous parts with its objectives and their order of priority and applied his expertise and knowledge to the requirements of the Manual, rather than seeking to make the express words of the Manual conform to his preconceptions of how dam operations should be conducted.

Dr Christensen's Qualifications

6 None of the defendants contended that any part of Dr Christensen's evidence should be rejected on the basis that he was not qualified to express the opinions that he did.[6] However, each of SunWater, the State and Seqwater contended that his experience was so limited that little weight should be afforded to his opinions and that other experts, such as Mr Fagot, should be preferred.[7] To that end, they both pointed to Dr Christensen's agreement that he had never operated a dam in flood conditions or otherwise[8] and had never acted as a flood engineer.[9]

7 Dr Christensen obtained a Bachelor of Science (Watershed Science) from Utah State University College of Natural Resources in 1978. He was awarded

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[6] *Evidence Act 1995* (NSW), s 79.
[7] SunWater subs at [859] to [865]; State subs at [368]; Seqwater subs at [33] to [42].
[8] T 984.43.
[9] T 1854.1 - .8.

a Master of Science (Civil Engineering) from Utah State University in 1980.[10] According to his affidavit, his bachelor degree “had an emphasis on wild land hydrology, flooding, rainfall/runoff hydrology and flood control”[11] and his Master’s degree included a study of “dam operations, including flood mitigation operations, hydropower systems, hydrology, flooding, river hydraulics, meteorology and storm drainage systems”.[12] In 1996, Dr Christensen was awarded a Ph.D. in Civil and Environmental Engineering from Utah State University.[13] His Ph.D. dissertation “examined changes over time of the administration of large water supply projects in Western United States”.[14] He has held and continues to maintain registrations as a professional engineer in Utah and New Mexico.[15]

8 While completing his undergraduate degree, Dr Christensen worked part-time as a hydrological technician.[16] After he graduated, from 1980 to 1985 Dr Christensen worked as “Civil/Water Resources Engineer” for an engineering firm, Rollins, Brown and Gunnell, Inc., in Utah.[17] His work included completing dam safety inspection and maintenance studies and reports which involved hydrological modelling of the probable maximum floods and an assessment of measures protecting the safety of the public from a dam break.[18] He undertook flood insurance studies which involved hydrological and hydraulic analyses for flood inundation mapping[19] and “designing and/or evaluating spillways” for small to medium sized dams,[20] as well as “undertaking stochastic statistical forecasting analyses to determine probable inflows based on historical stream gauge data”.[21]

[10] Ronald Christensen – Curriculum Vitae, EXP.ROD.001.0006, .0006.
[11] EXP.ROD.003.0001 at [6].
[12] Ibid at [7].
[13] EXP.ROD.001.0006, .0006.
[14] EXP.ROD.003.0001 at [9].
[15] Ibid at [14].
[16] EXP.ROD.003.0001 at [12].
[17] Ibid at [16].
[18] Ibid at [16(a)].
[19] Ibid at [16(b)].
[20] Ibid at [16(c)].
[21] Ibid at [16(e)].

9 From 1985 to 1990, Dr Christensen worked as a Staff Engineer for the Central Utah Water Conservancy District, which is the main water supply agency for the Central Utah Project ("CUP"). The CUP consists of a group of multipurpose dams which are used for, inter alia, water supply, irrigation, power generation and flood control.[22] Dr Christensen said that his work included hydrological modelling of rainfall and snow melt dams and modifying US Bureau of Reclamation hydrological models for the operation of five dams and Utah Lake,[23] as well as inspecting dams as part of a maintenance team.[24]

10 From 1990 to 2000, Dr Christensen was employed as a Supervising Civil/Water Engineer at Parsons Engineering Science, Inc. in Utah.[25] In addition to undertaking various studies and water supply evaluations, he stated that his work included "[e]valuating dam operations for water supply, flood control, recreation, and fish and wildlife conservation for reservoirs on the Rio Grande for Elephant Butte and Caballo Dams" including "determining flood mitigation strategies for the dams", as well as "[c]onducting water supply hydrologic modelling for various dams", such as the Hoover Dam.[26]

11 Since 2000, Dr Christensen has been the owner and consultant civil engineer of Water and Environmental Services, LLC, in Highland, Utah. As part of that consultancy, he is regularly engaged to provide expert opinions in litigation concerning flood control operations.[27] This has included "evaluat[ing] the flood operations and releases from a large privately operated dam" in Alabama and "evaluat[ing] changes to flood operational strategies under an operating manual for the largest flood control dam system in the United States, [namely] the Missouri River Mainstem System".[28] This work involved evaluating flood mitigation operations that "had actually occurred" during flood events in 2007, 2010 and 2011 "and determining whether the operations of the dam engineers

[22] Ibid at [17].
[23] Ibid at [18(a) and (b)].
[24] Ibid at [18(d)].
[25] Ibid at [19].
[26] EXP.ROD.003.0001 at [19(a)] and [19(b)].
[27] Ibid at [31] and [32].
[28] Ibid at [33] to [35]; T 2038.30.

were in accordance with manual requirements".[29] In cross-examination, he stated that his hydrology consultancy practice covered issues of water quality, environmental issues affecting water management, pipelines, tunnels and water supply for electricity generation, consumption and irrigation.[30]

12 In his affidavit, Dr Christensen listed various hydrological reports[31] and other papers[32] he had published over a twenty-year period and stated that he had participated in training workshops and conferences that covered a number of relevant topics, including rainfall forecast and computer modelling, flood control operations and hydrological modelling from rainfall forecasts.[33] According to Dr Christensen's curriculum vitae,[34] he also worked as an Adjunct Professor in the Civil and Environmental Engineering Department at Utah State University from 1998 to 2002. He was an Adjunct Instructor in Hydrology at Utah Valley State College in the Fall Semester of 2007.

13 In 1999, Dr Christensen qualified as a lawyer. He is admitted as an Attorney at Law at the Utah State Bar and Washington State Bar.[35] He has also practised law. He explained that his legal work predominantly involved addressing water rights disputes with the State Engineer's office.[36]

14 As noted, in cross-examination Dr Christensen agreed that he had never operated a dam[37] and had never undertaken work as a flood engineer.[38] Dr Christensen agreed that he had never trained to become a "real time dam operator" but stated that he attended a short workshop concerning how to "literally operate" a dam.[39] In their submissions, each of SunWater, the State and Seqwater emphasised these answers.[40] However, the submission overlooks that, under the Manual, the flood engineer does not "literally

[29] Ibid at [35].
[30] T 984.5 - .24.
[31] EXP.ROD.003.0001 at [28].
[32] Ibid at [42].
[33] Ibid at [41].
[34] EXP.ROD.001.0006.
[35] Ibid at 0007.
[36] T 983.5 - .25; see also EXP.ROD.003.0001 at [13].
[37] T 984.43.
[38] T 1854.1.
[39] T 985.15.
[40] State subs at [365]; SunWater subs at [860]; Seqwater subs at [34] to [36].

operate a dam" either. Under the Manual, the position of a flood engineer is different to that of "site staff", that is the "dam operator[s]" who effect gate openings and the like.[41]

15 SunWater noted that Dr Christensen's training in meteorology was confined to an undergraduate course.[42] The State submitted that Dr Christensen had no expertise as a flood forecaster or a flood forecast hydrologist.[43] However, Dr Christensen claimed that he had the expertise to take a rainfall forecast and use "hydrology [to] convert that to an estimated inflow and hydrograph and route that through a flood reservoir".[44]

16 The State contended that Dr Christensen would not satisfy the requirements for engagement as a flood engineer in section 2.5 of the Manual.[45] Those requirements are outlined in Chapter 3.[46] It was not suggested that Dr Christensen was registered as an engineer in Queensland but equally it was not suggested that he was not eligible to be registered. Otherwise, the matters set out in Dr Christensen's affidavit, including his work on designing spillways, suggest that he has acquired "knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams" and has suitable experience and expertise in at least the investigation or design of major dams. Similarly, he has extensive experience in hydrology with "particular reference to flooding", an "estimation of extreme storms" and "water management" and at least some experience in the field of meteorology. He has considerable experience with the maintenance of major dams and in the field of applied hydrology with flood forecasting (even though that was undertaken as part of other duties). I am satisfied that Dr Christensen satisfies the criteria for qualification as a flood engineer under the Manual.

[41] Manual at 5 ("suitably qualified personnel are available to operate the dams" and "site staff"); see also Manual at 6 ("site staff"); see also Manual at 44 ("officers in charge at each dam"); see Chapter 3 at [13].
[42] T 2800.24 - .31; see also State subs at [366].
[43] State subs at [366].
[44] T 2799.20.
[45] State subs at [365].
[46] Chapter 3 at [11].

17 However, being qualified as a flood engineer is one matter; having the necessary breadth of experience to comment on the conduct of other flood engineers and formulate an approach required of a flood engineer in complying with the Manual is another. SunWater submitted that Dr Christensen's "opinion evidence was of the most dangerous sort" because, although he had "some expertise relevant to flood operations", he "was not versed in flood operations principles and procedures, nor experienced in their practice".[47] It submitted that Dr Christensen "was a determined advocate for the Plaintiff's cause in a way that can give little comfort as to his understanding and acceptance of the proper role of an expert in a case such as this".[48]

18 I do not accept that Dr Christensen was an expert witness of a "dangerous sort". For the reasons set out below I also do not accept that he was a partisan advocate for the plaintiff's cause. Dr Christensen's educational qualifications and professional experience, which includes his review of flood operations and the like at other dams and water systems when retained as an expert witness, provides him with a solid background to comment on the flood engineers' actions. Nevertheless, his absence of direct experience in conducting flood operations has caused me to pause before accepting his opinions. Despite this, to a large extent I accept his opinions and approach when it is firmly grounded in the wording of the Manual. As stated, Dr Christensen impressed as a witness who was prepared to address the Manual in its terms and critique the flood engineers in a manner consistent with, and by reference to, the Manual. His approach compared very favourable to most of the defendants' witnesses who often contorted the Manual's language to an unreasonable degree to make it conform with their own views about the conduct of flood operations which stemmed from the dams and type of water control manuals they were familiar with. Further, Dr Christensen's extensive experience in hydrology meant that overall I was comfortable with his expertise in making quantitative assessments of inflow

[47] SunWater subs at [865].
[48] Id.

volumes, notwithstanding the exposure of some errors that affected his calculations.

19 Dr Christensen’s limited experience in meteorology and his general lack of previous familiarity with Australian weather forecasting products meant that close scrutiny had to be applied to his interpretation and use of PME forecasts. Most importantly, Dr Christensen’s lack of direct experience in the conduct of flood operations warranted the exercise of caution in accepting his opinion concerning acute “heat of the moment” aspects of flood operations, that is, periods when the Manual does not provide any or at least much assistance to the flood engineer in addressing rapidly changing circumstances. The adverse findings in Chapters 6 and 7 did not concern such decisions. The many failings of the flood engineers in those Chapters concern the period up to 5.00pm on 10 January 2011 and were mostly driven by their systemic failure to comply with the Manual that they in large part drafted. However, two particular aspects of Dr Christensen’s approach to flood operations involve difficult real-time judgment calls which are at the very least harder to reconcile with the Manual, namely closing the Somerset Dam crest gates during flood operations and suspending gate openings while Wivenhoe Dam is above EL 74m AHD and rising on 11 and 12 January 2011. With those matters, the lack of, or only qualified, acceptance of Dr Christensen’s approach are reinforced by the limits on his expertise and experience.

Errors in Dr Christensen’s Reports

20 SunWater made extensive submissions to the effect that the presence of various errors in his reports was demonstrative of Dr Christensen’s incompetence[49] and dishonesty.[50] I do not accept either contention.

21 One error relied upon was that, up to and including his Reply Report Dr Christensen’s simulations failed to take into account flows at Lowood in

[49] SunWater subs at [867].
[50] Ibid at [879].

determining the impact on Fernvale Bridge.[51] In effect, he overlooked the fact that the juncture of Lockyer Creek and the Brisbane River is above Fernvale Bridge and not below it. SunWater submitted that it was an "extraordinary error"[52] and discounted Dr Christensen's explanation that it arose out of his lack of familiarity with the "geography" of the region[53] and instead submitted that it involved a failure to properly apply the Manual.[54] The map included in the Manual is not particularly clear in indicating that the Lockyer Creek joins the Brisbane River above Fernvale Bridge,[55] although it does refer to considering both Wivenhoe and Lockyer Creek outflows when addressing the inundation level of Fernvale Bridge.[56] While a mistake of this kind would obviously affect any reliance placed on a simulation that replicated it, I do not accept that it demonstrates incompetence by a visiting hydrologist from Utah who prepared his reports without the benefit of active co-operation from any of the defendants or the flood engineers themselves.

22 Another set of errors related to the difficulties that Dr Christensen experienced in utilising the RTFM and the effect that had on his chosen loss rates. The evolution of Dr Christensen's simulations to those set out in the Response Report is set out in in *Rodriguez (No 9).*[57] In his Response Report, Dr Christensen acknowledged that "due to my lack of familiarity" with the RTFM the loss rates he used in the Supplemental Report were "in many instances, not appropriate to produce inflow estimates".[58] SunWater referred to this statement as somehow being a "forced" concession[59] and castigated Dr Christensen for his criticism of the flood engineers' loss rates in his Supplemental Report as being too high.[60] The State made a similar submission.[61]

[51] T 1855.1.
[52] SunWater subs at [868].
[53] T 1856.4.
[54] SunWater subs at [869].
[55] Manual at 25.
[56] Manual at 27.
[57] *Rodriguez (No 9)* at [32] to [44].
[58] Response Report, EXP.ROD.015.0005 at .0012, [14].
[59] SunWater subs at [871].
[60] SunWater subs at [871] to [875].
[61] See Chapter 9 at [279].

23 As noted, Dr Christensen was unable to use the RTFM in preparing his February 2015 Report and first utilised it in his Supplemental Report. In his Reply Report, Dr Christensen stated that, from reading an expert's report filed by one of the defendants, he learned that the "API component of the RTFM automatically approximated changing conditions in the Brisbane River catchment",[62] which meant that he had to recalculate his loss rates. The expert's report that Dr Christensen was responding to was not tendered.

24 There is nothing to suggest that the "flood ops" and "flood col" components of the RTFM are standard form software with which all hydrologists should be instantly familiar. To the contrary, it appears to have been developed within Seqwater and SunWater and manifests its own idiosyncrasies. There is nothing to suggest that the issue with the RTFM identified by Dr Christensen in his Reply Report is something that was or should have been obvious to a new user of the RTFM such as him. Thus, there is simply no means of ascertaining whether the particular issue identified with what appears to be suis generis software was something Dr Christensen ought to have been aware. The charge of incompetence levelled against Dr Christensen in relation to this matter had no proper foundation.

25 SunWater pointed to three further errors which were mainly arithmetical in nature. First, it pointed to a passage in Dr Christensen's Response Report where, in discussing his assessment of downstream flows, he stated that in "reviewing my simulations [in the Reply Report], I identified that the times that I specified that the case runs were conducted did not consistently correspond with the actual time of the flood engineers' case run" and thereafter corrected them.[63] In cross-examination, Dr Christensen explained that with the 2 January 2011 start simulations in the Reply Report there was a difference of four hours in the timing of a combined peak flow of around 5770m^3/s from

[62] Reply Report, EXP.ROD.004.0005 at .0075, [248].
[63] Response Report, EXP.ROD.015.0005 at .0014, [23(2)]; SunWater subs at [876].

Wivenhoe Dam[64] and otherwise some "inflows downstream were close but were not exactly correct".[65]

26 Second, SunWater pointed to an instance where in his Supplemental Report he double counted baseflow and in one of the simulations in his Reply Report he omitted it.[66] Dr Christensen explained that this arose as he was "still learning the [RTFM] system".[67]

27 Third, SunWater (and Seqwater[68]) pointed to an error by Dr Christensen in calculating one-day inflow volumes based on QPF forecasts[69] in two of his simulations.[70] Those forecasts were usually received at around 10.00am or 11.00am in the morning and 3.00pm or 4.00pm in the afternoon. In calculating the expected inflow volume from that 24-hour forecast, Dr Christensen added the figure derived from the forecasts to a volume for expected rain on the ground inflows from midnight that day instead of from the time of the forecast (thereby inflating the figures). Dr Christensen accepted that he made that error[71] and said he noticed it when reviewing one of the defendants' experts' reports.[72] The potential significance of this error is addressed below.

28 I do not accept that the fact that these errors occurred demonstrates incompetence on Dr Christensen's part. Dr Christensen was dealing with a complex hydrological system that was new to him. The production of a simulation that accounts for all the features of that system, including the RTFM, and builds allowance for forecasts was an exercise of a considerable difficulty for someone who had not encountered the system previously. The intrusion of arithmetical errors into that process is understandable. In that regard, I note that one of the State's experts, Mr Collins, initially made an error in his calculation of the relative frequency of the storm event on 10 and

64 T 1886.32 to T 1887.16.
65 T 1886.25.
66 T 1861.15 to T 1862.4.
67 T 1862.23; SunWater subs at [877].
68 Seqwater subs at [2419].
69 SunWater subs at [880].
70 Simulation C and Simulation H.
71 T 1648.28 to T 1649.3.
72 T 1894.43.

11 January 2011.[73] Another one of the State's experts Mr Giles calculated one-day inflow volumes but excluded base flow.[74] Mr Giles sought to address that in his fourth report[75] but the cross-examination revealed a further error arising from the use of inconsistent start times for the flood event,[76] which led to revised figures being provided in re-examination.[77] Mr Giles' fourth report also contains a correction of the application of the one-day volumes to predicted storage levels[78] but that corrected table itself was affected by a spreadsheet error.[79] I do regard these errors as demonstrative of incompetence on the part of Mr Collins or Mr Giles either. In contrast, the identified errors on the part of the flood engineers were of a systemic nature and ostensibly followed from their failure to apply the Manual according to its plain terms. The criticism of their 72-hour modelling discussed in Chapters 6 and 7 was not that they made some arithmetical error but that they did not acknowledge and address the difficulty of using loss rates calibrated to past instances of spasmodic rainfall to modelling future patterns of continuous rainfall.

29 SunWater further submitted that, prior to giving evidence, Dr Christensen discovered the error in his use of inflow data for the period 2 to 6 January 2011[80] but chose not to reveal it.[81] Dr Christensen explained that he realised the mistake but that under the "duress" of the circumstances and given that it was just a "small error … it didn't seem like there was any need" to correct it.[82] As it turns out, it was a small error that was immaterial.[83] I do not accept that Dr Christensen deliberately failed to comply with his obligations as an expert witness.

[73] See Chapter 7 at [377]; February 2015 Report, EXP.ROD.001.0016 at .0522.
[74] EXP.QLD.001.1359 at .1378, Table 2-5; see also T 8779.10.
[75] EXP.QLD.002.0040 at .0063, Table 4-1.
[76] T 8783.16 to T 8785.8.
[77] T 8931.
[78] EXP.QLD.002.0040 at .0064, Table 4-2.
[79] EXP.QLD.002.0093.
[80] Discussed in section 6.5 of Chapter 6.
[81] SunWater subs at [879].
[82] T 1891.46 and T 1892.25.
[83] See Chapter 10 at [70ff].

30 Finally on this topic, SunWater criticised Dr Christensen for his approach in relation to the statement in the Manual that "peak outflow should generally not exceed peak inflow".[84] Dr Christensen's evidence on this topic is addressed in Chapter 3[85] and his approach accords with the findings that were made.[86]

Dr Christensen's Partiality – SunWater Submissions

31 SunWater raised a multitude of issues that it contended demonstrated that Dr Christensen either saw himself as a "judge" of the flood engineer's conduct, rather than providing "admissible evidence as to the appropriate practices" of flood engineers,[87] or as otherwise demonstrating that he was a "constant advocate" for the plaintiff's cause.[88] SunWater referred to the fact that he was paid for his services and that, contrary to his denial, he felt responsible for the investment of (significant) funds in the conduct of the proceedings.[89] None of these points are deserving of weight. Being an expert witness in a case such as this is unlikely to be a charitable exercise. Dr Christensen's evidence should be assessed on its merits and not by impugning his motives.

32 SunWater also referred to Dr Christensen's defence of his expertise, his approach to errors in his reports and his description of practice in the USA concerning drawing below FSL. Save for two matters, those points have already been addressed.[90] The first is that Dr Christensen instanced witnessing flooding in the early 1980s,[91] a matter he ultimately indicated he did not want to put forward as supporting his expertise.[92] I regard that passage of evidence as no more than a witness becoming nervous under cross-examination. The second is an assertion by SunWater that when he was challenged about his training to become a *real time flood operations engineer* the only matter that Dr Christensen could point to was his "dubious

[84] Manual at 23; SunWater subs at [882].
[85] Chapter 3 at [276] to [280].
[86] Chapter 3 at [284] to [285].
[87] SunWater subs at [884].
[88] Ibid at [886].
[89] Ibid at [886] to [887].
[90] Ibid at [890] and [892] to [896].
[91] T 1969.47.
[92] T 1970.13 - .18.

claim to expertise based on a one-day workshop in the mid/late 1980's".[93] The question posed did not relate to being a "real time flood operations engineer" but a "real time dam operator".[94] The significance of the distinction between that position and a flood operations engineer is explained above.

33 SunWater accused Dr Christensen of deliberately misrepresenting the USACE Report.[95] In that part of his February 2015 Report which discussed drawing dams below FSL, Dr Christensen stated that the practice of doing so was "standard and competent practice both for flood control" and dam protection.[96] He stated that the USACE "specifically recommended that very procedure with respect to Wivenhoe Dam".[97] The relevant recommendation of the USACE was that there be an "investigat[ion] [of] increasing the flood mitigation storage available in Wivenhoe and/or Somerset lakes by temporarily lowering the full supply level under certain circumstances".[98] In cross-examination it was suggested to Dr Christensen that this was only suggesting an investigation and, in circumstances where the USACE exonerated the flood engineers, he was misleadingly suggesting that the USACE had recommended "a mode of operations that the flood engineers" had not engaged in.[99] Dr Christensen denied the suggestion and maintained that he cited the USACE Report in the context of a discussion about the merits of releasing below FSL generally.[100] I accept his evidence. It accords with the context of the discussion in Dr Christensen's February 2015 Report which cited the recommendation.

34 SunWater attacked Dr Christensen's honesty and partiality by pointing to evidence he gave concerning the operation of the initial gate opening trigger of EL 67.25m AHD in section 8.3 of the Manual. In one of his simulations which was modelled to commence on 5 January 2011 ("SIM E"), Dr Christensen would not have opened gates at Wivenhoe Dam until its storage

[93] SunWater subs at [892] to [894]; T 985.10.
[94] T 985.14.
[95] SunWater subs at [897] to [898].
[96] February 2015 Report, EXP.ROD.001.0016 at [285].
[97] Id.
[98] QLD.017.001.2024 at .2066.
[99] T 1913.46.
[100] T 1914.2 - .32.

level exceeded EL 67.25m AHD.[101] In cross-examination, Dr Christensen stated that in his view there should have been continuous flood operations since December 2010.[102] He further stated that the initial gate opening condition did not necessarily apply to SIM E[103] and that he only applied it to avoid any argument about the application of that condition to the circumstance where during a continuous flood event the gates are closed and then reopened.[104] He said that he applied that condition to a different simulation ("SIM B") which closed its gates on the morning of 5 January 2011.[105]

35 In his day-by-day release explanation for 5 January 2011 for SIM E, Dr Christensen stated that "[i]n accordance with the Manual, the spillway gates cannot be opened until Wivenhoe Dam reaches 67.25m and so the releases are delayed until that level is reached at around 6.00am".[106] SunWater submitted that this position represented Dr Christensen's actual understanding of the Manual and that his evidence that he applied that approach to the Manual in SIM E as a mere assumption was false. It submitted that he maintained to the contrary because he knew that if a "consistent approach was applied between Simulation E and many of his other Simulations, those other simulations would be contrary to the Manual".[107]

36 I do not accept this contention and I accept Dr Christensen's evidence. I note two matters. First, from the time of his (original) February 2015 Report, Dr Christensen maintained that there was one continuous flood event since early December 2010 and once the gate trigger level was first engaged it did not operate thereafter.[108] Second, even though Dr Christensen conceded that an application of a construction of the Manual that prevented gates being re-opened during a continuous flood event before Wivenhoe Dam reached EL

101 Response Report Vol 2, EXP.ROD.015.0261: Figures at .0785.
102 T 1980.45; T 1983.45.
103 T 1821.44.
104 T 1986.22.
105 T 1823.39; Response Report Vol 2, EXP.ROD.015.0261: Figures at .0547 to .0548.
106 Response Report, Vol 2, EXP.ROD.015.0261 at .0380.
107 SunWater subs at [901] to [910].
108 February 2015 Report, EXP.ROD.001.0016 at [304] to [306].

67.25m AHD would affect other simulations[109] in fact it would not have. Only SIM B applied this "assumption". In each of SIM A, C, D and I, at no point were all the gates at Wivenhoe Dam closed. At the time that each of SIM F, G, H and J would have commenced, Wivenhoe Dam was well above EL 67.25m AHD.

37 SunWater contended that Dr Christensen's preparedness to act "as an advocate, and a disreputable advocate at that" was demonstrated by his supposed resistance to the proposition that the 2 January 2011 eight-day forecast of 15mm to 25mm of rain was "unlikely to [yield] either any or any significant run off"[110] whereas he discounted 26mm of rain that fell from 9.00am on 5 January 2011 to 9.00am on 6 January 2011 on the basis that it would only produce "little" rain.[111] I do not accept this contention. Dr Christensen explained that his reliance on the 2 January 2011 eight-day forecast of 15mm to 25mm of rain was in the context of a flood engineer prospectively considering whether to end flood operations whereas his putting aside of 26mm of rain on 6 January 2011 was part of a hindsight calculation of the appropriate "curve number"[112] for the entirety of the January 2011 Flood Event;[113] ie, the latter was undertaken with the benefit of what hindsight showed about initial losses. I accept his explanation. SunWater's description of Dr Christensen as "disreputable" was unfortunate.

38 SunWater placed great emphasis on evidence given by Dr Christensen regarding a flood engineer being concerned about the presence of rain associated with Cyclone Tasha, at least at the commencement of the January 2011 Flood Event.[114] Seqwater made a similar submission.[115] In his February 2015 Report, Dr Christensen stated that, as at 2 January 2011, one circumstance known to a flood engineer was that "[h]eavy rainfall from the remnants of Cyclone Tasha in the past 5 to 7 days had produced rainfall not

[109] T 1988.37.
[110] T 2087.4 - .17.
[111] SunWater subs at [916]; Response Report, EXP.ROD.015.0005 at [122].
[112] See [85].
[113] T 2103.
[114] SunWater subs at [917] to [927].
[115] Seqwater subs at [2367].

too far to the northwest of the Brisbane River basins" which was more than "twice that which had fallen on the Upper Brisbane and Stanley River basis".[116] He also stated that an "additional 150mm of monsoonal-type rain [was] reasonably forecast[117] but stated that it was accidentally taken from another part of the February 2015 Report and the prevailing eight-day forecast was 15mm to 25mm.[118] In cross-examination, Dr Christensen stated that one of the prevailing circumstances for at least the start of the flood event was the presence of "cyclonic moisture" and "you don't know if it's going to cause trouble or not".[119] SunWater contended that there was no basis for that statement[120] and Dr Christensen's credit as a witness was affected because he did not accept that on 2 January 2011 a reasonably competent flood engineer could have acted on the basis that "Cyclone Tasha and its residual effects had dissipated".[121]

39 In his first report, Professor Manton stated that the BoM identified three major weather events during the period December 2010 to January 2011, the last two of which were "a six day sequence of heavy rainfall days following landfall of Tropical cyclone Tasha in late December", and "rainfall over 10 to 12 January associated with an 'unusual type of rainfall event with the major rain system having a scale of only several hundred kilometres, … over a concentrated region of south eastern Queensland'".[122] Dr Christensen was only asserting that, as at 2 January 2011, the reasonably competent flood engineer had to be cognisant of the possibility that the cyclone was still influencing weather in the catchments. His contention was supported by the evidence as to cyclonic weather affecting rainfall during the Late December Flood Event. His evidence on this topic does not undermine his credit in the manner suggested by SunWater.

116 February 2015 Report, EXP.ROD.001.0016 at [781(f)].
117 Ibid at [782(4)].
118 T 2114.38 to T 2115.8.
119 T 1928.14 - .21.
120 SunWater subs at [925].
121 T 2127.37; SunWater subs at [927].
122 EXP.SEQ.004.0131 at .0141.

40 SunWater also contended that Dr Christensen demonstrated that he was an "advocate for the Plaintiff" in aspects of his evidence concerning section 8.5 of the Manual which concerns gate closing strategies.[123] The passages cited were said to show Dr Christensen "tr[ying] to shoehorn the concept of forecast rainfall into base flow".[124] In fact, in the passages relied on, Dr Christensen was trying to explain that, if forecast rainfall is considered, then there will be an increase in the estimate of the amount and duration of baseflow that will result which will warrant a further reduction below FSL as contemplated by section 8.5.[125] Otherwise, Dr Christensen was attacked for relying on section 8.5 in support of the conclusion that the Manual requires the taking of reservoirs below FSL.[126] The textual arguments for and against that conclusion are addressed in Chapter 5.[127] None of the experts' views on the Manual on that topic represent a basis for suggesting that any of them were dishonest or partial in their evidence, including Dr Christensen.

41 SunWater contended that Dr Christensen had a "propensity to say what suited him".[128] This was said to be exemplified by Dr Christensen's evidence in which he accepted that a reasonably competent flood operations engineer would "keep a very keen eye on downstream flood warnings"[129] but did not "specifically use them" because there was "no definite information in them".[130] This criticism has no foundation. Dr Christensen's acceptance that a flood operations engineer would "keep a very keen eye on downstream flood warnings" has to be read with the balance of his evidence. Dr Christensen repeatedly stated that he did not "ignore" the flood warnings.[131] However, he said that he worked from the flood engineers' forecast and rain on the ground runs for downstream areas which incorporated forecast rainfall and recorded rain on the ground that had been received in that area[132] and which, unlike

[123] SunWater subs at [891], [899] and [911].
[124] Ibid at [891] and [911].
[125] T 2022.20; T 2022.45; T 2023.13.
[126] February 2015 Report, EXP.ROD.001.0016 at [290]; SunWater subs at [899].
[127] Chapter 5; section 5.2.
[128] SunWater subs at [928].
[129] T 1980.16.
[130] T 1979.43; SunWater subs at [928] to [930].
[131] T 2186.29; T 2188.21; T 2190.37.
[132] T 2187.18; T 2188.21; T 2190.37.

the warnings, included “definitive information” which could be used in gate operations.[133] As noted in Chapter 6,[134] the rain and stream gauge information available to the flood engineers was that which was utilised by the BoM to prepare storm warnings.[135] According to Mr Malone, the BoM and the flood engineers were operating “very similar models”.[136] When asked about the storm and flood warnings, Mr Malone stated that “I would have been receiving them, but I don't know whether I had been looking closely at them”.[137]

42 The balance of SunWater’s submissions either attacked Dr Christensen’s approach to the Manual as somehow reflecting adversely on his credit[138] or sought to characterise Dr Christensen’s demeanour in harsh terms (“deflect”, “evasive”, “devised in the witness box”, “combative”, “dissembling” “evasion”, “advocacy” and “non-responsive”).[139] I have considered the passages relied on. The Manual is addressed in Chapter 3. I do not accept that any aspect of Dr Christensen’s interpretation reflects adversely on his credit. My assessment of Dr Christensen’s demeanour is set out above.

Dr Christensen’s Partiality – State Submissions

43 The State also made a number of submissions to the effect that Dr Christensen was not a “credible independent expert witness” but instead an “advocate for the plaintiff”.[140] I do not accept those submissions.

44 The State contended that “Dr Christensen sought to have the Court believe that he had developed a hydrologic model which was used for draining the Great Salt Lake in Utah”.[141] The State’s written submissions do not identify where Dr Christensen made this claim. In his curriculum vitae, Dr Christensen simply referred to completing two evaluations that appeared to have

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[133] T 2190.44.
[134] At [17].
[135] T 5261.46 (Malone), see also T 7817.15 - .31; T 7881.17 - .28 (Ayre).
[136] T 5261.46.
[137] T 5270.35.
[138] SunWater subs at [914] to [915] and [935].
[139] Ibid at [912], [913], [931] to [936], [936] to [937].
[140] State subs at [369].
[141] State subs at [367] and [370].

relevance to the Great Salt Lake.[142] The State referred to Dr Christensen's oral evidence in which he explained that for his Master's thesis he modified a hydrological model concerning the Great Salt Lake[143] but was not was sure whether that model was the basis for the Great Salt Lake West Desert project in 1986.[144] The State did not demonstrate the falsity of Dr Christensen's evidence or that he had made a false claim.

45 The State also referred to an extract from the USACE Report for dam operations in Missouri cited by Dr Christensen in support of a contention that releases were made based on forecasts[145] but which omitted a sentence that clarified that releases did not increase until forecast rain fell.[146] The omission was material and it has already been founded that Dr Christensen overstated the position so far as the prevalence of pre-releases and releases below FSL in the USA are concerned.[147] That said, Dr Christensen said he did not "intentionally leave" the statement out.[148] I accept that answer.

46 The State also accused Dr Christensen of selectively quoting passages from the control manuals for the Appaloosa-Chattahoochee-Flint River Systems (ACF) in his Reply Report in an attempt to support his contention that rainfall forecasts were used in the USA to make pre-releases.[149] The text of the relevant manual indicates that forecasts are used for planning releases but actual releases are based on observed conditions.[150] Dr Christensen explained that his understanding of these systems was based on internet research.[151] When he was shown the details of the water control manuals for the individual dams, he accepted that actual release decisions appeared to be

[142] EXP.ROD.001.0006 at .0009.
[143] T 2804.13.
[144] T 2804.39; State subs at [367] and [370].
[145] Reply Report, EXP.ROD.004.0005 at [132].
[146] EXP.QLD.001.0505 at [17] to [19]; T 2792.15 to T 2793.5; State subs at [372].
[147] Chapter 5 at [129].
[148] T 2792.47.
[149] State subs at [373]; Reply Report, EXP.ROD.004.0005 at [134] to [138].
[150] T 1022.5 to T 1026; EXP.QLD.001.0524 at [68] to [75].
[151] T 2796.9.

based on rain on the ground.[152] Contrary to the State's submissions, I did not observe Dr Christensen to be "evasive" in his answers on this topic.[153]

47 Under the heading "Dr Christensen's lack of creditability", the State submitted that Dr Christensen "misstated the operations at Folsom Dam".[154] In his Reply Report, Dr Christensen cited two reports concerning Folsom Dam which indicated that in 1996 and 2005 storage was created at the dam in advance of forecast rain falling.[155] Dr Christensen explained the drawdowns in his report.[156] In his report, Mr Fagot stated that at Folsom Dam the top of the conservation pool is drawn down on 1 October each year (ie, a "seasonal draw down")[157] and there is a minimum area of flood space maintained with a variable component of flood space, known as "creditable storage", which is varied depending on the available flood storage space in three upstream dams.[158] Mr Fagot stated that Dr Christensen's analysis was incorrect because it suggested that "operations are taking place due to forecasted rainfall and not creditable storage considerations".[159] Dr Christensen was taken to Mr Fagot's analysis.[160] He did not dispute the claim but stated that the creditable storage concept allowed releases to be made as opposed to requiring them to be made, and that the reports he cited suggested releases were made because of a concern about the effect of weather forecasts.[161] There the dispute ended and it was not demonstrated that Dr Christensen had not properly summarised the 1996 and 2005 reports. None of this is demonstrative of Dr Christensen's lack of creditability as contended for by the State.

48 The State contended that Dr Christensen's evidence was "inconsistent with answers he gave as to the unreliability of rainfall forecasts" as recorded in

[152] T 1026.19.
[153] State subs at [373].
[154] State subs at [374].
[155] Reply Report, EXP.ROD.004.0005 at [139].
[156] Ibid at [141] to [144].
[157] EXP.QLD.001.0524 at [86].
[158] Ibid at [85] to [87].
[159] Ibid at [96].
[160] T 1028.40 to T 1033.32.
[161] T 1032.4 to T 1033.26.

depositions in litigation in the USA.[162] In his Reply Report, Dr Christensen referred to the Missouri River Mainstem System as an example of a dam system that operates using an annual drawdown procedure. He stated that it also uses "long term rainfall forecasts and, from time to time, uses short term rainfall forecasts to determine release strategies, if the circumstances of the event warrant it".[163] In cross-examination, Dr Christensen repeatedly stated that the form of use of short-term rainfall forecasts concerned downstream conditions and was used to determine whether *a reduction* in the planned release was warranted.[164]

49 The State contended that Dr Christensen's evidence was inconsistent with an answer he gave in a deposition in November 2016 in proceedings in the USA. In that deposition he was asked in relation to the same dam system whether "to determine releases, do they use forecasts of rainfall, or is it forecasts of runoff based on rain on the ground". He replied "[m]y understanding is that they use rain on the ground and streamflow, rain on the ground".[165] In cross-examination in the present case, Dr Christensen adhered to that answer but (repeatedly) stated that it was subject to the qualification that releases would be curtailed based on forecasts.[166] Critically, Dr Christensen made the same statement in the deposition. Just prior to the answer in the deposition relied on by the State, Dr Christensen noted that the USACE undertook five-day forecasts for the rivers in that system.[167] He was then asked:[168]

> "Q. So are you telling me, then, that you don't know one way or the other if they actually considered those forecasts in downstream areas as a basis for reducing releases to mitigate flooding due to increases in tributary discharge?
> A. I believe they do."

[162] State subs at [376].
[163] Reply Report, EXP.ROD.004.0005 at [127].
[164] T 992.24; T 2689.6; see also Chapter 9 at [29] to [31].
[165] QLD.016.001.0104 at .0263.
[166] T 2690.9.
[167] QLD.016.001.0104 at .0261.
[168] Id.

8.2: Methodology and Simulations - Overview

50 In his Reply Report, Dr Christensen summarised the effect of his earlier reports by describing his "general methodology" for flood operations in accordance with the Manual.[169] The following is mostly taken from that summary and mostly concerns the approach to flood operations in Simulations A, E and I. Aspects of this approach are applied to the other simulations, however, some are inconsistent with their governing assumptions or are not engaged because of the Manual's constraints or the prevailing circumstances.

51 Dr Christensen concluded that, having regard to the Manual's objectives and their order of priority, the "correct approach" was to conserve flood storage when catchment conditions and forecasts indicated that there was "a risk that the storage volume may be insufficient to contain potential inflows" and, based on the predicted inflow, "use the storage to: (i) reduce the magnitude (peak) of the release of water from the dams, (ii) change the timing of the peak release so that it does not coincide with high downstream flows".[170]

52 Dr Christensen's "primary" methodology effectively involved four steps.[171] The first step is the identification of the applicable strategy under the Manual.[172] Assuming one of the W1 to W4 strategies was selected, the second step was to determine whether to fill the reservoir storage or create storage by lowering water levels.[173] The third step was to determine a release rate when either filling or lowering the reservoir level.[174] The fourth step involved a regular reassessment of strategies and releases in light of changing conditions or considering whether flood operations should end.[175]

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[169] Reply Report, EXP.ROD.004.0005 at .0063 to .0072.
[170] Ibid at [203].
[171] The plaintiff analysed the methodology in three steps but the difference is immaterial: Plaintiff subs at [1470].
[172] Reply Report, EXP.ROD.004.0005 at [204].
[173] Reply Report, EXP.ROD.004.0005 at [214].
[174] Ibid at [224] to [236].
[175] Ibid at [237] to [238].

53 In relation to the first step, Dr Christensen determined the applicable strategy by calculating the predicted maximum water level in both[176] dams.[177] This was undertaken by modelling the runoff expected to be produced by the eight-day average forecast rainfall[178] and then determining the rise in lake level that would be produced by the modelled inflows, assuming no releases from the dams.[179] If it was necessary to decide between W2 and W3, Dr Christensen would determine the predicted peak flow at Lowood and Moggill by modelling the downstream runoff expected to be produced by the 24-hour forecast rainfall.[180] The significance of the 24-hour period for assessing downstream flows is addressed below.

54 In relation to the second step, Dr Christensen stated that a flood engineer would allow the reservoirs to fill if the downstream flows are forecast to rise near the threshold for non-damaging flows and allowing the dams to fill would not comprise the structural safety of the dams.[181] He added that a flood engineer *may* decide to fill the reservoirs if the forecasts indicated that heavy rainfall would end and not fill the remaining flood storage[182] and *may* allow Somerset Dam to fill if the forecasts indicated that Wivenhoe dam would rise above EL 73.0m AHD while Somerset Dam was not at risk of failure.[183] Dr Christensen's approach to Somerset Dam releases is discussed further below**.**

55 Dr Christensen stated that an engineer "would decide to lower the reservoirs, if catchment conditions and forecast inflow indicate there is reason for conserving or creating flood storage to control potential inflows based on the rain on the ground and 8-day forecasts".[184] If that decision was made, the

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[176] The predicted maximum water level in Somerset Dam is not relevant to the selection of Wivenhoe strategies, but is relevant because Strategies S1-S3 each apply only if Somerset Dam is predicted to exceed 99.0m.
[177] Reply Report, EXP.ROD.004.0005 at [205] to [206].
[178] Reply Report, EXP.ROD.004.0005 at [207] to [208]; February 2015 Report, EXP.ROD.001.0016 at [467].
[179] Reply Report, EXP.ROD.004.0005 at [209].
[180] Ibid at [212] to [213].
[181] Ibid at [215].
[182] Ibid at [216].
[183] Ibid at [217].
[184] Reply Report, EXP.ROD.004.0005 at [218].

flood engineer would then decide on a "desired target water level" for both dams "based on the operational objectives in the Manual".[185] In Strategies W1 to W4, Dr Christensen used a four-day average rainfall forecast (taken from the four-day PME) to determine the target level "because it balances the possibility of receiving the forecasted 8-day inflows into the catchment … against the possibility that those inflows may not eventuate if the forecasts are not realized".[186] According to Dr Christensen, the flood engineer would model the four-day inflow and then, in some of his simulations, decide whether to "lower the water levels in the dams by an amount up to that expected to enter the dams from the 4-day inflow", with consideration then given to lowering further to control the "potential 8-day inflow or more" beyond the four-day inflow.[187]

56 The translation of the four-day PME estimate into a release rate warrants explanation.

57 In some of the days in Simulations A, E and I, where a decision was made to lower the reservoir level, the first step that Dr Christensen identified was to select a "target" storage level below FSL. Dr Christensen stated that the selection of that target was not a "mechanical exercise".[188] He explained that the target level or volume below FSL (and above) was not precise and would be selected in 0.5m increments. He said that the target volume below FSL would ordinarily be set at less than that suggested by the four-day inflow estimate because the dams store more water per metre at higher levels and this ameliorates some uncertainty about refilling to FSL.[189] This approach was subject to taking an (even) "more cautious approach" to making releases if Wivenhoe Dam was more than 3 metres below FSL because of the "risk of the inability to return to FSL at the conclusion of the flood event"[190] and the necessity to operate both dams "in tandem to keep them roughly in

[185] Ibid at [219].
[186] Ibid at [220].
[187] Ibid at [222].
[188] Ibid at [223].
[189] Ibid at [223(a) and (b)].
[190] Ibid at [223(c)].

balance".[191] In that event, Dr Christensen's simulations indicated that he usually sought to model creating storage equal to a metre or more less than the forecasted rise.[192]

58 If it is determined to lower the reservoirs and once the target water level was set, Dr Christensen stated the flood engineer must then make a decision about the required release rate. Dr Christensen explained that the release rate was a product of the calculation of the total volume that needs to be released to reduce to the target level and the period of the release.[193] He said the period of the release was determined by considering downstream conditions specifically flows at Lowood and Moggill and minimising the inundation of downstream bridges, current and past releases, distribution of rainfall over the forecast period, gates and spillway capacities and the maximum release rates allowed by the applicable strategy.[194] The selected release period was usually one to two days. The assessment of downstream conditions is discussed below.[195] The application of this target approach in Simulation A is explained further in Chapter 10.[196] (In the other simulations,[197] the limits imposed by strategies, governing assumptions and downstream limits, together with the size of the rainfall forecasts, dictated release rates.)

59 With regard to the third step, if it was determined to fill the reservoirs in a W1, W2 or W3 Strategy then the "release rate is governed by the goal to keep releases at Lowood and Moggill below their target maximum flow levels if possible".[198] Releases from Somerset Dam are governed by a combination of the S2 operating target line and the "goal" of reducing the "contribution of outflows from Somerset Dam to Wivenhoe Dam where there is a risk of the water level in Wivenhoe Dam reaching the top of its spillway gates"[199] (with scope to depart from the operating target line to avoid the risk of a fuse plug

[191] Ibid at [223(d)].
[192] See for example Response Report Vol 2, EXP.ROD.015.0261 at 0292; SIM A on 7 January 2011.
[193] Reply Report, EXP.ROD.004.0005 at [230].
[194] Id.
[195] At [100] to [115].
[196] Chapter 10 at [200ff].
[197] Leaving aside simulations E and I.
[198] Reply Report, EXP.ROD.004.0005 at [224].
[199] Ibid at [225].

initiation, provided the safety of Somerset Dam is not compromised).[200] As explained in Chapter 9,[201] this aspect of his methodology was overlooked by the defendants in their criticisms of his simulated operations above EL 74.0m AHD.

60 Dr Christensen stated that "it is a matter for the engineer's judgment, taking into account the magnitude of expected inflows and the releases necessary to accommodate them, whether a strategy for ending operations should be adopted or whether flood operations need to be continued". However, he added that "the engineer may form the view that flood operations can end if there is no possibility based on the forecasts that the water levels in the reservoir will rise back to FSL after planned releases have been made".[202] This was addressed in Chapter 3. The findings in Chapter 3[203] are consistent with this save that I do not accept that there has to be "no possibility" of a rise above FSL before the flood event can end. In his February 2015 Report, Dr Christensen stated that the eight-day high range forecast should be used to determine how far below FSL the water levels need to be to end flood operations.[204] This aspect of Dr Christensen's methodology, which only affects Simulation A and J, is addressed in Chapter 10.[205]

61 In relation to the fourth step, Dr Christensen stated that the flood engineer must re-evaluate their operational and release strategy "at least once every day when the engineer receives new rainfall and streamflow forecasts and that re-evaluation itself takes account of the uncertainty of forecasts by adjusting the strategy and the decisions each day as new information becomes available".[206] Otherwise Dr Christensen advocated a constant monitoring of the flood event, including the undertaking of "intermediate [RTFM] runs to update the flood operations spreadsheets" especially when

[200] Ibid at [228].
[201] Section 9.7.
[202] Reply Report, EXP.ROD.004.0005 at [237].
[203] Chapter 3 at [140].
[204] February 2015 Report, EXP.ROD.001.0016 at [470].
[205] Chapter 10 at [193].
[206] Reply Report, EXP.ROD.004.0005 at [238].

"actual rainfall and runoff deviated significantly from the rainfall amounts and [the] timing [that was modelled]".[207]

8.3: Methodology – Upstream Forecasts

62 In Chapter 2, there is outlined the evidence concerning the rainfall forecast products available during the January 2011 Flood Event.[208] Dr Christensen accepted that the one-day QPF forecasts were the most accurate and, in general, the accuracy of the forecasts decreased relative to the length of the forecast period. Nevertheless, he assessed the forecasts for periods of up to five days as being "of particularly good quality for dam operations". Dr Christensen further stated that forecasts for periods of "7 to 10 days are reasonably accurate for use under the principle that flood operations must err on the side of caution" and have a greater degree of accuracy and reliability for high rainfall events resulting from "large scale features" such as "decaying tropical cyclones".[209] This evidence is addressed in section 9.2 of Chapter 9.

63 Chapter 3 refers to the concept of "best forecast rainfall" as used in the Manual.[210] Based on both the Manual and the FPM, Dr Christensen concluded that a reasonably competent flood operations engineer would have determined that a consideration of "best forecast rainfall" meant "consideration of all forecasts because … all available forecasts are needed to estimate how much runoff there is likely to be and whether Wivenhoe Reservoir is 'likely' to rise above the key operational thresholds".[211]

64 Even though he accepted the one-day QPF forecast was the most reliable, Dr Christensen considered that they could not qualify as "best rainfall forecasts" when the "2-day, 3-day, 4-day or 8-[day] forecasts show the reservoirs are likely to fill".[212] Dr Christensen noted that the travel times of rain falling in the catchments above the dam and then arriving at the dams necessitated the

[207] Supplemental Report at [143] to [144].
[208] Chapter 2; section 2.10.
[209] February 2015 Report, EXP.ROD.001.0016 at [126].
[210] Chapter 3; section 3.3.5.
[211] February 2015 Report, EXP.ROD.001.0016 at [215], [302]; Reply Report, EXP.ROD.004.0005 at [53].
[212] February 2015 Report, EXP.ROD.001.0016 at [215].

use of four-day and eight-day forecasts “to determine total upstream inflow volumes … so that the [flood] engineer has sufficient time to plan and implement operational releases if necessary to plan flood storage”.[213]

65 As noted, in selecting strategy under the Manual, Dr Christensen determined an inflow volume based on the average rainfall predicted by the eight-day PME forecast[214] cumulated with a rain on the ground assessment.[215] In his Reply Report, Dr Christensen justified that choice by explaining that he interpreted the Manual’s description of “maximum storage levels” as a reference to the “maximum storage level during the entire anticipated flood event”. He stated that this figure cannot be determined “based on rain on the ground or a 24-hour forecast as that forecast period does not provide sufficient foresight of the potential magnitude of the event”.[216] He noted the Manual’s warning that two or more closely spaced flood producing storms can occur in the Brisbane River within a “short time of each other” and therefore the aim during a flood event “should be to empty stored floodwaters within *seven days* after the flood peak has passed” (although with a “very large flood” that may not be achievable given downstream conditions).[217]

66 In cross-examination, Dr Christensen explained the connection between the seven-day draindown period and the selection of the eight-day forecast. He noted that the Manual specifies a criteria that “whatever you store in flood storage needs to be drained down in seven days” such that it is necessary to have “forecasts that are at least up to seven days so that you can evaluate the ability to drain down and whether you're going to have additional rainfall that is going to interfere with and preclude or cause change in your drain down”.[218] He said that as a seven-day forecast was not available an eight-day forecast was selected.[219] In fact, the draindown period lasts for seven days

[213] Reply Report, EXP.ROD.004.0005 at [71] and [100].
[214] Dr Christensen first identified the use of eight-day forecasts for that purpose in his February 2015 Report, EXP.ROD.001.0016 at [464(4)].
[215] Reply Report, EXP.ROD.004.0005 at [208].
[216] Ibid at [207].
[217] Manual at 10; Ibid at [207(c)].
[218] T 1946.21.
[219] T 1948.1. - .8.

measured from the peak of the flood event (ie, not necessarily any given time) but that does not appear to affect Dr Christensen's rationale.

8.4: Methodology – Derivation of Inflows

67 The application of Dr Christensen's primary methodology requires the utilisation of the eight-day PME forecasts to derive an inflow volume to the dams for the purpose of making predictions of lake levels to select a strategy, and then the use of four-day PME forecasts to calculate a target volume and then determining a release rate. (As noted, the target level approach of determining releases was not used in every day of Simulations A, E and I and was not used in other simulations.)[220]

68 In preparing his February 2015 report, Dr Christensen encountered technical difficulties in using the RTFM to calculate inflow volumes from forecasts. To determine inflow volumes from the rainfall forecasts he used a manual method known as the "curve method" and cross-checked the results using another manual method known as the "straight line method", both of which are described below.[221] Dr Christensen used the RTFM in his Supplemental Report but later accepted the continuing loss rates he used were too low as he was not aware of a feature of the RTFM that automatically approximated changing conditions in the Brisbane River catchment.[222] This was addressed in his Reply Report. In that report, Dr Christensen explained that he utilised the RTFM but indicated that the curve method and straight line method were used "in order to check whether the curve numbers and runoff percentages indicated by the loss rates …selected [or used in the RTFM] were within a reasonable range".[223] In his Response Report, Dr Christensen corrected certain errors in the simulations set out in the Reply Report and added further simulations.[224]

[220] Save for one day of SIM C: see Chapter 10 at [107].
[221] Response Report, EXP.ROD.015.0005 at [32] and below at [83] to [91].
[222] Reply Report, EXP.ROD.004.0005 at [248].
[223] Response Report, EXP.ROD.015.0005 at [34]; Reply Report at [264] to [268].
[224] See *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 9)* [2017] NSWSC 1116 at [34].

69 For each day of his simulated operations, Dr Christensen generated a no rain RTFM run, a RTFM run using the four-day average forecast, a RTFM run using the eight-day average forecast and a RTFM run using the eight-day high range forecast. Dr Christensen also generated two runs for each 24-hour period utilising the most recently published QPF forecast.[225] The input parameters for each run were specified in appendices to Dr Christensen's Response Report[226] and the spreadsheets produced were tendered.[227] To calculate the total inflow volumes, Dr Christensen imported the hydrographs produced by these runs into a gate operations spreadsheet, totalled the hourly volumes up to 19 January 2011 and then added the no rain inflow volume to the four-day inflow volume or eight-day inflow volume as was required.[228] The rain on the ground and four and eight-day forecast rain components were prepared separately as different loss rates were used.

70 There were three relevant input parameters for each of the RTFM runs, namely rainfall depth, temporal patterns and loss rates. Each will be addressed in turn.

Rainfall Depths

71 For each RTFM run Dr Christensen was required to select a rainfall depth for each of the sub-catchments above the dam. For the no rain runs the rainfall depth was zero.[229] For the 24-hour run the high range of the relevant QPF forecast was uniformly applied to all sub-catchments.[230] For most of the four-day average and eight-day average RTFM runs different rainfall depths were selected for each sub-catchment.[231] Dr Christensen explained that the average of the inputs was the same as what he interpreted to be the average of the four-day or eight-day PME forecast for the catchment area above the

[225] Response Report, EXP.ROD.015.0005 at [257(1)].
[226] Ibid at .0157 to .0158 and .0222.
[227] See for example MSC.010.058.0001.
[228] Response Report, EXP.ROD.015.0005 at [257(5)] to [257(7)].
[229] See for example, Response Report, EXP.ROD.015.0005 at .0210.
[230] See for example, Response Report, EXP.ROD.015.0005 at .0247; the Appendix A runs also used the high range of the QPF forecast: see Chapter 6 at [24].
[231] See for example, Response Report at .0182.

dam[232] and that more rainfall was distributed into WDI and SDI sub-catchments "because they are adjacent to mountainous areas and they are closest to the coast" and that the "PME forecasts showed that the rainfall forecasts was heaviest closest to the coast".[233] This approach is further addressed in Chapter 9.

Temporal Pattern

72 For each of the forecast runs[234] it was necessary to select a temporal pattern for the projected rainfall over the relevant period. Apparently, the RTFM allows for both user defined temporal patterns and standard temporal patterns. However, Dr Christensen was unable to utilise the user defined patterns and he resorted to standard rainfall patterns.[235] Dr Christensen explained that, in selecting a temporal pattern, he was "primarily concerned with selecting a pattern [of rainfall timing] that when combined with [his] selected loss rates, would produce a runoff volume at least consistent with the percentage derived from the [L]ate December [Flood] [E]vent".[236] Thus, he explained that the "rainfall pattern selected was … incidental because the loss rates were adjusted".[237]

73 For the 24-hour forecast runs, Dr Christensen utilised the same temporal pattern used in the Appendix A with forecast runs (being the ARI.1-30).[238]

Loss Rates – No Rain and 24 Hour Run

74 The third parameter was the selected loss rates. In describing them it is necessary to differentiate between the no rain and 24-hour QPF runs on the one hand and the four-day and eight-day runs on the other. Appendix D to this judgment sets out a table comparing the initial and continuing loss rates used by the flood engineers and the corresponding loss rates used by Dr

[232] T 1428.42 (Christensen).
[233] See for example, Response Report, EXP.ROD.015.0005 at .0182 and .0195.
[234] Ie, the four-day average, the eight-day average and the eight-day high.
[235] Supplemental Report at [52] (similar to those described in Chapter 6 at [275]).
[236] Response Report, EXP.ROD.015.0005 at .0200 and at .0248.
[237] Id.
[238] EXP.QLD.001.0813 at .0834; EXP.ROD.015.0005 at .0225.

Christensen for both his rain on the ground and 24-hour rainfall forecast on the one hand and his four and eight-day forecast modelling on the other.

75 In relation to the no rain and 24-hour QPF runs, it is necessary to note the initial and continuing loss rates used by the flood engineers for their rain on the ground modelling during the January 2011 Flood Event from 6 January 2011 onwards. Their initial loss rates altered but their continuing loss rates did not change much. On 6 January 2011, all of the continuing loss rates for the sub-catchments above the dam used by the flood engineers were set at 2.5mm per hour.[239] By midnight on 8 January 2011, they had all been reduced to .5mm an hour, except for WDI and CRE which remained at 2.5mm an hour.[240] Those rates were applied for the balance of the January 2011 Flood Event.[241]

76 In selecting his initial loss rates for the no rain and 24-hour QPF runs, Dr Christensen agreed that the initial loss figures utilised by the flood engineers from 6 January 2011 were reasonable. He utilised those initial loss rates for all no rain and 24-hour QPF runs undertaken for the period 5 January 2011 onwards.[242] As the flood engineers did not undertake RTFM runs during the period 2 to 5 January 2011, Dr Christensen applied the 6 January 2011 initial loss rates to runs undertaken for 5 January 2011. He applied zero as the initial loss for each of 2, 3 and 4 January 2011 on the basis that, given the state of the catchment, initial losses had been satisfied during the Late December Flood Event.[243]

77 In relation to continuing losses for the no rain and 24-hour QPF runs, by the time of his Reply Report Dr Christensen agreed that the continuing loss rates applied by the flood engineers from midnight on 8 January 2011 onwards were reasonable, save for CRE and WDI which he contended should have

[239] Reply Report, EXP.ROD.004.0005 at .0077.
[240] Id; see Chapter 6 at [299] to [319]; Appendix D to this judgment.
[241] Reply Report, EXP.ROD.004.0005 at .0077.
[242] Ibid at [254] and Table 3 at .0076.
[243] Ibid at [255] to [257].

been set at 0.8mm per hour. Dr Christensen applied those same continuing loss rates to no rain and 24-hour modelling undertaken from 2 January 2011.

78 Dr Christensen justified reducing the 2.5mm continuing loss rate used by the flood engineers in their modelling for all sub-catchments from 6 January 2011 (and in WDI and CRE from 8 January 2011), on the basis that a reasonably competent flood engineer would have used loss rates "similar to those indicated by the Late December [Flood] Event" as only a few days had passed between the end of that event and 2 January 2011.[244]

79 The 2010 FER indicated that the "adopted" continuing loss rates for each of the sub-catchments above the dam during the Late December Flood Event were 0.8mm/hr for CRE, 0.3mm/h for COO, 0.3mm/hr for Lin, 0.3mm/hr for EMU, 1.5mm/hr for GRE, 0.3mm/hr for SDI and 0.8mm/hr for WDI.[245] Dr Christensen described those as the "average" rates but noted that a no rain run "on the server computer" dated 29 December 2011 used lower continuing loss rates, namely 0.75mm/hr, 0mm/hr, 0mm/hr, 0.3mm/hr, 1.5mm/hr, 0.25mm/hr and 0.75mm/hr for the same catchments respectively.[246]

80 Dr Christensen accepted that, as there was "little to no rain" between 29 December 2011 and 2 January 2011, there would have been "some drying out" by 2 January 2011 which would justify a "slight increase" in the continuing loss rates used for the Late December Flood Event for some of the sub-catchments. Based on those adopted rates Dr Christensen concluded it would be appropriate to increase those adopted rates used during the Late December Flood Event from 0.3mm/hr for each of COO, LIN, EMU and SDI to 0.5mm/hr for the period commencing 2 January 2011 and there was no reason to select a different rate for GRE.[247]

81 Given the short period of drying out, Dr Christensen concluded that there was no justification for the flood engineers to increase the continuing loss rates for

[244] Reply Report, EXP.ROD.004.0005 at [260].
[245] 2010 FER, ROD.650.003.6506 at .6621; Supplemental Report at [86].
[246] Supplemental Report at [87].
[247] Reply Report, EXP.ROD.004.0005 at [260] to [262].

WDI and CRE from .8 to 2.5mm per hour when they commenced modelling on 6 January 2011.[248]

82 The defendants' criticisms of Dr Christensen's assessment of the rain on the ground loss rates is addressed in Chapter 9.[249]

Future Loss Rates – Straight Line Method and Curve Method

83 To explain how Dr Christensen derived the loss rates for projected rainfall over four and eight-day periods it is necessary to describe the straight line method and curve method referred to above.

84 Under the straight line method, Dr Christensen "computed runoff volume from the amount of runoff inflow volume into Wivenhoe Dam per [mm] of rainfall".[250] This method simply determines a simple percentage of runoff to rain[251] bearing in mind that if rain falls directly onto a dam or lake that percentage will be 100%. A percentage of the amount of runoff from an earlier flood event in the same catchment can then be used to inform an assessment of the likely percentage of runoff that would be yielded from future rainfall of a given depth. The principal difficulty with the straight line method is that it assumes a linear relationship between rain and runoff when hydrological studies suggest the relationship is non-linear; ie, the response curve depicted in Figure 2-7 in Chapter 2. The result is that the method yields higher estimates of runoff from lower amounts of rainfall than that suggested by the runoff response curve and lower estimates from higher amounts than that suggested by the aforementioned curve. Nevertheless, Dr Christensen stated that it can yield a reasonably accurate runoff estimate for future rainfall of the same or similar depth to that which yielded the percentage of runoff for past rainfall. It can also be used to estimate the low range of runoff from high

[248] Reply Report, EXP.ROD.004.0005 at [260] to [262].
[249] Section 9.5.
[250] February 2015 Report, EXP.ROD.001.0016 at [394].
[251] Reply Report, EXP.ROD.004.0005 at [267].

amounts of rainfall and the high range of runoff from low amounts of rainfall, as well as being used as a check on other results.[252]

85 Dr Christensen stated that the “Curve Number Method is a widely used and accepted precipitation runoff computational method or model originally developed and adopted for use by the United States Soil Conservation Service”. He stated that for “over 40 years since, the method has had extensive evaluation and successful use in the United States and worldwide”.[253] There was a substantial dispute as to its suitability for estimating runoff for a catchment the size of that above Wivenhoe Dam, an issue that is addressed in Chapter 9.[254]

86 At the heart of the curve method are two related equations that compute the depth of rainfall in inches (Q) that can be expected to become runoff from a given rainfall or precipitation depth (P), namely:

$Q = (P - 0.2S)^2/(P + 0.8S)$ where $S = (1000 – 10)/CN$ and CN = the Curve Number

87 Dr Christensen described the curve number as representing “the overall runoff producing characteristics of a catchment in a number that ranges between 1 and 100”.[255] A curve number of 1 describes a catchment that does not produce any runoff and a curve number of 100 describes a catchment that will produce 100 percent runoff. As Q is the runoff depth (in inches) it can be converted to a volume by converting it to mm (by multiplying it by 25.4) and multiplying that number by the area of the catchment (which in this case is $7020km^2$).

88 The curve number for a given catchment can be determined by calculating backwards from a past event where it was known what the depth of rainfall received was and the volume of runoff produced; ie, P and Q are substituted

[252] February 2015 Report, EXP.ROD.001.0016 at [396].
[253] Ibid at [397].
[254] Section 9.3.
[255] February 2015 Report, EXP.ROD.001.0016 at [398].

into the above formula, S is calculated and then CN is determined. For projected rainfall of a given depth (ie, a new P) Q can be calculated and consequently the projected inflow volume.[256]

89 Dr Christensen described the curve method as "curvilinear so it yields better runoff estimates for rainfalls higher and lower than the calibration rainfall than does the straight-line method".[257]

90 Dr Christensen's application of the curve method and the straight line method to either predict or verify a prediction of future inflow volumes requires a comparison with an earlier flood event either in the relevant catchment or somewhere else. In this case, Dr Christensen determined "that the best evidence of the likely hydrological performance of the catchment in January 2011 would be provided by the hydrological performance of the catchment in the recent late-December 2010 event".[258] He concluded that from the early to late December flood events there was a "clear progression …, whereby the proportion of runoff received from rainfall was steadily increasing". He concluded that a reasonably competent flood operations engineer "would have considered that the catchment would produce runoff, at least consistent with the late-December 2010 event, during any significant rainfall event occurring a few days later in January 2011".[259]

91 To that end, Dr Christensen prepared the following table providing rainfall depths, runoff volumes and curve numbers for the four flood events between October 2010 and the end of 2010:[260]

[256] February 2015 Report, EXP.ROD.001.0016 at [398] to [401].
[257] Ibid at [397].
[258] Response Report, EXP.ROD.015.0005 at [36].
[259] Id.
[260] February 2015 Report, EXP.ROD.001.0016 at [402].

	Rainfall (mm)	Runoff (ML)	Straight-line (ML/mm)	Curve Number
October 2010 Flood Event	138	628,000	4550.7 (64.8%)[261]	83
Early December 2010 Flood Event	122	127,000	1041.0 (14.8%)[262]	52
Mid December 2010 Flood Event	79	390,000	4936.7 (70%)[263]	91
Late December 2010 Flood Event	85	513,000	6035.3 (86%)[264]	96

Table 8-1: Straight Line Percentages and Curve Numbers for the 2010 Flood Events

The calculated percentages in brackets represent the proportion of runoff to rainfall.

Loss Rates – Four-Day and Eight-Day Forecasts

92 Dr Christensen stated that it was "not possible" to use the flood engineers' loss rates that were utilised for rain on the ground modelling for the four-day and eight-day forecast runs because "if the selected rainfall distribution pattern in the RTFM has rain falling throughout the forecast period and the same loss rate is used as was applied to the rain on the ground run", large and "unrealistic" amounts will be modelled as absorbed by the catchment.[265] This is the same phenomenon discussed in Chapter 6,[266] namely the consequence of applying loss rates calibrated to past episodes of spasmodic rainfall to future projections by the RTFM of continuous rainfall. In cross-examination, Dr Christensen explained it in those terms.[267] In his Reply Report, Dr Christensen gave two examples of RTFM runs he conducted applying the flood engineers' loss rates to eight-day PME forecasts. He stated that his modelling 143mm of rain on 6 January 2011 and 200mm of

[261] Percentage has been calculated = 628000/138 x 7020.
[262] Percentage has been calculated = 127000/122 x 7020.
[263] Percentage has been calculated = 390000/79 x 7020.
[264] Percentage has been calculated = 513000/85 x 7020.
[265] Reply Report, EXP.ROD.004.0005 at [249] to [252].
[266] Chapter 6 at [299] to [319].
[267] T 2399.41 and T 2401.23.

rain on 8 January 2011 using those rates yielded runoff percentages of only 14% and 41% from the rainfall respectively.[268] He described these as "severe" under-predictions.[269]

93 Instead of using the flood engineers' loss rates, Dr Christensen stated that he used an iterative process that was premised on his assessment that, given the progression of rainfall over December 2010, the catchment would produce runoff consistent with the Late December Flood Event.[270] Next, Dr Christensen noted that the Late December Flood Event produced 513,000ML runoff from an average rainfall of 85mm which yielded a percentage of runoff to rain of 86%[271] and a curve number of 95.85 (rounded to 96). Dr Christensen concluded that, if the rainfall being modelled was 85mm, then he would expect 86% to be converted to runoff but if there was lower rainfall a lower percentage would be expected and if higher rainfall then a higher percentage would be expected.[272] The amount of difference could be determined by utilising the curve method based on the curve number of 96 for the Late December Flood Event.[273]

94 Dr Christensen's iterative method involved him considering each day of the January 2011 Flood Event and assessing whether there was any reason to adjust the loss rate for projected rainfall from the previous day. He compared the runoff produced using the loss rate that he selected to that which would be expected from the equivalent rainfall had it fallen during the Late December Flood Event by using the curve number of 96.[274] Dr Christensen stated that, if the application of the selected loss rates yielded runoff that was "reasonably similar" to that which would have been produced by the Late December Flood Event, then he would be satisfied with the selected loss rates, but if not he would adjust the loss rates and repeat the process until the result was

268 Reply Report at [250] to [251].
269 Id.
270 Response Report, EXP.ROD.015.0005 at [152(1)].
271 Ibid at [152(2)(a)], [64].
272 Ibid at [152(2)(b)].
273 Ibid at [152(2)(c) to (e)].
274 Ibid at [152(4)].

"satisfactory".[275] The initial and continuing loss rates yielded by this process are set out in a table in Dr Christensen's Reply Report.[276]

95 In his Response Report, Dr Christensen set out his reasoning for the selection of loss rates for the conduct of four-day and eight-day RTFM runs on each day from 2 January 2011 to 12 January 2011.[277] The outcome of this analysis can be considered by reference to the following table:[278]

	2 Jan	**3 Jan**	**4 Jan**	**5 Jan**	**6 Jan**	**7 Jan**	**8 Jan**	**9 Jan**	**10 Jan**	**11 Jan**	**12 Jan**	**Avg. Overall**
Rain (mm) [279]	20[280]	113 [281]	119.3 [282]	125 [283]	142.85[284]	136.4 [285]	200[286]	200.7 [287]	147.1 [288]	75.7 [289]	38 [290]	
CN96 runoff predict	55%	89%	90%	90%	91%	91%	94%	94%	91%	84%	72 %	
CN	94	90	92	93	93	94	94	94	95	97	92	89
Runoff %	44% [291]	81%	81%	84%	88%	88%	91%	91%	90%	89%	56 %	91%

Table 8-2: Dr Christensen's Curve Numbers for each day of the January 2011 Flood Event

96 The first row of the table constitutes the average depth of forecast rain for an eight-day period that Dr Christensen modelled for each day (ie, the eight-day average PME). The second row constitutes the percentage of runoff that a curve number of 96 calculates would be yielded by that depth of rainfall. The

[275] Response Report, EXP.ROD.015.0005 at [152(5)].
[276] Reply Report at .0076 to .0077.
[277] Response Report, EXP.ROD.015.0005 at .0052 to .0068.
[278] Compiled from Table 4 in Reply Report, EXP.ROD.004.0005 at .0080.
[279] ie, 8-day average forecast based on PME assessment.
[280] Response Report, EXP.ROD.015.0005 at [156].
[281] Ibid at [167].
[282] Ibid at [175].
[283] Ibid at [185].
[284] Ibid at [192].
[285] Ibid at [200].
[286] Ibid at [209].
[287] Ibid at [218].
[288] Ibid at [226].
[289] Ibid at [235].
[290] Ibid at [244].
[291] Corrected from 53%: T 2356.8 (Christensen).

third row is the curve number that is determined by applying the volume of runoff that is yielded by Dr Christensen's RTFM modelling of the rainfall depths in the first row using the loss rates he selected. The fourth row is the percentage of runoff that is yielded by Dr Christensen's RTFM modelling of the eight-day rainfall depths in the first row using the loss rates he selected.[292] With the exception of 11 January 2011, the percentages in the fourth row are less than those in the second row. On those days, Dr Christensen's selected loss rates yielded a lower runoff response than that yielded by the catchments above the dam in the Late December Flood Event notwithstanding the generally greater amounts of rain modelled compared to that which fell. The exception is 11 January 2011 which Dr Christensen justified on the basis that the difference in runoff volumes was not large and the amount of rain that had fallen in the catchments by this time far exceeded that which fell during the Late December Flood Event and thus suggested a higher curve number was warranted.[293] Given that a significant amount of rain above the dams fell directly onto Lake Wivenhoe on 11 January 2011,[294] and subject to the discussion in Chapter 9, that approach at least appears to be justified. The last column is a post-event (ie, hindsight) curve number that Dr Christensen calculated by reference to rain that fell from 9.00am on 6 January 2011.[295]

97 As noted, the defendants' criticism of Dr Christensen's forecast loss rates are addressed in Chapter 9.[296]

Combining Hydrographs

98 After Dr Christensen completed the rain on the ground and forecast RTFM runs for each day, he added their hydrographs to "determine predicted inflow over the forecast period".[297] This was the subject of criticism by Mr Giles who pointed out that the RTFM runoff routing model is based on a non-linear

[292] Mr Giles sets out the % runoff for four-day modelling in Table 3-3 in his July 2018 report: EXP.QLD.002.0040 at .0061; see Table 9-4; Chapter 9 at [192].
[293] Response Report, EXP.ROD.015.0005 at [237].
[294] Chapter 7; Table 7-3 at [374].
[295] EXP.ROD.015.005 at [117] to [123].
[296] Section 9.3.
[297] Reply Report, EXP.ROD.004.0005 at [269].

relationship between the storage within a catchment and the flow rate,[298] such that the addition of the two hydrographs will lead to a different result for the magnitude and timing of the inflows at any given point compared to one hydrograph.[299] Seqwater took up this criticism.[300]

99 Four matters should be noted. First, the RTFM does not provide the facility for modelling based on two different sets of loss rates, one set for rain on the ground and the other set for forecast rain.[301] Second, at least with the example addressed by Mr Giles, the effect of this is relatively modest, being a difference of around 13% at the trough of the hydrograph and much less at the peak.[302] Third, this limitation on the RTFM makes no difference upon the assessment of total inflow volumes, which is the predominant reason that Dr Christensen undertook the assessment of loss rates in the first place.[303] Fourth, its effect upon the analysis of predicted peak inflow rates is addressed in Chapters 9 and 10.

8.5: Methodology – Monitoring Downstream Conditions

100 As noted, Dr Christensen's explanation of his primary methodology states that one of the critical integers that informs the setting of a release rate is an assessment of downstream conditions. Dr Christensen explained that the release rate in Strategies W1 to W4 and any draindown sequence was informed by the one-day forecast concerning the flows at Lowood and Moggill over the subsequent 24 to 48-hour period.[304] He said that this would be undertaken to provide protection of urban areas from inundation and to take into account the need to minimise the risk of the inundation of downstream bridges.[305]

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298 EXP.QLD.001.0611 at .0664, [760].
299 T 8801.26 (Giles).
300 Seqwater subs at [2108].
301 T 8775.5, T 8801.20 (Giles).
302 T 8804.41 to T88805.5; EXP.QLD.001.0611 at .0665, Figure 4-2.
303 T 8801.29 (Giles).
304 Reply Report, EXP.ROD.004.0005 at [231].
305 Ibid at [232].

101 In his Reply Report, Dr Christensen explained that the selection of the 24-hour forecast of downstream flows was made by considering the time taken for releases from the dams to reach points of significance downstream.[306] The Manual refers to an assessment of peak flow rates downstream (at Lowood and Moggill) using the "best forecast rainfall and stream flow information".[307]

102 The general upstream travel times for inflows into Wivenhoe Dam are set out in Chapter 2.[308] The approximate flow time downstream from Wivenhoe Dam to Lowood, Moggill and Moreton Bay are described in Chapter 3 but relevantly include a flow time of 16 hours to Moggill and a further ten hours to the city gauge.[309] To that end, Dr Christensen prepared the following map of the Brisbane River basin:[310]

Figure 8-1: Catchment areas determined by reference to flow times to Moggill

[306] Reply Report, EXP.ROD.004.0005 at [231] to [232].
[307] Manual at 23.
[308] See Figure 2-6; Chapter 2; SUN.001.007.0088.
[309] SUN.001.007.0085.
[310] Reply Report, EXP.ROD.004.0005 at .0024.

103 The purple area represents the catchment area above Wivenhoe dam, being 7008km^2 (or just under 52% of the total basin). All rain falling in this area would take longer than 16 hours to arrive at Moggill. The brown area consists of the catchment area below the dam where water entering a watercourse would take more than 16 hours to arrive at Moggill.[311] It represents 3852km^2 or 28.43% of the total basin. The purple area consists of the catchment area below the dam where water entering a watercourse would take less than 16 hours to arrive at Moggill. It represents 1761km^2 or 13% of the total basin. The green area is the catchment area downstream of Moggill. It comprises 927km^2 or 6.84% of the total basin.[312]

104 A number of the defendants' experts pointed to the risk of exacerbating downstream flooding if releases were made based on rainfall forecasts in the event where the forecast rain fell downstream rather than upstream.[313] Dr Christensen responded by pointing to the above map and the fact that only 13% of the entire Brisbane River watershed area has a travel time of 16 hours or less to Moggill, with that figure reduced if account is taken of the time it takes for rain to travel from the place it has fallen into a watercourse.[314]

105 Dr Christensen stated:[315]

> "These downstream travel times mean that there is an opportunity for the engineer to respond by reducing or if possible, ceasing releases, if the rain falls downstream of the dam rather than upstream as anticipated. To put it differently, if the rain falls downstream and the releases from Wivenhoe Dam at the time would cause Lowood or Moggill to exceed their target maximum flows of 3,500 m³/s and 4,000 m³/s respectively, then the engineer would have to take measures to reduce or if possible, cease releases from Wivenhoe Dam in order to avoid exacerbating the flooding downstream. This would involve taking gate closure action at Wivenhoe Dam to stem releases. How quickly the radial gates at Wivenhoe Dam can be closed depends on the rate of releases from Wivenhoe Dam at the time. If it is necessary to reduce or cease releases very quickly, the engineer can implement rapid gate closure procedures."

311 Mr Pokarier agreed it was a "fair description" of that area: T 6928.38.
312 Reply Report, EXP.ROD.004.0005 at [57].
313 EXP.QLD.001.0232 at [16], [18], [44(d)], [102], [243], [252].
314 Reply Report, EXP.ROD.004.0005 at [64]; T 6929.10 (Pokarier).
315 Reply Report, EXP.ROD.004.0005 at [65].

106 Dr Christensen noted that the probability estimates that accompanied the PME forecasts issued throughout the January 2011 Flood Event indicated that over the ensuing 24 hours after releases were made “there was only a small probability of any one day rainfall above 50mm that could cause Lowood and Moggill to rise above 3,500m^3/s and 4000m^3/s”.[316] He noted that it took around three days for the downstream flows without Wivenhoe releases to build up to a level that exceeded 4000m^3/s, which provided time to reduce releases from Wivenhoe Dam if that was possible.[317]

107 Dr Christensen later explained the significance of using a 24-hour forecast in monitoring downstream flows to this analysis compared to using a four-day and eight-day forecast upstream:[318]

> “Given the travel time from Wivenhoe Dam to Moggill is 16 hours, the engineer would be concerned to know what the flows at Lowood and Moggill will be within the next 24 hours or so which is within the approximate time that the releases from Wivenhoe Dam will reach those downstream [gauges] so that the engineer can know whether his/her release is going to cause downstream flooding. When considering the conditions downstream, the engineer is not concerned about preserving flood storage downstream, but is only concerned about not exceeding target flows at Lowood and Moggill. Moreover, it is not reasonably possible to predict hourly downstream flows using 4-day and 8-day forecasts because the hourly timing and distribution of the forecasts would not be reliable. The engineer would only use 4-day and 8-day forecasts on areas downstream to evaluate whether it would be better to release more reservoir volume earlier or later.”

108 As noted, Dr Christensen contrasted this approach with the necessity of using four-day and eight-day forecasts upstream because this enabled the engineer “sufficient time to plan and implement operational releases if necessary to preserve flood storage”.[319]

109 In conducting his simulations, Dr Christensen monitored downstream flows by using the without release predicted flows for Lowood and Moggill derived from the flood engineers’ Appendix A “with forecast” runs.[320] Their preparation was

[316] Ibid at [67].
[317] Id.
[318] Reply Report, EXP.ROD.004.0005 at [71].
[319] Id.
[320] Response Report, EXP.ROD.015.0005 at [257(4)].

described in Chapter 6.[321] It suffices to state that they effectively apply the upper bound of the above dam QPF forecast to the catchments below the dam.

110 Hence Dr Christensen's approach addresses the risk that the rain may fall downstream and combine with existing releases on two levels. First, he set his current release rate by accommodating the estimate of downstream flows produced by a 24-hour forecast which uses a relatively high estimate of forecast rain for that period. Second, via step 4 of his method, Dr Christensen monitors downstream rainfall with a view to being able to reduce releases should downstream rainfall sufficient to occasion damaging flows materialise. Depending on the rate of current releases (and dam storage levels), releases can be reduced or potentially ceased should downstream flooding materialise. Even with high releases, the Manual permits rapid gate closure if necessary "to reduce downstream flooding".[322]

111 Two potential areas of risk in terms of damaging downstream flows remain. The first is that the water which has been released will combine with rainfall that falls within the 16-hour area noted in the above diagram. The second risk is that runoff from the catchment area beyond Moggill that reaches the Brisbane River in a time between 16 hours and 26 hours after the current releases are made (26 hours being the travel time to the city gauge) will combine with those releases to cause damaging flows.

112 However, in each such case the scope of this risk is defined by the relatively small area of downstream catchment that it pertains to (ie, the blue area and the green area) bearing in mind that with the first risk the rain that falls must accumulate in a watercourse in 16 hours. Further, for either of these risks to materialise, the amount of runoff that accumulates must be caused by a depth of rainfall that was sufficiently in excess of what was forecast so as to cause damaging downstream flows when it combined with existing releases,[323] a

[321] Chapter 6 at [24].
[322] Manual at 33.
[323] See Chapter 7 at [121] to [122].

matter which the probability of exceedance figures in the PME forecasts can assist in addressing.[324]

113 Two further matters should be noted.

114 First, it must be remembered that these risks pertain with all releases from Wivenhoe Dam regardless of whether they were occasioned by a consideration of forecast rainfall above the dam or only rain on the ground.[325] As explained in Chapters 6 and 7, throughout the January 2011 Flood Event until around midnight on 10 January 2011, the flood engineers were able to monitor downstream flows such that existing releases did not combine with downstream flows to inundate bridges. In the end result, they were forced to make releases on 11 January 2011 that did combine with downstream flows to cause urban flooding downstream.

115 Second, this analysis of risk is very much a product of the geography of the basin, the size of the dam, the available forecast products and the nature of the weather. As a counter-example, consider a dam with two or three times the storage of Wivenhoe Dam with upstream catchments that took a number of days to transport rain from a watercourse to the dam. If the dam was located say three days' flow time above a city and a very large proportion of the downstream catchment area was located within that three-day envelope then, depending on other factors, the justification for making releases based on forecast rain upstream would likely be much diminished. In that example, the potential for such releases to combine with rain forecast to fall upstream that falls downstream and causes damage would be that much greater.

116 These were some criticisms of Dr Christensen's approach to monitoring downstream flows. They are addressed in Chapter 9.[326]

[324] EXP.ROD.004.0005 at [67].
[325] T 8421.28.
[326] Section 9.10.

8.6: Methodology – Somerset Dam Operations

117 In his reports, Dr Christensen outlined his approach to Somerset Dam Strategies S2 and S3.

Strategy S2 and the Operating Target Line

118 In considering so much of the Manual that refers to the Operating Target Line, it is necessary to recall that it forms part of Strategy S2 and that the Manual states that the overall "intent" of Strategy S2 "is to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of the dam".[327]

119 As discussed in Chapter 3, one of the four "action" boxes in Strategy S2 specifies that the Operating Target Line is to "generally be followed".[328] In discussing the target line, the Manual refers to a "target point at any point in time" which is based "on the maximum storage levels in Wivenhoe and Somerset Dams using the best forecast rainfall and stream flow information at the time".[329] Leaving aside the position when the Somerset Dam crest gates are closed, Dr Christensen stated that the target point was chosen by firstly utilising an eight-day PME forecast with a no release assumption.[330] Such an exercise will produce a predicted maximum height for Wivenhoe Dam and for Somerset Dam, but it is unlikely that those two heights will coincide with a point on the target line that corresponds to both heights.[331] Leaving aside S3 operations, Dr Christensen stated that the selection of the "target point" would depend on the current state of both dams. If the current state of the dams is that the duty point, ie, current point, is below the target line, then the target point would be the point on the line that is vertically above the *forecast height* of Somerset Dam[332] (and not the current height which was the flood engineers' approach on 10 January 2011). For example, if the current height of Wivenhoe Dam was EL 68.0m AHD and Somerset Dam was EL 102.00m

[327] Manual at 40.
[328] Manual at 40.
[329] Ibid at 42.
[330] T 1792.12.
[331] T 1797.11.
[332] T 1797.17.

AHD and the projected maximum heights based on forecasts was EL 71.0m AHD for Wivenhoe Dam and EL 103.00m AHD for Somerset Dam then the target point would be the point on the line that corresponds to a height of EL 103.00m AHD for Somerset, namely EL 72.75m AHD for Wivenhoe Dam.

120 In cross-examination, Dr Christensen modified this approach to account for the risk of overtopping. He gave an example in which the no release rise for Wivenhoe Dam was EL 74.73m AHD and the no release rise for Somerset Dam was EL 108.04m AHD.[333] That point is below the Operating Target Line and if a line was drawn vertically upwards from that point upwards to the operating target line it would yield a point that corresponds to EL 78m AHD for Wivenhoe Dam. Dr Christensen stated that, in this example, in selecting a target point one would move further down the line to the point (EL 77.5m AHD; EL 107.46m AHD) as that corresponds to the overtopping level for Somerset Dam which is a point to be "avoided".[334] Dr Christensen stated that he used the no release forecast level (or target point) of Somerset Dam as a "controlling determination" which informs the risk to dam safety if the gates are shut.[335]

121 Dr Christensen explained that he did not interpret Strategy S2 as requiring releases to be made in order to arrive at the target point on the Operating Target Line, or the line itself, by the most direct route. The Manual contemplates that it will "not necessarily be possible to adjust the duty point directly towards the target line in a single gate operation".[336] Dr Christensen stated that at least sometimes "it's undesirable … to head directly for that target line"[337] because to "protect people downstream, I should temper that and not go directly toward it, or not go directly straight up to the S2 line and not do my best to get to the S2 line and then follow it".[338]

[333] T 1194.1 - .32; T 1393.33.
[334] T 1194.17; T 1218.29 - .40; T 1394.39.
[335] T 1797.31 to T 1798.8; T 1219.4 - .12.
[336] Manual at 42.
[337] T 1798.29.
[338] T 1798.43; T 1219.3.

Strategy S3

122 As noted in Chapter 3,[339] the combination of Strategy W4B and S3 contemplate that, provided the safety of Somerset Dam is not compromised, "consideration can be given to [a] temporary departure from the operating protocols contained in this strategy" (ie, the Operating Target Line).

123 In his Reply Report,[340] Dr Christensen explained his views as follows:[341]

> "Use of Operating Target Line in S3
>
> Strategy S3 is engaged when both dams are above FSL, and when Wivenhoe Dam is expected to exceed 75.5m AHD (fuse plug initiation). As with Strategy S2, the intent of this operation is to maximize the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams.
>
> …
>
> 193. As discussed at paragraphs [337]-[338] of [Dr Christensen's February 2015 Report], I used a modified Operating Target Line which is simply a diagrammatic representation of the Manual's permission to depart from the S2 operating target line in circumstances where the engineer is trying to avoid fuse plug initiation at Wivenhoe Dam, but is not concerned, based on forecasts, that the safety of Somerset Dam will be compromised. This is represented by the blue line in Figure 38, Volume 2 of my Expert Report. This strategy is contingent upon ensuring that Somerset Dam does not overtop higher than elevation 109.70 m … The moment overtopping becomes a concern for either dam based on rainfall forecasts, a reasonably competent flood engineer would move the reservoir water levels back towards the S2 Operating Target Line. That line equalizes the risk of overtopping … Similarly, if rain falls in excess of what was forecast and such rainfall would place Somerset Dam at risk of overtopping, I would move back to the S2 operating target line."

124 The modified Operating Target Line referred to in this passage is simply a line drawn from the current height of the dams to the point at which Wivenhoe

[339] Chapter 3 at [90].
[340] Reply Report, EXP.ROD.004.0005 at [189].
[341] Reply Report, EXP.ROD.004.0005 at [191] to [194]; Earlier in the report Dr Christensen dated that "S2 operations are to be used when there is no risk of overtopping at either dam" at [189]. In cross-examination Dr Christensen stated that the reference to "S2" was incorrect and it should be "S3" (at T 1294.39). I accept that it was an error given the passage extracted.

Dam is EL 75.5m AHD (ie, the first fuse plug initiation) and Somerset Dam is at EL 109.70m AHD.[342]

125 In his Response Report, Dr Christensen expanded on what approach should be adopted in S3.[343] He noted that the W4B strategy referred to retaining water in Somerset Dam[344] and that the S3 strategy's stated intent was "to maximise the benefits of the flood storage capabilities of [Somerset] Dam while protecting" its structural safety.[345] As the Manual does not expressly address what a departure from the S2 Operating Target Line entailed,[346] Dr Christensen concluded that a reasonably competent flood engineer would, in departing from the Operating Target Line to store water in Somerset Dam in S3, consider four matters.

126 First, the Manual identifies the crest level of Somerset Dam (EL 107.46m AHD) as a "critical level", such that the reasonably competent flood engineer should "strive to avoid overtopping" it while noting that there is a further 2.2 metres of storage above it.[347]

127 Second, the Manual identifies the top of the Wivenhoe Gates (EL 73.0m AHD) as a "critical level" because if they are overtopped "the gates become inoperable if the lifting tackle is fouled by debris from the overflow".[348]

128 Third, once the level of Wivenhoe Dam exceeds EL 74.0m AHD then the safety of Wivenhoe Dam is the primary concern and "forced spills" become necessary.[349]

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342 February 2015 Report, EXP.ROD.001.0016 at [339]; Dr Christensen also suggested another version of a "modified target line", being the orange line as stated in Figure 38 to his February 2015 Report, which he stated "should have been used whether in S2 or S3 operations to maximise the flood mitigation capabilities of both dams operated in tandem so long as overtopping of either dam was not a likely concern" [February 2015 Report, EXP.ROD.001.0016 at [352]]. In his Reply Report [Christensen Reply Report, EXP.ROD.014.0001 at [194]] and in cross-examination [T 1203.19 and T 1203.37] Dr Christensen confirmed that this line, ie the orange line in Figure 38 of his February 2015 Report, was only applicable to the circumstance where the Somerset Dam crest gates were kept closed during flood operations.
343 Response Report, EXP.ROD.015.0005 at .0077 to .0081.
344 Manual at 31.
345 Ibid at 42.
346 Response Report, EXP.ROD.015.0005 at [277].
347 Response Report, EXP.ROD.015.0005 at [278(1)]; Manual at 38.
348 Response Report, EXP.ROD.015.0005 at [278(2)]; Manual at 20.

129 Fourth, the determination of whether there is a risk of overtopping of either dam requires a consideration of a range of forecasts for different periods "in order to have sufficient lead time" to be able to respond to overtopping concerns.[350] Dr Christensen concluded that:[351]

> "…a reasonably competent flood operations engineer would adopt intermediate target levels of 73.0 m AHD and 74.0 m AHD at Wivenhoe and 107.46 m AHD at Somerset Dam as a guide when operating in W4B and S3. Once a flood engineer anticipates *that either dam is likely to overtop beyond those levels given regard to the forecasts, the engineer would return to following the S2 Operating Target Line* as much as reasonably practical, to equalize the risk of likely failure at both dams." (emphasis added)

130 Dr Christensen was cross-examined about the emphasised portion of this extract.[352] With some hesitation, he agreed that the reference to overtopping "beyond those levels" was a reference to EL 107.46m AHD for Somerset and EL 74.0m AHD for Wivenhoe such that if it is anticipated that either of those levels will be overtopped then the flood engineer should return to "following the S2 Operating Target line".[353] However, Dr Christensen explained that "following the S2 Operating Target Line" did not mean immediately releasing water from Somerset into Wivenhoe Dam but orientating towards that line, which could include orientating towards a point above EL 107.46m AHD.[354]

131 The effect of the application of Dr Christensen's approach to S2 and S3 in his various simulations of the January 2011 Flood Event is that his "in tandem operation of the dams" resulted in flood operations occurring mostly below the Operating Target Line.[355] This is a product of a number of factors that vary from simulation to simulation but include: Dr Christensen taking Wivenhoe Dam below FSL; the amount of runoff that was generated in the Somerset catchment (especially on 9 January 2011); and, with two of his simulations, the closing of the Somerset Dam crest gates in S3.[356] Further, as explained in Chapters 9 and 10, in those simulations in which the dam crest gates cannot

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[349] Response Report, EXP.ROD.015.0005 at [278(3)].
[350] Ibid at [278(4)].
[351] Ibid at [279].
[352] T 1788 to T 1792.13.
[353] T 1790.11 - .18.
[354] T 1790.41 to T 1791.4.
[355] EXP.ROD.015.0461 at .0506, .0586, .0664, .0744, .0814, .0871, .0914, .0956, .1019 and .1085.
[356] Simulation I and Simulation J.

be closed, the engagement of W4B/S3 makes no difference to operation as all, or most, of the sluice gates are already closed when that occurs.

8.7: Overview of Simulations

132 At this point it is appropriate to provide an overview of each of Dr Christensen's simulations, although they will be considered further in addressing the particular submissions made about them by the defendants.

133 In the end result, Dr Christensen put forward ten simulations in his Response Report, five of which had a start time of midnight on 2 January 2011,[357] one of which had a start time of midnight on 5 January 2011,[358] three of which had a start time of midnight on 8 January 2011[359] and one of which had a start time of midnight on 10 January 2011.[360] In his February 2015 Report, Dr Christensen included simulations with start times of midnight on 6 January 2011, midnight on 7 January 2011 and midnight on 9 January 2011. However, the tender of those simulations was rejected in circumstances where, due to the revision process identified above, Dr Christensen could not attest to the calculation of the inflow volumes upon which they were said to depend (*Rodriguez (No 10)).*[361]

134 For each of the simulations in his Response Report, Dr Christensen provided a table explaining the applicable strategies used on each day of the simulation, the volumetric calculations used to determine no release rises[362] and a narrative explaining for each day up to 14 January 2011 the basis upon which release rates were determined.[363] Dr Christensen also provided a spreadsheet (his "Simulation Analysis") for each simulation, which included: a simulation analysis that displayed the hourly storage levels and outflows for each dam in each simulation compared to the actual storage levels and outflows with "remarks" that cross-referenced forecasts and changes in

357 SIM A, B, C, D and I.
358 SIM E.
359 SIM F, H and J.
360 SIM G.
361 *Rodriguez (No 10)* at [11].
362 Eg for Simulation A, EXP.ROD.015.0261 at .0272 to .0285.
363 Eg for Simulation A, EXP.ROD.015.0261 at .0286 to .0302.

strategy up to 19 January 2011,[364] the same information with accompanying tables showing consumed and available flood storage, inflows and outflows,[365] a table of gate openings for each hour of the simulation up to 19 January 2011,[366] graphs depicting the flow and height levels at each dam,[367] graphs depicting simulated flow levels at Moggill,[368] and a graph depicting the simulated and actual height levels for each dam mapped onto the S2 Operating Target Line.[369]

Simulations I and A - 2 January 2011 Start

135 Both Simulation I ("SIM I") and Simulation A ("SIM A") commence at midnight on 2 January 2011. SIM I applies Dr Christensen's primary methodology, including the use of the average eight-day PME forecast to determine strategy, the adoption of a target level below FSL determined by reference to the four-day inflow estimate (for at least some days), and the making of releases below FSL subject to an ability to refill the dams based on an inflow estimate derived from the use of the four-day PME forecast. Simulation I assumes that the crest gates at Somerset can be opened and closed during a flood event.[370]

136 SIM A is the same, except that it assumes that the crest gates at Somerset Dam had to remain open through the flood event.[371]

137 Both SIM A and SIM I modelled increasing releases from Wivenhoe Dam at midnight on 2 January 2011 from 395m^3/s to approximately 1417m^3/s at midday on 2 January 2011 and maintaining a similar rate of releases thereafter. This approach would have kept Mt Crosby Weir Bridge open until

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[364] Eg for Simulation A, EXP.ROD.015.0461 at .0466 to .0485; EXP.ROD.015.0450, Wivenhoe sim tab; EXP.ROD.015.0450, Somerset sim tab.
[365] Eg for Simulation A, EXP.ROD.015.0461 to .0485; EXP.ROD.015.0450, day by day tab.
[366] Eg for Simulation A, EXP.ROD.015.0466 at .0486 to .0502; EXP.ROD.015.0450, gate operations tab.
[367] Eg for Simulation A, EXP.ROD.015.0466 at .0503 and 0505; EXP.ROD.015.0450, Wivenhoe chart tab; EXP.ROD.015.450, Somerset chart tab.
[368] Eg for Simulation A, EXP.ROD.015.0466 at .0504; EXP.ROD.015.0450, Moggill chart tab.
[369] Eg for Simulation A, EXP.ROD.015.0466 at .0506; EXP.ROD.015.0450, S2 target chart tab.
[370] Response Report, EXP.ROD.015.0005 at .0088.
[371] Ibid at .0087.

7 January 2011[372] and Fernvale Bridge open until 9 January 2011.[373] Thereafter, releases are increased to approximately 1800m^3/s but maintained at a level that avoids exceeding the downstream threshold for non-damaging flows until the morning of 11 January 2011, when the estimate of natural occurring downstream flows at Lowood and Moggill increases dramatically.[374] At that point in SIM A, the modelled level of Wivenhoe Dam would have been EL 68.97m AHD and, at that point in SIM I, the modelled level of Wivenhoe Dam would have been EL 68.82m AHD.[375] In both simulations, releases are then reduced. In SIM A, they are reduced to around 900m^3/s until just after midday on 12 January 2011. In SIM I they are reduced to around 500m^3/s later in the day on the 12th, when Wivenhoe Dam has risen above EL 73.0m AHD but is below EL 74.0m AHD.[376] Thereafter, releases were steadily increased on the downward limb of the downstream hydrograph.[377]

138 Four points should be noted about these simulations.

139 First, in SIM A Wivenhoe Dam is below FSL between 11.00am on 2 January 2011 and 1.00pm on 10 January 2011.[378] SIM I returns Wivenhoe Dam to FSL one hour prior on 10 January 2011.[379] In SIM A, Wivenhoe Dam's lowest level is EL 62.90m AHD at 1.00pm on 9 January 2011.[380] SIM I's lowest level is also EL 62.90m AHD at 1.00pm on 9 January 2011.[381]

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[372] Response Report Vol 2, EXP.ROD.015.0261 at .0277; Simulation Analysis, EXP.ROD.015.0461 at .0466.
[373] Response Report Vol 2, EXP.ROD.015.0261 at .0279; Simulation Analysis, EXP.ROD.015.0461 at .0466 to .0477.
[374] SIM A: Simulation Analysis, EXP.ROD.015.0461 at .0470; SIM I: Simulation Analysis, EXP.ROD.015.0461 at .0983.
[375] SIM A: Simulation Analysis, EXP.ROD.015.0461 at .0470; SIM I: Simulation Analysis, EXP.ROD.015.0461 at .0983.
[376] SIM A: Simulation Analysis EXP.ROD.015.0461 at .0471; SIM I: Simulation Analysis, EXP.ROD.015.0461 at .0984.
[377] SIM A: Simulation Analysis, EXP.ROD.015.0461 at .0472 to .0475; SIM I: Simulation Analysis, EXP.ROD.015.0461 at .0985 to .0988.
[378] Simulation Analysis, EXP.ROD.015.0461 at .0466 to .0470.
[379] Ibid at .0983.
[380] Ibid at .0470.
[381] Ibid at .0983.

140 Second, in SIM A Somerset Dam reaches a peak height of EL 105.67m AHD at 3.00am on 12 January 2011.[382] In SIM I, Somerset Dam reaches a peak height of EL 106.95m AHD at 8.00am on 12 January 2011 and remains at that level for some hours.[383] During the January 2011 Flood Event, Somerset Dam reached a peak height of EL 105.11m AHD at 6.00am on 12 January 2011.[384]

141 Third, a determination of the contribution of the outflows from SIM A to the hypothetical peak flows downstream in the simulation is not straightforward. It appears to differ according to whether one uses the simulated downstream flows included in Dr Christensen's spreadsheets, which appear to be based on what was available to the flood engineers,[385] or whether one uses Dr Altinakar's modelling (or even Mr Collins' figures).[386] Dr Christensen estimated that, if implemented, SIM A would have contributed 910m^3/s of outflows from Wivenhoe Dam to the downstream peak flows and SIM I would have contributed 460m^3/s,[387] compared to somewhere between 4200m^3/s and 5300m^3/s from actual operations.[388]

142 Fourth, the differences between SIM I and SIM A, especially in relation to the maximum height of Somerset Dam and the outflows from Wivenhoe Dam during the peak of the flood, are attributable to the assumption adopted in SIM I that, at least during S3 operations, the Somerset Dam crest gates can be closed. In SIM I, the crest gates are closed at the beginning of 10 January 2011 (although two sluice gates are opened).[389] This prevents uncontrolled spilling of water from Somerset Dam into Wivenhoe Dam above EL 100.45m AHD, forcing its release from Somerset Dam and causing Wivenhoe Dam levels to increase.

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[382] Ibid at .0481.
[383] Ibid at .0994 to .0995.
[384] Ibid at .0994.
[385] See "Moggill calcs" tab in SIM A, EXP.ROD.015.0450.
[386] See Chapter 7; section 7.9.
[387] Response Report, EXP.ROD.015.0005 at .0087 to .0088.
[388] Chapter 7 at [404].
[389] Response Report Vol 2, EXP.ROD.015.0261 at .0430.

Simulation B - 2 January 2011 Start – Rain on the Ground

143 Like SIM A, Simulation B ("SIM B") assumed that the Somerset Dam crest gates had to remain open during a flood event. However, SIM B varied Dr Christensen's primary methodology so that runoff predictions using only rain on the ground were made for "operational decisions".[390] In particular, strategies and release rates were selected based on no release rises determined by rain on the ground runoff estimates and releases were only made below FSL to the extent that the water level could be refilled to FSL from runoff estimates determined by rain on the ground. However, runoff from rainfall forecasts was assessed and considered within these constraints.[391]

144 Under SIM B, releases would have continued to be made at a rate of around 380m^3/s from midnight on 2 January 2011 until midnight on 5 January 2011.[392] This would have been sufficient to keep Burtons Bridge open and led to a reduction of the storage level of Wivenhoe Dam to around EL 66.70m AHD, which could be refilled based on rain on the ground estimates. Gates would then have been closed until Wivenhoe Dam exceeded EL 67.25m AHD, which would not have occurred until 4.00am on 7 January 2011.[393] As rain on the ground modelling pointed to a W3 strategy, releases would then have increased to around 1800m^3/s on 7 January 2011, which would have inundated Mt Crosby Weir Bridge and Fernvale Bridge.[394] Releases would have continued at that rate until around 1.00pm on 11 January 2011, save for a period from 2.00am to 12.00pm on 9 January 2011 when rain on the ground modelling would have restricted flood operations to Strategy W1B.[395] Releases on 11 January 2011 would have increased to around 2600m^3/s on 12 January 2011 as Wivenhoe Dam was modelled to peak at around EL 75.08 AHD at 2.00pm on 12 January 2011.[396] Releases above 3000m^3/s

[390] Response Report, EXP.ROD.015.0005 at .0087.
[391] See for example Response Report Vol 2, EXP.ROD.015.0261 at .0309.
[392] Simulation Analysis, EXP.ROD.015.0461 at .0547 to .0548.
[393] Simulation Analysis, EXP.ROD.015.0461 at .0550.
[394] Response Report Vol 2, EXP.ROD.015.0261 at .0309.
[395] Simulation Analysis, EXP.ROD.015.0461 at .0550 to .0551.
[396] Ibid at .0552.

would have been made from 14 January 2011 on the downward limb of the downstream hydrograph.[397]

145 The maximum level of Somerset Dam modelled in SIM B was EL 105.42m AHD at 4.00am on 12 January 2011.[398] Dr Christensen estimated that, if implemented, SIM B would have contributed 2250m^3/s of outflows from Wivenhoe Dam to the downstream peak flows.[399]

Simulation C - 2 January 2011 Start – 24-Hour QPF

146 Simulation C ("SIM C") also assumed that the Somerset Dam crest gates had to remain open during a flood event. It varied Dr Christensen's primary methodology so that only run-off predictions based on the 24-hour QPF forecasts were used for "operational decisions".[400] With SIM C, strategies were selected based on no release rises determined by reference to QPF forecasts and releases were only made below FSL to the extent that the water level could be refilled to FSL from runoff estimates determined by rain on the ground and QPF forecasts. This approach to releases is described further in Chapter 10.[401] It suffices to note that runoff from longer term rainfall forecasts was assessed and considered within these constraints,[402] being in effect a form of "situational awareness".

147 SIM C modelled increasing the release rate of 395m^3/s at midnight on 2 January 2011 to around 470m^3/s two hours later before reducing that rate to 377m^3/s at 11.00am on 3 January 2011 based on a relatively benign QPF forecast and to allow Burtons Bridge to reopen.[403] SIM C modelled continued releases at that rate until 7.00pm on 5 January 2011 when a QPF forecast (and longer range forecasts) would have caused the implementation of Strategy W3 and an increase in releases to around 1380m^3/s by the end of

[397] Ibid at .0553.
[398] Simulation Analysis, EXP.ROD.015.0461 at .0562.
[399] Response Report, EXP.ROD.015.0005 at .0087.
[400] Id.
[401] Chapter 10 at [176ff].
[402] See for example Response Report Vol 2, EXP.ROD.015.0261 at .0332.
[403] Simulation Analysis, EXP.ROD.015.0461 at .0627.

the day, with the consequent closure of Burtons Bridge and Kholo Bridge[404] (although by this stage in the January 2011 Flood Event Kholo Bridge was already closed due to surface damage).[405] In light of further forecasts, releases would have increased during 6 January 2011 to around 2400m^3/s which would have caused the inundation of the remaining bridges but kept downstream flows below 4000m^3/s.

148 By midday on 8 January 2011, in SIM C Wivenhoe Dam would have been at around EL 64.55m AHD such that the maximum storage level based on a one-day QPF with no release modelling required the adoption of a W1E Strategy which limited releases to 1900m^3/s even though Mt Crosby Weir Bridge and Fernvale Bridge could not be reopened.[406] This rate was maintained until the one-day QPF forecast resulted in the invocation of Strategy W3 at around 5.00pm on 9 January 2011 but given the predicted downstream flow rate at Moggill, releases would not have been increased so as to avoid exceeding the limit on non-damaging flows.[407] In light of the severe increase in the estimate of downstream flows, releases would have been reduced from 1566m^3/s at around 9.00am on 11 January 2011 to around 1076m^3/s at 9.00pm on the same day, before being increased early in the morning of 13 January 2011 on the downward limb of the downstream hydrograph.[408] The release rate of 1076m^3/s was in part driven by the need to have all the Wivenhoe gates raised to avoid overtopping at EL 73.0m AHD.[409]

149 In SIM C, Wivenhoe Dam was modelled as reaching a maximum height of EL 73.86m AHD at 2.00am on 13 January 2011 and would not have exceeded EL 73m AHD on 11 January 2011.[410] The lowest storage level of Wivenhoe Dam would have been EL 63.79m AHD at 1.00pm on 9 January 2011.[411] The maximum modelled storage level of Somerset Dam in SIM C is EL 105.07m

[404] Ibid at .0628.
[405] Chapter 6 at [55].
[406] Simulation Analysis, EXP.ROD.015.0461 at .0629.
[407] Ibid at .0630; see also Response Report Vol 2, EXP.ROD.015.0261 at .0343.
[408] Simulation Analysis, EXP.ROD.015.0461 at .0631.
[409] Response Report Vol 2, EXP.ROD.015.0261 at .0345.
[410] Simulation Analysis, EXP.ROD.015.0461 at .0631.
[411] Ibid at .0630.

AHD at around 5.00am on 12 January 2011.[412] Even though in SIM C Wivenhoe Dam would have been in Strategy W4B on 10 and 11 January 2011, Dr Christensen would have kept Somerset Dam in Strategy S2.[413] Through 9 and 10 January 2011, Dr Christensen modelled releasing less from Somerset Dam into Wivenhoe Dam than in the events which happened, although he modelled increasing releases from Somerset Dam from mid-morning on 10 January 2011 given the lower levels of Wivenhoe Dam in the simulation.[414] There is little difference between the storage levels of Somerset Dam in SIM C compared to the actual storage levels of Somerset Dam from late on 10 January 2011.

150 Dr Christensen estimated that, if implemented, SIM C would have contributed 1110m^3/s of outflows from Wivenhoe Dam to the downstream peak flows.[415]

Simulation D - 2 January 2011 Start – Maintenance of FSL

151 Simulation D ("SIM D") assumed that the Somerset Dam crest gates had to remain open during a flood event. It applied Dr Christensen's primary methodology except that it assumed that flood releases could be made below FSL from Wivenhoe Dam only to the extent that there was sufficient water above FSL in Somerset Dam to refill Wivenhoe Dam to FSL (the "FSL assumption").[416]

152 In SIM D, Dr Christensen would have maintained outflows at around 329m^3/s to 395m^3/s from midnight on 2 January 2011 until 1.00am on 3 January 2011, when releases would have been reduced to 98m^3/s because of the FSL assumption.[417] The FSL assumption dictated the adoption of release rates of either 98m^3/s, 147m^3/s or 49m^3/s until the evening of 5 January 2011.[418] Dr Christensen would have increased releases from that time until reaching a

[412] Ibid at .0640.
[413] Response Report Vol 2, EXP.ROD.015.0261 at .0336 to .0338.
[414] EXP.ROD.015.0461 at .0639.
[415] Response Report, EXP.ROD.015.005 at .0087.
[416] Response Report, EXP.ROD.015.0005 at .0088.
[417] Simulation Analysis, EXP.ROD.015.0461 at .0705.
[418] Ibid at .0707.

rate of around 1930m^3/s on the morning of 7 January 2011 but he was then prevented from increasing the rate of releases due to the FSL assumption.[419]

153 In SIM D, the release rate of around 1900m^3/s would have been maintained until the morning of 8 January 2011 when release rates would have been limited because of the height of Somerset Dam (even though Strategy W4A was engaged).[420] Release rates from Wivenhoe Dam are then increased from 1206m^3/s at 10.00am on 9 January 2011 as inflows increased to both dams and would have reached 2043m^3/s at 7.00pm on 9 January 2011.[421] Thereafter, release rates would have been maintained at between 1700m^3/s and 1900m^3/s until around 3.00pm on 11 January 2011 to keep downstream flows at Moggill below 4000m^3/s or minimise their rise above that amount.[422] At around 5.00pm, the release rate would have been increased to around 2228m^3/s as the dam level approached EL 74.0m AHD with the aim of avoiding a fuse plug breach.[423] Releases would have reached a rate of around 2750m^3/s at 4.00pm on 12 January 2011 and would have been increased from there to drain the dam down on the downward limb of the downstream hydrograph.[424]

154 Dr Christensen estimated that, if implemented, SIM D would have contributed 2315m^3/s of outflows from Wivenhoe Dam to the downstream peak flows.[425]

Simulation E - 5 January 2011 Start

155 Simulation E ("SIM E") was modelled to commence at midnight on 5 January 2011. It assumed that the Somerset Dam crest gates had to remain open during the flood event and otherwise applied Dr Christensen's primary methodology.

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419 Response Report Vol 2, EXP.ROD.015.0261 at .0362 to .0363; Simulation Analysis, EXP.ROD.015.0461 at .0707.
420 Simulation Analysis, EXP.ROD.015.0461 at .0708.
421 Ibid at .0708 to .0709.
422 Ibid at .0709 to .0710.
423 Response Report Vol 2, EXP.ROD.015.0261 at .0366; Simulation Analysis, EXP.ROD.015.0461 at .0710.
424 Simulation Analysis, EXP.ROD.015.0461 at .0710 to .0711.
425 Response Report, EXP.ROD.015.00005 at .0087.

156 In SIM E, Dr Christensen would have delayed releases from Wivenhoe Dam until its storage level reached EL 67.25m AHD,[426] which was partly caused by releases from Somerset Dam.[427] Dr Christensen determined that Strategy W3 was applicable and would have increased releases up to around 1800m^3/s by 11.00am, which would inundate all bridges other than Fernvale Bridge and Mt Crosby Weir Bridge.[428] A revision of the target volumes in light of the forecasts would have caused Dr Christensen to increase releases on 6 January 2011 to around 2400m^3/s which would keep flows at Lowood and Moggill below 3500m^3/s but which would have inundated all the remaining bridges.[429] In SIM E, Dr Christensen would have maintained releases at around that level until late in the afternoon of 8 January 2011 when Wivenhoe Dam was drained down to around EL 64.0m AHD.[430] Releases would have been maintained at around 1800m^3/s from 9 January 2011 to around 7.00am on 11 January 2011 when the forecast of increases in natural flows at Moggill meant releases had to be reduced to just under 1000m^3/s from 1.00pm on 11 January 2011 to 11.00am on 12 January 2011.[431] Thereafter, releases would have been increased as downstream flows subsided.[432]

157 Under SIM E, the maximum storage level that Wivenhoe Dam would have reached was EL 73.68m AHD at 8.00am on 13 January 2011.[433] The lowest storage level was EL 63.14m AHD at 1.00pm on 9 January 2011.[434] The maximum storage level that Somerset Dam would have reached was EL 105.60m AHD at 5.00am on 12 January 2011.[435] Dr Christensen estimated that, if implemented, SIM E would have contributed 975m^3/s of outflows from Wivenhoe Dam to the downstream peak flows.[436]

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[426] Simulation Analysis, EXP.ROD.015.0461 at .0785.
[427] Ibid at .0793.
[428] Response Report Vol 2, EXP.ROD.015.0261 at .0380; Simulation Analysis, EXP.ROD.015.0461 at .0785.
[429] Response Report Vol 2, EXP.ROD.015.0261 at .0381 to .0382; Simulation Analysis, EXP.ROD.015.0461 at .0785 to .0786.
[430] Simulation Analysis, EXP.ROD.015.0461 at .0787.
[431] Simulation Analysis, EXP.ROD.015.0461 at .0788 to .0789.
[432] Ibid at .0789.
[433] Id.
[434] Ibid at .0787.
[435] Ibid at .0796.
[436] Response Report, EXP.ROD.015.0005 at .0087.

Simulations F and H - 8 January 2011 Start

158 Three of Dr Christensen's simulations commenced at midnight on 8 January 2011: simulations F, H and J.

159 Simulation F ("SIM F") assumed that the Somerset Dam crest gates had to remain open during a flood event and applied Dr Christensen's primary methodology (although releases were not set by reference to any "target" volume below FSL).[437] Dr Christensen did not expressly apply the same FSL assumption that was applied in SIM D. However, given the storage levels for both dams at the time the simulation commenced, the downstream release constraints and the volume of inflows, that assumption effectively applied to this simulation: ie at no stage in SIM F would Wivenhoe Dam have fallen below a storage level that could not have been replenished by water retained above FSL in Somerset Dam.[438]

160 As at midnight on 8 January 2011, Wivenhoe Dam was at EL 68.32m AHD and releasing just over 500m^3/s. Somerset Dam was at EL 100.31m AHD and releasing just over 200m^3/s. In SIM F Dr Christensen would have immediately increased releases such that by around 10.00am on 8 January 2011 Wivenhoe Dam was releasing around 2700m^3/s to 2800m^3/s, which was around the highest level of releases that could be made without causing downstream flows to exceed the threshold for non-damaging flows.[439] This rate of release was maintained through 9 January 2011 until the predictions of downstream flows worsened and releases were reduced to around 1900m^3/s at 11.00pm that night.[440] Due to the forecast peak of Moggill flows, Wivenhoe Dam levels and gate constraints, Dr Christensen determined that the Wivenhoe gates on 11 January 2011 "should be open at least to 2.0 to 2.5m below 75.0m and open at least 3.0m from a little below 75.0".[441] To give effect to this determination, five further gate increments were opened at 1.00pm that

[437] Ibid at .0088.
[438] Response Report Vol 2, EXP.ROD.015.0261 at [23]; SunWater subs at [1429] to [1430].
[439] Response Report Vol 2, EXP.ROD.015.0261 at .0398; Simulation Analysis, EXP.ROD.015.0461 at .0846.
[440] Simulation Analysis, EXP.ROD.015.0461 at .0847.
[441] Response Report Vol 2, EXP.ROD.015.0261 at .0401.

day[442] with a consequential increase in the rate of release to just above 2200m^3/s by 4.00pm that afternoon. Releases (and gate openings) would have been held at that level until around 4.00pm the following day, when they would have started to increase to close to 3000m^3/s. By that time, inflows had substantially reduced and the downstream hydrograph was on its downward limb.[443]

161 The maximum storage level that would have been reached in Simulation F was EL 75.12m AHD at 6.00pm on 12 January 2011.[444] The lowest level of Wivenhoe Dam would have been EL 66.54m AHD at 2.00pm on 9 January 2011,[445] at a time when Somerset Dam would have been at EL 101.54m AHD and could replenish Wivenhoe Dam to refill to FSL.[446] The maximum storage level that Somerset Dam would have attained in SIM F was EL 106.25m AHD at 2.00am on 12 January 2011.[447]

162 Simulation H assumed that the Somerset Dam crest gates had to remain closed during a flood event. It varied Dr Christensen's primary methodology so that, like SIM C, predictions based on the 24-hour QPF forecasts were used for "operational decisions", especially the selection of strategies.[448] As explained in Chapter 10, given the storage levels for both dams at the time the simulation commenced, the release constraints and the volume and timing of inflows predicted by all of the forecasts, there was no material difference between the releases in this simulation and Simulation F.[449] The FSL assumption also effectively applied to this simulation.

[442] Simulation Analysis, EXP.ROD.015.0461 at .0862.
[443] Ibid at .0848 to .0849.
[444] Ibid at .0848.
[445] Ibid at .0847.
[446] Ibid at .0853.
[447] Ibid at .0855.
[448] Response Report, EXP.ROD.015.0005 at .0088.
[449] Response Report Vol 2, EXP.ROD.015.0261 at .0270, at [22]; Chapter 10 at [6].

163 Dr Christensen estimated that, if implemented, SIM F and SIM H would have contributed 2310m^3/s of outflows from Wivenhoe Dam to the downstream peak flows.[450]

Simulation J - 8 January 2011 Start – Somerset Gates Closed

164 Simulation J ("SIM J") assumed that the Somerset Dam crest gates could be opened and closed during a flood event and applied Dr Christensen's primary methodology.[451] The only relevant difference between SIM J and SIM F is that in SIM J the Somerset Dam crest gates would have been progressively closed at the beginning of 8 January 2011 and thereafter outflow from Somerset Dam into Wivenhoe Dam is regulated through the sluice gates.[452] In SIM J, Dr Christensen would have released water from Somerset Dam through three sluice gates from 2.00am on 8 January 2011 until 7.00am on 12 January 2011 when another sluice gate was opened, bringing the total to four.[453] In contrast, in SIM F all the sluice gates would have been closed until midnight on 14 January 2011 and unregulated flow would have occurred above EL 100.45m AHD at a rate determined by the height of Somerset Dam.[454] The result is that until 1.00am on 10 January 2011, in SIM J more water was modelled as being released from Somerset Dam into Wivenhoe Dam than in SIM F but thereafter the position is reversed as the storage level in Somerset Dam increases.

165 The maximum storage level for Wivenhoe Dam reached in SIM J would have been EL 74.82m AHD at 1.00pm on 12 January 2011.[455] In SIM J, Wivenhoe Dam would not have fallen below FSL. The maximum storage level for Somerset Dam in SIM J would have been EL 106.93m AHD at 11.00am on 12 January 2011.[456] Dr Christensen estimated that, if implemented, SIM J

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[450] Response Report, EXP.ROD.015.0005 at .0088.
[451] Ibid at .0089.
[452] Response Report Vol 2, EXP.ROD.015.0261 at .0445.1; Simulation Analysis, EXP.ROD.015.0461 at .1074.
[453] Simulation Analysis, EXP.ROD.015.0461 at .1074 to .1076.
[454] Ibid at .0860 to .0866.
[455] Simulation Analysis, EXP.ROD.015.0461 at .1062.
[456] Ibid at .1069.

would have contributed 1920m^3/s of outflows from Wivenhoe Dam to the downstream peak flows.[457]

Simulation G - 10 January 2011 Start

166 Simulation G ("SIM G") would have commenced gate operations at midnight on 10 January 2011. It assumes that the crest gates at Somerset Dam had to remain open during the flood event.[458] At the time this simulation would have commenced, Wivenhoe Dam was at EL 69.80m AHD and releasing 1462m^3/s. Dr Christensen would have increased that rate of release to just over 3100m^3/s by 7.00am on 10 January 2011 and, subject to a small variation downwards on the evening of 10 January 2011, would have maintained releases within 200m^3/s of that rate until around 10.00am on 11 January 2011, when the gates were closed by five increments[459] yielding a release rate of around 2700m^3/s. Gates would have been opened by one increment at 6.00pm on 11 January 2011, by another increment at 6.00pm on 12 January 2011, and two further increments at 5.00am on 13 January 2011 increasing releases to around 3000m^3/s,[460] with further increases on 14 January 2011 on the downward limb of the downstream hydrograph.[461]

167 Under SIM G, the storage levels in Wivenhoe Dam would have reached a maximum height of EL 75.10m AHD at 10.00am on 12 January 2011.[462] The storage level in Somerset Dam would have reached a maximum height of EL 105.82m AHD at 2.00am on 12 January 2011.[463] Neither dam would have ever been below FSL during flood operations under this simulation. Dr Christensen estimated that, if implemented, SIM G would have contributed 2870m^3/s of outflows from Wivenhoe Dam to the downstream peak flows.[464]

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457 Response Report, EXP.ROD.015.0005 at .0089.
458 Ibid at .0088.
459 Simulation Analysis, EXP.ROD.015.0461 at .0905.
460 Ibid at .0895 and .0905 to .0906.
461 Ibid at .0896 and .0907.
462 Simulation Analysis, EXP.ROD.015.0461 at .0895.
463 Ibid at .0900.
464 Response Report Vol 1, EXP.ROD.015.0005 at .0087.

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CHAPTER 9: DR CHRISTENSEN'S METHODOLOGY – DEFENDANTS' CRITICISMS

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CHAPTER 9: DR CHRISTENSEN'S METHODOLOGY – DEFENDANTS' CRITICISMS

1 Dr Christensen's evidence was adduced by the plaintiff with a view to the Court using it to inform its analysis of breach by the flood engineers and to demonstrate what the outflows from Wivenhoe Dam would have been had flood operations been conducted in a non-negligent manner. Without the latter being ascertained, the plaintiff would have no pattern of outflows to input into Professor Altinakar's modelling to enable a determination of whether any of the damage to, or the inundation of, the plaintiff's store or the property of the group members was caused by the defendants' (alleged) negligence.

2 As explained in Chapter 12[1], it was accepted by the plaintiff that, one way or another, in respect of each simulation relied on, it had to demonstrate that a reasonably competent flood engineer would or must have adopted release rates and gate operations substantially in accordance with that simulation.[2] In addressing that issue it is necessary, but not sufficient, to ascertain whether a reasonably competent flood engineer *could* have made such releases. If the making of those releases or the rationale behind it was inconsistent with the Manual, then that simulation would fail at the outset. However, even if the proposed action was consistent with the Manual, it was still necessary to determine whether the circumstances required it to be undertaken. That said, the analysis of that issue in this and the following Chapter is being undertaken in a context where none of the defendants put forward any methodology for conducting flood operations in accordance with the Manual that could have been adopted by the reasonably competent flood engineer.[3] Thus, they did not suggest *any* means by which a flood engineer would select strategy by using the "best forecast rainfall and stream flow information... [to determine the] [m]aximum storage levels in Wivenhoe and Somerset Dams".[4] Instead, the defendants' response to Dr Christensen's approach and his simulations was limited to stating that it and they were contrary to the Manual, contrary to

[1] Chapter 12 at [15].
[2] T 9419.14; eg PLE.010.001.0092 at [211]; particular D.
[3] In one of his reports, Mr Pokarier formulated a series of "release plans" using PME forecast rainfall for 8 days: EXP.SEQ.016.0220 at .0258. This approach was not taken up in submissions.
[4] Manual at 23.

proper practice, error ridden or not something that was demonstrated as having been required to be undertaken. This Chapter and the following Chapter address those contentions. In particular, this Chapter addresses the overall criticisms made by the defendants of Dr Christensen's methodology and its application, including criticisms concerning:

(i) Whether his methodology and its application were inconsistent with any established practices of flood engineers;

(ii) His use of forecasts in flood operations;

(iii) His derivation of inflow estimates based on the four and eight-day PME forecasts;

(iv) His derivation of inflow estimates based on the QPF forecasts and rain on the ground;

(v) His simulated flood operations on 11 and 12 January 2011 as modelled levels at Wivenhoe Dam approach and then exceed EL 74.0m AHD; and

(vi) His simulated operation of Somerset Dam.

9.1: Practice at Other Dams

3 The parties adduced a considerable amount of evidence concerning the practices adopted at other dams, both in Australia and overseas, in relation to the use made of rainfall forecasts in the conduct of flood operations. The evidence was sought to be deployed by the defendants in various ways. The present context concerns Seqwater's contention that the practice at other dams, so far as forecasts are concerned, was part of the "context" in which flood operations were being conducted at Wivenhoe and Somerset Dams in January 2011[5] and that this bears upon the reasonableness of Dr Christensen's simulations.[6] However, the evidence concerning other dams is also an important aspect of the reliance by each of the defendants on s 22 of

[5] Seqwater subs at [1715] to [1884].
[6] Ibid at [1676].

the *CLA* (Qld),[7] the operation of which has already been adverted to in Chapter 5.[8]

4 The precise manner in which the defendants sought to rely on this evidence is addressed below (at [51] to [60]). However, it is first necessary to describe the evidence that was adduced having regard to the present "context", namely flood operations at Wivenhoe Dam and Somerset Dam where the Manual clearly requires the use of a quantitative assessment of inflows based on rainfall forecasts to select strategies and also requires that forecasts be considered in making releases. In summary, given that context, the evidence adduced concerning other dams did not support the contention that Dr Christensen's approach and his simulations were unreasonable or should not otherwise have been adopted by a reasonably competent flood engineer. Instead, the evidence reveals that whether or not rainfall forecasts are to be used in flood operations is usually a decision recorded in the relevant water control manual and not made by the flood engineers conducting flood operations. Further, whether they are so used is usually a product of conditions specific to the dam including its location, purpose, priorities, timing of upstream flows, timing of downstream flows, catchment characteristics, dam capacity, forecast capacity and the stability of the seasonal weather.

Australian Dams

5 The evidence adduced concerning practices at other Australian dams did not support any contention that, overall, forecasts are not to be used in the conduct of flood operations.

Hume Dam

6 Hume Dam is located upstream of Albury-Wodonga. It is the main river regulating structure on the Murray River.[9] The former Executive Director of the Murray-Darling Basin Authority (the "Basin Authority"), Mr Dreverman,

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[7] PLE.020.010.0001 at .0157, [299(d)] (Seqwater); PLE.030.008.0001 at .0093, [213(c)] (Sunwater); PLE.040.007.0001 at .0127, [308] (State).
[8] At section 5.6.
[9] SEQ.244.001.0187.

stated that its primary purpose is water conservation and its secondary roles include "[the] generation of hydroelectric power, flood mitigation and recreation".[10] At least as at 2010 to 2011, it did not have a manual or document governing its operating procedures. Instead, its operators were afforded "a reasonable degree of professional judgment … should a flood event occur". However, they were required to act in accordance with an "Objectives and Outcomes" statement, which documents the policy objectives set out by the "Basin Officials Committee" set up under the Murray-Darling Basin Agreement ("MDBA").[11]

7 The 2009 version of the MDBA specifies a list of objectives that include preserving the structural integrity of the dams, water supply and security and "manag[ing] floods to conserve water and manag[ing] impacts on communities".[12] It did not specify an order of priority for the objectives, instead leaving it to the Basin Authority to select the highest priority in the event of a conflict.[13] A revised version of that document published in 2016 specified three objectives of the Hume Dam in the following order, namely: protecting the structural integrity and safety of the dam, maximising water availability and "limit[ing] flood damage to downstream communities and increase[ing] benefits to the environment and public amenity".[14] It also included a provision requiring that consideration be given to, inter alia, the "high variability and uncertainty of the River Murray system relating to ... rainfall and streamflow forecasts by the Bureau of Meteorology for the River Murray system".[15]

8 A publication on the Basin Authority's website which was downloaded in 2016 states that when Hume Dam is close to full it seeks to ensure flood mitigation by using "airspace management" below full supply level and managing that airspace by reference to, inter alia, rainfall forecasts:[16]

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[10] LAY.SEQ.012.0001 at [15].
[11] Ibid at [10] to [13].
[12] SEQ.244.001.0001 at .0063 to .0064.
[13] Ibid at Clause 6.1(b).
[14] LAY.SEQ.012.0001 at [21].
[15] Ibid at [22].
[16] SEQ.244.001.0187 at .0188 to .0189.

"Airspace is the difference between the actual volume of water in storage and the volume when full. The airspace is used to capture a proportion of the peak inflow during a flood event; with the degree of downstream flood reduction dependent on the volume of airspace prior to the event and the volume of the event. Active airspace management prior to a major rain event can assist in providing some flood mitigation, even if the storage is close to full.

Airspace targets at Hume Reservoir are determined by MDBA dam operators to provide a measure of flood protection without jeopardizing the ability to fill the reservoir. *The airspace target at Hume Reservoir takes account of the storage level, catchment conditions, rainfall and inflow forecasts, and likely water demands during the weeks and months ahead. The airspace target is regularly reviewed by operators as conditions and forecasts change.* A key factor in determining the airspace target is that there must be a very high chance that the reservoir will be full when downstream demand recommences, even if conditions suddenly turn very dry.

Key goals of airspace management are:

• preserve airspace during small inflow events to help reduce the impact of future larger floods

• use airspace carefully, taking account of Bureau of Meteorology short- and long-range forecasts;

• recover any used airspace as soon as reasonably practicable (aiming for about 1 week);

• ensure that the reservoir is full by the time downstream demand exceeds inflow.

Passing smaller events to maintain airspace

When storage levels are high, the airspace target is constantly reviewed and smaller inflow events will be passed, with only limited mitigation, to preserve airspace. *If further rain is forecast in the short term, releases may be increased to match inflows even if downstream channel capacity is exceeded.* This approach means that airspace is maintained to provide some ability to reduce any future larger flood event that may quickly follow. An extra benefit of passing smaller floods through the reservoir is a more natural pattern of flow downstream to improve river health and floodplain environments." (emphasis added)

9 In September, October and December 2010, three significant inflow events occurred at Hume Dam. The inflows experienced during the first two events were able to be stored in the dam. In relation to the third, Mr Dreverman stated that flood operations commenced on 3 December 2010, following heavy overnight rainfall and with further heavy rain forecast. This resulted in a lowering of the reservoir volume by 20 additional gigalitres over the following

five days.[17] In cross-examination, Mr Dreverman agreed that the above extract from the website downloaded in 2016 represented a “fair summary” of the approach adopted in 2010.[18] He also agreed that the forecasts used were supplied by the BoM and varied “from one day up to eight days”.[19] He stated that they were not able to “master” calculating a possible inflow volume to the dam from the forecast.[20]

10 A report into the operations of the Murray River noted that pre-releases had also occurred in February 2011 (and previously in 1993), that the Basin Authority advised the report’s authors that the releases in 2011 were consistent with prior practice and that other “jurisdictions” (ie, water officials or water managers in New South Wales, Victoria and South Australia)[21] “also confirmed that they were of the view that actual operations undertaken were consistent with prior practice”.[22]

11 This material clearly demonstrates that in December 2010 (and February 2011) as part of a strategy of flood mitigation at Hume Dam, precautionary releases of water were made in advance of rain falling based on rainfall forecasts and that this approach was consistent with “prior practice”.

12 Seqwater contended that this did not involve a “quantitative” use of rainfall forecasts,[23] which is correct on any view of the concept of the phrase “quantitative” given Mr Dreverman’s affirmation that the Basin Authority did not have the capacity to calculate inflow volumes. There are other relevant differences between this dam and Wivenhoe and Somerset Dams including the size of the flood events, the absence of storage above FSL, the respective dam priorities and the absence of a manual or governing document at Hume Dam. However, those differences only highlight the problem in seeking to establish a widely accepted practice not to use rainfall forecasts. Instead, this

[17] LAY.SEQ.012.0001 at [34].
[18] T 4143.28.
[19] T 4112.39.
[20] T 4113.27.
[21] T 4127.15.
[22] LAY.SEQ.012.0001 at .0033.
[23] Seqwater at [1870].

comparison suggests that it is a dam-specific assessment. The evidence concerning Hume Dam undermines Seqwater's pleading of the existence of a practice of "not making precautionary releases based on the weather forecasts … or, in the alternative, in not making precautionary releases based on the 4-day and 8-day weather forecasts".[24] That is exactly what occurred at Hume Dam in December 2010.

13 SunWater submitted that the plaintiff overemphasised operations at Hume Dam. It contended that Hume Dam was "not comparable to Wivenhoe and Somerset Dams" because its primary purpose was water conservation. It noted that Hume Dam did not operate under a water manual, had no surcharge capacity above FSL, used airspace below FSL and otherwise did not use forecasts quantitatively.[25] However, it was the defendants seeking to establish a common practice in relation to not using forecasts, not the plaintiff seeking to establish a common practice of using them, and an analysis of Hume Dam very much undermines their attempts to do so. Otherwise, the various factors pointed to by SunWater again only emphasise how the use of forecasts is a matter for a dam-by-dam assessment. The absence of a water control manual makes the position stronger so far as Wivenhoe and Somerset Dams are concerned as they did have a water control manual and it did require the use of forecasts.

Burrinjuck Dam

14 There was tendered a report into flooding in Gundagai and Wagga Wagga in December 2010 which discussed the conduct of flood operations at Burrinjuck Dam.[26] There was a "Flood Operation Manual" for that dam but it was not tendered.[27] The regulatory approach to FSL at that dam is addressed in Chapter 5.[28] The report indicates that four releases were made from Burrinjuck Dam "to create airspace in response to forecasts of significant rainfall and [the] likelihood of increased flows during late October and

[24] PLE.020.010.0001 at [299(d)(i)].
[25] SunWater subs at [557] to [559].
[26] MSC.010.286.0001.
[27] Ibid at .0028.
[28] Chapter 5 at [129].

November 2010".[29] It also stated that, based on forecasts of rainfall, releases were reduced on three occasions during October and November 2010 from the Snowy Scheme[30] and Blowering Dam, although the rainfall did not eventuate. A further reduction in releases in advance of forecast rain (presumably downstream) was made from the Snowy Scheme just prior to and during December 2010.[31]

15 The report described the approach to releases as follows:[32]

> "BOM short term weather forecasts are used during floods to inform dam management decisions. BOM forecasts used for this purpose include descriptive forecasts, which indicate the type of conditions expected for a particular day or days (for example "isolated showers"), and quantitative precipitation forecasts, which indicate the expected quantum of precipitation for the next day or two. BOM weather forecasts are taken into account by dam operators in deciding whether to make releases to create airspace in the dam, the rate at which surcharge should be evacuated from the dam, what inflows can be expected, whether releases should be delayed due to heavy rainfall forecasts downstream of the dam."

16 This passage and the other instances cited confirm that by the end of 2010 another three dams in Australia, namely Burrinjuck, Snowy Scheme and Blowering Dam, adopted the practice of either making pre-releases based on rainfall forecasts or reducing releases based on forecast rainfall.

17 Seqwater noted that so far as Burrinjuck Dam was concerned the forecasts relied on did not appear to be four-day and eight-day forecasts, the documentary material was ambiguous as to whether rainfall forecasts were used in decision making quantitatively and that a graph of peak inflows and outflows in the report suggested the latter did not exceed past peak inflows.[33] SunWater made similar submissions.[34]

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[29] Ibid at .0006.
[30] Which is a dam.
[31] MSC.010.286.0001 at .0006.
[32] Ibid at .0024.
[33] Seqwater subs at [1881] to [1884].
[34] SunWater subs at [560] to [562].

18 In describing certain precautionary releases made at the end of November 2010, the report stated:[35]

> "Airspace releases were made in *late November 2010* in response to the forecast of some rainfall in *early December 2010*. In particular, on the 28 November 2010 Burrinjuck storage was 97.9 per cent full at 1004 GL and experiencing inflows of 2,463 ML per day. At that time there was 24,000 ML of airspace available in the dam. The releases were set at 9,255 ML per day and were made primarily to create additional airspace in the dam. The release rate was restricted as a result of high downstream tributary flows. The rain continued during *this period*, recording 38.0 mm on 29 November 2010, 23.2 mm on 30 November 2010 and 24.0 mm on 1 December 2010. During this period the releases were reduced due to increasing flows at Gundagai but were continued at maximum permissible rates." (emphasis added)

19 Three matters should be noted about this passage. First, it suggests that the precautionary releases were made based on forecast periods of longer than a day in that the period of releases at least included 29 November 2010 when there was forecast rain for early December 2010. This conclusion is supported by a table of storage levels and releases in the same report which indicates that there was an increase in releases on or around 28 November 2010.[36]

20 Second, the same table suggests that these releases were greater than those previously made for at least a fortnight and possibly five weeks, leaving doubt as to whether there was the application of any principle of keeping peak outflows below *past* peak inflows.

21 Third, leaving aside Dr Christensen's approach of selecting a target level to release to which he adopted on some days in SIM A, SIM E and SIM I, the above description of the approach to releases is very similar to his. Otherwise, there does not appear to be any equivalent approach to selecting strategies at Burrinjuck Dam compared to Wivenhoe Dam, much less any mandated approach to selecting strategies based on predicted maximum storage heights using rainfall forecasts.

22 Otherwise, leaving aside the Manual, the findings in Chapter 4 reveal that releases were made based on rainfall forecasts or anticipated rain from

[35] MSC.010.286.0001 at .0038.
[36] Ibid at .0037.

Somerset Dam during the May 2009 Flood Event and the March 2010 Flood Event.[37]

USA Dams

23 Both Mr Fagot and Mr Swain stated that it is common or typical practice at dams operated by the USACE and the Bureau of Reclamation not to make releases based on forecast rainfall.[38] Similarly, Dr Christensen accepted that it was a "general principle" of USACE that flood operations were "typically made based on the principle of water-on-the-ground which includes observed precipitation that has fallen in the form of rain or snow".[39]

24 However, three related matters should be noted about that "practice".

25 First, although there was a debate about how many dams in the USA adopted this method,[40] there is no doubt that one method of reducing flood risk from anticipated rainfall is via the use of annual or seasonal drawdowns to create additional storage space for anticipated inflows.[41] Mr Swain agreed that at the Hoover Dam the most "significant flood mitigation" strategy is a seasonal drawdown, which he agreed involved making a "precautionary release of water" for the purpose of creating storage space for flood waters thus reducing the "imperative to have regard to more short term forecasts of inflows".[42] Mr Fagot described the approach with seasonal drawdowns as follows:[43]

> "At some rainfall driven systems, there is *a season that is typically wetter*. At these types of systems, the bottom of the flood storage may vary each year. During the *typically wetter times of year*, the bottom of flood storage is at a lower elevation creating a larger flood pool. During the typically drier times of year, the bottom of flood storage is kept at a higher elevation creating a larger conservation pool. Note that this change is based on long term historical

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[37] Chapter 4, section 4.4 and section 4.8.
[38] EXP.QLD.001.0232 at [50(e)].
[39] T 1007.22; see also T 1005.9.
[40] See Chapter 5 at [127].
[41] Reply Report, EXP.ROD.004.0005 at [180]; EXP.ROD.012.0073 at [17] (Schleiss); EXP.SUN.008.0001 at [107] (Ickert); T 7526.20 (Ayre), see also Chapter 5 at [127] and [130].
[42] T 7381.28.
[43] EXP.QLD.001.0232 at [493].

observations and not in response to a single forecasted event." (emphasis added)

26 Thus, one justification for seasonal drawdowns appears to be that the seasonal weather conditions are sufficiently stable from one year to the next to warrant the reduction in water levels. An obvious example of such stability is where there is likely to be inflows from snowmelt.[44] Again, this only confirms that whether or not making precautionary releases based on a particular forecast or based on an assessment of a stable seasonal weather patterns is a decision that varies from dam system to dam system.

27 Second, although it was not the usual practice, a number of the dams operated by the USACE nevertheless used forecasts in making release decisions. Mr Swain, who said he was familiar with the Hoover Dam manuals and procedures, accepted that rainfall forecasts are at least used at that dam for reducing or curtailing releases.[45]

28 As noted in Chapter 8,[46] Dr Christensen described how the Missouri River Mainstem System ("MRMS") uses rainfall forecasts for downstream areas to lower planned releases. In relation to upstream areas, Dr Christensen agreed that the MRMS has "a long lead time in flows in the Missouri basin, so that each dam has a long period to estimate inflows from observed conditions".[47]

29 Seqwater contended that when Dr Christensen was cross-examined on the Master Water Control Manual for that system he conceded that the curtailing of releases was based on an inflow "forecast" that only used rain on the ground.[48] In fact, Dr Christensen only accepted that it was a forecast which "incorporates rain on the ground", ie, an estimate that included rain on the ground data.[49] The passage from the water control manual that he was cross-examined on referred to using "both" an "RCC" forecast that used rain on the ground and an "NWS" forecast that included forecast rainfall as the

[44] Ibid at [468].
[45] T 7368.13; T 7440.35 to T 7441.7.
[46] At [48].
[47] T 994.4 to T 994.17.
[48] Seqwater subs at [1791].
[49] T 1013.7.

"use of both forecasts can provide a reasonable range of future streamflow and river stage [the height of a river in its channel]".[50] When Mr Swain was cross-examined on the same manual, including other provisions that referred to the use of forecasts,[51] he agreed that NWS rainfall forecasts were used to curtail releases.[52]

30 This aspect of the MRMS is borne out by another passage in the Master Water Control Manual which exemplifies how the use of forecasts in a particular dam system is dependent on a multi-factorial assessment that includes the catchment characteristics. Paragraphs 7-04.18 onwards of the MRMS water control manual address the curtailing of releases from one of the dams in the MRMS, namely the Gavins Point Dam, as part of the co-ordinated regulation of that system's reservoirs with the reservoirs in the Kansas River Basin downstream.[53] The approach to curtailing releases from the dam is described as follows:[54]

> "7-04.19. Lower Missouri River Flood Flows. *Because the water travel time to Missouri River locations below Kansas City is over 6 days from Gavins Point Dam, the Kansas City flow target location is the most downstream location for which System releases will normally be scheduled based on a forecast*. Experience has shown that *predicted hydrologic conditions that could produce large rainfalls are only mildly accurate for periods 3 to 6 days in advance and are not accurate for periods more than 6 days in advance*. If System release reductions will not result in missing flow targets and hydrologic forecasts indicate that System release reductions will result in flood damage reductions below Kansas City, a reduction in System releases will be scheduled. This should not be attempted if it will significantly impact System or tributary reservoir flood storage evacuation. Due to the long-range forecasts required and the current state-of-the-art forecasting technology, such System release reductions for this purpose will seldom be necessary except during severe, prolonged downstream flooding periods." (emphasis added)

31 This passage reveals that, in some circumstances, releases are curtailed on account of forecast rainfall over a three to six-day period ("predicted hydrologic conditions that could produce large rainfalls"). It also suggests that an approach was adopted that seeks to account for downstream flow times

[50] ROD.901.002.0160 at .0257; T 1012.43 to T 1013.46.
[51] ROD.901.002.0160 at .0263, cl 6-03.1; T 7391.32 to T 7392.25.
[52] T 7387.35; T 7394.9.
[53] ROD.901.002.0160 at .0302.
[54] Ibid at .0303.

and the relative accuracy of the available forecasts. It is a similar analysis to that undertaken by Dr Christensen in relation to downstream forecasts.[55]

32 Precautionary releases based on three-day forecasts were made in April 2010 from the Cumberland River Basin system operated by the USACE, as noted in the "Final After Action Report".[56] SunWater submitted that no weight should be attached to this given the water control manual was not tendered.[57] I do not agree. There is no reason to expect that these releases were not undertaken in accordance with the relevant water control manual. Seqwater noted that Mr Fagot's evidence was that it was his expectation "that such operations would have to be within the terms of the manual for the relevant dams",[58] a proposition that is at the core of the plaintiff's submissions in respect of practice at USACE dams and elsewhere. Seqwater referred to other passages in the report which were said to be consistent with a "qualitative" use of forecasts only,[59] which I assume means a methodology that does not involve calculating and releasing a volume of water calculated by reference to a forecast.[60] The passages referred to are equivocal.

33 Mr Fagot analysed the operation of the Tennessee Valley Authority that operates forty-seven reservoirs in the Tennessee River watershed. He observed that it allows for advance releases based on short-term weather forecasts which he describes as being necessitated by the system's "criteria of holding pools at high levels in the summer for recreation".[61] Seqwater contended that there was no evidence as to whether the forecasts were used "quantitatively" or "qualitatively".[62]

34 The debate about whether releases were made from Folsom Dam on account of rainfall forecasts in 1996 and 2005 was noted in Chapter 8.[63] In addition,

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[55] See Chapter 8, section 8.5.
[56] MSC.010.544.0001 at .0049 to .0050.
[57] SunWater subs at [568].
[58] T 8980.34 - .44.
[59] Seqwater subs at [1818] to [1823].
[60] See Chapter 3 at [256] to [258].
[61] EXP.QLD.001.0232 at [469].
[62] Seqwater subs at [1816].
[63] At [47] to [49].

the plaintiff noted that Mr Fagot and Mr Swain accepted that since 2011 the relevant water control manual for Folsom Dam expressly requires the use of forecasts for pre-release decisions,[64] although Mr Swain said he did not know if it "ha[d] been implemented yet".[65] The methodology at Folsom Dam involved lowering the reservoir down less than previously as part of the seasonal drawdown, with further increases in releases made on the basis of forecasts.[66]

35 Seqwater emphasised the long period of testing that predated this proposal for Folsom Dam and Mr Swain's evidence that pre-releases from Folsom are not capable of causing downstream damage due to the presence of downstream levees.[67] However, this still supports the plaintiff's position. The periods of testing and calibration no doubt predated the amendment of the water control manual for Folsom Dam to reflect the use of forecasts. Even if Seqwater did not undertake such a process before seeking amendments to the Manual that required the use of forecasts, this does not mean the Manual must not be complied with. The fact that downstream damage may not be occasioned by pre-releases simply illustrates that a consideration of whether or not to use forecasts is a dam dependent assessment, the outcome of which is recorded in the relevant water control document.

36 SunWater contended that Folsom Dam could be "distinguished" from Wivenhoe and Somerset Dams because there are clear procedures in its water control manual for the conduct of operations based on rainfall forecasts.[68] Whether that is a basis for distinction depends on the point being made. If the assertion is that forecast rainfall is not to be used in flood operations at Wivenhoe and Somerset Dams, then this distinction is not valid. In any event, as already explained, the Manual is not of the highly prescriptive

[64] T 9021.26 (Fagot); T 7416.20 (Swain).
[65] T 7361.15 (Swain).
[66] T 1379.7 to T 1380.28 (Christensen); see also Engineering Report: Folsom Dam Water Control Manual Update (8 June 2017), SEQ.093.001.0314, .0317 to .0319, .0348; Folsom Dam Water Control Manual (September 2017), SEQ.093.001.0604, .0826.
[67] T 7363.9; Seqwater subs at [1806].
[68] SunWater subs at [569] citing Mr Swain: T 7416.16.

type commonly used in the USA, although it is unambiguous in stating that strategies are to be selected based on a quantitative use of rainfall forecasts.

37 Third, however one describes the practice in the USA in relation to the use of forecasts in the conduct of flood operations, it is always circumscribed by the necessity for flood engineers to comply with the relevant water control manual. Each of Mr Fagot and Mr Swain accepted that necessity without hesitation.[69] All that Seqwater has in fact proved is that it is usual practice for USACE *water control manuals* to either not require the use of forecasts in making release decisions or expressly exclude their use by specifying that such forecasts are made by reference to rain on the ground. An examination of what happens in practice at USACE dams is therefore simply a reflection of what those water control manuals provide. This aligns with the practice that the plaintiff demonstrated, namely the necessity for flood engineers to comply with those manuals.[70] The evidence does not demonstrate that at USACE controlled dams there is some practice of not using forecasts when the relevant water control manual expressly requires their use or is even silent as to their use. It is only a "practice" to the former effect which could be of any assistance to the defendants in this case.

ICOLD Bulletins and European Dams

38 As noted in Chapter 3, Bulletin 125 issued by the International Committee on Large Dams (ICOLD), published in 2003, described eight different methods for releases from dams, one of which was the "Advanced discharge method".[71] That method involved the release of water in advance of the flood peak and was thus inconsistent with any suggested prohibition that peak outflow should always be less than past peak inflow. The Bulletin noted that such methods could be used in "cases where flood forecasting systems are installed and provide reliable and timely information".[72] It also stated that "*in special circumstances* when reservoir inflows can be forecast several days or

[69] T 8975.36 (Fagot); EXP.SEQ.008.0065_OBJ at .0079 (Swain); Chapter 3 at [2].
[70] Chapter 3 at [2].
[71] SEQ.093.001.0001 at .0186 to .0187; Chapter 3 at [282].
[72] Ibid at .0186.

weeks in advance (for example when the runoff occurs from snowmelt), the degree of control for a particular flood may be determined on the basis of current forecasts to best utilise storage".[73] It added that "[a]lso, the amount of flood reduction storage space may be varied seasonally, if the reservoirs are used for multiple purposes".

39 Seqwater noted that this passage identified the ability to forecast reservoir inflows from snowmelt as a "special circumstance" and effectively submitted that an inflow time series which uses forecast rainfall is too uncertain to meet these standards.[74]

40 Two matters should be noted. First, the relevant passage only identified forecasts based on a snowmelt as an example of when reservoir inflows could be ascertained from forecasts days or weeks in advance. Second, the chapter of the ICOLD bulletin from which these passages are taken is entitled "Guidelines for the Hydrological Design of Flood Mitigation Dams".[75] It is not directed to giving guidance to flood engineers in interpreting flood control manuals or conducting flood operations. Instead, it is designed to give guidance to the hydrological design of the dams themselves, including the design of their method of operation. To the extent that a judgment is required about the adequacy of the flood forecasting system at Wivenhoe and Somerset Dams to deal with forecasts and assess reservoir inflows over several days, that judgment is recorded in the Manual. The Manual directs that forecasts were to be used.

41 The ICOLD Bulletin undermines this aspect of Seqwater's case in two respects. First, because it acknowledges the advanced discharge method, including advanced discharges based on forecasts, as a legitimate method of dam operation. Second, because the Bulletin is premised on the assumption that in conducting flood operations, flood engineers will act in accordance with the relevant flood control manual.

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[73] Ibid at .0171.
[74] Seqwater subs at [1766] to [1769].
[75] SEQ.093.001.0001 at .0169.

42 To similar effect, Seqwater cited an ICOLD Bulletin published in 2016 concerning Multipurpose Water Storage in support of the proposition that "in selecting a method for operating a multipurpose dam *the decision maker* should expressly analyse the issue of the uncertainty in the flood forecast before making a decision on the inherent allocation of risk to different stakeholders".[76] Seqwater's submissions then set out a passage from the Bulletin describing a decision-making process called "Predictive Uncertainty" which is for the benefit of "a developer or a Government" (ie, not for a flood engineer). Thus, the Bulletin is addressed to the decision-making process that leads to, inter alia, the approval of a water control manual, not the conduct of flood operations in accordance with such a manual.

43 Seqwater referred to another ICOLD Bulletin, issued in 2012, on the Safe Passage of Extreme Floods which discussed, inter alia, the relationship of meteorological and hydrological forecasts to runoff models.[77] It noted that "improvements in timeliness of hydrological forecasting for any but the very large rivers will hinge chiefly on progress made in rainfall forecasting" but that "the input to [rainfall/runoff] models, usually the rainfall quantity during a given time period, is normally obtained from the actual observations and for most rivers the flood forecast from the model based on this input is but a few hours ahead of the actual event".[78]

44 Professor Schleiss was a member of this committee. When he was asked whether "it was a widely accepted practice to use only rain on the ground as at 2011", he replied: "Yes. But not exclusively. It was a practice to use rain on the ground, but there were also some cases when it was useful also to use rainfall forecasts."[79] Seqwater contended that answer was sufficient to invoke s 22 of the *CLA* (Qld).[80] I address that in Chapter 11, but it suffices to state that, as the answer is divorced from the context of considering a Manual that expressly requires the use of forecasts, it was not.

[76] Seqwater subs at [1828] citing SEQ.093.004.0292 at .0318, .0384 to .0388.
[77] SEQ.092.004.1475 at .1605.
[78] Ibid at .1605 to .1607.
[79] T 3051.25 - .42.
[80] Seqwater subs at [1827].

45 In his report, Professor Schleiss described the development from 2002 of the MINERVE flood forecast system for the Upper Rhone Basin in the Swiss Alps. This system seeks to optimise flood management by making pre-releases based on weather forecasts in certain circumstances.[81] The occasion for its use had not arisen prior to 2011.[82] In its submissions, Seqwater addressed the operation of the MINERVE system, in detail noting the elaborate testing and evaluation undertaken of the system,[83] how arrangements are in place to compensate hydroelectric-generators from any loss in capacity that might arise from making pre-releases[84] and how, prior to 2011, the operating committee that was convened to operate the dams in question in the event of an anticipated flood event had not yet acted on a recommendation to make a pre-release.[85] This does not add to the analysis above.

46 Seqwater also placed emphasis on an answer from Professor Schleiss to the effect that, in that system, releases based on forecasts were not to commence unless there was at least the start of a flood event, as evinced by rain on the ground.[86] This appears to be analogous to the operation of the gate trigger level for Wivenhoe Dam, such that even under Dr Christensen's simulations, pre-releases based on forecasts do not commence until a flood event has commenced and the height of Wivenhoe Dam has risen above EL 67.25m AHD.

47 Otherwise I note that, based on his research and discussions with officials at the Loire River dam system, Professor Schleiss described the lowering of the water level in that system based on forecast rain in 2016.[87] Professor Schleiss stated that this involved the implementation of a system established in 2006.[88] His research revealed that similar action was taken at the dam system on the Nabari River in Japan in 2009.[89] Seqwater noted that Professor

[81] EXP.ROD.012.0073, [21].
[82] T 3025.33 (Schleiss).
[83] Seqwater subs [1845] to [1850].
[84] Ibid at [1851].
[85] Ibid at [1852] to [1853].
[86] Ibid at [1854]; citing T 3017.19 - .29.
[87] EXP.ROD.012.0073 at [34] to [37].
[88] T 3072.12.
[89] EXP.ROD.012.0073 at [30].

Schleiss did not have access to the water control manuals for either dam,[90] however, there is no reason to assume that either action was inconsistent with any such manual. It also noted that the article Professor Schleiss cited concerning the Nabari River revealed that the releases were made in the context of an approaching typhoon and that the operators had available to them rainfall forecasts for short periods with very small temporal and spatial distributions.[91] Again, this only reinforces the point previously made, that a determination as to whether or not to use forecasts in dam operations is a product of each dam's particular circumstances.

Pleaded Practices

48 In its Amended Defence, Seqwater responded to the plaintiff's allegations of breach by relying on s 22(1) of the *CLA* (Qld) and pleading that "in not making precautionary releases based on the weather forecasts … or, in the alternative, in not making precautionary releases based on the 4-day and 8-day weather forecasts … the Flood Engineers acted in a way that was widely accepted by peer professional opinion by a significant number of respected practitioners in the field as competent professional practice".[92] As noted in Chapter 5,[93] SunWater's reliance on s 22 was unparticularised, although its submissions identified a practice concerning releases below FSL.[94] The State also pleaded reliance on "accepted peer professional opinion" and particularised the USACE report and other expert opinions.[95]

49 One of the issues between the parties concerns the geographical scope of s 22 of the *CLA* (Qld). At this point it is appropriate to make findings in relation to the various areas referred to by the parties. At least so far as Seqwater's pleading is concerned, no such practice was demonstrated in relation to Queensland. The only Queensland dams the subject of evidence were Wivenhoe, Somerset and North Pine Dams. The relevant manual for two of

[90] Seqwater subs at [1855] to [1856].
[91] Ibid at [1857].
[92] PLE.020.010.0001 at .0157, [299(d)].
[93] Chapter 5 at [194].
[94] Eg PLE.030.008.0001 at .0093, [213(b)].
[95] PLE.040.007.0001 at .0127, [308].

them expressly required the use of forecasts and, as noted, prior to January 2011, rainfall was used as the basis for releases from Somerset Dam.[96] Further, given the evidence concerning Hume and Burrinjuck Dams, the existence of such a practice was not demonstrated in relation to Australia.

50 In relation to the USA, as noted, all that was demonstrated was that there was a usual, or even widely accepted, but not invariable practice of preparing (highly prescriptive) water control manuals that required releases to be determined by reference to rain on the ground assessments and a practice that flood engineers comply with the applicable manual. In the present circumstance, namely, a water control manual that expressly requires the use of rainfall forecasts in flood operations, this finding is irrelevant. The position is no better for the defendants in relation to Europe. Otherwise, I am satisfied that whether a water control manual requires, permits or excludes the use of forecasts in flood operations is the outcome of a multi-factorial analysis that depends on the particular circumstances of each dam.

Submitted Practices

51 The plaintiff did not contend for any generally or widely accepted practice save for the necessity for flood managers to act in accordance with the relevant water control manual regardless of their own views,[97] a proposition that I accept. So far as using forecasts in making operational decisions during flood operations and the making of releases below FSL are concerned, the plaintiff contended there was no widely accepted practice applicable to flood mitigation dams generally.[98] Instead, it submitted that "whether such practices are required, permissible or prohibited turns on the terms of the manual for each dam".[99] I have already accepted that contention so far as releasing below FSL is concerned subject to the proviso that it also depends on the

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[96] See Chapter 4 at [66].
[97] Plaintiff subs at [148] to [151].
[98] Plaintiff subs at [152].
[99] Id.

regulatory regime at the relevant dam and not just the relevant water control manual.[100] I accept the balance of the submission.

52 In its submissions, Seqwater sought findings to the following effect as to what the evidence established was "as at January 2011 a widely accepted approach to undertaking flood operations in real time", namely:[101]

> "(a) To select releases so that outflow rates did not exceed inflow rates until after the peak inflow rate had occurred, and thereby to ensure compliance with the fundamental principle and satisfaction of the no dam scenario comparison;
>
> (b) To prepare flood forecasts and to develop release plans based on *quantitative* inflow time series derived using water-on-the-ground;
>
> (c) *Not* to prepare flood forecasts or develop release plans based on *quantitative* inflow time series or *quantitative* volume estimates using rainfall forecasts;
>
> (d) Rather, to use rainfall forecasts *qualitatively* to evaluate future planned releases and "what if" scenarios, which (depending on an exercise of engineering judgment) may in some circumstances lead a Flood Operations Engineer to "adjust" or "shade" a release plan otherwise developed, most commonly by reducing releases because of anticipated worsening downstream conditions;
>
> (e) To use the capabilities of a computer tool like the RTFM in an iterative way to develop potential release plans and assess the likely effects of those potential plans using storage routing, and to reanalyse the selected release plan frequently (e.g. every 1, 3 or 6 hours) to respond to changes in conditions;
>
> (f) In a multipurpose system, to respect pre-determined allocations of reservoir storage into compartments allocated for different purposes (e.g. water supply);
>
> (g) In multi-reservoir and major river basin systems, to pre-allocate lower portions of a flood storage compartment to fill so as to maximise flood risk management for more frequent events, and if and when those lower portions are filled to switch to different approaches designed to deal with less common, more extreme events;
>
> (h) When the lake level reaches a pre-determined dam safety level, to make releases at rates equal to or greater than inflow to stop the rise in lake level." (emphasis added)

[100] Chapter 5 at [197] to [200].
[101] Seqwater subs at [1721].

53 These contentions represent far more refined "practices" than those pleaded by Seqwater in its defence. They appear to be specifically tailored to reflect how the flood engineers asserted that they conducted flood operations compared to Dr Christensen. One difficulty with an acceptance of these contentions is the more refined, nuanced and dam specific the asserted practice becomes, the less likely that it can be demonstrated to be "widely accepted".

54 Sub-paragraph (a) is in effect a re-formulation of the suggested construction of the Manual to the effect that peak outflow not exceed past inflow rates as a "widely accepted practice". This was addressed in Chapter 3.[102] I do not accept the evidence establishes that "practice". First, none of the extensive discussion in Seqwater's submissions concerning overseas dams addresses that issue.[103] Second, the advance discharge method described in ICOLD Bulletin 125 noted above is inconsistent with that practice (although that is not determinative of whether the practices is nevertheless "widely accepted"[104]). It contemplates release rates exceeding past peak inflow rates where forecasts are used, something the Manual expressly requires. Third, Mr Fagot's evidence was directly inconsistent with the existence of such a widely accepted practice if it was authorised by the relevant water control manual ("I don't have a problem with releasing inflows that are … releasing higher than the inflows to date"[105]).

55 Similarly, sub-paragraphs (b) to (d) all concern the specific methods of either preparing release plans only by reference to rain on the ground and/or the approach to considering or not considering rainfall forecasts. Again, Seqwater's review of the evidence of practice at other dams did not establish such specific "widely accepted" practices. The same applies for (e). All of these matters are governed by the relevant water control manual for the dam in question and the relevant "practice", so far as flood engineers are concerned, is to comply with the relevant water control manual. There was no

[102] Section 3.3.9 and [375] to [376] in relation to Mr Fagot.
[103] Seqwater subs at [1741] to [1884].
[104] *CLA* (Qld); s 22(1).
[105] T 9008.19.

evidence bearing on the widely accepted practice on these topics when the relevant water control manual does not address them.

56 Sub-paragraph (f) concerns releases below FSL, a topic which was addressed in Chapter 5. Sub-paragraph (h) appears to be an attempt to elevate that part of the Manual that requires releases above EL 74.0m AHD to stabilise the height increases from inflows to the status of a widely accepted practice. Again, the only relevant practice that was demonstrated was to comply with whatever the relevant water control manual specified on such a topic.

57 In relation to contention (e), the only evidence that Seqwater pointed to in support of it[106] was the following answer from Mr Swain:[107]

> "Q. Have you gone back to the response report simulations to see whether the point in time at which Dr Christensen moves to an S3 strategy in some simulations is too early or too late?
>
> A. I think, in general, most of - he was advancing most of his strategies pretty early, just partly because of the way he was choosing his simulation strategies. I think the *normal way for choosing a strategy would be to have sort of an iterative approach*, where you get your inflows and your outflows all considered to determine your water levels, and that goes into your consideration of what strategy you have. Most of the time it was looking to me *like his strategies were based on taking the inflows, seeing about how high the water level would be*, and then going to that strategy rather than considering what the possible outflows were." (emphasis added)

58 In this passage, Mr Swain was not addressing the approach to releases but instead Dr Christensen's method of determining strategies and doing so based on "how high the water level would be"; (ie, the "maximum storage level"). His reference to the "normal way for choosing a strategy" does not establish any widely accepted professional practice in relation to strategy selection and, even if it did, it would be of no relevance to this matter given that he refers to it in contrast to Dr Christensen's approach to selecting strategy using the precise method stated in the Manual.

[106] Seqwater subs at [1785].
[107] T 7321.43 to T 7322.11.

59 So far as setting releases are concerned, as opposed to strategy, no aspect of the negligence alleged against the flood engineers is that they were negligent per se in using iterative modelling via the RTFM to set releases. Instead, the case against them concerns the limitations they imposed on themselves in doing so, specifically selecting strategies by reference to actual levels and then failing to make releases by reference to inflow estimates derived from rainfall forecasts as opposed to rain on the ground data.

60 SunWater's submissions in respect of "well-recognised and accepted practices"[108] are noted in Chapter 3.[109] Those submissions were principally or solely based on Mr Fagot's evidence. In any event, the evidence concerning the practices at dams elsewhere in Australia and overseas only reinforces the conclusion in Chapter 3.[110] (The State's submissions on this topic are addressed in Chapter 11.[111])

9.2: Use of PME and QPF Forecasts in Flood Operations and Addressing Forecast Uncertainty

61 The defendants took issue with Dr Christensen's reliance on forecasts in the conduct of flood operations on the basis of practice at other dams, the uncertainty that inure in rainfall forecasts, and their overall unreliability. One part of that response has just been addressed. Their other criticisms are addressed below, but in summary:

(i) Dr Nathan's analysis of the uncertainties associated with forecasts and flood modelling provide significant support for Dr Christensen's approach;

(ii) Both QPFs and four-day PME forecasts are sufficiently reliable for use in flood operations provided the method of their utilisation addresses the uncertainties associated with forecasts. There is insufficient

108 SunWater subs at [82] to [109].
109 At [374] to [376].
110 At [377].
111 Section 11.7

justification for the use of eight-day PME forecasts in the conduct of flood operations other than for deriving “situational awareness”;

(iii) Given the dam capacity and catchment characteristics, the obligation to consider “best forecast rainfall” in the Manual required the use of upstream forecasts for periods longer than a day. On the evidence available, it followed that the four-day PMEs were required to be used to select strategies and, at the very least, considered in determining releases;

(iv) Dr Christensen’s methodology, especially his approach to releases, sufficiently addressed the uncertainties associated with the PME and QPF forecasts in a manner consistent with the Manual;

(v) Leaving aside Dr Christensen’s adjustment to PME ranges for orographic effect, his method of ascertaining PME forecast depths was reasonable;

(vi) Dr Christensen’s allocation of rainfall predicted by PME forecasts to above dam sub-catchments by taking into account orographic effect was not material to his modelling of inflow volumes;

(vii) There was a reasonably narrow variation in the range of reasonable assessments of rainfall depths in the four-day and eight-day PMEs by the various witnesses. Dr Christensen’s rainfall depths were well within, but towards the higher end of, a reasonable range of figures. The materiality of the differences, if any, will be addressed, in the context of Dr Christensen’s simulations.

Dr Nathan’s Forecast Uncertainty Analysis

62 In his report entitled “Assessment of Forecast Uncertainty in the January 2011 Event” (“Forecast Uncertainty Report’),[112] Dr Nathan recorded the results of his “stochastic” modelling of the four-day 8 January 2011 00UTC forecast which forecast rainfall of between 75mm and 300mm for the four-day period

[112] EXP.SEQ.014.0013.

commencing at 10.00pm on 8 January 2011, according to the plaintiff, and 50mm to 300mm of rain above the dam and 100mm to 400mm of rain below the dam according to the State.[113] It was one of the highest four-day forecasts during the January 2011 Flood Event.[114] Dr Nathan varied several parameters within the modelling which resulted in six different scenarios. Variation of these key forecast inputs, a technique known as "stochastic simulation", was used to assess each input's relative level of uncertainty in the forecast (based on data collected during the January 2011 Flood Event).[115]

63 The results of Dr Nathan's analysis in respect of flood peak, flood timing and flood volume are set out in the following "tornado plot":[116]

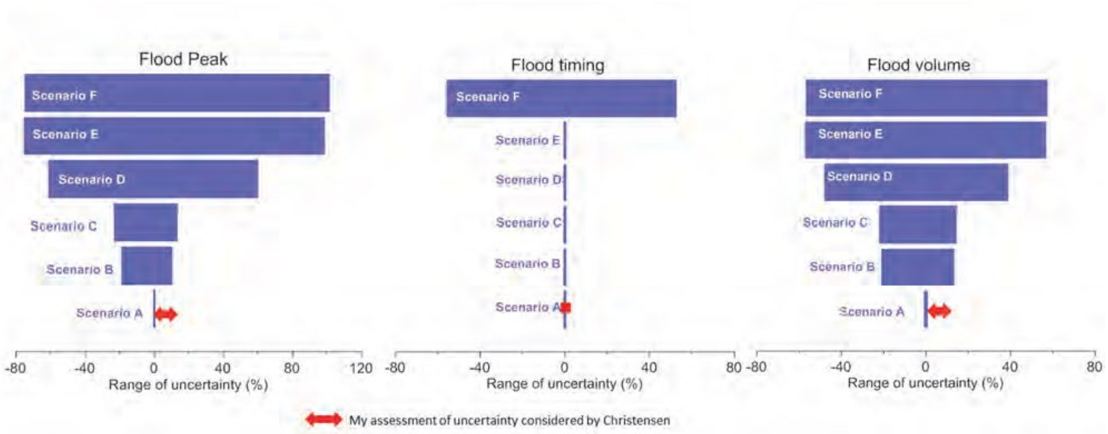

Figure 9-1: Dr Nathan's "Tornado" Analysis of Rainfall Uncertainty

64 Dr Nathan's Forecast Uncertainty Report includes the following table explaining the six scenarios as follows.[117]

[113] See Chapter 7 at [137].
[114] See Chapter 6 at [3].
[115] EXP.SEQ.014.0013 at [54] to [55].
[116] Ibid at .0028.
[117] EXP.SEQ.014.0013 at .0027.

Scenario	Description	Continuing loss	Rainfall depth	Spatial distribution of rainfall	Temporal distribution of rainfall
A	"Best estimate" based on fixed inputs	Fixed	Fixed	Uniform	Fixed
B	Uniform uncertainty in losses	Uncertain	Fixed	Uniform	Fixed
C	Scenario B combined with fixed rainfalls that vary by sub-area	Uncertain	Fixed	Uniform by sub-catchment	Fixed
D	Scenario C combined with uncertainty in catchment average rainfalls	Uncertain	Uncertain	Uniform by sub-catchment	Fixed
E	Scenario D combined with uncertainty in spatial distribution of rainfalls	Uncertain	Uncertain	Uncertain	Fixed
F	Scenario E combined with uncertainty in temporal and spatial distribution of rainfalls	Uncertain	Uncertain	Uncertain	Uncertain

Table 9-1: Dr Nathan's Table of Scenarios used for different sources of uncertainty

65 In scenario A, Dr Nathan used a single rainfall amount across all sub-catchments,[118] namely 222mm,[119] with a single continuing loss rate of .81mm/hour[120] and a single temporal pattern.[121]

66 Scenario B was the same as scenario A but Dr Nathan modelled changes in loss rates by conducting 100 runs that randomly selected continuing loss rates between 0 and 1.5mm/hour.[122]

67 Scenario C was no different from scenario B except that the rainfall amounts were varied across the sub-catchments subject to maintaining the catchment average rainfall constant, the "relative sense of spatial uncertainty".[123] However, as that catchment average covered downstream areas, this meant that the catchment average rainfall above the dam may have differed from scenario A in some iterations.[124] Dr Nathan agreed that this form of spatial distribution is likely to only yield a "modest" change in inflow volumes.[125]

[118] T 4397.28.
[119] T 4399.35.
[120] T 4399.39.
[121] T 4400.3.
[122] T 4400.46; T 4401.25.
[123] T 4403.8.
[124] T 4405.31 - .40.
[125] T 3732.34; T 4383.29 to T 4384.5.

68 Scenario D varied the continuing loss rates but also assigned different rainfall in each sub-catchment,[126] with no correlation between different rainfall amounts and loss rate values.[127] Scenario E represented a variation on scenario D whereby the difference between forecast rain and actual rain was correlated to a nearby sub-catchment.[128] Thus, for example if "a particular forecast in the upper reaches of the Wivenhoe catchment over-estimate[d] the actual rainfall by 30%, then the errors in forecast rainfalls over the Somerset catchment w[ould] be similar".[129]

69 Scenario F was the same as scenario E but it accounted for temporal uncertainty by changing the timing of the rain falling.[130] Two matters should be noted. First, in the scenario that was modelled, the timing of the rain falling had little impact on the inflow volume and size of the peak but significantly impacted the timing of the peak. So much can be seen in the "tornado plot" that is Figure 9-1 above. Second, there is an interrelationship between loss rates and the effect of a variation on the timing of rainfall. As the loss rates trend to zero in a saturated catchment the effect of any temporal variation on the volume of inflows will also trend towards zero.[131]

70 Dr Nathan's analysis showed that, for the 8 January 2011 four-day 00UTC forecast, a movement from scenario A to scenario B (ie, the utilisation of different loss rates) caused a variation of around 37% in inflow volumes.[132] There was a slight change with scenario C but a much larger increase of 50% (to around to a total of around 89% inflow volume variability) for scenario D, which changed both loss rates and rainfall depths.[133] There was a 27% increase in the variability of inflow volumes to scenario E which involved a correlated variation in rainfall depths. Finally, there was a relatively slight

[126] T 4406.42 to T 4407.3.
[127] T 4409.26.
[128] EXP.ROD.014.0013 at [29].
[129] Id.
[130] Ibid at [30]; T 4417.33; These temporal variations do not involve episodic rain of the kind discussed in Chapter 6 at [299] to [319]: see [222] below.
[131] T 4417.35 to T 4418.20.
[132] T 4418.42.
[133] T 4421.35 to T 4422.11.

increase in inflow volumes when temporal uncertainty was allowed for in scenario F.

71 In one part of his Forecast Uncertainty Report, Dr Nathan noted that the "combined impact of uncertainty in the spatial and temporal characteristics of rainfall depth are around – six times greater than that of losses on the magnitude of the peak [and] three times greater than that of losses on the volume of the inflow flood".[134] However, in cross-examination Dr Nathan modified that statement so that it referred to the combined impact of uncertainty in the spatial and temporal characteristics of rainfall depth *as well as uncertainty about loss rates* being orders of magnitude higher than simply uncertainty with loss rates alone.[135]

72 This modification was significant because in its uncorrected form it was the basis for criticising Dr Christensen's emphasis on the significance of loss rates. Thus, later in his Forecast Uncertainty Report Dr Nathan stated:[136]

> "… it is clear that Dr Christensen has failed to give account to the spatial variability in the rainfall depths; that is he has largely ignored a factor [ie rainfall depths] which, *compared to losses*, has a six-fold greater influence on flood peak, and a threefold greater influence on flood volume." (emphasis added)

73 This statement extrapolates from the analysis of a single four-day PME forecast to enunciate a general proposition concerning all forecasts in the January 2011 Flood Event. It incorrectly asserts that an analysis of that forecast suggested that variations in rainfall depth had a threefold greater influence on flood volume when the correct position was that variations in rainfall depth, temporal patterns *and loss rates* had a threefold greater influence on flood volume, as opposed to just variations in loss rates. Further, the spatial uncertainty being referred to is not spatial distribution of rainfall

[134] EXP.SEQ.014.0013 at [31].
[135] T 4426.12.
[136] EXP.SEQ.014.0016 at [34].

within the catchment but spatial distribution either within or outside the catchment, which is in effect a variation in rainfall depths.[137]

74 Five other matters should be noted about Dr Nathan's analysis.

75 First, his stochastic modelling of the four-day 00UTC 8 January 2011 forecast supports so much of Dr Christensen's approach that emphasises modelling of inflow volumes as opposed to inflow rates. On any view of Dr Nathan's analysis, inflow volumes are less sensitive to movements in the various parameters than peak inflow rates are.

76 Second, Dr Nathan's analysis suggests that there is likely to be little difference in inflow volumes from variations in temporal patterns of sporadic rainfall as evinced by the lack of any substantial variation between scenario E and scenario F. However, Dr Nathan accepted that an assumption of uniform spatial and temporal distribution would "absolutely always lead to an underestimate".[138]

77 Third, even allowing for the fact that the modelling was undertaken on a very large forecast, the second biggest contributor to uncertainty in determining inflow volumes in his analysis was variation in loss rates. The degree of uncertainty associated with variations in loss rates is likely to increase with lower forecast rainfall. This is borne out by considering the variations in inflow volumes derived from using different loss rates discussed elsewhere in this Chapter.

78 Fourth, the largest contributor to uncertainty in the assessment of inflow volumes is the uncertainty over rainfall depths, which includes uncertainty over whether forecast rainfall falls inside or outside of the catchment. This aspect of uncertainty is addressed next.

79 Fifth, temporal uncertainty in the sense used by Dr Nathan is the most significant contributor to the uncertainty over the timing of the peak rate of

[137] T 4426.25.
[138] T 3707.1 - .27.

forecasted inflows.[139] However, it only had a minimal impact on the assessment of the volume of inflows with a forecast of this size.

Forecast Reliability and Uncertainty

80 It is necessary to describe the reliability and uncertainty associated with the various forecast products.

81 It is trite to observe that weather forecasts, like all predictions, are uncertain and, the longer the advanced time of the prediction, the greater the uncertainty. The complexity (ie, non-linearity) of climate systems exacerbates the uncertainty.[140] However, advances in the availability of data and computing power have contributed to increasing accuracy in forecasting.[141] Professor Manton noted that "advances in numerical weather prediction have recently been described as a 'quiet revolution'" and that there has been a demonstrated increase in the "*skill* of NWP models in recent decades".[142]

82 Professor Walsh explained that the concept of "skill" in relation to weather forecasting is the "ability of a model to make a forecast that is statistically significantly better than chance, or a forecast made using random numbers".[143] He stated that a full assessment of skill requires an evaluation "over a period that is long enough so that the inclusion of additional evaluation data does not change the statistical evaluation of … skill",[144] which presumably is a reference to additional short term data. He identified various statistical measures of skill.[145]

83 As noted in Chapter 4, there was some analysis of QPF forecasts in Mr Ayre's 2001 Pre-Release Report;[146] the Connell-Wagner Paper[147] and the 2006 BoM

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[139] T 4386.12 - .20 (Nathan).
[140] EXP.SEQ.004.0131 at .0153.
[141] MSC.010.274.0001 at .0017.
[142] EXP.SEQ.004.0131 at .0153.
[143] EXP.ROD.014.0034 at [1.2].
[144] Id.
[145] EXP.ROD.014.0034 at [1.10] to [1.12].
[146] SUN.001.002.6314; Chapter 4 at [4] to [6].
[147] ROD.901.001.115; Chapter 4; section 4.3.

Report.[148] The latter report noted that "it is likely that verification [of QPFs] would show reasonable skill in identifying rainfall events but quite poor skill in predicting extreme events".[149] Similarly, the 2009 FER prepared by Mr Ayre stated that a "comparison between the forecasted and recorded rainfalls shows that generally the QPF estimates were reasonable, although the forecasted rainfall tended to underestimate the larger totals recorded in the North Pine catchment".[150] SunWater's training and flood preparedness reports from 2007 and 2009 described the QPFs as providing "a relatively reliable indicator of the likelihood of rainfall in the catchments up to 24 hours in advance".[151]

84 In July 2009, the BoM advised that the then version of the PMEs that possessed a spatial resolution of 100km (as opposed to the version with a spatial resolution of 50km that was available in January 2011) "*easily outperform[ed] a random guess*", and that they outperformed climatology even when forecasting five days ahead.[152] The subsequent adoption of 50km resolution PMEs enhanced the accuracy of the PME forecasts.[153] Professor Manton agreed with the statement by the BoM that, while forecast systems are not perfect, "people [can] be confident that, on average, the forecast would supply them with information to help shape their decisions".[154] However, the same publication also noted that "the forecast maps have been prepared on a grid roughly 100km by 100km" and that "[b]ecause rainfall is seldom uniform over such an area (particularly when rain is falling as showers or thunderstorms, or when local topography is influencing the location of the heavier falls), [one] should treat the totals as a guide only".[155]

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148 SEQ.001.018.9373; Chapter 4; section 4.3.
149 Ibid at .9374.
150 SEQ.084.003.0365 at .0381.
151 SEQ.001.001.4400, at .4436; SEQ.084.003.0326 at .0355.
152 MSC.010.263.0001; T 3632.28 (Manton); T 6052.14 - .21 (Tibaldi); see also Walsh 1, EXP.ROD.014.0034, [1.13] (older PMEs had skill for rainfall predictions at least up to 72 hours in advance).
153 T 3387.3 (Walsh).
154 T 3633.14 (Manton).
155 QLD.012.002.1638; State subs at [398].

Professor Walsh and Professor Manton

85 Professor Walsh noted that the BoM's own assessment in 2010 concluded that the higher resolution PME forecasts introduced in 2010 "provided slightly superior rainfall forecasts to the 1 degree PMEs for the period 1 June – 15 November 2010, summed over all grid points over Australia". He considered that there was likely to be sufficient grid points across Australia for the "statistics [underlying the analysis] to be robust".[156] While he accepted that it was "more difficult to forecast in January in the northern part of the country"[157] he stated that he would "also expect [the BoM's] assessment of skill over the entire country to translate into improved skill in the various parts of the country".[158] He also noted that a 2013 longer term study of the PMEs concluded that they had "some skill (ie, were statistically significantly better than a random forecast) for rainfall predictions up to 72 hours in advance", were "better for shorter, 24-hour forecasts" and were "better for light rainfall events … than for heavy rainfall events". He stated that "[h]eavy rainfall events were consistently under-predicted by the PMEs".[159] In referring to this study, Professor Manton accepted that "forecasts at day 3 are better than random, [but] they are far less accurate than at day 1",[160] although he did not agree that they consistently under-predicted heavy rainfall.[161]

86 Professor Manton analysed the QPFs for the period of December 2010 to January 2011 including the January 2011 Flood Event. He calculated a mean error of 7mm and a correlation with observed data of 0.66.[162] He observed that the mean error was "quite low, because there is a tendency to over-estimate small events and under-estimate the large events".[163] He noted that the errors on individual days were up to 102mm.[164] Professor Manton described the QPF forecasts as the "best available forecasts for the Wivenhoe

[156] EXP.ROD.014.0034 at [1.11].
[157] T 3385.31.
[158] T 3385.22.
[159] EXP.ROD.014.0034 at [1.13].
[160] EXP.SEQ.010.0011 at [62].
[161] Ibid at [63].
[162] EXP.SEQ.004.0131 at .0158.
[163] Id.
[164] EXP.SEQ.004.0131 at .0159.

and Somerset Dams from a meteorological perspective”,[165] but in doing so he disclaimed any suggestion that he was seeking to interpret that phrase in the Manual.[166] The basis for his conclusion was that they were specifically prepared by the BoM for the catchment, were provided twice a day and were tailored so the time at which they were provided generally corresponded with the time period the subject of the forecast.[167]

87 Professor Manton undertook a similar analysis of the PME forecasts available during the period of December 2010 to January 2011. He concluded as follows:[168]

> “Generally there is little discernible difference between the forecasts with 10 am base time and those with 10 pm base time. It is also seen that the forecasts and observations are well correlated when assessed over the whole period. Indeed, the correlation over all 10 am forecasts is largest for the North region, where it is 0.78; it is 0.76 for Lockyer Creek 0.71 for Bremer and 0.69 for Lower Brisbane. However, there are substantial errors, especially during the severe storms of January 2011. For the 24 hours ending at 10 pm on 9 January, both the 10-am and 10-pm PME forecasts under-estimate the rainfall in the North region by more than 80 mm, and over-estimate the rainfall in the Lower Brisbane by more than 115 mm. For the following 24 hours (ending at 10 pm on 10 January), the forecasts over-estimate by more than 180 mm in the Lower Brisbane. The large errors in the individual regions over 9 to 11 January demonstrate the difficulty in accurately predicting the precise timing and spatial variation of extreme-rainfall events.”

88 Professor Manton also concluded that the errors in the day-two PME forecast were similar to those for day-one “but there is little accuracy beyond day 2 for 10-am base time forecasts and beyond day 3 for 10-pm base time forecasts”.[169] However, Professor Manton agreed that an analysis of the four-day PME forecasts over the period 1 December 2010 to 8 January 2011 showed that they were “reasonably good, displaying skill”[170] (as were the QPFs).[171]

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[165] Ibid at .0135.
[166] T 3597.44.
[167] T 3598.13.
[168] EXP.SEQ.004.0131 at .0155.
[169] Ibid at .0157.
[170] T 3663.43 and AID.020.018.0001 at .0002.
[171] T 3582.41 and AID.020.018.0001; cf State subs at [411].

89 Overall, Professor Walsh concluded that "PMEs typically have been shown to have reasonable skill for forecasts up to five days"[172] or, as he stated in oral evidence, "one could obtain some moderate skill from the PME forecasts out to about five days".[173] Professor Manton stated that, based on his analysis of the period of December 2010 to January 2011, he disagreed with that statement to the extent that it went beyond three days.[174] The State also referred to an analysis by Mr Giles of a single four-day PME on 8 January 2011.[175] It was directed to undermining the accuracy of the daily breakdown of rainfall. If anything, it undermines the flood engineers' approach of assuming releases can be made later rather than sooner.

Dr Nathan

90 Dr Nathan undertook a retrospective analysis of the uncertainty of forecast predictions during the January 2011 Flood Event of flood inflows and volume; that is, he compared the performance of the forecasts against the rain that eventually fell. Without describing his approach in detail, it suffices to state that his analysis revealed that the forecasts systematically under-forecast the amount of rain that fell in the January 2011 Flood Event such that if he had undertaken the analysis prospectively then he would have manually inflated forecast rainfall to account for the systemic under-prediction in rainfall.[176] In particular, Dr Nathan concluded that the one-day and four-day PMEs in the upper reaches of the catchment were typically 30% lower than actual rainfall, with the bias reducing to near zero in the lower reaches.[177] He concluded that these showed "some skill",[178] but the skill level was "poor"[179] where "skill" in this context is a measure of bias and scatter.[180]

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[172] EXP.ROD.014.0034 at [1.14].
[173] T 3390.16.
[174] EXP.SEQ.010.0011 at [65].
[175] State subs at [410].
[176] EXP.SEQ.014.0013 at .0016, [S7]; T 4612.5 (Nathan).
[177] EXP.SEQ.014.0013 at .0016, [S7].
[178] T 3684.1.
[179] T 3695.23 - .31.
[180] T 3686.28 to T 3687.6.

91 Dr Nathan concluded that the eight-day PMEs had very little skill anywhere in the catchment[181] and later in cross-examination stated that they had “almost no skill”.[182] Dr Nathan also concluded that the QPFs were only slightly more reliable than the PMEs and that their order of accuracy was also “poor”.[183] To the extent that there is difference in the qualitative assessment of the skill of the forecasts between Professor Manton and Walsh on the one hand and Dr Nathan on the other, then, given their greater experience with forecasts, the former is to be preferred.

Conclusion

92 Both Professor Walsh and Professor Manton provided little support for the reliability and accuracy of an eight-day PME forecast (and neither did Dr Nathan). For shorter periods, Professor Walsh expressed some confidence for forecasts up to five days whereas, at least in his reports, Professor Manton did not express the same opinion beyond three days. Professor Walsh’s opinion was based on more long-term studies whereas Professor Manton’s conclusions appear to result from his analysis of rainfall data in the period of December 2010 to January 2011. However, even with that data, he acknowledged some skill with the four-day PMEs (see [88]). Subject to considering how uncertainty was addressed and the other issues addressed below, their evidence provides significant support for the use of four-day PMEs in flood operations beyond merely using them for “situational awareness”.

93 Five further matters should be noted about the analysis of the forecasts.

94 First, Professor Walsh and Professor Manton disagreed about the utility of a single event analysis in determining the performance of a forecast such as that undertaken by Professor Manton for the period of December 2010 to January 2011.[184] In the end result, in light of the evidence noted at [88], it is not necessary to resolve that disagreement as there was no substantive

[181] EXP.SEQ.014.0013 at .0016, [S7].
[182] T 3683.46.
[183] T 3695.21 - .31.
[184] EXP.ROD.014.0034 at [2.1], [2.12] and [2.14]; EXP.SEQ.010.0011 at [47] to [48].

difference between their conclusions as to the relative "skill" of at least the one-day to four-day PMEs (or the QPF forecasts).

95 Second, Professor Walsh and Professor Manton disagreed over the statistical significance of a PME forecast. Professor Walsh stated that a PME forecast provides the median estimate of rainfall at a particular location; ie an estimate in respect of which there is a 50% chance that actual rainfall will be either higher or lower.[185] Professor Manton disagreed. He stated that in having regard to the method by which the PME forecasts are compiled from their constituent forecasts, the PME forecast does not equal the median forecast.[186] He opined that the 50% probability of exceedance forecast was the median,[187] as it represented the midpoint between the four lowest and four highest Access forecasts which contributed to the overall PME forecast.[188] I accept Professor Manton's evidence on this point as he displayed a greater knowledge of the method by which the PME forecasts were prepared. That said, I am not persuaded that anything turns upon any failure on Dr Christensen's part to understand this aspect of the PME forecasts.

96 Third, regardless of whether the analysis was based on material available before, during or after the January 2011 Flood Event, a common theme of the above materials is the tendency of both QPF forecasts and PME forecasts to overestimate smaller events and underestimate larger events.[189]

97 Seqwater noted that the eight-day forecasts over-predicted the rainfall in the downstream catchments in the period of 9 to 14 January 2011 and across all the catchments during the Late December Flood Event.[190] It contended that the potential for overestimation was ignored by the plaintiff and Dr Christensen. In relation to the period of 9 to 14 January 2011, the fact that, at the time the forecast was issued, an extremely close analysis of the PMEs

185 EXP.ROD.014.0034 at [1.6].
186 EXP.SEQ.010.0011 at [7] and [38].
187 Ibid at [38], [40].
188 Ibid at [33]-[34], [86].
189 EXP.SEQ.004.0131 at .0155; EXP.SEQ.010.0011 at [40].
190 Seqwater subs at [1953] to [1954].

suggested that more rain would fall downstream rather than upstream, coupled with Dr Nathan's analysis of the significance of rainfall depth to uncertainty in assessing the volume and rate of inflows, only highlights the need for the conduct of flood operations to guard against the risk of more rain falling upstream, not less (and certainly not none).

98 In relation to the Late December Flood Event, Seqwater contended that the significance of that overestimate is the difficulty that would occasion "if one were looking at the January 2011 PMEs and trying to assess whether or not there would be an over-prediction or an under-prediction … in circumstances where the [Late December Flood Event] constantly over-predicted the rainfall which in fact fell".[191] However, that submission only emphasises the fact that, at least so far as a flood engineer is interpreting the PMEs in real time, they should not be undertaking the exercise of attempting to calculate whether there is some systemic bias in the PMEs by reason of the most recent weather event or other data. Instead, they should have been obtaining rainfall estimates from the PMEs and seeking to address uncertainty including the possibility of underestimation, whether caused by systemic bias or other causes, in some other way.

99 Fourth, accepting for the present the appropriateness of an analysis purely based on rainfall between December 2010 and January 2011, a comparison of the QPF forecasts to actual rainfall totals during that period reveals that on every occasion when at least 20mm of rain was forecast at least 7mm of rain fell.[192]

100 Fifth, in cross-examination Dr Nathan accepted that it was "very self-evident" that a rain on the ground prediction will always give the "extreme low range" outcome for inflows.[193]

[191] Seqwater subs at [1955].
[192] AID.020.014.0001.
[193] T 4478.5 - .17.

Dr Christensen's Analysis of Forecast Accuracy

101 In Chapter 8[194] I explained Dr Christensen's approach to forecasts. In his February 2015 Report, Dr Christensen discussed forecast accuracy in detail. He concluded as follows:[195]

> "[1] In sum, the reasonably competent flood operations engineer should have recognized that the 1-day BOM rainfall forecasts were the most accurate and that multiple day forecasts become less accurate the longer the forecast range. [2] However, the reasonably competent flood operations engineer should have recognized that forecasts up to five days are of particularly good quality for dam operations. [3] Forecasts of 7 to 10 days are also reasonably accurate for use under the principle that flood operations must err on the side of caution. [4] Particularly, these longer range forecasts for high rainfall events resulting from "large-scale features" that "include decaying tropical cyclones, east coast lows, and significant upper level troughs and lows," such as occurred in the 2010-11 Flood Event, have even greater accuracy and reliability. [5] Further, the reasonably competent flood operations engineer should have recognized that the manuals required use of BOM rainfall forecasts for making operational decisions at the dams." (numbers added)

102 The first proposition was common ground amongst the experts. I accept that the fifth proposition accurately reflects the Manual. In light of the evidence noted above, and Professor Manton's concession that the four-day forecast displayed skill, I partially accept the second proposition at least so far as four days are concerned, such that they are suitable or "sufficient" for dam operations.[196] In relation to the third proposition, I accept that flood operations "must err on the side of caution" in the sense of guarding against the possibility of larger rainfall or rainfall in excess of the forecast. However, it has not been established that forecasts for seven to ten days are "reasonably accurate". As for the fourth proposition, Dr Christensen identified the source of that statement in a footnote to his February 2015 Report[197] and it was not explored in cross-examination. In light of the other conclusions, it is not necessary to consider that further.

103 It is necessary to address a number of submissions made by the defendants about Dr Christensen's knowledge and analysis of PME forecasts.

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[194] Chapter 8 at [62] to [66],
[195] February 2015 Report, EXP.ROD.001.0016 at [126].
[196] T 1250.19.
[197] February 2015 Report, EXP.ROD.001.0016 at [126], fn 66.

104 First, Seqwater contended that in his February 2015 Report, Dr Christensen incorrectly stated that the PME forecasts were made available in digital format, [198] as opposed to maps on the internet and otherwise wrongly assumed that the 00UTC four-day and eight-day forecasts were available from 6.00pm in the evening Brisbane time as opposed to midnight Brisbane time.[199] Neither of these errors was material. Dr Christensen only had the PMEs available in a contour map format. The timing of the availability of the four-day and eight-day PME forecasts is addressed in Chapter 2.

105 Second, citing Professor Manton's evidence, Seqwater submitted that Dr Christensen's use of spatial gradients in PME forecasts "under-estimate[d] the true uncertainty in the forecasts".[200] Professor Manton levelled this criticism at Dr Christensen, because from reading the PME forecast maps, Dr Christensen listed a range for the forecasts and this somehow meant that Dr Christensen ignored the "uncertainties in intensity and timing" of the rainfall.[201] I do not accept that criticism. Given the limited tools that Dr Christensen had available to him in interpreting the maps, his approach of specifying a range was no different from that of the flood engineers' assessments as included in the situation reports.[202] The only information available to him in relation to timing was the daily PMEs and, as explained below, he accounted for uncertainties in timing, intensity and accuracy in the approach he adopted to releases, a matter that Professor Manton, like Dr Nathan, did not address.

106 Third, again based on Professor Manton's evidence, Seqwater contended that Dr Christensen misrepresented the BoM data in evaluating the accuracy of PME forecasts.[203] In his February 2015 Report, Dr Christensen extracted a BoM chart of the one-day rainfall forecasts for Brisbane and Toowoomba which he described as "84 per cent accurate" and "88 per cent accurate"

[198] Ibid at [391].
[199] Seqwater subs at [1957(a)]. The State also made a submission about the timing of the PMEs: State subs at [415] to [416], however it appears to assume the 00UTC 4-day and 8-day PMEs were not available at midnight.
[200] Seqwater subs at [1957(b)]; EXP.SEQ.004.0131 at 6.4.2.
[201] EXP.SEQ.004.0131 at 6.4.2.
[202] See T 1450.37 (Christensen).
[203] Seqwater subs at [1957(c)].

respectively.[204] The relevant chart included a figure for “correlation” of 0.84 and 0.88 with the annotation that “correlation coefficients > 0.8 are considered a good match”.[205] Professor Manton stated that it was “incorrect to equate a correlation with percentage accuracy”.[206] Dr Christensen was not cross-examined on this topic. In the absence of further analysis of how the correlation coefficients were derived then I am not satisfied that there was any misconception or misrepresentation on Dr Christensen’s part or that it was material. The relevant opinion that Dr Christensen expressed on the reliability of forecasts was that set out above.

107 Fourth, Seqwater criticised Dr Christensen’s comparison of one-day forecasts with actual rain on the basis that, as he acknowledges, the day was “partly out of sync because the rain forecast is made for the coming 24 hour day at 0:00 A.M. hours whereas the rainfall received is recorded at 9.00am each morning”.[207] This criticism was not taken up with Dr Christensen in cross-examination. In any event, it appears that, at the time Dr Christensen prepared his February 2015 Report, actual rainfall figures to midnight were not available to enable a comparison to be made to the forecasts available for the same period.

Addressing Forecast Uncertainty

108 The next matter to address is how the unreliability and the uncertainty that inures in rainfall forecasts and flood forecasting was addressed by Dr Christensen. By reference to Dr Nathan’s evidence, Seqwater effectively contended that Dr Christensen’s methodology failed to address those uncertainties. For the reasons that follow I do not accept that contention.

109 In considering this issue, the approach dictated by the Manual to the use of forecasts must inform the analysis. As noted in Chapter 3, the Manual expressly acknowledges the uncertainties in rainfall forecasts but nevertheless mandates their use, especially in determining the maximum

[204] February 2015 Report, EXP.ROD.001.0016 at [125].
[205] EXP.ROD.001.0583 at .0610.
[206] EXP.SEQ.004.0131 at .0163.
[207] February 2015 Report, EXP.ROD.001.0016 at [221]; Seqwater subs at [1957(e)].

storage level in each dam for the purpose of selecting strategies.[208] To the extent that there is uncertainty, the Manual directs the flood engineer to manage that uncertainty by reference to the order of priority of the flood mitigation objectives set out in the Manual.

110 Amongst other matters, the defendants effectively contended that the difficulties with forecasts are such that they should not be used in flood operations and that this justified the flood engineers' rain on the ground approach.[209] As already explained, that approach is inconsistent with the Manual. Further, all of the above evidence (including that adduced by the defendants) only reinforces the unreasonableness, in the context of the Manual, of the rain on the ground approach adopted by the flood engineers. The effect of the above is that, in circumstances where significant rainfall was forecast, the flood engineers' utilisation of a rain on the ground approach to flood operations involved the generation of an estimated inflow volume that was guaranteed to produce an unreasonably low estimate of the maximum storage level in Wivenhoe and Somerset Dams and in turn cause them to evacuate only the minimum amount of inflows. This means that the uncertainty inherent in forecasts and the variables affecting inflow rates and lake level volumes was only "addressed" by maximising the risk that flood storage space would later prove insufficient. This approach prioritised avoiding lower level impacts above the management of the risk of higher level impacts. It was directly contrary to the Manual.

111 The State contended that there was a range of possibilities as to the amount of rainfall that might fall and whether it will fall above or below the dam.[210] It contended that this meant that a rain on the ground scenario was the "middle of the range position" because it balanced the "locational risk of the rainfall falling either above [the] dam or below the dam".[211] It is notable that this assertion was made without any reference to specific catchment characteristics such as travel times upstream and downstream, the location of

[208] Manual at 23.
[209] Seqwater subs at [2018]; State subs at [228(a)]; SunWater subs at [290].
[210] State subs at [428] to [430].
[211] Ibid at [431].

population centres, dam capacity, and also without reference to any analysis of relative forecast accuracy. Instead, it appears to be a blanket proposition applicable to all dams. However, the discussion in section 9.1 is inconsistent with the suggestion that in all dams a proper assessment of all aspects of the risks associated with the dam are such that the risk of forecast rain falling above precisely matches the risk of rainfall downstream with the invariable consequence that all forecast products should be ignored. In this case, to the extent that a judgment has to be made on that topic, it is found in the Manual which resolves it in favour of the use of forecasts and dictates how the relevant risks are prioritised.

112 Dr Christensen repeatedly acknowledged the uncertainties associated with rainfall forecasts.[212] The State sought to rely on that acknowledgment as a basis for rejecting their use altogether.[213] In fact, Dr Christensen reasoned that as rain received "seldom, if ever" matches the rainfall forecast, "[c]ompetent dam operations work with a forecast rainfall range and formulate operational decisions based on what is needed to conservatively operate within that range of forecast, keeping in mind that even that forecast range can be half or double what will actually occur."[214] As explained next, Dr Christensen's methodology respects the Manual's choice on that topic and addresses forecast uncertainties as follows.

113 First, in relation to inflows, Dr Christensen focused on inflow volumes over a number of days rather than inflow rates.[215] Dr Nathan's analysis confirms that there is less uncertainty with calculations of inflow volumes as opposed to inflow rates.[216] Leaving aside his use of eight-day forecasts, Dr Christensen used four-day forecasts to determine inflow volumes, which according to both Professor Walsh and Professor Manton possess some amount of skill.

[212] February 2015 Report, EXP.ROD.001.0106 at [220], [779(f)]; Reply Report, EXP.ROD.004.0005 at [46].
[213] State subs at [423].
[214] February 2015 Report, EXP.ROD.001.0016 at [220].
[215] T 1310.38 (Christensen).
[216] Chapter 11 at [75].

114 Second, in determining inflow volumes based on forecasts, Dr Christensen explained that he, at least in part, addressed uncertainty in rainfall depths, temporal patterns and spatial distribution by calibrating inflow volumes such that the runoff response of the catchment was similar to the Late December Flood Event (which had a high runoff response).[217] Dr Nathan did not accept that calibrating to the Late December Flood Event addressed uncertainty in rainfall depths but otherwise accepted that calibrating to the Late December Flood Event was "not a bad starting point".[218] To the extent that temporal patterns and spatial distribution are used to determine when and where a given amount of rainfall will fall within the catchment area, as opposed to whether or not it will fall in the catchment, then I accept that calibration of inflow volumes to the Late December Flood Event at least partially addresses uncertainty, although Dr Nathan described that as "not a significant source of uncertainty" in determining inflow volumes (at least for high rainfall amounts).[219]

115 Third, Dr Christensen described his approach as being to "conserve flood storage when catchment conditions and forecast conditions indicate that there is a *risk* that the storage volume may be insufficient to contain *potential* inflows"[220] in determining inflow volumes and release rates. Thus, for example in some days of SIMs A, E and I which utilised his target method of calculating releases,[221] Dr Christensen erred on the side of releasing higher amounts by starting with a target determined by a four-day PME forecast which he generally released over one to two days if downstream conditions, the amount of dam storage space and the Manual otherwise would have permitted. This approach, including the making of releases below FSL, addresses much of the uncertainty associated with the four-day estimate being too low which, as the above evidence demonstrates, was a particular concern with large rainfall events. With the other days of SIMs A, E and I, and depending on their governing assumptions, the other simulations, Dr

[217] T 1372.24.
[218] T 3727.27 and .38; see below at [170].
[219] T 3732.37 - .45.
[220] Reply Report, EXP.ROD.004.0005 at [203(a)].
[221] See Chapter 8 at [57].

Christensen also seeks to address the risk of the forecast inflows being too low by making releases and creating as much storage space as possible within the Manuals constraints, having regard to concerns about refill to FSL and monitoring downstream flow.

116 Fourth, Dr Christensen addressed one of the downside risks associated with either determining too large an inflow volume or releasing too much water (or both), by also addressing the effect of releases on downstream flows over a 24-hour forecast period, bearing in mind the characteristics of the downstream catchment.[222] This enabled him to avoid the difficulty that Dr Nathan identified with the effect of variations on temporal patterns upon the timing of peak (downstream) flow rates for periods of beyond 24 hours.[223]

117 Fifth, Dr Christensen addressed the other downside risk of determining too large an inflow volume and releasing too much, namely, the risk to the water supply if the dam falls below FSL. He did so in a number of different ways in the various simulations.[224] In summary, in SIM A, SIM E and SIM I, Dr Christensen released to a target below FSL that was always higher by at least 0.5m to 1m than the height generated by the "no release" rise based on the four-day inflow estimate.[225] In SIM C, he only modelled making releases to a level below FSL that was less than the "no release" rise based on the one-day inflow estimate in circumstances where the longer forecasts predicted more rain.[226] In SIM D, SIM F and SIM H, he only released from below Wivenhoe Dam to the extent that water above FSL in Somerset Dam could refill Wivenhoe Dam to FSL.[227] SIM G and SIM J never fell below FSL.

118 Seqwater's submissions acknowledged that Dr Christensen sought to address the uncertainty in rainfall forecasts by his approach to the selection of a target level in determining releases.[228] However, they note that on some days in

[222] See Chapter 8, section 8.5 and section 9.9.
[223] T 2154.22; T 2158.33; T 2160.4 (Christensen).
[224] See Chapter 10.
[225] Chapter 10 at [193] to [198].
[226] Chapter 10 at [176].
[227] Chapter 8 at [159].
[228] Seqwater subs at [2166].

some of his simulations he releases more than his target level.[229] This is addressed in Chapter 10.[230] In short, Dr Christensen releases an amount slightly in excess of his target on three days in SIM A but still leaves a “buffer” between the four-day inflow volume and the volume below FSL.

119 Sixth, Dr Christensen sought to minimise the length of time that reliance is placed on a forecast by only making release decisions for a maximum period of one day and revisiting forecasts accordingly.[231]

Dr Nathan’s Evidence on Use of Forecasts

120 In its written submissions,[232] Seqwater emphasised Dr Nathan’s evidence-in-chief where he stated that he would not rely upon the QPFs “quantitatively” and that the inflows could be higher or sometimes lower “and I wouldn’t know where I was”[233] because “I wouldn’t have any confidence that the high and low range of the QPF bracketed the answer”.[234] Dr Nathan also stated that as at January 2011, he “wouldn’t see the point of putting the data quantitatively through a model, because I couldn’t do anything with that interpretation”.[235] Mr Kane’s evidence on that topic has already been noted.[236] He stated that he would always provide a flood engineer with inflow volume(s) derived from a forecast and an explanation of how these were to be interpreted.[237]

121 In his report, Dr Nathan noted that the plaintiff’s experts “maintain that any non-zero forecast of rainfall is better than the reliance on rain on the ground forecasts”. However, he opined that “without a demonstrated understanding of the quantitative propagation of the uncertainties involved, such opinions

[229] SIM A and SIM I.
[230] At [200].
[231] T 1244.38 (Christensen).
[232] Seqwater subs at [1985(a)].
[233] T 3701.24 - .31.
[234] T 3708.10.
[235] T 3721.33.
[236] Chapter 3 at [247] to [251].
[237] T 3276.10 to T 3277.34.

should be viewed as an unproven assumption".[238] In his oral evidence-in-chief, Dr Nathan expanded upon this stating: [239]

> "…the problem with assuming that if you've got something its better than nothing is that if the "something" you have is wrong, then it's misleading. … if the information you've got, you don't know whether its materially low or about on the best estimate or materially high, if you don't know where you are on that spectrum, having knowledge of it doesn't mean you can make a better *decision*. … if you don't understand the impact of uncertainty on the decision, then I think not having the right information could lead to a wrong *decision*." (emphasis added)

122 The short answer to this aspect of Dr Nathan's evidence is that it depends on the "decision" and its parameters. Dr Nathan's analysis is limited by his lack of knowledge and expertise of the relevant "decision", this being release decisions made in flood operations generally, including Dr Christensen's approach in particular. In commenting on Dr Christensen's approach to utilising one-day, four-day and eight-day forecasts, Dr Nathan stated "I can't comment on ... how he uses it for his decisions around releases but ... if the question is does using a one-day, four-day and eight-day forecast tell you anything about the uncertainty in the rainfall forecast, the answer is certainly no".[240] However, as explained above, Dr Christensen's approach did address the uncertainty in the forecast (and other parameters), not just at the point of ascertaining rainfall depths and modelling inflows but, as Seqwater's submissions acknowledge,[241] largely in its approach to releases. As to whether such decisions are "better", the Manual directs the adoption of the assumption that the use of forecasts is "better" than reliance on rain on the ground forecasts, at least so far as achieving the flood objectives in their order of priority. The Manual unambiguously directs their use in selecting strategies.

123 Otherwise, the suggestion that forecasts cannot be used for decision making unless the decision maker has "ascertain[ed] a quantitative propagation of the uncertainties involved" in the forecast is contrary to BoM's advice, contrary to

[238] EXP.SEQ.014.0013 at [36].
[239] T 3720.1 - .16.
[240] T 3736.45 to T 3737.2.
[241] Seqwater subs at [2166].

the common use made of forecasts and not supported by either the Manual or any other evidentiary source. Dr Christensen rejected the suggestion that he had to statistically analyse all of the uncertainties; stating that his was a "practical methodology not a statistical one".[242]

124 There is nothing in the Manual to suggest that it is a prerequisite to the use of the forecasts that a quantitative analysis of forecast uncertainties be undertaken before they can be used in either a quantitative or qualitative manner. No doubt the making available to the flood engineers of a more complex modelling system that undertook stochastic modelling of forecasts with sufficient speed to use in real time flood operations would have been advantageous. Equally, with sufficient time an analysis of forecast products by reference to past events to ascertain whether there was any systemic bias in the forecasts might have been able to be undertaken.[243] However, Seqwater did not do that even though its own flood engineers drafted a Manual (and the FPM) that mandated the use of forecasts over a year prior to the January 2011 Flood Event. In those circumstances, the reasonably competent flood engineer could not have been expected to undertake complex statistical modelling in real time.[244] Instead, the reasonably competent flood engineer was confronted with more limited materials to work with and a Manual that directed the use of forecasts. In those circumstances the undertaking of deterministic modelling and the making of release decisions that account for the risks associated with the forecast depth and volumes being too high or too low in a practical manner was sufficient in the sense of being the minimum required by the Manual (and any applicable duty of care) compared to a purely rain on the ground approach which was insufficient to meet that standard.

125 Seqwater also cited Dr Nathan's evidence as supporting the proposition that Dr Christensen placed "disproportionate emphasis on losses, which [are] of very little significance compared to the dominant source of uncertainty"

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[242] T 1373.7.
[243] T 3702.24 - .47 (Nathan).
[244] See T 3284.40 (Kane).

namely "spatial variability in depth over the catchment".[245] The evidence cited in support of that contention that loss rates have "very little significance" is the passage from Dr Nathan's Forecast Uncertainty Report noted above[246] which, as discussed, requires correction in view of his oral evidence.[247] Otherwise, the suggestion that Dr Christensen placed disproportionate emphasis on losses appears to be based on a characterisation of his approach to flood operations that overlooks his approach to releases.[248] Other parts of Seqwater's submissions cited Dr Nathan's evidence as rejecting the use of forecasts in flood operations without Dr Nathan addressing the precise use made by Dr Christensen of forecasts and how overall his approach to flood operations addresses the relevant uncertainties.[249]

"Best Forecast Rainfall"

126 I have addressed the meaning of the term "best forecast rainfall" as it is used in the Manual in Chapter 3.[250] I will not repeat that discussion save to note that I accepted that all forecasts had to be considered and compared, that the best forecast rainfall product does not necessarily equate to the most accurate[251] and a flood engineer would, or at least could, consider the accuracy of the forecast product.[252]

127 In light of the findings in this Chapter, it is necessary to consider this further. Seqwater submitted that the QPF forecasts were the "best available forecasts" for the Wivenhoe and Somerset Dam catchments "from a meteorological perspective".[253] Consistent with the above evidence, it noted that they were specialised forecast products tailored to the catchment and that, in contrast to the PMEs, they had "accurate timeliness" in the sense that

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[245] Seqwater subs at [1989].
[246] See EXP.SEQ.014.0013 at [34] as cited in Seqwater subs at fn 2612.
[247] See Chapter 11 at [71] to [7272].
[248] See above and for example EXP.SEQ.014.0013.at .0023, [13].
[249] Eg Seqwater subs at [1992].
[250] At [180] to [192].
[251] Chapter 3 at [184] to [185].
[252] Chapter 3 at [187] to [188].
[253] Seqwater subs at [1917].

the time of its preparation, time of its issue and commencement of its forecast period generally coincided.[254]

128 I accept that the QPF was clearly the most accurate of the forecast products available but I am also satisfied that the four-day PME showed sufficient skill to warrant, and indeed require, its use in flood operations, including for determining the maximum storage capacity of the dam for the purpose of selecting strategy. As discussed in Chapter 3,[255] as Mr Malone accepted[256] and as Dr Christensen repeatedly explained in his evidence, which I accept, given the size and characteristics of the upstream catchments, the 24-hour forecast period provided by a QPF is too short a planning period to make decisions about dam operations sufficient to maximise its flood storage capacity.[257] None of the defendants were able to address that contention.[258] However, the material available concerning the eight-day PME is such that I am not satisfied that its use was mandated in determining the maximum storage level of the dams for the purposes of the Manual, even allowing for Dr Christensen's explanation for its use.

129 Consistent with the analysis in Chapter 3, I am also satisfied that predicted inflow volumes had to be "used" in setting releases. In particular, at the very least, such "use" had to involve the preparation of the volumetric estimate to determine the maximum storage capacity to select strategy and the employment of that estimate as an integer or input in the decision-making process about releases.[259] In light of the findings in Chapter 10 concerning SIM A and SIM E, it is not necessary to go further and determine whether the required use was in the "quantitative" sense described by Seqwater, namely,

[254] Ibid at [1917] to [1918].
[255] Chapter 3 at [185] to [192].
[256] Chapter 3 at [184] to [185].
[257] See Chapter 8 at [64]; T 1230.46 to T 1232.20, T 1245.21; See Chapter 3 at [185] to [192]; Reply Report, EXP.ROD.004.0005 at [71] to [76]; Kane 1, EXP.ROD.011.0011 at [2].
[258] See for example State subs at [388].
[259] Chapter 3 at [256], [258] to [261].

as leading to the release of a "volume of water calculated by reference to estimated inflows from the rain that is forecast to fall above the dams".[260]

130 The State also referred to the three and five-day SILO forecasts as likely candidates for the "best forecast rainfall"[261] as they allowed the flood engineers to access meteograms for specific sub-catchment locations and provided rainfall predictions at three-hourly intervals.[262] It also referred to the availability of the SILO forecasts,[263] a matter addressed in Chapter 6.[264] Dr Christensen acknowledged the potential utility of SILO forecasts[265] and, as noted, he interpreted the phrase "best forecast rainfall" as embodying a consideration of all rainfall products, a proposition that I accept. However, there is only limited evidence that SILO forecasts were obtained; it appears that none were preserved. None were tendered. It was not suggested that the plaintiff could have retrieved them and tendered them. Given the evidence as to the connection between SILO forecasts and the Access models that are used to compile the PME forecasts,[266] there is no basis for concluding that any materially different outcome would have been yielded from their use compared to the four-day PME forecast (especially so far as SIM C, F and H are concerned).[267]

131 Seqwater contended that a reasonably competent flood engineer would not utilise forecasts to make releases in the absence of specific BoM advice as to their reliability and the absence of some reasonably long term contemporaneous analysis of their reliability.[268] The State made a similar submission.[269] Four matters should be noted in regard to these submissions.

[260] Seqwater subs at [715(b)]; Chapter 3 at [256].
[261] State subs at [382(b)], [383] to [387].
[262] Ibid at [385].
[263] Ibid at [417] to [418].
[264] Chapter 6 at [279] to [298].
[265] Reply Report, EXP.ROD.004.0005 at .0021, [52].
[266] See Chapter 6 at [282] to [290].
[267] See Chapter 10 especially sections 10.1 and 10.2.
[268] Seqwater subs at [2022] to [2025] and [2026] to [2032].
[269] State subs at [389].

132 First, parts of the above discussion include some analyses that predated the January 2011 Flood Event, specifically the BoM study referred to by Professor Walsh and Dr Christensen's own analysis.

133 Second, Seqwater staff drafted a Manual (and FPM) that referred to forecasts more than 12 months prior to the January 2011 Flood Event. As noted, there was more than ample time for them to evaluate the reliability of the available forecast products, including by reference to the flood events that preceded January 2011. The fact that they did not do so is no basis for criticising Dr Christensen, who undertook the best analysis he could on the date available in circumstances where he correctly determined that the Manual required forecasts to be used.

134 Third, the evidence relied on by Seqwater and the State in relation to these submissions has already been addressed.[270]

135 Fourth, the evidence concerning the uncertainties in the forecasts never rose to the point of justifying their wholesale rejection as opposed to the alternative of conducting flood operations that accommodated their uncertainty. Given the wording of the Manual, the relevant inquiry was never whether forecasts should be used but instead: what forecasts should be used and how? Subject to addressing the remaining issues addressed below, I am satisfied that the use of four-day PMEs to select strategies and to make releases, although not necessarily by reference to a "target", was the minimum that was required.

136 The State also pointed to the rough resolution of the PMEs which, amongst other matters, was said to have the effect of "not reliably account[ing] for potential clusters of intense rainfall".[271] They noted that a spatial grid size of 50 x 50km meant that there was only a single average rainfall figure for an

[270] Note State subs at [389]: In relation to Professor Walsh, Professor Manton and Dr Nathan, see above at [79] and [89]. In relation to the flood engineers see Chapter 6 at [184] to [203] and Chapter 7; sections 7.15 to 7.18; In relation to Mr Kane, see Chapter 3 at [247] to [251]; In relation to Mr Fagot, see Chapter 3 at [355] to [362]; In relation to Mr Swain, see Chapter 3 at [198] to [200]; In relation to Mr Pokarier, see Chapter 3 at [246] and Chapter 5 at [114] to [117]; Otherwise, Mr Dreverman was not familiar with PMEs (T 4113.20); Mr Ickert's particular concern was with the "temporal aspect" of rainfall (T 8529.31); Mr Giles' evidence is addressed below.
[271] State subs at [399].

area covering 2500km^2 and that there were only two grid points in the catchment area above the dams.[272] They also note that the temporal distribution of the PME forecasts were limited to 24-hour timeframes for the first five days and only provided totals thereafter.[273] However, none of these matters provide any justification for the wholesale rejection of the use of PMEs in flood operations generally nor the rejection of their use for determining the maximum storage level of the dams in a manner required by the Manual in particular. Leaving aside the SILO forecasts, which are addressed above, the four-day PME was the only forecast product available to a flood engineer for a period beyond one day and the dam and catchment characteristics were such that one-day forecasting was too short a planning horizon. The matters identified by the State represent aspects of uncertainty that need to be considered and addressed in flood operations in accordance with the Manual's priorities.

137 The State also pointed to the numerous PME forecasts of differing lengths that were made available over time, including the individual daily PMEs, and the potential for inconsistency between those forecasts and other forecast products.[274] A complaint based on the premise that if a flood engineer was required to utilise forecasts they might receive too much information is not promising. In any event, faced with a number of forecasts a flood engineer must exercise professional judgment as to what weight to give each forecast product and to guard against the uncertainties they create.[275] However, the potential existence of inconsistent forecasts is not a reason to reject the use of all of them.

Dr Christensen's Selection of Rainfall Depths from the 4-Day PME Forecasts

138 There were a number of criticisms of Dr Christensen's methodology for selecting a rainfall depth from the PME forecast.[276] They are best addressed

[272] Ibid at [400]; citing Manton, EXP.SEQ.004.0131 at .0149, .0162.
[273] State subs at [404].
[274] State subs at [406] to [407].
[275] See T 1234.5 (Christensen).
[276] Seqwater subs at [2075] to [2080].

by first setting out the four-day figures he determined and comparing them to those determined by the defendants and their experts.

Table 9-2: Four-Day 00UTC PME Estimates

Date / Midnight [277]	Christensen [278]	State Range [279]	Manton [280]	Pokarier [281]	Nathan [282]	Giles [283]	Range
1 Jan	10-25 [284]		11				
2 Jan	6 (2-10) [285]	1–10 (5)	4	5		5	4-6
3 Jan	75 (50-100) [286]	50-100 (75)	56	75	59	67	56–75
4 Jan	116 (75-150) [287]	50-150 (100)	97	104.7	97	95	95-116
5 Jan	75 (50-100) [288]	25–100 (62.5)	83	75	83	61	61-83
6 Jan	88 (50–125) [289]	25–150 (87.5)	76	84.5	76	83	76-88
7 Jan	100 (50–150) [290]	25–150 (87.5)	74	84.5	65	84	74-100
8 Jan	200 (100-300) [291]	50-300 (175)	156	159.5	151	155	151-200
9 Jan	188 (75-300) [292]	50-300 (175)	184	159.5	179	161	161-188
10 Jan	150 (75–225) [293]	50-200 (125)	157		153	122	122-157
11 Jan	80 [294] (40-120) [295]	25-100 (62.5)	56		54	56	54-80

277 Represents the forecast for the 4-day period from 10.00pm the evening before; eg the first entry represents the period 10.00pm on 31 December 2010 to 10.00pm on 4 January 2011.
278 Most of the four and eight-day PME forecast depth estimates are sourced from Dr Christensen's February 2015 Report. Some of the depth estimates for individual sub-catchments were adjusted slightly as inputs into the RTFM later on in the Response Report to more closely reflect the average rainfall of the forecast in question. This is explained further below at [146] to [148].
279 AID.500.035.0001; average calculated and noted in brackets.
280 EXP.SEQ.004.0131 at .0179 (Figure 26, North Region); AID.500.022.0001. Tab D.
281 EXP.SEQ.016.0252 at .0271 to .0272; AID.500.022.0001, Tab E.
282 EXP.SEQ.014.0013 at 00135, Table C5; AID.500.022.0001, Tab F.
283 For 2 January 2011 to 6 January 2011, EXP.QLD.001.1359 at .1469 to .1473 (Tables C1 to C5); for 7 January 2011 onwards EXP.QLD.001.0611 at .0790 to .0794 (Tables C3 to C7); compiled in AID.500.022.0001, Tab G.
284 EXP.ROD.001.0583 at .0680 (Figure 41); see also AID.500.022.0001, Tab A. Although this was altered in cross-examination (see below at [157].
285 February 2015 Report, EXP.ROD.001.0016 at [771] to [772]; In cross-examination Dr Christensen agreed that Mr Giles' georeferenced version suggested it was "perhaps 1 and 5mm, maybe as high as 10mm", T 2705.27; see also AID.500.022.0001, Tab A.
286 Ibid at [798] to [800]; see also AID.500.022.0001, Tab A.
287 This average forecast rainfall depth was changed from 113mm in the February 2015 Report (ibid at [821] to [822]) to 116mm in the Response Report (EXP.ROD.015.0005 at .0170 to .0171); see also AID.500.022.0001, Tab A.
288 Ibid at [837] to [838].
289 February 2015 Report, EXP.ROD.001.0016 at [853] to [854]; see also AID.500.022.0001, Tab A.
290 Ibid at [872] to [873]; see also AID.500.022.0001, Tab A.
291 Ibid at [907] to [908]; see also AID.500.022.0001, Tab A.
292 Ibid at [927] to [928]; see also AID.500.022.0001, Tab A.
293 Ibid at [953] to [954]; the plaintiff's assessment of Dr Christensen's average rainfall depth figure for this forecast was 152mm (AID.500.022.0001, Tab A), despite the Response Report stating that the sub-catchment averages had not been adjusted from the February 2015 Report and that the figure of 150mm was correct (EXP.ROD.015.0005 at .0206). There is no explanation for this variance but in any event it is immaterial.

12 Jan	30 (10–50)[296]	5–25	12		8		

139 The second column represents the "average" of the range identified by Dr Christensen which formed the basis for his modelling of four-day inflows. The range he identified is in brackets.

140 The third column represents the PME four-day forecast range for the catchment area above the Dams identified by the State in its "visual inspection". It derived its figures by identifying a range of rainfall totals for the catchment areas above and below the dams from the PME maps. As Chapters 6 and 7 make clear, from the evening of 6 January 2011 onwards the State identified that PME rainfall forecasts were predicting greater rainfall totals below the dam rather than above it.

141 The fourth column sets out Professor Manton's figures. He used specialised software that analysed the underlying PME data used to generate the PME maps.[297]

142 Mr Pokarier undertook a visual inspection and divided the Brisbane catchment area into four regions: SDI, WDI, Bremer River and Lockyer Creek. He treated the threshold lines separating two different PME colour zones as representative of the value at that threshold.[298] If the centroid of a region was within a PME coloured zone then he took the average of the upper and lower bound for the coloured area. He treated the former value (the threshold line calculation) as subject to less interpretation error than the latter.[299] The

[294] Ibid at [976] to [977]; see also AID.500.022.0001, Tab A.
[295] In cross-examination, Dr Christensen reassessed his figure and determined it to be 25 to 100: T 2712.15.
[296] February 2015 Report, EXP.ROD.001.0016 at [999] to [1000]; the plaintiff's assessment of Dr Christensen's average rainfall depth figure for this forecast was 24mm (AID.500.022.0001, Tab A), despite the Response Report stating that the sub-catchment average had not been adjusted from the February 2015 Report and that the figure of 30mm was correct (EXP.ROD.015.0005 at .0217 to .0218). There is no explanation for this variance but in any event it is immaterial.
[297] EXP.SEQ.004.0131 at .0177.
[298] EXP.SEQ.016.0220 at .0269, [34].
[299] Ibid.

figures in the fifth column represent an area weighted average of the figures he derived for SDI and WDI.[300]

143 Dr Nathan used georeferencing software and identified a figure for each of the following catchments: Upper Brisbane, Somerset Dam, Wivenhoe Dam, Lockyer Creek, Bremer River and Lower Brisbane.[301] The figure in the sixth column above is also an area weighted average of the figures he derived for the catchments above the dam.[302]

144 Mr Giles determined figures for sub-catchment rainfall above and below the dams by georeferencing each sub-catchment boundary and superimposing it over a scaled version of each PME forecast map.[303] The figures in the seventh column represent an area weighted average calculated by the plaintiff from his figures.[304]

145 I have omitted figures determined by Mr Kane for 6 January 2011 onwards. Mr Kane georeferenced a particular location of the Brisbane Basin Region and stated that he "selected the low to average contour of grid cell value associated with the Brisbane River [b]asin [r]egion".[305] There is no valid justification for choosing the low figure.

146 Once rainfall depths from a PME are identified, an inflow volume must be determined using the RTFM. Dr Christensen's method of allocating rainfall depths amongst the sub-catchments in the RTFM was referred to in Chapter 8.[306] In his Response Report, he set out each of the allocations in each sub-catchment. In his four-day runs for 2, 3 and 5 January 2011, the average rainfall figure was distributed evenly across each sub-catchment.[307] For the other four-day forecasts, Dr Christensen distributed the amounts unevenly

[300] Ibid at .0271 to .0272, (Table 6.1 and Table 6.2); AID.500.022.0001, Tab E.
[301] EXP.SEQ.014.0013 at .0135, (Table C5, C6); EXP.SEQ.014.0219 at [9] to [18].
[302] EXP.SEQ.014.0013 at [82]; AID.500.022.0001, Tab F.
[303] EXP.QLD.001.0611 at [715].
[304] AID.500.022.0001, Tab G.
[305] EXP.ROD.011.0011 at [98].
[306] Chapter 8 at [71].
[307] Response Report, EXP.ROD.015.0005 at .0160, .0165 and .0176.

across the sub-catchments. He provided the following explanation for the allocations:[308]

> "The average of these inputs is the same as the 4-day average forecast … This amount [ie the 4-day average] was distributed across the catchment. I was using 5mm to 10mm minimum increments to distribute the rainfall over the catchment, but these numbers are not precisely the values shown in the maps. They are rough estimates only. I distributed more rainfall over the SDI and WDI sub-catchments because they are adjacent to mountainous areas and they are closest to the coast. Further, the PME forecasts showed the rainfall forecast was heaviest closest to the coast."

147 In addition to SDI and WDI, for most of these forecasts additional rain was allocated to CRE at the expense of other sub-catchments on the basis that it was adjacent to mountainous areas as well.[309]

148 Dr Christensen explained that he applied a number of elements of engineering judgment in deriving forecast rainfall figures for each sub-catchment. As the above passage indicates, Dr Christensen sought to allocate rainfall so that overall the average rainfall depths allocated for the catchments above generally matched the average he identified for the entire area above the dams. This meant that, with some sub-catchments, the amount he allocated was more than what he derived from an attempt to visually interpret the PME map specific to that location.[310] Further, in selecting depths for sub-catchments, Dr Christensen made allocations based on his assessment of the orographic effect. This had two elements, one being the allocation of rainfall between sub-catchments as explained in the above passage. The other was the process of determining the applicable range across the entire catchment area above the dams. Thus, for example, Dr Christensen explained that in determining that the range above the dams on 8 January 2011 was 100 to 300mm (as opposed to 50 to 300mm), he considered the lower bound of 100mm "conservative" and that he would

[308] Ibid at .0170, .0182, .0187 to .0188, .0194, .0199 to .0200, .0206, .0211 to .0212, .0217 to .0218.
[309] T 1439.11 (Christensen).
[310] Eg T 1427.44 and T 1428.20 (Christensen).

select this lower limit based on the presence of a contour line near a mountainous area.[311]

149 Seven matters should be noted.

150 First, there was some confusion about how the amounts of rainfall that Dr Christensen allocated to sub-catchments compared with the four-day average for the PME forecast. With the exception of 4 January 2011, the allocations of rainfall to sub-catchments in his Response Report were identical to the allocations that Dr Christensen listed in his Supplemental Report.[312] In the latter report, Dr Christensen explained that the area weighted average of those rainfall allocations to sub-catchments "generally matched" the four-day average taken from the four-day PME forecast.[313] However, during cross-examination on the allocation of rainfall to sub-catchments for the eight-day average RTFM run for 8 January 2011 in his Response Report, Dr Christensen stated that he reconciled the allocated sub-catchment rainfall to the average taken from the eight-day PME by adding the allocations and dividing by the number of sub-catchments (7) (ie, it was not a weighted average but a simple average).[314] However, as noted, all of the figures for allocated rainfall for four-day PME forecasts from 6 January 2011 onwards are the same as the Supplemental Report. Further, all of the simple averages derived from the allocations of sub-catchment rainfall for the four-day RTFM runs for each of 4, 6, 7, 8, 9, 10 and 11 January 2011 are *less than* Dr Christensen's average forecast rainfall depths noted in the second column of the above table.[315] If Dr Christensen sought to model sub-catchment rainfall that produced a simple average that matched the second column above, he would have increased the rainfall amounts and produced a (slightly) higher volume of runoff. This suggests that Dr Christensen either did prepare an area

[311] T 1425.33.
[312] EXP.ROD.002.0097 at .0113 to .0119. Sub-catchment rainfall was re-allocated on 4 and 5 January 2011 for the eight-day 00UTC PME forecast in Dr Christensen's Response Report.
[313] Supplemental Report, EXP.ROD.002.0005 at [130] (footnote 20).
[314] T 1440.16.
[315] 4 January 2011: 110mm v 116mm; 6 January 2011: 85mm v 88mm; 7 January 2011: 94.2mm v 110mm; 8 January 2011: 190.7mm v 200mm; 9 January 2011: 177.8mm v 187mm; 10 January 2011: 147.1mm v 152mm and 11 January 2011: 75.7mm v 80mm.

weighted average or his process of adjustment for orographic effect meant that overall rainfall depths were less than the simple average.

151 Second, Seqwater's submissions cited Professor Manton's analysis in support of an overall contention that Dr Christensen misinterpreted and misused the PME forecasts.[316] A number of those criticisms have been addressed (see [104] to [107]). However, Seqwater placed particular emphasis on Professor's Manton's critique of Dr Christensen's explanation of how he determined sub-catchment rainfall for the purpose of RTFM modelling. Thus, in cross-examination, it was suggested to Dr Christensen that he could not interpret the PMEs to ascertain "different reliable figures" for the "seven [upstream] sub-catchments".[317] Consistent with the above, Dr Christensen stated that an engineer "would need to read it at a different scale and focus in on the area of that map - where this rainfall is predicted" and "use his [or her] reasonable judgment as to how to read that map to protect the public safety".[318] Dr Christensen noted that the "[M]anual tells you that you have to use forecasts" so that "rather than assuming zero, you read it to the best ability you've got".[319] Dr Christensen referred to adjustments for orographic influence, a matter addressed next. The cross-examination continued:[320]

> "Q. My question was that you cannot get that level of detail for different depths of the seven sub-catchments from the four-day PME map. Do you disagree with that?
>
> A. I agree that there would need to be a judgment made in reading those maps, yes. Without judgment and without careful reading of the maps, you would have a difficulty coming up with within 5mm, but what you would do is you have a range of low and high. That's what you first use, is you come up with your low and your high. *You determine average, and then you distribute that average the best you can according to your judgment as to where that rainfall, according to the map, may fall*. And you can make a measured judgment, which is what is done there.
>
> Q. I also suggest that the allocation of rainfall in the seven sub-catchments you have used is down to measurements as precise as 5mm, and you cannot get that from the PME map?
>
> A. No, you cannot.

[316] Seqwater subs at [1957].
[317] T 1412.15.
[318] T 1412.24.
[319] T 1412.47 to T 1413.3.
[320] T 1413.7.

…

Q. Those precise figures you have used - are they a guess on your part?
A. They are major judgment. They are far from a guess. Far from a guess." (emphasis added)

152 In his evidence-in-chief,[321] Professor Manton was taken to this extract from Dr Christensen's cross-examination and a passage from Dr Christensen's Response Report where he explained the basis for allocating rain across sub-catchments when modelling the four-day PME forecast for 8 January 2011 in similar terms.[322] Professor Manton described Dr Christensen's approach as being based "on a chain of false premises".[323] The first false premise was said to be that the "PME values are given by the [BoM] as a range, whereas the PME values are given only for each of the 50km grid points across the country".[324] The second false premise was said to be that "the uncertainty in the value of the PME at each grid point is given by the spatial gradient in the maps" whereas Professor Manton said that the uncertainty in each of the grid point values "is related to errors or uncertainties in the intensity, timing and location of the rainfall" which does not "show up in the spatial gradients".[325] The third false premise was said to be that Dr Christensen's supposedly "assum[ed] that by looking at the coloured [PME] maps … we could infer what the actual uncertainty range is".[326] Seqwater noted that Professor Manton explained that the contours produced by the software package that interpolates between grids points are "virtually arbitrary".[327] The fourth false premise was said to be that it was possible to derive the average value across a region by taking a simple average of the areas of each of the coloured bands.[328] Professor Manton contended that those bands do not have equal widths in terms of millimetres of rainfall in that,

[321] T 3569.1.
[322] Response Report, EXP.ROD.015.0005 at .0194.
[323] T 3571.21.
[324] T 3571.24.
[325] T 3571.28.
[326] T 3571.35.
[327] T 3571.42.
[328] T 3572.1.

at the low end the bands are 4-5mm in width while, at the top, rainfall is presented in 100mm ranges.[329]

153 These matters were not taken up with Dr Christensen in cross-examination even though he explained his approach to deriving and allocating sub-catchment rainfall in the above passage and other parts of his reports. Nevertheless, the first and fourth so-called false premises are simply a reflection of the limited information that Dr Christensen and any flood engineer conducting flood operations during the January 2011 Flood Event had to work with. The evidence in the trial did not suggest that the flood engineer had access to the precise forecast for each of the relevant grid points,[330] especially as the contour lines did not "go through the grid points".[331] Dr Christensen did not have access to the PME forecasts in digital form as Dr Nathan did.[332] Further, in relation to the third so-called false premise, Professor Manton qualified his statement that the contours and colours are "virtually arbitrary"[333] to mean that "arbitrariness is the determination [of] which contours to draw" and the "contours … give a good representation of what's happening between the grid points".[334] In those circumstances, and leaving aside any adjustment for orographic effect, the approach of deriving an average across the catchments based on the contour lines was entirely justified and in fact the only reasonable approach to adopt. Otherwise, I do not accept that Dr Christensen's approach was based on the so-called second false premise. Dr Christensen was cognisant of the actual and potential uncertainty in the intensity, timing and location of rainfall and sought to address that in his overall approach to flood operations, especially through his approach to releases.

[329] T 3572.3.
[330] See for example EXP.SEQ.004.0131 at .0139; T 3638.40 (Manton).
[331] T 3639.16 (Manton).
[332] February 2015 Report, EXP.ROD.001.0016 at [383].
[333] T 3571.42.
[334] T 3638.36.

154 Third, a number of the defendants were critical of Dr Christensen's adjustment of sub-catchment rainfall to account for so-called orographic effects.[335] One part of Seqwater's submissions[336] cited Professor Manton's evidence to the effect that "from a meteorological point of view" it was "very dangerous" to use the different climatic conditions associated with the Late December Flood Event to adjust forecasts in the January 2011 Flood Event.[337] In fact, this overstated Dr Christensen's reliance on the Late December Flood Event for this purpose. Dr Christensen stated that he reviewed the Late December Flood Event (and the 1974 Queensland flood data) to simply ascertain whether there was an "orographic influence from [the] mountains" to the east of the area above the catchments.[338] Ultimately, Professor Manton said that his concern with Dr Christensen's approach was not that there was no orographic effect but with "trying to make an orographic adjustment without proper historical analysis of the data and the forecasts".[339] Otherwise, Professor Manton noted that orographic influences are accounted for "within the PME system" and that any such effect is "very much a function of what the prevailing conditions are at a given time".[340] Mr Giles accepted that a reasonably competent flood engineer would, or at least could, have appreciated that orographic effect was likely to increase rainfall in the vicinity of the dams and would, or at least could, have considered this effect in interpreting the PME forecast images.[341]

155 In the end result, insofar as Dr Christensen distributed rainfall across the sub-catchments to adjust for an orographic effect, I am not satisfied that his adjustments were unreasonable. Equally, I am not satisfied that, if forecasts were used with the RTFM modelling, it was necessary to make any adjustment to sub-catchment rainfall depths to account for such an effect. However, I am satisfied that any such adjustments made no material difference to Dr Christensen's volumetric assessments or his simulations. As

[335] State subs at [442] to [451] (although much of the State's submissions were directed to eight-day estimates).
[336] Seqwater subs at [1961(a)].
[337] T 3578.25 (Manton).
[338] T 1435.17.
[339] T 3651.9.
[340] T 3573.35 - .41.
[341] T 8918.45.

noted in the above extract, Dr Christensen explained that, even though there were adjustments to sub-catchment rainfall depths to account for orographic effect, this was done within a constraint that overall the four-day average forecast was maintained. As Dr Nathan's analysis makes clear, the spatial variation of rainfall within the catchment makes very little difference to an assessment of overall inflow volumes (ie, scenario C),[342] especially in circumstances where there is very little difference in loss rates between sub-catchments. This was the case with Dr Christensen's forecast rainfall depths which meant that initial losses and continuing loss values were both satisfied.[343]

156 Fourth, to the extent that Dr Christensen determined a higher forecast range for the catchment area above the Dams using the four-day PME forecasts by adjusting for orographic effect, then again I am not satisfied that his adjustments were unreasonable and I am also not satisfied that, if forecasts were used with the RTFM modelling, it was necessary to make any adjustment to the range of rainfall to account for such an effect. However, in light of Dr Nathan's analysis, I accept that the adoption of such an approach has the potential to be material in any determination of inflow volumes. In this case the extent to which it might be material can be ascertained from the degree of variance between Dr Christensen's estimates and the other estimates. As noted below, that variation was not significant, although that will need to be addressed in the context of each simulation.

157 Fifth, the State noted that, in cross-examination, Dr Christensen "departed significantly from the PME forecast amounts" he provided in his reports and upon which the simulations were based.[344] In relation to the four-day PMEs, the only rainfall depth totals he "departed from" were for 10.00pm on 1 January 2011 and 10.00pm on 10 January 2011.[345] The former was immaterial. The latter involved a slight reduction in the suggested range: from

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[342] See above at [67] and [70].
[343] See Reply Report, EXP.ROD.004.0005 at .0076 to .0077; Plaintiff subs at [1712]; See T 8118.37 to T 8121.26 re differences in initial losses (Ickert) and T 8123.26 - .35 re continuing losses (Ickert).
[344] State subs at [380] and [451].
[345] See AID.500.035.0001, T 2705.26; T 2712.15 (Christensen).

40mm to 120mm to 25mm to 100mm.[346] Given the state of the January 2011 Flood Event, especially the downstream catchments and the one-day forecasts at that time, as well as the modelled releases in all of his simulations, that alteration was also immaterial. Otherwise, the State noted aspects of Dr Christensen's evidence where the temporal pattern he modelled was at variance with the depths suggested by the PMEs.[347] This is addressed below, but it suffices to state that, in broad terms, Dr Christensen was seeking to model inflow volumes and was less concerned with replicating actual temporal patterns in his inflow modelling.[348]

158 Sixth, one of the obvious difficulties with the use of PME forecasts in flood operations is the potential for subjective interpretations of the PME maps to differ. Mr Giles referred to the "coarse nature" of the mapping and stated that he "considered [them] unsuitable for the forecasts of rainfall within each sub-catchment".[349] Given the manner in which the PMEs were presented to the Court, it was generally not in a position to resolve any differences over their interpretation, especially as a flood engineer in real time had a greater capacity to expand the image. The use of georeferencing software such as that available to Dr Nathan and Professor Manton potentially enabled that to be overcome. However, that software was not available to the flood engineers and, in any event, such an approach appears to attribute to a degree of certainty to the contours and colours of a PME map at a particular location that Professor Manton stated they do not possess. However, even after allowing for the potential for varied interpretations, there was a reasonable degree of consistency between the rainfall depths taken from the four-day PMEs, with the larger variances occurring as the forecasts became larger and flood storage space was contracting and the January 2011 Flood Event worsened. If anything, the increase in forecasts warranted a more and not less cautious approach in estimating future rainfall, not just because of the evidence suggesting PMEs underestimate large rainfall events but also because, at those times, the downside risk of underestimating larger rainfall

346 T 2712.22; see above at [138].
347 State subs at [452] to [456].
348 Cf State subs at [404] to [405], [456].
349 EXP.QLD.001.0611 at .0662 to .0663.

far outweighed the risk of overestimating rainfall. Most importantly, the difficulty in interpreting the PME forecast images was not a justification for their wholesale rejection, but instead a matter to be addressed in the conduct of flood operations.

159 Seventh, allowing for these matters, I have reviewed the depths based on the four-day PME forecasts set out in Table 9-2 above. I do not regard any of the estimates, including Dr Christensen's, as outliers. Bearing in mind the caution to be exercised, I am satisfied a reasonably competent flood engineer reviewing the maps could select either of the ranges nominated by Dr Christensen or the State. If the reasonably competent flood engineer did not have the geo-referencing ability of the other experts then they would at least commence by taking the middle of (either of) those ranges. They might have attempted to examine the forecasts more closely to ascertain more precise figures for the sub-catchments. However, depending on their approach to flood operations, such an engineer should be very reluctant to adopt a lower catchment wide average from such a process given the disproportionate risks that follow from underestimating inflow and the uncertainties associated with the PME forecasts (especially in large rainfall events). If anything, the reasonably competent flood engineer would select rainfall depths above that average. In Dr Christensen's simulations the significant four-day forecasts are for the period of 3 to 7 January 2011 as he operates in draindown on 2 January 2011 and all possible forecast interpretations on and after 8 January 2011 are extremely dire. The range of interpretations in that period is relatively narrow especially as between Dr Christensen and the State. The result is that I am satisfied that Dr Christensen's selected rainfall depths from the forecasts are reasonable although they tend on the high side of a relatively narrow range.

Dr Christensen's 8-Day Rainfall Depths

160 I have already rejected the use of the eight-day PME forecasts as a candidate for "best forecast rainfall" in the selection of strategies under the Manual. However, even considering the evidence about its level of skill, it is

nevertheless a valuable forecast product that had to be considered in the conduct of flood operations even if only as part of a consideration of all available forecasts and for ascertaining situational awareness in determining the approach to releases within strategies. For example, if the flood engineer is utilising QPFs and four-day PMEs then the eight-day PME would provide a guide as to the potential or lack of it for rain beyond the period of those forecasts.

161 The equivalent table for the eight-day PME to the table in [138] is:

Table 9-3: Eight-Day 00UTC PME Estimates

Date (at midnight)	Christensen[350]	State's Range[351]	Manton[352]	Pokarier[353]	Nathan[354]	Giles[355]	Range
1 Jan	20 (15-25)[356]		12.3				12.3-20
2 Jan	20 (15-25)[357]	15-25 (20)	14.3	19.5		22	14.3-22
3 Jan	113 (75-150)[358]	50-150 (100)	67.5	104.7	70	96	67.5-113
4 Jan	124 (90-150)[359]	50-150 (100)	109.8	104.7	109	110	104.7-124
5 Jan	127 (100-150)[360]	50-200 (125)	115.9	125.0	113	106	106-127
6 Jan	150 (100-200)[361]	50-200 (125)	146.8	134.5	148	126	125-150
7 Jan	138 (75-200)[362]	50-300 (175)	103.7	109.5	94	125	94-175
8 Jan	210 (100-320)[363]	50-300 (175)	175.7	179.5	172	176	172-210

350 See fn [144] for information on the source of Dr Christensen's forecast rainfall depth estimate data.
351 AID.500.035.000; average calculated and noted in brackets.
352 EXP.SEQ.004.0131 at .0180 (Figure 27, North Region); AID.500.022.0001, Tab D.
353 EXP.SEQ.016.0252 at .0272, Table 6.2; AID.500.022.0001, Tab E.
354 EXP.SEQ.014.0013 at .0136, Table C6; AID.500.022.0001, Tab F.
355 For 2 January 2011 to 6 January 2011, EXP.QLD.001.1359 at .1469-.1473 (Tables C1 – C5); for 7 January 2011 onwards, EXP.QLD.001.0611 at .0790 - .0794 (Tables C3- C7); compiled in AID.500.022.0001, Tab G.
356 February 2015 Report, EXP.ROD.001.0016 at [756]-[757]; see also AID.500.022.0001, Tab A; see also EXP.ROD.001.0583 at .0680.
357 February 2015 Report, EXP.ROD.001.0016 at [771]-[772]; see also AID.500.022.0001, Tab A.
358 Ibid at [798]-[800]; see also AID.500.022.0001, Tab A.
359 This average forecast rainfall depth was changed from 113mm in the February 2015 Report (ibid at [821] – [822]) to 124mm in the Response Report (EXP.ROD.015.0005 at .0172 - .0173); see also AID.500.022.0001, Tab A.
360 This average forecast rainfall depth was changed from 125mm in the February 2015 Report (ibid at [837] – [838]) to 127mm in the Response Report (EXP.ROD.015.0005 at .0177 - .0178); see also AID.500.022.0001, Tab A.
361 February 2015 Report, EXP.ROD.001.0016 at [853]-[854]; the plaintiff's assessment of Dr Christensen's average rainfall depth figure for this forecast was 149mm (AID.500.022.0001, Tab A), despite the Response Report stating that the sub-catchment averages had not been adjusted from the February 2015 Report and that the figure of 150mm was correct (EXP.ROD.015.0005 at .0182). This variance is immaterial.
362 Ibid at [872]-[873]; see also AID.500.022.0001, Tab A.

9 Jan	210 (100-320)[364]	50-200 (125)[365]	184.7	159.5	180	161	125-210[366]
10 Jan	150 (75-225)[367]	25-100 (62.5)	157.2		153	123	62.5-157.2
11 Jan	80 (40-120)[368]	25-50 (37.5)	57.2		56	58	37.5-80
12 Jan	38 (25-50)[369]	1-5 (3)	30.9		31		3-38

162 In cross-examination, Dr Christensen altered his assessment of the eight-day forecast available at midnight on 3 January 2011 from 75mm to 150mm to 50mm to 150mm which accords with the State's range.[370] Also, like the four-day PME for the same day, Dr Christensen altered his assessment of the eight-day forecast available at midnight on 10 January 2011 from 40mm to 120mm to 25mm to 100mm.[371] On the findings I have made in this Chapter and Chapter 10, both changes are immaterial.

163 As with the four-day PMEs, I have reviewed the eight-day PME forecasts the subject of this table. Save for the State's estimate on 9 January 2011, I do not regard any of these estimates, including Dr Christensen's as outliers. With the eight-day PME available on 9 January 2011 my inspection of the eight-day PME map leads to me conclude that a reasonably competent flood engineer would have had to conclude that the upper bound of that range was at least 300mm.[372] With the lower bound a tiny portion of the far reach of the upstream catchments supports the estimate of 50mm although Dr Christensen's analysis of the range is preferable. When allowance is made for that correction and Dr Christensen's corrections then, like the four-day PMEs, the range of assessments of rainfall depths from the eight-day PME forecasts, especially as between the State and Dr Christensen, is relatively narrow.

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363 Ibid at [907]-[908]; see also AID.500.022.0001, Tab A.
364 Ibid at [927]-[928]; see also AID.500.022.0001, Tab A.
365 Should be 50 to 300 – see [163].
366 Should be 159.5 to 210 – see [163].
367 Ibid at [953]-[954]; the plaintiff's assessment of Dr Christensen's average rainfall depth figure for this forecast was 152mm (AID.500.022.0001, Tab A). The Response Report stating that the sub-catchment averages had not been adjusted from the February 2015 Report and that the figure of 150mm was correct (EXP.ROD.015.0005 at .0207). This variance is immaterial.
368 Ibid at [976]-[977]; see also AID.500.022.0001, Tab A. Should be 25 to 100: see [162].
369 Ibid at [999]-[1000]; see also AID.500.022.0001, Tab A.
370 T 2706.17.
371 T 2712.22.
372 EXP.SEQ.014.0219 at .0399.

Again, I am satisfied that Dr Christensen's selected rainfall depths are reasonable although they tend on the high side of a relatively narrow range.

9.3: Four-Day and Eight-Day PME Loss Rates and Temporal Patterns – Defendants' Criticisms

164 The methodology by which Dr Christensen modelled four-day and eight-day forecast inflows, including his choice of temporal patterns and determination of loss rates, is described in Chapter 8.[373] As noted in Chapter 8,[374] Dr Christensen determined to adopt different loss rates for determining four-day and eight-day forecast inflows compared to calculating inflows for rain on the ground and 24-hour forecast inflows. This meant that he had to undertake separate RTFM runs as it could not accommodate more than one set of loss rates and then combine hydrographs. [375] Mr Giles' concern about that is noted in Chapter 8[376] and Seqwater adopted that concern in its submissions.[377] That has been addressed.[378]

165 This section addresses the balance of the defendants' criticisms in relation to Dr Christensen's use and selection of forecast loss rates. For the reasons that follow, I am satisfied that the loss rates he used to estimate future inflows were reasonable.

Use of Different Loss Rates

166 One aspect of Dr Christensen's justification for using loss rates for forecast rainfall that were different and lower than those used by the flood engineers for determining rain on the ground inflows, is set out in Chapter 8[379], namely, the difficulty presented by applying loss rates calibrated to past incidents of episodic rain to assumptions of continuous future rainfall inherent in the multi-day temporal patterns set out in the RTFM. Another concerned the use of loss rates computed by reference to past amounts of relatively low rainfall which

[373] At [67] to [99].
[374] At [92].
[375] Chapter 8 at [98] to [99].
[376] Chapter 8 at [98]
[377] Seqwater subs at [2108].
[378] Chapter 8 at [99].
[379] Chapter 8 at [92].

correspondingly produced low amounts of runoff to estimate future runoff that will occur under forecasts of high rainfall and a much wetter catchment.[380] In its submissions, the plaintiff addressed the rationale for adopting different loss rates in detail,[381] including by reference to Mr Giles' own modelling.[382] Save for two matters, the defendants did not take issue with that reasoning in their submissions,[383] although they strongly disputed the validity of the loss rates that Dr Christensen adopted and the rationale for those rates,[384] specifically his reliance on the runoff response from the Late December Flood Event and the use of the curve method. The first matter was that Seqwater submitted that using different loss rates disrupted non-linear routing. That contention has already been addressed[385] and is addressed further below. Second, Seqwater also contended that using two different sets of loss rates for separate runs "was not an approach identified in the Manual".[386] As noted, the Manual requires that forecasts be used to determine maximum dam heights. However, other than referring to the RTFM by name, it does not specify how that is to be undertaken and specifically what loss rates should be used.[387]

167 At this point it suffices to state that I accept the plaintiff's submissions on the justification for the usage of different loss rates and note that it is consistent with the analysis in Chapter 6.[388] I reject Mr Giles' attempts to justify the use of loss rates calibrated to rain on the ground for modelling inflows of forecast rain for periods of four and eight days.[389] Mr Giles calculated inflow volumes for Wivenhoe Dam based on his interpretation of the four-day PMEs using his rain on the ground loss rates[390] and also inflow volumes based on the 24-hour QPF forecasts using his loss rates.[391] As an illustration of the difficulty with his loss rates, the inflow volumes he calculated for the four-day PME forecasts for

[380] T 1064.36.
[381] Plaintiff subs at [1645] to [1666].
[382] Plaintiff's subs at [1663(c)].
[383] Seqwater subs at [2111] to [2139]; SunWater subs at [1011] to [1040]; State subs at [466] to [468].
[384] Seqwater subs at [2131] to [2139]; SunWater subs at [1019] to [1040]; State subs at [466] to [468].
[385] Seqwater subs at [2108]; Chapter 8 at [99].
[386] Seqwater subs at [2107] to [2109].
[387] Manual at 13.
[388] Chapter 6 at [299] to [319].
[389] See Chapter 6 at [314] to [319]; see also plaintiff subs at [1663(c)].
[390] EXP.QLD.001.1359 at .1377 to .1378.
[391] SBM.010.018.0001 and SBM.040.007.0001.

5, 6 and 7 January 2011[392] were less than the one-day inflow volumes he calculated for the QPF forecasts from the afternoon of 5 January 2011 through to the afternoon of 7 January 2011,[393] even though the rainfall depths he used for the four-day PMEs[394] were significantly higher than those in the QPF forecasts.[395] I am satisfied that the four-day volumes that Mr Giles calculated were unreasonably low.

Use of Loss Rates Calibrated to an Earlier Event (Allegedly) Contrary to the Manual

168 Seqwater contended that Dr Christensen's utilisation of the curve method to calibrate his future loss rates to the Late December Flood Event was contrary to the Manual.[396] It contended that section 5.1 of the Manual required the flood engineers use the RTFM to model inflows, that "the Manual [does] not include any information suggesting that the curve number should be used for deriving inflow estimates" and that the RTFM did not have a function of "calibrating inflow modelling to match the rainfall to-runoff ratio of a prior event".[397] As noted, the Manual is silent as to how loss rates are to be determined. The Manual leaves that matter to the flood engineer's judgment.

Calibrating to the Late December Flood Event

169 Dr Christensen pointed to the Late December Flood Event as a recent occasion where, in contrast to the standard temporal patterns for future rainfall provided for in the RTFM, there was a "realistic pattern" of rainfall.[398] As noted above, he explained that calibrating inflow volumes to that event addressed, at least to an extent, the uncertainty associated with the temporal

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392 EXP.QLD.001.1359 at .1378 (Table 2-5): 5 Jan: 111,000ML; 6 Jan: 138,000ML; 7 Jan: 203,000ML.
393 SBM.010.018.0001 at .0003: 5 Jan late: 210,000; 6 Jan early: 206,900; 6 Jan late: 216,900; 7 Jan early: 219,000; 7 Jan late: 286,000.
394 See [138] above. 5 Jan: 61mm; 6 Jan: 83mm; 7 Jan: 84mm.
395 EXP.QLD.001.1359 at .1380: 5 Jan late QPF: 30 to 50mm; 6 Jan early QPF: 30 to 50mm; 6 Jan late QPF: 20 to 30mm; 7 Jan early QPF: 20 to 30mm; 7 Jan late QPF: 20 to 30mm.
396 Seqwater subs at [2119] to [2121].
397 Seqwater subs at [2119] to [2120].
398 T 1527.1.

and spatial distributions of rainfall,[399] although he said they were also addressed in other ways.

170 In his evidence-in-chief, Dr Nathan was taken to this part of Dr Christensen's evidence and stated as follows:[400]

> "…The one aspect of this methodology that makes some sense to me is the use of a December - the understanding of the relationship between rainfall and runoff in December 2010 being of some use in predicting the proportion of runoff and rainfall in January 2011. So it's only one data point but it's not unreasonable to use it. So it seems to me that the only thing you can infer from December 2010 is the likely conversion or - yes, the likely conversion of rainfall to runoff, so what proportion of the rainfall appears as runoff. There is variation in that between events, there's variation in that within one event, but if you were needing a guide, that's not a bad guide to say, look, if the runoff proportion *in late December was 86 per cent, then you could expect, under similar rainfall conditions when the catchment is at a similar degree of wetness, that's not a bad starting point for the proportion of runoff*; so that's the bit I agree with.
>
> …
>
> I think December 2010 would go to my kind of knowledge of how the catchment responds to large rainfalls, and if for some reason I was, during my progressive calibration moving forward, finding a loss rate or a conversion of rainfall to runoff that was very different to what I was expecting, and that could be on the basis of December 2010, I would be thinking I was doing something wrong and I would be looking for a way of reconciling it. So I think there's some relevance in late December in terms of how the catchment responds to rainfall, but it is purely in terms of what proportion, what the loss rates - what likely loss rates I would be expecting moving forward, nothing else." (emphasis added)

171 Later in his evidence-in-chief, Dr Nathan was asked about the "appropriateness" of applying the 86% conversion of rain to runoff figure referred to in the above extract to every day of the January 2011 Flood Event.[401] He responded:

> "So I'm quite comfortable in, as I said, my earlier answer that that's a reasonable assumption for the latter part of the event because by that time the *catchment is probably similarly wet or a lot of rain has been falling*, … So from our first report, when I look at the losses during the event, it's quite apparent that losses decrease during the course of that rainfall event, and I'd say that's consistent with the physical processes described by Dr

[399] T 1372.15.
[400] T 3727.10 to T 3729.27.
[401] T 3750.42.

Christensen. He would say that as the catchment gets wetter, the runoff proportion increases. And all I'd be - so I think we're in agreement on that. The only thing that we're possibly disagreeing on is *that I would be saying from the beginning of January the catchment was not as wet as it was at the end of December*, that in the intervening time there has been some additional drainage from the subsurface soil stores or some evaporation, but whatever the physical mechanism, the catchment losses at the beginning of January were clearly higher than they were by the 14th. *So what this amounts to is that by adopting a runoff proportion that's around that 86 per cent at the beginning of January, you would be overestimating the runoff proportion* and I think while I generally wouldn't be too fussed by that compared to the uncertainties in the rainfall forecast, it just happens, though, at the beginning of January the rainfall depths were a lot smaller, so the degree of, if you like, overestimation of that runoff proportion would have a more material impact on the degree of bias in the estimated inflow volumes." (emphasis added)

172 Three points should be noted about these answers.

173 First, Dr Nathan's evidence provides support for the approach of Dr Christensen to the extent that in determining inflow volumes he calibrated to the runoff response of the catchment to the Late December Flood Event.

174 Second, at least for the latter part of the event when the catchment was *"probably similarly wet or a lot of rain has been falling"*, Dr Nathan agreed he would be "looking for a way of reconciling" his loss rates with the runoff percentage in the Late December Flood Event and he agreed that as the catchment became wetter the proportion would increase. As is evident from the last row of Table 8-2 in Chapter 8[402] from 6 January 2011 to 11 January 2011 Dr Christensen applied runoff percentages (derived from a curve number) that were comparable to, although slightly in excess of, the calculated percentage referable to the Late December Flood Event, namely 86%, being a range of 88% to 91%. Those numbers were applied in circumstances where, from at least the morning of 6 January 2011, the flood engineers were describing the catchments as "remain[ing] wet and likely to generate additional runoff in the event of rain".[403]

175 Third, the second of these passages from Dr Nathan's evidence appears to proceed on the false premise that Dr Christensen applied the conversion

[402] Chapter 8 at [95].
[403] QLD.001.001.2256.

percentage of 86% throughout the entirety of the January 2011 Flood Event. Dr Nathan contended that this was inappropriate as he determined that the catchment was *“not as wet as it was at the end of December”.* In fact, as the last row of Table 8-2 in Chapter 8[404] makes clear, from 2 to 5 January 2011 Dr Christensen applied a lower percentage runoff than 86% (and a lower percentage than as predicted by the application of a curve number of 96).

176 Dr Nathan’s evidence on the use of the curve number method is addressed next. At this point it suffices to state that the process undertaken by Dr Christensen was not in substance different from that suggested by Dr Nathan. Dr Nathan accepted the validity of using as a starting point the runoff percentage that approximated to the Late December Flood Event in the latter part of the January 2011 Flood Event and a lesser figure for the earlier part of the event. As the last row of the Table 8-2 makes clear, that was the approach that Dr Christensen in fact adopted.

177 Mr Ickert agreed with the first passage of the above extract from Dr Nathan’s oral evidence.[405] He agreed that it was a “good assumption” that the catchment response in the January 2011 Flood Event in terms of volume would be the same as the Late December Flood Event.[406] He agreed that it was reasonable to use parameters derived from a similar event in the same catchment in undertaking forecast modelling.[407] Ultimately, he agreed:[408]

> “Q. For all the reasons we've discussed this morning, if an engineer was trying to model the January 2011 4- and 8-day forecasts, they would model it using the loss rates that Dr Christensen has used because of that reference back to late December; correct?
>
> A. Once again, I mean, without having anything better to use - that's the problem with forecast rainfall, you don't have anything to work against. But, I mean, it would be reasonable. I'm not saying it is the right thing to do, but there's not a good option in that situation.
>
> Q. If that's what you wanted to do, it is the best of the available options; is that correct?

[404] Chapter 8 at [95].
[405] T 8180.43.
[406] T 8168.26; T 8167.42.
[407] T 8162.7.
[408] T 8183.17.

A. If you said, "Hey, I need a model of 4- and 8-day rainfall forecasts", it's as good as any other option."

Reliance on the Curve Method

178 Seqwater contended that the curve method (and straight line method) are not utilised in Australia and its use was not supported by the bulk of the witnesses.[409] Seqwater noted Dr Christensen's concession that the origins of the curve method was as a "simple and easy" method of estimating surface runoff from hillscape plots and small agricultural catchments in the USA[410] which yielded recommended curve numbers for similar locations and soil types.[411] Thus, Seqwater submitted that the curve method uses "curve number tables which set out recommended curve numbers depending on location and soil type" which are set out in the textbook "Australian Rainfall and Runoff" discussed below[412] and referred to evidence of Dr Nathan that it had little utility.[413] Seqwater also cited Dr Christensen's own evidence that the straight line method wrongly assumes that the relationship between rainfall and runoff is linear but that he nevertheless relied on it.[414]

179 These submissions mischaracterise Dr Christensen's reliance on the curve method and the straight line method. Dr Christensen's reliance on the straight line method is described in Chapter 8. In summary, he relied on it for the starting proposition that, if the same amount of rain fell in the January 2011 Flood Event as fell in the Late December Flood Event, then the proportion of runoff would be expected to be the same or at least similar. In the passage from his evidence set out above, Dr Nathan substantially agreed with that. Otherwise, Dr Christensen explained that he used the straight line method as a "check [that] my loss rates were within a range that would reasonably be

409 Seqwater subs at [2114] and [2117].
410 T 1480.25 – .40; Seqwater subs at [2122] to [2124].
411 See EXP.SUN.001.0001 at [322]; T 8175.11 (Ickert)].
412 Seqwater subs at [2126]; See [237].
413 Seqwater subs at [2130].
414 Ibid at [2124] to [2125].

expected given the proximity" of the Late December Flood Event to the January 2011 Flood Event.[415]

180 In relation to the curve method, unlike the situation with small agricultural holdings, the present context does not concern the use of a curve number derived by reference to one particular catchment which is then applied to other catchments with similar characteristics such as soil type. Instead, it involves the use of a curve number derived from one multi-day storm on a particular catchment (ie, the Late December Flood Event affecting the Wivenhoe Dam catchments and the Somerset Dam catchment) to ascertain the response of the *same catchment* to another multi-day storm. Even though Mr Ickert's written reports were critical of the use of curve numbers (especially for events longer than 24 hours),[416] he accepted that there was "nothing wrong" and "no problem" with applying a curve number derived from a storm event of a particular length to another storm event of the same duration in the same catchment[417] provided that "you can discretise" the events. This is a reference to correctly identifying the rainfall and runoff referable to each event, a matter addressed next.

181 In one of his reports, Dr Nathan addressed the literature of hydrological studies on the utility of the curve number, including studies conducted in Australia.[418] Dr Nathan noted that Dr Christensen described the curve method as a "scientifically sound method" and stated that "[i]f Dr Christensen uses this phrase to infer that the method encapsulates the physical processes involved in the conversion of rainfall into runoff then I profoundly disagree".[419] Dr Nathan continued:[420]

> "The [curve method] approach was originally developed by the US Dept of Agriculture as a "simple and easy"[421] means of estimating surface runoff from hillslope plots and small agricultural catchments. The method does not involve the use of any physical equations that govern the movement of water

[415] Reply Report, EXP.ROD.004.0005 at [267].
[416] EXP.SUN.001.0001 at [323] and EXP.SUN.009.0001 at [61].
[417] T 8172.44; T 8173.39.
[418] EXP.SEQ.014.0013 at [139] to [144].
[419] Ibid at [139].
[420] Ibid at [139] to [141].
[421] Reference from text omitted.

in porous media, rather it is a parsimonious empirical function that is used to relate observations of rainfall to those of runoff…

…

The method is used widely in the US (and some other countries) by engineering hydrologists, but this is because of its convenience rather than its scientific defensibility."

182 Dr Nathan noted that curve numbers are not fixed or constant "as is implied in the normal handbook approach",[422] an assumption that Dr Christensen did not make. He concluded that "there is good evidence that wide adoption of a method does not equate to it scientific defensibility".[423] Seqwater also noted Mr Ayre and Mr Malone's evidence rejecting the use of the curve method and Mr Tibaldi's evidence that he had never heard of it before reading Dr Christensen's reports.[424]

183 However, as noted, Seqwater's reliance on this evidence was premised on a misconception of what use Dr Christensen made of the curve method and what he contended the reasonably competent flood engineer should have done. In his evidence, Dr Christensen was asked:[425]

"Q. You indicated earlier in one of your reports that you didn't believe that the flood operations engineers operating this dam would be likely to have any knowledge of such a methodology, didn't you?
A. Yes.

Q. So reasonable competence of a reasonable Australian flood operations engineer wouldn't involve a requirement that they used a curve number for any purpose, would it?
A. Not a requirement. They should be checking the RTFM with *reasonable additional methods*." (emphasis added)

184 Thus, Dr Christensen did not treat the curve method as any more than an empirical means of mathematically determining the runoff response curve of the Wivenhoe catchment by reference to the Late December Flood Event. Moreover, he did not assert that a reasonably competent flood engineer had to utilise the curve method to calibrate to the Late December Flood Event;

[422] EXP.SEQ.014.0013 at [142].
[423] Ibid at [142].
[424] Seqwater subs at [2128].
[425] T 2344.24.

only that they utilise a "reasonable additional method" to determine appropriate future loss rates. The method he adopted was to calibrate to the Late December Flood Event, resulting in a runoff conversion ratio of 86% relative to 85mm of rain.[426] He then identified the "curve number method" as "*one way* that a reasonably competent flood operations engineer would know how much lower or higher the percentage of rainfall converted to runoff would be if less or more rain fell across the catchment".[427] Mr Ickert's evidence provides some support for that. As the above passage from Dr Nathan's evidence illustrates, he agreed that at least the starting point would be the runoff percentage derived from the Late December Flood Event and it would need to be adjusted depending on the state of the catchment and the amount of actual and forecast rainfall during the January 2011 Flood Event. Whether that adjustment is undertaken by relying on the curve method or some other additional (but reasonable) method does not matter. Subject to the calculation of the runoff proportion for the Late December Flood Event being "correct" (or sufficiently accurate), given Dr Nathan's and Mr Ickert's evidence, there is no basis for suggesting that any other "reasonable additional method" of runoff estimation would have produced any materially different result.

Correct Calculation of Runoff Conversion from the Late December Flood Event

185 Both Seqwater and the State contended that the figures Dr Christensen used to derive his curve number were incorrect.[428] The manner in which those contentions emerged was unsatisfactory given that the proceedings were governed by s 56 of the *Civil Procedure Act 2005* (NSW).

186 The method by which Dr Christensen calculated his curve number of 96 for the Late December Flood Event is explained in Chapter 8.[429] It was derived by attributing to the Late December Flood Event a rainfall depth of 85mm and runoff volume of 513,000ML. Dr Christensen identified these two parameters as the basis for the calculation that the curve number was 96 in his February

426 Response Report, EXP.ROD.015.0005 at [152(2)(a)-(b)].
427 Ibid at [152(2)(c)].
428 Seqwater subs at [2131] to [2139]; State subs at [467] to [468].
429 At [83] to [91].

2015 Report.[430] He identified the source of his information as, inter alia, the October to December Flood Event Report (ie, the 2010 FER).[431] In his Response Report he identified the precise table from the 2010 FER that was the basis for the calculation of rainfall depths for the Late December Flood Event.[432] As noted, on a straight line basis the percentage of runoff is 86%.

187 In an affidavit filed 30 November 2017, being the day prior to the commencement of the hearing, Mr Malone stated that Dr Christensen had underestimated the catchment average rainfall for the Late December Flood Event by approximately 9mm.[433] Mr Malone also used a slightly different inflow volume for the Late December Flood Event compared to Dr Christensen, namely 508,194ML compared to 513,000ML.[434] Mr Malone derived a ratio of runoff to rain of 77%.[435]

188 Dr Christensen was cross-examined on Mr Malone’s figures by Senior Counsel for Seqwater. He defended his use of the inflow volume calculation of 513,000ML on the basis that he had access to a gate operations spreadsheet for the Late December Flood Event which finished at 6.00pm on 1 January 2011 and which showed inflows of around 508,000ML. He said he projected the figures forward to derive the balance of the inflows referable to the rest of that event beyond that time.[436] He was not examined on the difference between the rainfall figures but was simply asked whether, if Mr Malone’s figures were correct, he had calibrated his modelling of four-day and eight-day volumes to “an incorrect benchmark”.[437] Dr Christensen only agreed it was “slightly higher”.[438]

[430] February 2015 Report, EXP.ROD.001.0016 at [402]; see also Reply Report, EXP.ROD.004.0005 at [267].
[431] February 2015 Report, EXP.ROD.001.0016 at [388(k)].
[432] Response Report, EXP.ROD.015.0005 at [61].
[433] LAY.SEQ.013.0001 at [78(b)].
[434] Ibid at [80].
[435] Ibid at [82].
[436] T 1559.47 to T 1560.44.
[437] T 1562.15.
[438] T 1562.16.

189 Later, Dr Christensen was cross-examined by Senior Counsel for the State on his estimate of inflow volumes referable to the Late December Flood Event.[439] It was suggested that his volumetric estimate was inflated because it included inflows from rain that occurred in the period immediately prior to the commencement of the Late December Flood Event, namely from 20 to 23 December 2010. Dr Christensen agreed that some of the rain that fell in that period flowed into the dams later.[440] By reference to the gate operations spreadsheet referable to 6.00pm on 1 January 2011,[441] it was suggested that it showed inflows into both dams at the time of the commencement of the Late December Flood Event of 180m^3/s.[442] Later it was suggested that, if all the inflows for 24 December 2010 were set to zero supposedly to effect a removal of inflows from rain prior to the commencement of the event, it would yield a revised inflow figure of 446,104ML.[443] Having just been shown those figures in cross-examination, Dr Christensen stated that he would need to undertake a "full evaluation", especially having regard to the "scale factors" in the spreadsheet to verify that.[444] In re-examination, it was suggested to Dr Christensen that a reduction of 50,000ML in the inflow volume for the Late December Flood Event would yield a conversion rate of rainfall to runoff of 77.5% and a curve number of 93.[445] On that basis, he stated that it would not cause him to alter his simulations.[446]

190 Dr Christensen completed his evidence on 22 March 2018. Mr Malone swore another affidavit on 24 April 2018.[447] He referred to Dr Christensen's oral evidence on this topic including the cross-examination by Senior Counsel for the State.[448] Despite referring to this cross-examination, Mr Malone did not comment on the suggestion that the estimate of inflows for the Late December Flood Event was affected by rainfall that occurred prior to it

[439] T 2724.6 to T 2729.33; T 2732.36 to T 2738.17.
[440] T 2726.27.
[441] QLD.001.001.1955.
[442] T 2732.24 to T 2733.32.
[443] T 2735.20.
[444] T 2736.8 - .18.
[445] T 2821.16 - .31.
[446] T 2821.37.
[447] LAY.SEQ.016.0001.
[448] Ibid at [117] to [118].

commencing. To the contrary, he agreed that the difference between the volumetric estimates of 508,000ML and 513,000ML produced by himself and Dr Christensen respectively were “minor”.[449] If anything, that amounts to a reaffirmation of those volumetric estimates. As for the 9mm difference in rainfall, Mr Malone stated that there was an error in the rainfall table in the 2010 FER relied upon by Dr Christensen in that it listed the rainfall for the Upper Brisbane and Middle Brisbane catchments as zero on 2 January 2011[450] when it should have shown rain.[451]

191 In July 2018, being months after Dr Christensen finished giving his evidence, Mr Giles provided a report in which he documented the calculations put to Dr Christensen in cross-examination by Senior Counsel for the State concerning the calculation of the runoff volume for the Late December Flood Event.[452] Adjusting the spreadsheet in the manner suggested yielded a revised volume of 448,374ML (being a reduction of around 642,85ML[453]) and a revised conversion ratio of rainfall to runoff for the Late December Flood Event of 75%.[454] Using that percentage, Mr Giles then adjusted his forecast loss rates to account for what he contended to be the correct rain and runoff figures for the Late December Flood Event. Mr Giles said that he sought to adopt a process that was as “consistent as possible with the approach of Dr Christensen with runoff percentages lower than the Late December Flood Event for the early part of the January 2011 Flood Event and higher for the later part of the flood event”. In his July 2018 report,[455] Mr Giles combined the forecast figures for Wivenhoe Dam and Somerset Dam and then provided a combined reduced figure based on the application of the lower runoff to rain conversion rates which did not include rain on the ground.[456] Mr Giles stated that he adopted a “target percentage runoff for each day other than 2nd January [2011 that] was set according to the ratio of the correct runoff

[449] Ibid at [118].
[450] ROD.650.003.6506 at .6598.
[451] See ROD.650.003.6506 at .6594, .6598; Malone 5, LAY.SEQ.016.0001 at [118].
[452] EXP.QLD.002.0040 at .0057 to .0058.
[453] T 8895.40.
[454] T 8895.12.
[455] EXP.QLD.002.0040.
[456] Ibid at .0061, Table 3-3.

percentage and that [was] adopted by Dr Christensen".[457] Thus, for example, according to Mr Giles, Dr Christensen accepted a runoff percentage of 80.8 percent for the eight-day PME on 4 January 2011, then "[u]sing the corrected runoff percentage to that adopted by Dr Christensen, the target runoff percentage is 70.5% (ie, 80.8 x 75/86 = 70.5%)".[458]

192 The adjusted loss rates that Mr Giles derived were as follows:[459]

Date	Dr Christensen			Corrected Runoff Volume		
	Initial Loss (mm)	Continuing Loss		Initial Loss (mm)	Continuing Loss	
		CRE, COO, LIN, GRE, EMU (mm/h)	WDI and SDI (mm/h)		CRE, COO, LIN, GRE, EMU (mm/h)	WDI and SDI (mm/h)
2 January	0	0.12	0.10	0	0.21	0.18
3 January	10	0.12	0.10	10	0.26	0.23
4 January	10	0.10	0.05	5	0.20	0.16
5 January	2.1	0.10	0.05	0	0.18	0.15
6 January	0	0.10	0.05	0	0.20	0.15
7 January	0	0.09	0.07	0	0.22	0.20
8 January	0	0.20	0.18	0	0.44	0.41
9 January	0	0.25	0.23	0	0.50*	0.80*
10 January	0	0.25	0.23	0	0.50*	0.80*
11 January	0	0.20	0.18	0	0.45	0.43

Table 9-4: Mr Giles' Adjusted Loss Rates for the 8-Day PME Forecast

193 The revised four-and eight-day runoff volumes that Mr Giles calculated compared to Dr Christensen's were as follows:[460]

[457] Ibid at .0059.
[458] Id; T 8897.24.
[459] Ibid at .0060.
[460] Ibid at .0061.

Date	4-Day PME				8-Day PME			
	Dr Christensen		Revised Loss Rates		Dr Christensen		Revised Loss Rates	
	Runoff (ML)	Percent Runoff (%)	Runoff (ML)	Percent Runoff (%)	Runoff (ML)	Percent Runoff (%)	Runoff (ML)	Percent Runoff (%)
2 January	5,000	11.9	0.0	0.0	62,000	44.2	26,000	5.3
3 January	418,000	79.4	378,000	71.8	644,000	81.2	563,000	71.0
4 January	665,000	86.1	642,000	83.1	677,000	80.8	593,000	70.8
5 January	442,000	84.0	399,000	75.8	736,000	83.9	642,000	73.2
6 January	541,000	90.7	477,000	79.9	888,000	88.6	777,000	77.5
7 January	617,000	93.3	534,000	80.8	839,000	87.6	729,000	76.1
8 January	1,229,000	91.8	1,071,000	80.0	1,276,000	90.9	1,109,000	79.0
9 January	1,139,000	91.2	993,000	79.5	1,289,000	91.5	1,136,000	80.6
10 January	930,000	90.1	809,000	78.3	930,000	90.1	809,000	78.3
11 January	474,000	89.2	414,000	77.9	474,000	89.2	414,000	77.9

Note: Values in table refer to runoff due to forecast rainfall and do not include runoff resulting from recorded rainfall prior to the time of forecast.

Table 9-5: Mr Giles' Adjusted 4 and 8-Day PME Inflow Volumes

194 As the note below Table 9-5 makes clear, the volume figures shown in that table do not include rain on the ground. Further those figures are combined Wivenhoe and Somerset inflow volumes (see below at [233]).

195 The plaintiff was clearly frustrated by the manner in which this evidence emerged, describing it as an exercise in "belated cleverness that has no real legal consequence".[461] It noted that this evidence was not raised in any of Mr Giles' reports until after Dr Christensen gave evidence and submitted that "Seqwater's best contemporaneous understanding of rainfall and runoff amounts generated by the [Late December Flood Event] is that set out in the [2010 FER] and it is that understanding that would have been applied by a reasonable engineer to calculating loss rates in January 2011".[462]

196 As noted, the process by which the attack on Dr Christensen's rainfall depths and runoff volumes for the Late December Flood Event emerged was unsatisfactory. Not only was the material served late and, in some respects,

[461] Plaintiff subs at [1686].
[462] Ibid at [1684].

well after Dr Christensen gave evidence, but the genesis of the dispute lies in errors in the 2010 FER. Mr Malone's acknowledgement of error in the reporting of rainfall during the Late December Flood Event has already been noted.

197 Further, Dr Christensen's failure, if it was one, to exclude inflows from rain received prior to 9.00am on 24 December 2010 was also understandable. The relevant table from the 2010 FER which sets out the rainfall received during December 2010 was extracted in Dr Christensen's Response Report where he explained how he calculated the rainfall to runoff conversion percentage and curve number for that event.[463] That table indicates that no rain was received in the Upper Brisbane catchment on any day throughout 21 to 24 December 2010. For the Stanley River catchment, it lists rainfall of 0, 1, 11 and 3mm respectively. That amount of rainfall in the Stanley River catchment alone could never be expected to produce sufficient runoff after 9.00am on 24 December 2010 to materially affect the calculation of runoff from the Late December Flood Event, much less produce around 60,000ML in runoff.

198 However, elsewhere in the 2010 FER, a rainfall gauge map lists readings for the gauges in the Upper Brisbane catchment for the 24 hours to 9.00am on 24 December 2010 of between 11 and 29mm.[464] The equivalent map for the 24 hours to 9.00am on 23 December 2010 lists negligible rainfall for both catchments.[465] To add to the confusion, Mr Malone's Observed Rainfall Analysis report ascribes 16mm and 11mm of catchment average rainfall for the 24 hours to 9.00am on 23 December 2010 and 6mm and 3mm for the 24 hours to 9.00am on 24 December 2010 for the Upper Brisbane and Somerset catchments respectively.[466]

199 Thus, in the end result, if Dr Christensen's figures are wrong, they were induced by Seqwater's publication of incorrect rainfall figures. Those figures, and Dr Christensen's calculations based on them, remained uncorrected for

[463] Response Report, EXP.ROD.015.0005 at [56].
[464] ROD.650.003.6506 at .6568.
[465] Ibid at .6567.
[466] SEQ.004.046.0230 at .0256 and .0257.

many years and he was not provided with a proper opportunity prior to giving evidence to address any competing analysis.

200 Nevertheless the evidence has to be addressed as best as it can bearing in mind how it emerged. The plaintiff effectively submitted that Mr Giles' analysis tends to overestimate future losses in that the estimation takes place at a point when the initial losses are satisfied.[467] This is so because the estimation involves a comparison between past figures for rain and runoff where past initial losses had yet to be satisfied with future inflows, at a point where only continuing losses are to be experienced. Mr Giles accepted this proposition.[468] Mr Giles' assessment of the Late December Flood Event was that its initial loss of 10mm was equivalent to 70,000ML.[469] Mr Giles agreed that this figure should be "notionally add[ed] back in" if one "were looking at a forecast run at a point in time after initial loss had been satisfied",[470] which on any view was from 5 January 2011 (and earlier on Dr Christensen's modelling). Hence the plaintiff submitted that, for modelling after initial losses are satisfied, Mr Giles' analysis does not provide "any reason to criticise the forecast continuing loss rates calculated by Dr Christensen".[471] I accept that submission.

201 Otherwise, in relation to Mr Giles' revised loss rates set out in Table 3-2 above I note four matters.

202 First, in determining his loss rates for 4 and 5 January 2011, Mr Giles reduced the initial loss rates determined by Dr Christensen which will necessarily tend to increase the continuing loss rates.[472]

203 Second, the forecast loss rate produced by Mr Giles for the SDI from 8 January 2011 of 0.8mm/hr exceeds the rain on the ground loss rates used

[467] Plaintiff subs at [1683].
[468] T 8893.42 and T 8896.26.
[469] T 8895.24 - .35.
[470] T 8895.42 to T 8896.29.
[471] Plaintiff subs at [1683(f)].
[472] T 8897.36.

by the flood engineers from that time (0.5mm/hr) which is extremely counter intuitive.

204 Third, even though Mr Giles noted that, similar to Dr Christensen's approach, the conversion percentages in his derived figures were lower than the (revised) Late December Flood Event figure for the early part of the January 2011 Flood Event (ie, 75%) and higher than that figure for the latter part of that event, it is doubtful that they properly reflect Dr Christensen's methodology. Dr Christensen's loss rates estimated that 81% of the predicted 113mm of rain from 3 January 2011 over eight days would become runoff. [473] A prediction of 113mm of rain well exceeds the amount of rain that fell in the Late December Flood Event. Generally, it would be expected that a higher proportion of runoff would be expected from that higher rainfall amount even allowing for some drying out of the catchment.

205 Fourth, Mr Giles' revised figure for the rainfall to runoff percentage for the Late December Flood Event yields a revised curve number of over 92.[474] Consistent with Dr Christensen's answers in re-examination, the use of a curve number of 92 for the Late December Flood Event and a conversion percentage of 75% was not likely to yield much difference in assessed loss rates for the January 2011 Flood Event given the amount of predicted rain from 3 January 2011 onwards. In that regard, I note that Mr Malone's revised figures also yields a curve number of just under 92.[475]

206 Finally, I note that this process of determining loss rates for four-day and eight-day forecasts involved modelling by Dr Christensen of eight-day forecasts and then applying those rates to the four-day forecasts. I have already expressed a lack of satisfaction with the use of eight-day PME

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[473] Table 8-2; Chapter 8 at [95].

[474] Using the mm rainfall figures from Table 8-1 in Chapter 8 at [91], T 8895.40 and formulas in Response Report EXP.ROD.015.0005 at [37]: P converted to inches = 85/25.4 = 3.3465; Q converted to inches = 448,374 ML/(7020km^2 x 25.4) = 2.5146; S= 5(P + 2Q – (4Q^2 + 5PQ)$^{1/2}$) = 5(3.3465 + 2x2.5146 – (4x2.5146^2 + 5x3.3465x2.5146)$^{1/2}$) = 0.8394 = 0.84 (2dp); CN = 1000(S + 10) = 1000/(10.84) = 92.25.

[475] Using Malone's figures from LAY.SEQ.013.0001 at [78] to [80] and the formulas in Response Report EXP.ROD.015.0005 at [37]: P converted to inches = 94/25.4 = 3.7402; Q converted to inches = 508,194 ML/(7020km^2 x 25.4) = 2.8501; S= 5 (P + 2Q – (4Q^2 + 5PQ)$^{1/2}$) = 5(3.7402 + 2x2.8501 – (4x2.8501^2 + 5x3.7402x2.8501)$^{1/2}$) = 0.8900 = 0.89 (2dp); CN = 1000(S + 10) = 1000/(10.89) = 91.83.

forecasts in flood operations because of the lack of evidence as to the skill displayed by those forecasts (see above at [93] and [130]). In his July 2018 report, Mr Giles stated that the "use of the same loss rates for the 4-day and 8-day PME forecasts results in the overestimation of the percentage of runoff from the catchment for the 4-day PME for the period of 4 January to 8 January compared to the runoff that occurred for the Late December 2010 event used by Dr Christensen for the derivation of losses for the 8-day PME".[476]

207 This conclusion warrants scrutiny of the runoff ratios in Dr Christensen's modelling of four-day inflows. Table 9-5 shows that for 2 January 2011, Dr Christensen's loss rates produced runoff that was only 11.9% of the modelled four-day rainfall prediction and it can thus be put aside. For 3 January 2011, Dr Christensen's loss rates produced runoff that was 79.4% of the modelled four-day rainfall prediction of 75mm which was less than Dr Christensen's calculated runoff conversion percentage for the entirety of the Late December Flood Event of 86%.[477] For 4 January 2011, Dr Christensen's loss rates produced runoff that was 86.1% of the modelled four-day rainfall prediction of 116mm which is (slightly) greater than the total rainfall to runoff ratio for the Late December Flood Event. Mr Giles agreed that the difference was of no consequence and the difference in rainfall suggested that a higher proportion of runoff might be expected from the forecast rain.[478] For 5 January 2011, Mr Giles agreed that the difference between the runoff conversion percentage for the four-day PME forecast of 84.0% and the eight-day PME forecast of 83.9% was "essentially nothing".[479] The same conclusion applies to 6 January 2011 where the runoff conversion percentage for the four-day forecast was 90.7% and the eight-day forecast was 88.6%.[480] The same conclusion also applies in relation to the differences for 8 January 2011 to 11 January 2011.[481] In respect of 7 January 2011, Dr Christensen's loss rates produced a runoff

[476] EXP.QLD.002.0040 at .0055.
[477] EXP.QLD.002.0040 at .0055; See Table 8-1 in Chapter 8 at [91] for 86% figure.
[478] EXP.QLD.002.0040 at .0055; T 8892.21.
[479] EXP.QLD.002.0040 at .0055; T 8892.41.
[480] T 8893.3.
[481] EXP.QLD.002.0040 at .0055; 8 Jan: 91.8mm v 90.9mm; 91.2mm v 91.5mm; 90.1mm v 90.1mm; 89.2mm v 89.2mm.

conversion percentage of 93.3% for the four-day forecast compared to 87.6% for the eight-day forecast.[482] The difference between those figures and the runoff conversion percentage for the Late December Flood Event is not insignificant. However, given the size of the forecasts, the absorption of initial losses by that time and the rain that had already fallen in the January 2011 Flood Event, a percentage runoff of 93.3% for that forecast was not unreasonable.[483]

208 In the end result, and subject to what follows, I am satisfied that Dr Christensen's selected loss rates for the modelling of four-day and eight-day inflows determined, as they were, by reference to the Late December Flood Event, were reasonable. At most, the analysis of Mr Giles and Mr Malone creates some limited uncertainty that slightly higher continuing loss rates could have been adopted by a reasonably competent flood engineer modelling inflow volumes for four and eight-day forecast periods. That uncertainty reduces at the point when initial losses in the January 2011 Flood Event were satisfied and modelling was being undertaken that used continuing loss rates determined by reference to figures for the Late December Flood Event that included rainfall that was absorbed as initial losses. Otherwise, the table of four-day inflow volume calculations set out in Table 9-6 below include the revised volumes calculated using the loss rates determined by Mr Giles as set out in Table 9-4. They should generally correspond with any rates determined by reference to Mr Malone's figures for the Late December Flood Event.

Post-Event Validation

209 SunWater submitted that Dr Christensen's post-event assessment of the appropriate curve number for the January 2011 Flood Event invalidated the loss rates that he determined.[484]

[482] EXP.QLD.002.0040 at .0055.
[483] T 8894.2 - .27 (Giles).
[484] SunWater subs at [1028].

210 In his Response Report, Dr Christensen set out various calculations in which he compared his runoff conversion percentage figures and curve numbers to the actual runoff conversion percentage and curve numbers generated by the January 2011 Flood Event (calculated by reference to Seqwater's estimate that the event produced 2,650,000ML of runoff).[485] Using the rainfall figures from 9.00am on 6 January 2011 to 9.00am on 12 January 2011, he derived a curve number of 89 for the event.[486] (Using those figures, the total runoff conversion percentage for the event was 91.18%.)[487] Dr Christensen explained that he chose that period because almost all of the runoff was produced from rainfall in that period whereas very little of the 26mm of average rainfall received on 5 January 2011 apparently produced runoff.[488]

211 Dr Christensen also undertook calculations based on the inclusion of rainfall and runoff from prior days up to and including 12 January 2011 based on his estimate of the rain that fell. They revealed that, if the calculation had commenced on 6 January 2011, the curve number would have been 81 and the runoff conversion percentage 86%; if it had commenced on 5 January 2011, the curve number would still have been 81 and the runoff conversion percentage 85%; and, if it had commenced on either 3 or 4 January 2011, the curve number would have been 80 and the runoff conversion percentage 85%.[489] Dr Christensen concluded that, with the benefit of hindsight, the straight line method of using a runoff ratio of 86% from the Late December Flood Event produced predictions very close to the runoff conversion percentage from the January 2011 Flood Event, being a range of a 1% over-estimation to an under-estimation of 6% depending on the length of the period chosen.[490] Dr Christensen also calculated that, if loss rates determined (solely) by reference to a curve number of 96 had been utilised, then it would

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485 Response Report, EXP.ROD.015.0005 at [117].
486 Ibid at [119].
487 2,650,000/(7020 x 414).
488 Response Report, EXP.ROD.015.0005 at [122].
489 Response Report, EXP.ROD.015.0005 at [123].
490 Ibid at [128].

have produced an over estimation of the total inflow between 6% and 14% depending on the length of the period chosen.[491]

212 In his Response Report, Mr Ickert noted that the use of a curve number of 96 to determine inflow volumes would yield a difference in inflow volumes of around 390,300ML over the course of the January 2011 Flood Event.[492] He stated that this “14% difference is highly significant” given that Dr Christensen used an eight-day forecast with a no release assumption.[493] However, these observations are of no assistance for three reasons.

213 First, the loss rates used by Dr Christensen were not solely determined by a curve number of 96. As the last row of Table 8-1 makes clear, all of the loss rates that were utilised to generate Dr Christensen’s runoff conversion percentage were reflective of a curve number of less than 96, save for 11 January 2011.

214 Second, no aspect of the application of Dr Christensen’s loss rates was capable of producing a difference in volume of 390,000ML because Dr Christensen never modelled the amount of rain that actually fell.

215 Third, Mr Ickert agreed that data obtained in hindsight cannot be used to criticise forecast rainfall loss rates.[494] SunWater contended that insofar as Dr Christensen’s material was being used for causation, his after-the-event analysis invalidated the loss rates he used.[495] Dr Christensen’s simulations are being used for causation to the extent that the plaintiff contended that, but for the flood engineers’ negligent conduct of flood operations, continuous non-negligent flood operations would have involved the adoption of at least one of his simulations. No aspect of that chain of reasoning allows for the intrusion of hindsight in relation to the assessment of Dr Christensen’s simulations. Hindsight can only intrude at the point the Court is considering

[491] Ibid at [131].
[492] EXP.SUN.009.0001 at [80].
[493] Ibid at [82].
[494] T 8186.20.
[495] SunWater subs at [1036].

what the consequences would have been from the adoption of those simulations.

216 Otherwise, SunWater noted a passage of questioning in which Dr Christensen agreed that if he "had calculated a curve number from the late-December event of around 80 and a lower percentage runoff, say 75 per cent" then he would have adopted higher loss rates for 2 January 2011 onwards.[496] That evidence does not assist because, as the above figures demonstrate, a runoff conversion percentage of 75% for the Late December Flood Event derived from using either the inflow figures that Mr Giles calculated or the rainfall depth that Mr Malone calculated does not yield a curve number of 80 but instead yields a curve number of around 92.[497]

217 Overall, to the extent that hindsight can be considered, then both the curve numbers and rainfall to runoff ratios calculated from the actual rain and runoff amounts suggest that there was a slight to modest degree of overestimation of the runoff response of the catchment by Dr Christensen in his determination of the forecast loss rates. It is true that the runoff ratios noted in [213] above were either equivalent to that experienced during the Late December Flood Event or slightly higher (as measured by Dr Christensen). However, the Late December Flood Event involved 85mm of rain (or 94mm on Mr Malone's figures), whereas the January 2011 Flood Event involved more than 400mm of rain; so it is to be expected that the rainfall to runoff ratios should be higher for the latter. Similarly, in the end result the runoff conversion percentages listed in the last row of Table 8-2 in Chapter 8[498] are slightly less than that which was ultimately experienced. However, again, the former were determined on forecasts of less rain than actually fell and, as noted, a consideration of the reasonableness of the rates does not turn on a hindsight analysis. In the end result, a consideration of the post-event data does not affect the conclusion in [208].

[496] T 2364.29 to T 2365.3.
[497] See footnote 475.
[498] Chapter 8 at [95].

Temporal Patterns

218 Dr Christensen's approach to the selection of a temporal pattern for modelling four-and eight-day inflows is described in Chapter 8.[499] The plaintiff submitted that this approach was supported by three matters.[500] First, the plaintiff accepted that Dr Christensen was unable to create his own user defined temporal patterns with spasmodic rainfall for modelling four and eight-day forecasts, even though the RTFM did have that function. However, by reference to Mr Giles' evidence, it contended there would be insufficient time during real time flood operations to engage that function.[501] Second, the RTFM's standard distribution patterns all involved patterns of effectively continuous rainfall such that the better approach was to treat loss rates and temporal patterns together in an endeavour to match a catchment response similar to the Late December Flood Event. Third, in any event, PMEs only provided a breakdown of rainfall in periods of one day and did not enable the adoption of temporal patterns for smaller periods, which could be used to build a temporal pattern in the RTFM.

219 Seqwater noted Dr Christensen's statement in his Reply Report that the "RTFM is extremely sensitive to the temporal distribution of rainfall"[502] and certain evidence of Dr Nathan and Mr Malone about the sensitivity of calculating runoff to the intensity of the rainfall as supportive of its contention that the adoption of a temporal pattern without regard to the distribution of rainfall in the forecast undermines Dr Christensen's approach.[503] However, Seqwater's submissions mischaracterise the use Dr Christensen made of the temporal patterns, the effect of uncertainty in temporal periods and how Dr Christensen addresses that uncertainty.

[499] Chapter 8 at [72].
[500] Plaintiff subs at [1697].
[501] T 8818.28 (Giles).
[502] Reply Report, EXP.ROD.004.0005 at [249].
[503] Seqwater subs at [1993(j)] and [2140] to [2146].

220 The starting point is the passage from Dr Christensen's Reply Report relied on by Seqwater in which he acknowledged the sensitivity of the RTFM to variations in temporal patterns:[504]

> "It is not possible to use the same loss rates for rain on the ground runs as for the 4-day and 8-day forecast runs. This is because, as is explained in paragraphs 291-295 of Dr [David] Curtis' report, *the **RTFM** is extremely sensitive to the temporal distribution of rainfall*. As such, if the selected rainfall distribution pattern in the RTFM has rain falling throughout the forecast period, and the same loss rate is used as was applied to the rain on the ground run, a very large and unrealistic amount of runoff will be computed as lost. Consequently to achieve realistic results, a lower continuing loss rate is required to be used." (bold and italic emphasis added)

221 This passage is simply an explanation of the phenomenon discussed in Chapter 6[505] namely the problem with *the RTFM* of using loss rates calibrated to past incidents of spasmodic rainfall and applying these rates to its pre-defined future temporal pattern of continuous rainfall. In circumstances where there was no facility for Dr Christensen to use any distribution pattern of spasmodic rainfall then, in an endeavour to model realistic amounts of inflow volumes, he considered his loss rates and selected an "incidental" temporal distribution pattern in order to model a catchment response similar to the Late December Flood Event.

222 At this point, it is important to note that there are two types of temporal distribution being referred to. The first concerns the contrast between continuous rain on the one hand and rainfall in episodic bursts on the other. The second concerns the reference to whether the rain falls on the second, third or fourth day etc within a forecast period. Dr Christensen's forecast loss rates, selected with an "incidental temporal pattern" in mind, were designed to address the first of these problems, which as Chapter 6 shows was a particular problem with modelling future inflows using the RTFM.[506] Thus, in his Reply Report Dr Christensen stated that "[g]iven the RTFM's sensitivities to the temporal distribution of rainfall, I found it was necessary to adopt

[504] Reply Report, EXP.ROD.004.0005 at [249].
[505] Chapter 6 at [299] to [319].
[506] Chapter 6 at [299] to [319].

different continuing loss rates for my 4-day and 8-day case runs".[507] In his oral evidence, he referred to the problem of the RTFM rainfall distributions on dealing with hourly rainfall.[508]

223 With the second aspect of temporal distribution, namely the daily distribution of rainfall, in his Reply Report Dr Christensen stated that a "reasonably competent flood operations engineer would choose a pre-determined rainfall distribution pattern in the RTFM that would provide reasonable distribution of the rainfall considering the forecast daily rainfall pattern".[509] However, Dr Christensen agreed that "some of them [ie, the chosen patterns] didn't fit very well".[510] He ultimately stated that this aspect was "immaterial, because all you're doing is calculating a volume … you're not calculating when it's going to come in" and for volume "it didn't matter if it came in on day one, day two, day three or day four".[511] Two matters should be noted about that answer. First, it is consistent with Dr Nathan's uncertainty analysis set out above at [64] to [77]. The variation in temporal patterns is reflected in scenario F and that has little effect on either volumes or peak rates, although it has a large effect on the timing of the peak.[512] Mr Giles accepted that the use of pre-set temporal patterns will have "limited impact" on volumetric assessments.[513] Second, on Dr Christensen's approach, the uncertainty associated with this aspect of the timing of rainfall for forecasts longer than a day is addressed in his approach to releases[514] as well as his revisitation of forecast circumstances and flood operations at least once a day.

224 In its submissions, Seqwater referred to the evidence of Mr Malone whereby he described the interaction between continuing loss rates and temporal patterns of rainfall and concluded that the "temporal and spatial pattern of rainfall is an extremely important factor in determining whether any particular

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507 Reply Report, EXP.ROD.004.0005 at [263]; T 2218.6 - .18 (Christensen).
508 T 1524.30; T 1525.3.
509 Reply Report, EXP.ROD.004.0005 at [118]; T 2409.35.
510 T 2410.45; see also T 2717.6.
511 T 2412.40.
512 See [69] and [76].
513 T 8871.35.
514 T 2216.40 to T 2217.23.

forecast is likely to generate runoff".[515] Again, this is simply the first aspect of temporal uncertainty that was just addressed, being the same phenomenon discussed at the end of Chapter 6.[516] It is because of, and not in spite of that interaction, that Dr Christensen considers loss rates and temporal patterns together to model inflow volumes.

225 Seqwater also relied on a passage from Dr Nathan's Forecast Uncertainty Report as supportive of its criticism of Dr Christensen's approach to modelling temporal patterns.[517] That passage and an associated passage are as follows:[518]

> "Dr Christensen gives no account to the uncertainty in the losses and temporal distribution of rainfall, indeed he repeatedly makes it clear that he selected a temporal pattern and loss rate with the express intent of producing a runoff volume that was "at least consistent" with his estimate of runoff characteristics from December 2010 (Annexure D, Christensen, 2017); that is, rather than giving explicit – indeed any – regard to uncertainty in these factors, ***Dr Christensen makes the hydrologically indefensible assumption that the proportion of runoff for a forecast event should be identical to that of a prior event, and compounds this error by selecting a temporal pattern with the express intention of reproducing this hindsight*** (see Section 5.1)
>
> …
> Both Mr Kane and Dr Christensen fail to quantify or adequately consider the critical importance of the uncertainty in the spatial and temporal patterns of rainfalls on the formation of floods. A simple sensitivity analysis would clearly show the dominant impact of such influences, yet these either were not undertaken or were ignored. Dr Christensen's lack of appreciation of this is evident in his assumption (paras. 113, 114, 117, 118; Christensen, 2016) that the flood engineers had quick access to realistic patterns of rainfall; his assumption that such "pre-determined" patterns of rainfall could account for uncertainty in forecast rainfall is fundamentally inconsistent with the elementary observation that rainfall is highly variable in both space and time. This view is also inconsistent with his own statement that "the RTFM is extremely sensitive to the temporal distribution of rainfall" (para. 249; Christensen, 2016); *it is wholly illogical to observe that the* ***floods*** *are highly sensitive to this factor but then ignore the uncertainty in its determination. Of even greater inconsistency, are the statements repeatedly made by Dr Christensen in Annexure D of his July 2017 report that "the rainfall pattern selected was thus incidental because the loss rates were adjusted". The assumption that somehow temporal patterns are "incidental" and that losses can account for either the variability or uncertainty in rainfall demonstrates no*

515 Seqwater subs at [1244]; Malone, LAY.SEQ.007.0001 at [94]; SEQ.004.046.0291 at .0291.
516 Chapter 6 at [299] to [319].
517 Seqwater subs at [2144].
518 EXP.SEQ.014.0013 at [14(iii) and (vi)].

awareness of the dominant importance of the temporal patterns, or else contradicts his earlier statement concerning their "[extreme] sensitivity" (para 249; Christensen, 2016)." (bold and italic emphasis added)

226 The first of these passages criticises Dr Christensen for making the supposedly "hydrologically indefensible assumption" that the "proportion of runoff for a forecast event should be identical to that of a prior event". As the above explanation makes clear Dr Christensen did not assume it would be identical but instead started his analysis from the more limited position that, if 86% of the 85mm of rainfall that fell was converted into runoff during the Late December Flood Event, then the catchment would produce a similar result in early January 2011. He used that as a "reasonable comparison".[519] Dr Nathan's oral evidence set out at [170] to [171] is inconsistent with any suggestion that that approach was "hydrologically indefensible".

227 The second emphasised passage in this extract was relied on by Seqwater as demonstrating the difficulties with Dr Christensen's selection of his temporal pattern.[520] The reference in this passage to "paras 113, 114, 117, 118; Christensen, 2016" are references to passages in Dr Christensen's Reply Report in which he refers to the use of the RTFM's predetermined rainfall distribution patterns.[521] The reference to "para 249; Christensen, 2016" is to the passage from his Reply Report set out above at [220]. In that passage, Dr Christensen did not state that the "floods" are highly sensitive to the temporal distribution of rainfall. Instead, he stated that *the RTFM* was highly sensitive to the temporal distribution of rainfall, and that was because of its use of pre-set temporal patterns that assumed continuous rainfall. Otherwise, the balance of the passage misstates Dr Christensen's approach. He did not assume that loss rates could account for the uncertainty in rainfall depths. Instead, he determined that, in calculating forecast inflow volumes, he would adjust loss rates to account for the problems posed by the continuous rainfall patterns pre-set in the RTFM. To the extent that he made an assumption, it was that the daily distribution of rainfall depths did not affect total inflow volumes. Dr

[519] T 2218.35.
[520] Seqwater subs at [2144].
[521] Reply Report, EXP.ROD.004.0005 at [113] to [118].

Nathan's own uncertainty analysis and Mr Giles' evidence supports that assumption.

228 Seqwater also referred to an analysis of the temporal patterns used by Dr Christensen undertaken by Mr Malone.[522] Mr Malone was critical of how the distribution of rainfall across Dr Christensen's modelling of four-day and eight-day inflows compared to the PME forecasts. He concluded that:[523]

> "It seems extraordinary that a real time flood forecaster would not be vitally interested in *when* the heavy rainfall was likely to occur not only upstream of the dams but also downstream of the dams. The temporal pattern of the forecast rainfall informs the forecaster when the highest runoff may occur. Assuming that release decisions were to be made on the basis of forecast rainfall, the forecaster would not know the best time to make releases without this information. As referred to above, Dr Christensen's methodology (paragraph 234 of the Reply Report) suggests that the temporal distribution is important in setting the release rate when "lowering" the reservoirs. However, Dr Christensen's own approach to the selection of a temporal pattern in the RTFM means that, even assuming that releases were to be set on the basis of forecast rainfall, he could not obtain a reasonable representation of how the inflows were expected to arrive at the dam over time. The inconsistent application of the first four days of the forecast in the 4 day and 8-day forecasts means that the predicted peak inflow (and time at which it was estimated to occur) could vary by several days (e.g. Table 6-2 above)." (emphasis added)

229 The concern raised by this paragraph is with the timing of the peak inflow during a flood event. The short answer to the problem raised by this passage is that, as Mr Malone acknowledges, the object of Dr Christensen's modelling exercise is to ascertain a best estimate of the volume of the inflows rather than the timing of the peak. As Mr Malone's analysis, and more importantly Dr Nathan's analysis, demonstrates[524] the timing of the peak inflow is especially sensitive to the temporal distribution of rainfall yet the assessment of inflow volumes is not. One of the most uncertain aspects of the PME forecasts is their distribution of rainfall over subsequent days. Dr Christensen deals with uncertainty in relation to that aspect of the rainfall by his approach to releases and gate operations rather than having it effect his assessment of the volume of inflows. In the above passage, Mr Malone referred to paragraph 234 of Dr

[522] Seqwater subs at [2146]; SEQ.004.046.0291.
[523] SEQ.004.046.0291 at .0362.
[524] See above [62].

Christensen's Reply Report in which he referred to the importance of the distribution in time of rainfall over the target period to the setting of a release rate. However, it is clear from that description that such an assessment can be made on a review of the daily breakdowns of the PME forecasts, rather than building those distributions into the forecasting at the expense of relative accuracy in determining inflow volumes.

230 In its submissions, the State referred to an analysis by Mr Giles in his June 2016 report of the temporal patterns used by Dr Christensen in the modelling of four-day and eight-day inflows as set out in his February 2015 Report and his Supplemental Report.[525] In that report, Mr Giles noted that the "runoff estimated for a catchment is therefore highly dependent on the temporal pattern selected to represent the distribution of an adopted rainfall over time".[526] He commented on what he described as the "arbitrary" selection of temporal patterns by Dr Christensen for his modelling which he contended was not explained or sufficiently justified.[527] The State noted that the effect of using Dr Christensen's selected temporal patterns generated discrepancies in the timing of inflows between the four-day and eight-day forecasts.[528] However, this analysis was overtaken by many of the subsequent reports, especially those of Dr Christensen and Mr Giles himself. Dr Christensen's subsequent reports explained the basis for the selection of the temporal patterns, specifically for the purpose of calibration to the Late December Flood Event. Mr Giles' July 2018 report addressed in a more focused way how that process may or may not have opened up discrepancies between the modelling of the four-day and eight-day flow volumes (see [206]). Otherwise, the extent to which the volume, peak rate and timing of peak inflows is sensitive to alterations in temporal patterns has already been addressed.[529]

231 In the end result, a consideration of Dr Christensen's selected temporal patterns does not affect the conclusion noted in [208].

[525] State subs at [471] to [473].
[526] EXP.QLD.001.0611 at .0675.
[527] Ibid at .0677.
[528] State subs at [472].
[529] cf State subs at [473].

9.4: Revised Wivenhoe Dam Four-Day Inflow Volumes

232 It follows from the above that there are three available sets of figures for the inflow volumes based on four-day PME forecasts. The first is Dr Christensen's figures which use his rainfall depths ascertained from PME forecasts and loss rates calibrated to his understanding of the runoff volumes from the Late December Flood Event. It follows from the above that I consider the loss rates to be reasonable and the rainfall depths within but towards the higher end of a reasonable range based on the information available to a flood engineer during the January 2011 Flood Event.

233 The second set is Mr Giles' figures in which he adjusted his loss rates to account for what was contended to be correct runoff figures for the Late December Flood Event. As noted in his July 2018 report,[530] Mr Giles combined the forecast figures for Wivenhoe Dam and Somerset Dam and then provided a combined reduced runoff figure based on the application of the higher loss rates which did not include rain on the ground.[531] To arrive at the adjusted four-day inflow volume figures for Wivenhoe, the table set out below takes Dr Christensen's inflow volume calculation from the four-day PME forecast only for Wivenhoe Dam (ie, without rain on the ground inflows) and multiplies it by the ratio of the revised runoff conversion percentage that Mr Giles derived from the Late December Flood Event to the original runoff conversion percentage figure that Dr Christensen derived from the Late December Flood Event[532] and then adds Dr Christensen's estimate of rain on the ground inflows.[533] For example, Dr Christensen's four-day volume estimate for Wivenhoe Dam from midnight on 3 January 2011 was 335,536ML.[534] When combined with the Somerset Dam runoff figure, this represented a 79.4% proportion of runoff to rain.[535] Mr Giles recalculated that percentage based on what he stated was the corrected Late December Flood Event figures to be a proportion of 71.8%. To derive the revised Wivenhoe

[530] EXP.QLD.002.0040.
[531] Ibid at .0061 (Table 3-3).
[532] EXP.QLD.002.0040 at .0061 (Table 3-3).
[533] EXP.QLD.001.1359 at .1378 (Table 2-5, under the heading recorded rainfall only).
[534] MSC.010.061.0001, Input Data tab (H7).
[535] EXP.QLD.002.0040 at .0061 (Table 3-3); see [193].

figure, Dr Christensen's volume of 335,536ML was multiplied by 71.8/79.4 to yield a figure of 303,419ML. Dr Christensen's rain on the ground figure was 24,959ML (rounded to 25,00ML). When these figures were combined it yielded a revised figure of 328,378ML (rounded to 328,000ML). It follows from the above that I consider the loss rates utilised in this process, especially after the satisfaction of initial losses, to be at the lower end of any reasonable range, with Dr Christensen's rainfall depths used by Mr Giles tending on the high side of a reasonable range.

234 The third set of figures is derived from Mr Giles' use of his PME forecast rainfall depths to the loss rates used by the flood engineers during the flood event.[536] As I consider those loss rates to be far too high for modelling forecast inflows over that period, it follows that this set represents an unreasonably low estimate of inflow volumes.[537]

235 These figures are set out in the following table, which for ease of reference includes the respective rain on the ground calculations. (The potential materiality of those differences between rain on the ground inflow estimates is addressed below[538] and in Chapter 10.) The four-day estimates are meant to incorporate those figures.

Revised 4 day Inflow Volumes

Forecast Date/time	Christensen ROG inflow (ML)	Giles ROG inflow (ML)	Christensen (ML)[539]	Giles (adjusting to his corrected figures for LDE) (ML)	Giles (using Giles' rainfall depths and flood engineers' loss rates)[540] (ML)
2 Jan 00:00	30,000	20,000	33,000	30,000[541]	20,000
3 Jan 00:00	25,000	11,000	361,000	328,000[542]	175,000
4 Jan	29,000	6,000	517,000	501,000[543]	250,000

536 EXP.QLD.001.1359 at .1378.
537 See also [167].
538 See [284].
539 See EXP.QLD.001.1359 at .1378; these figures include rain on the ground inflows.
540 EXP.QLD.001.1359 at .1378.
541 Revised runoff conversion percentage is zero.
542 See [233].
543 =488,852 x (83.1/86/1) + 29,000; for figure of 488,852 see MSC.010.063.0001.

00:00					
5 Jan 00:00	14,000	4,000	364,000	329,585[544]	111,000
6 Jan 00:00	79,000	29,000	460,000	414,500[545]	138,000
7 Jan 00:00	155,000	124,000	608,000	547,000[546]	203,000
8 Jan 00:00	168,000	159,000	1,048,000	934,954[547]	468,000
9 Jan 00:00	79,000	75,000	886,000	782,000[548]	622,000
10 Jan 00:00	615,000	593,000	1,288,000	1,199,500[549]	988,000
11 Jan 00:00	343,000	328,000	683,000	639,840[550]	447,000
12 Jan 00:00		N/A	431,000	NA	N/A

Table 9-6: Range of 4-Day Volumetric Estimates

9.5: Rain on the Ground and 24-Hour Loss Rates

236 The loss rates adopted by Dr Christensen for modelling ROG and 24-hour inflows in the period 2 to 12 January 2011 are set out in Appendix D to this judgment. The supporting rationale for those rates is summarised in Chapter 8.[551] Without descending to identify which of the rates were accepted or disputed, the defendants were disparaging of his selected loss rates and his rationale for adopting them.[552] The defendants' criticisms of the rates adopted are best addressed having first addressed the evidence they adduced on this topic. In summary, I accept that Dr Christensen's rain on the ground loss rates were appropriate for modelling rain on the ground and 24-hour forecast inflows. To the extent that his rates differ from those adopted by the flood engineers, Dr Christensen's loss rates are to be preferred. However, the differences between them are immaterial to so much of Chapter 10 that addresses SIM C, SIM F and SIM H.

[544] =349,725 x (75.8/84.0) + 14,000; for figure of 349,725 see MSC.010.067.0001.
[545] =380,849 x (79.9/90.7) + 79,000; for figure of 380,849 see MSC.010.071.0001.
[546] =452,881 x (80.8/93.3) + 155,000; for figure of 452,881 see MSC.010.076.0001.
[547] =880,080 x (80.0/91.8) + 168,000; for figure of 880,080 see MSC.010.080.0001.
[548] =806,910 x (79.5/91.2) + 79,000; for figure of 806,910 see MSC.010.084.0001.
[549] =672,626 x (78.3/90.1) + 615,000; for figure of 672,626 see MSC.010.092.0001.
[550] =339,900 x (77.9/89.2) + 343,000; for figure of 339,900 see MSC.010.096.0001.
[551] Chapter 8 at [74] to [82].
[552] See below at [279] to [281].

Industry Standards

237 As noted, from 6 January 2011 the flood engineers adopted a continuing loss rate of 2.5mm/hr for each sub-catchment. This was a default rate adopted by the RTFM at the commencement of every flood event[553] based on a 1987 Engineers Australia publication which provided an assessment of a median rate for all of Eastern Queensland, namely, "Australian Rainfall and Runoff" ("ARR").[554] Each of Messrs Malone, Ayre, Tibaldi and Giles referred to that publication.[555] Seqwater noted that[556] each of Mr Malone, Mr Ayre, Mr Tibaldi, Dr Nathan and Mr Giles also referred to the Brisbane River and Pine River Flood Study, which documented the basis of the calibration of the RTFM.[557] However, that study makes no reference to a catchment-wide continuing loss rate of 2.5mm/hr[558] and Mr Ayre agreed that the 2.5mm/hr rate came from ARR.[559]

238 Seqwater noted[560] that Mr Malone and Mr Giles both referred to a study of the Queensland catchment areas undertaken in a PhD thesis by a Mr Mahbub Ilahee in 2005.[561] Seqwater submitted that "Mr Malone was familiar with the study's outcomes in January 2011, which he understood were that 2.5mm/hr was generally an appropriate continuing loss rate."[562] That is an accurate summary of Mr Malone's stated understanding but an inaccurate statement of Mr Ilahee's conclusions. His study of Queensland catchments concluded that the "[t]he average of the median CL value for eastern catchments is 39.2% less than [the ARR] recommended median continuing loss value" of

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553 T 7758.12 (Ayre).
554 SUN.316.001.0039 at .0045; T 7757.39 (Ayre).
555 LAY.SEQ.007.0001_2 at [513(d)(i)]; LAY.SUN.007.0001 at [32]; LAY.SEQ.004.0001_2 at [633(c)]; EXP.QLD.001.0611 at .0638; T 7499.13 - .21 (Ayre).
556 Seqwater subs at [2101].
557 LAY.SEQ.007.0001_2 at [513(d)(ii)]; LAY.SEQ.004.0001_2 at [633(b)]; LAY.SUN.001.0001 at [465] and [480]; EXP.SEQ.002.0116 at [57] and [101]; EXP.QLD.001.0611 at .0638-9 and 0643; T 7499.23 - .42.
558 SEQ.004.042.0502; The 1992 calibration of the runoff-routing model did see the adoption of a continuing loss rate of 2.5mm/hr for the Amberley-Worill Creek catchment with respect to the second flood event of April 1989 in order to match peak discharge with flood volumes for that event (at .0564). It is the only reference to a continuing loss rate of 2.5mm/hr in that document.
559 T 7758.6 (Ayre).
560 Seqwater subs at [2100].
561 LAY.SEQ.007.0001_2 at [513(d)(iii)]; EXP.QLD.001.0611 at .0638.
562 Seqwater submissions at [2100]; LAY.SEQ.007.0001_2 at [513(d)(iii)].

2.5mm/hr.[563] Mr Ilhaee also disputed ARR's assumption that the continuing loss rates are constant.[564] Mr Ilahee contended that they decreased as rainfall continued. Contrary to Mr Malone's understanding, Mr Ilahee's PhD thesis undermined the flood engineer's reliance on the default continuing loss rate of 2.5mm per hour.

239 Seqwater noted[565] that, in his affidavit, "Mr Malone also referred to Seqwater's calibration report for its new hydrology models, which superseded the RTFM".[566] This was a report completed after the January 2011 Flood Event which involved an assessment of a number of past flood events to calibrate a new Stanley River catchment flood model[567] and an Upper Brisbane River catchment flood model.[568] Seqwater noted that it suggested a typical continuing loss rate for the Stanley River catchment of 2.0mm/hr and for the January 2011 Flood Event of 1.3mm/hr,[569] which was higher than the Late December Flood Event.[570] For the Upper Brisbane River catchment, it referred to a typical continuing loss rate of 2.5mm/hr[571] and estimated a continuing loss rate for the January 2011 Flood Event of 2.2mm/hr.[572]

240 To the extent that any reliance is sought to be placed on these continuing loss rates, then I reject them. First, in his affidavit Mr Malone only referred to this post-event study for its determination of initial losses and not continuing losses as Seqwater's submissions sought to do.[573] Second, as noted, the report addressed a new hydrological model to replace the RTFM and recommended a completely new set of parameters of which initial and continuing losses were only one component,[574] and where all the components were interrelated.[575] While it is not clear, the model does not appear to have

[563] SEQ.004.037.0256 at .0422.
[564] Ibid at .0423.
[565] Seqwater subs at [2102].
[566] LAY.SEQ.007.0001_2 at [513(e)]; SEQ.009.003.0359.
[567] SEQ.009.003.0359 at .0473.
[568] Ibid at .0499.
[569] Ibid at .0479.
[570] Ibid at .0477.
[571] SEQ.009.003.0359 at .0507.
[572] Ibid at .0504.
[573] LAY.SEQ.007.0001_2 at [513(e)].
[574] SEQ.009.003.0359 at .0480.
[575] See for example, SEQ.004.037.0256 at .0420.

a separate sub-catchment that corresponds to Middle Brisbane. Third, as discussed below, Dr Nathan's post-event analysis demonstrated the reasonableness of Dr Christensen's rain on the ground and continuing loss rates. Overall, I am not satisfied that this calibration report's continuing loss rates can be directly compared to the RTFM loss rates used by the flood engineers or Dr Christensen as contended by Seqwater.

Dr Nathan

241 Dr Nathan produced a report entitled "Derivation of Inflows for January 2011 event".[576] This report documents the process undertaken by Dr Nathan of calibrating loss rates through six-hourly time intervals for the January 2011 Flood Event by reference to observed flows at upstream and downstream gauges and the storage levels at both Somerset and Wivenhoe Dams. He produced a series of initial and continuing loss rates for each time interval.[577] These rates generally exceeded those used by Dr Christensen for the upstream catchments for the period up to 8 January 2011 and, in some respects, exceeded those used by the flood engineers.[578] Dr Nathan noted that the derived "loss values are generally an order of magnitude higher than those derived by [Dr Christensen]".[579]

242 It emerged in cross-examination that Dr Nathan had undertaken a very different analysis to that undertaken by Dr Christensen such that I am satisfied that Dr Nathan's approach is one that would not be applied by a reasonably competent flood engineer conducting flood operations. Dr Nathan agreed that the purpose of his modelling was to achieve the "best calibration [of the inflow data] you can up to time 'now' without thinking about how your parameters might be performing for a forward-looking perspective".[580] In contrast, Dr Nathan also agreed that a "flood engineer who is undertaking

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576 EXP.SEQ.002.0116.

577 Ibid at .0223; the initial and continuing loss rates for Brisbane River at Gregors Creek were applied to all upstream sub catchments; the loss rates for Stanley River at Woodford were applied to the SDI catchment; the loss rates for Wivenhoe Dam were applied to the WDI catchment: EXP.SEQ.002.0227, input tab C_CL.

578 Eg, the continuing loss rate of 3.2mm/hr for the Upper Brisbane sub-catchments for the period from 9.00pm on 6 January 2011 to 9.00pm on 7 January 2011: EXP.SEQ.002.0227, input tab C_CL.

579 EXP.SEQ.002.0016 at [S7].

580 T 3872.40.

modelling for the purposes of operating a dam is not interested in modelling past behaviour of the catchment, except insofar as that is necessary to calibrate loss rates to see what's going to happen in the future".[581] Dr Nathan agreed that, if he was undertaking the latter for of modelling, he would be "considering other things"[582] and, at least so far as the gauge at Gregors Creek was concerned, he would have selected different loss rates.[583]

243 The difference between the two approaches is best illustrated by reference to two examples which are of particular relevance to an assessment of Dr Christensen's rain on the ground loss rates.

Gregors Creek Gauge

244 The first concerns Dr Nathan's calibration of loss rates at the Gregors Creek gauge. Dr Nathan used that gauge as the point from which he calibrated loss rates for all of the Upper Brisbane sub-catchments and then applied those loss rates to all sub-catchments above that point.[584] All of the outflows from those sub-catchments (that is, Linville (LIN), Cooyar (COO) and Emu Creek (EMU)) flow through the Gregors Creek gauge.[585]

245 Dr Nathan's hydrograph used for calibrating at Gregors Creek at 9.00pm on 6 January 2011 is as follows:[586]

[581] T 3854.38.
[582] T 3872.47.
[583] T 3859.12.
[584] T 3849.4 (Nathan).
[585] EXP.SEQ.002.0116 at .0135; LAY.SUN.007.0001 at [27] (Ayre).
[586] MSC.010.220.0001 at .0014.

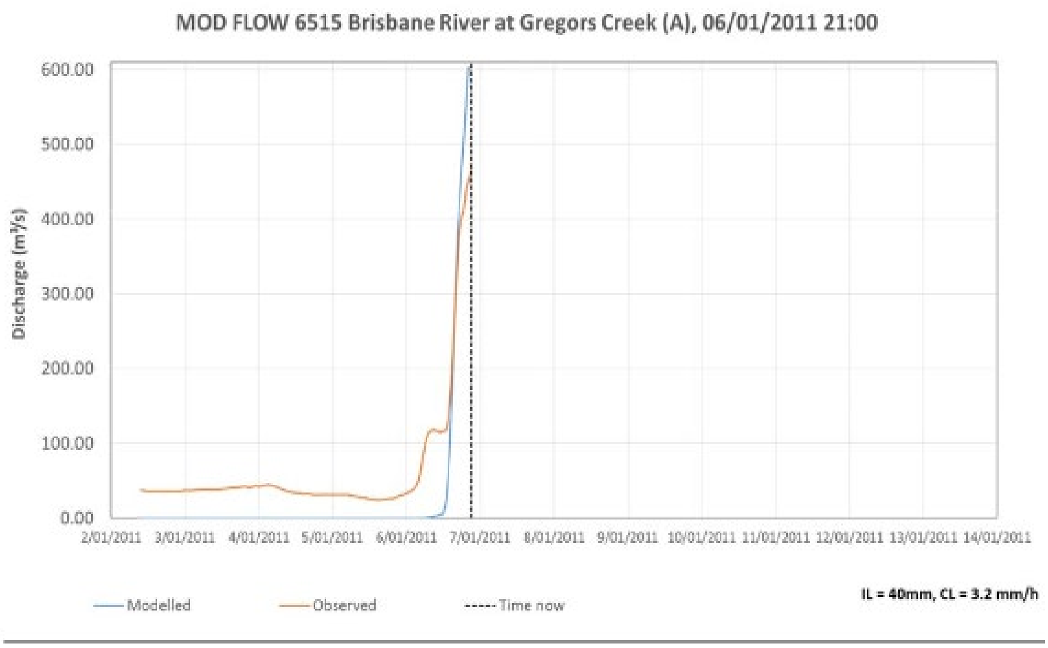

Figure 9-2: Gregors Creek Hydrograph as at 6 January 2011

246 The blue line represents the modelled inflow rate using the rates adopted by Dr Nathan, namely an initial loss of 40mm and a continuing loss of 3.2mm per hour. The red line represents the observed flow. The vertical dotted line represents "time now", ie the point at which the calibration exercise is being undertaken. The adoption of those rates resulted in a reasonable correlation of the two discharge rates in the immediate period just prior to time "now".[587] As noted, Dr Nathan applied the loss rates calibrated to this gauge to the upstream sub-catchments, that is, he did not calibrate the loss rates to the particular upstream catchment hydrographs.[588] A review of the screenshots for an RTFM run that used his loss rates reveals that the applied loss rates calibrated poorly to the gauges for LIN, COO and EMU.[589] Dr Nathan accepted that his approach "sacrifice[d]" the "calibration of an upstream location" to achieve an accurate calibration at Gregors Creeks and ultimately an accurate calibration of inflows into Wivenhoe Dam.[590] He accepted that this approach would lead to "significantly underpredicting flow at Gregors Creek" by "the time [upstream flows] get to [the gauge]"[591] but stated that this

[587] T 3848.27.
[588] T 3850.12.
[589] MSC.010.226.001 at .0002 to .0004; T 3853.16.
[590] T 3853.20.
[591] T 3853.37.

fit would be consistently evaluated on a reassessment of the parameters at later times.[592] Dr Nathan agreed that he was not "worried about whether what you were doing was likely to give you a good idea of what Gregors Creek would be doing in eight hours' time" but was instead "only interested in what Gregors Creek was doing at time now".[593] By contrast, a flood engineer undertaking rain on the ground (and forecast) modelling is (more) interested in determining the flows in eight hours' time rather than at "time now". Such an engineer would be inclined to lower the loss rates so as to obtain a better calibration upstream to facilitate a better assessment of downstream flows in the future. At this time, Dr Christensen applied a loss rate of 0.5mm/hr for GRE and the catchments upstream of Gregors Creek.[594]

247 Dr Christensen was cross-examined on a screenshot of an RTFM run for midnight on 7 January 2011 that showed the calibration of his loss rates for Gregors Creek (as set out in one of Mr Ickert's reports[595]) as follows:

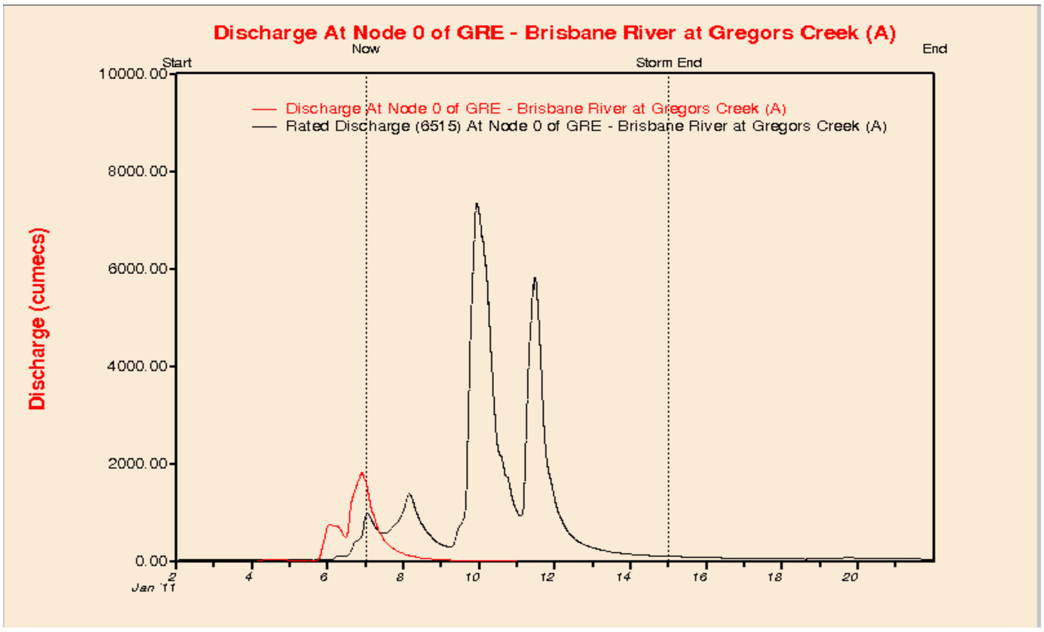

Figure 9-3: RTFM Screenshot of Gregors Creel Hydrograph as at 7 January 2011

248 The red line represents the modelled discharge rate using Dr Christensen's loss rates. Both Seqwater and SunWater submitted that, as the red line is

592 T 3853.43.
593 T 3857.31.
594 Reply Report, EXP.ROD.004.005 at .0077.
595 EXP.SUN.009.0001 at .0028.

above the black line at time "now", this table demonstrates that his loss rates were "performing poorly" in the sense of overestimating the gauged flow at Gregors Creek.[596] When shown this, Dr Christensen explained that "what you are doing is projecting the red line forward" because "you're not estimating anything from the past"[597] and that the "Gregors Creek hydrograph would not calibrate well" with rainfall occurring at that time as "that's not picked up well with the gauge".[598] In re-examination, Dr Christensen explained that there was little rain in the early part of the January 2011 Flood Event and otherwise there was "apparently some rainfall and some runoff that wasn't adequately represented in the gauges".[599] These answers reflect the difference in the objective of Dr Christensen's modelling and Dr Nathan's modelling and also reflect the proposition accepted by Dr Nathan about calibrating at Gregors Creek compared to upstream catchments in an endeavour to obtain accurate estimates of future inflows.

249 The RTFM screenshots for runs based on Dr Nathan's rates applied throughout 7 January 2011 show that his rates were underestimating Gregors Creek and upstream catchment flows.[600] Dr Nathan recalibrated the Gregors Creek continuing loss rate (and the rates for CRE, COO, LIN and EMU) from 3.2mm/hr to 0.5mm/hr in the 3.00am run on 8 January 2011.[601] Those rates were either equal to or less than the rates that Dr Christensen adopted for those sub-catchments, although he began applying them from 2 January 2011.[602] Dr Nathan agreed that if he had adopted a "forward-looking aspect" to the calibration approach then that would be a "good reason" why they would have recalibrated to 0.5mm/hr at 9.00pm on 7 January 2011.[603] I note that this calibration would be three hours in advance of the commencement of SIMs F, H and J.

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[596] Seqwater subs at [2092]; SunWater subs at [1024].
[597] T 2288.28.
[598] T 2288.37.
[599] T 2809.16.
[600] MSC.010.237.0001.
[601] EXP.SEQ.002.0227, C_CL tab.
[602] 0.8mm/hr for CRE and 0.5mm/hr for the remainder: Reply Report, EXP.ROD.004.0005 at .0076 to .0077.
[603] T 3884.2.

Baseflow for WDI and SDI

250 The second matter concerns the method by which Dr Nathan determined loss rates for SDI and WDI. In his reports, Dr Nathan adopted a continuing loss rate of 1.5mm/hr for both SDI and WDI throughout the January 2011 Flood Event. He adopted an initial loss rate of 10mm for each of them from the beginning of the event, reduced that rate to zero for both on the morning of 9 January 2011, and finally increased the WDI initial loss rate alone to 15mm at 3.00pm on 10 January 2011 before reducing it back to 0mm (to join SDI) until the conclusion of the event.[604] In respect of Somerset Dam, the only gauged flow into SDI was at Stanley Creek.[605] Dr Nathan's selected continuing loss rate of 1.5mm/hr produced a poor calibration to that gauge which continuously underestimated the flow volume.[606] Dr Nathan stated that the difficulties of calibrating to the flow rates at that gauge led to him to calibrate volumes to the storage levels of Somerset Dam instead.[607]

251 Once a calibration is undertaken against storage levels in a dam, this requires an assumption (or determination) of a level of baseflow which in turn affects the adopted continuing loss rate. Dr Nathan assumed a constant baseflow across the entire modelling period for each model run.[608] If his baseflow assumption was changed it was then retrospectively applied from 2 January 2011 and prospectively applied from the point of alteration. In contrast, the flood engineers and Dr Christensen used a variable baseflow metric that was added in using an algorithm contained in the gate operations spreadsheet.[609] This difference in baseflow significantly affected the resulting selection of Dr Nathan's loss rates compared to Dr Christensen's loss rates.

252 Dr Nathan's approach to calibrating to inflow volumes and adjusting baseflow is illustrated by comparing the following hydrographs for the height of

[604] EXP.SEQ.002.0227, tab C_IL.
[605] T 3888.44 (Nathan).
[606] T 3889.8 to .37; see MSC.010.221.0001 at .0003, .0005, .0011 and .0015; MSC.010.222.0001 at .0003, .0007, .0011, .0015; MSC.010.223.0001 at .00037 and .0012.
[607] T 3889.27.
[608] T 3794.27.
[609] T 3794.30.

Somerset Dam at 3.00am on 7 January 2011[610] and then at 3.00am on 8 January 2011:[611]

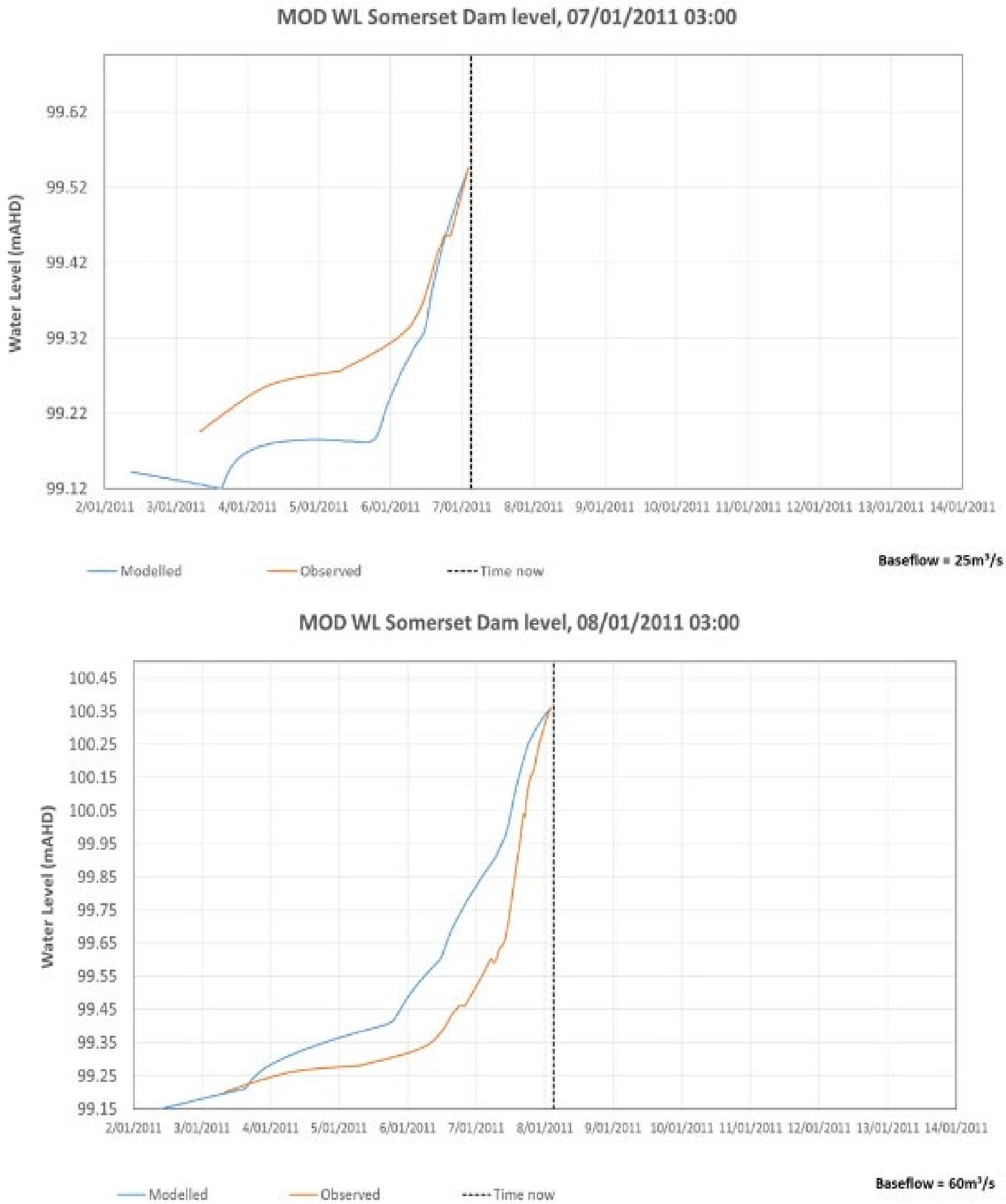

Figure 9-4: RTFM Screenshots of Somerset Dam Water Levels as at 3.00am on 7 January 2011 and as at 3.00am on 8 January 2011

253 Both hydrographs use a continuing loss rate for SDI of 1.5mm/hr and an initial loss rate of 10mm. The first uses an assumption of continuous baseflow of 25m^3/s and the second uses an assumption of continuous baseflow of 60m^3/s.

[610] MSC.010.221.0001 at .0004.
[611] MSC.010.222.0001 at .0004.

The change in the baseflow assumption caused the modelled flows (ie, the blue line) to be adjusted upwards in the later hydrograph.[612] Both hydrographs result in the modelled *height* of Somerset Dam at time "now" being close to the actual height and, to that extent, calibrate well. If the baseflow adjustment to 60m^3/s had not been made in the second hydrograph, then the blue line would be substantially below the actual height of the dam. The making of that adjustment was consistent with Dr Nathan's modelling objective of calibrating to time "now".[613] However, that adjustment is not necessarily apposite to a flood engineer seeking to determine the appropriate rates for the purpose of modelling rain on the ground inflows (and QPF forecast inflows) after time "now".[614] In the second hydrograph, it can be seen that at time "now" the *rate* of actual inflows exceeds the rate of modelled inflows (ie, the slope of the red line is steeper than the slope of the blue line). A flood engineer calibrating loss rates for the purpose of rain on the ground modelling of future inflows would be seeking to model loss *rates* to the current rate of inflows in preference to calibrating to current *volumes*.

254 To the same effect, the remainder of Dr Nathan's modelling of inflows to Somerset Dam on 8 to 10 January 2011 involve increases in the assumed baseflow rate and reductions in the initial loss values in an endeavour to calibrate to Somerset Dam levels at time "Now". The overall effect is that his modelled inflow rates in the early part of the January 2011 Flood Event overestimated actual inflows but underestimated them in the latter part of the event, even with a reduction in the continuing loss rate from 1.5mm/hr to 0.7mm/hr at 9.00pm on 9 January 2011.[615] Having regard to the calibration of flows at the Stanley River gauge, Dr Nathan agreed that on 10 January 2011 the selected loss rate of 0.7mm/hr is "too high".[616] The rate used by Dr Christensen was 0.5mm per hour.

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612 T 3891.31; T 3892.6 (Nathan).
613 T 3893.7.
614 T 3893.17 - .25; T 3895.13; T 3896.11; T 3899.26.
615 T 3906.12; T 3907.45; EXP.SEQ.002.0227, tab "C_CL"; T 3892.10; T 3894.31; MSC.010.223.0001 at .0016; MSC.010.223.0001 at .0016; T 3896.21.
616 T 3903.22.

255 As stated, unlike both the flood engineers and Dr Christensen, Dr Nathan used a constant baseflow assumption throughout his modelling.[617] I am satisfied that, if that assumption was not applied to the above hydrographs and the objective of the exercise was to determine rates designed to provide a reliable estimate of inflows after time "now", then the appropriate response would be to lower the continuing loss rate so as to achieve a closer match between the rate of actual inflows into the dam and the rate of modelled inflows rather than the storage level. Dr Christensen's continuing loss rate for SDI (0.5mm/hr) was lower than that determined by Dr Nathan (1.5mm/hr) for that period.

256 In a different report, Dr Nathan noted that, considered in hindsight, Dr Christensen's loss rates and baseflow assumption lead to an *underestimate* of inflows into Somerset Dam and his, ie Dr Nathan's, loss rates and baseflow assumption produced a closer match to observed inflow volumes.[618] Given that Dr Nathan's loss rates generally exceeded Dr Christensen's, it follows that the difference is attributable to the approach to modelling baseflow. Dr Nathan conceded that, given Dr Christensen's baseflow assumption, his loss rates were "certainly not … too low" ("that's fair, yes").[619]

257 There is no gauge for the Middle Brisbane catchment (ie, WDI) so Dr Nathan's calibration with respect to this catchment was undertaken by reference to inflows into Wivenhoe Dam. From 7 January 2011 to 10 January 2011, Dr Nathan steadily increased his baseflow assumption: from 60m^3/s at 3.00pm on 7 January 2011,[620] to 65m^3/s the next day,[621] to 100m^3/s at 3.00pm on 10 January 2011[622] and finally to 135m^3/s on 9.00pm on 10 January 2011.[623] Dr Nathan observed that Dr Christensen's selected combination of loss rates and baseflow "in the Wivenhoe catchment are

[617] T 3917.2.
[618] EXP.SEQ.014.0013 at .0076, [154].
[619] T 3919.24.
[620] MSC.010.221.0001 at .0012.
[621] MSC.010.222.0001 at .0012.
[622] MSC.010.227.0001 at .0012.
[623] Ibid at .0016.

reasonable".[624] Given that Dr Nathan's final adopted continuing loss rates are generally higher than Dr Christensen's loss rates but both produce reasonably accurate inflow estimates,[625] this again suggests that the difference in modelling is attributable to the approach to baseflow.

2 to 5 January 2011 Loss Rates

258 Dr Nathan's conclusions noted in [256] concern a hindsight consideration of Dr Christensen's loss rates. It remains to be considered what Dr Nathan's calibrated loss rates at each time interval say about Dr Christensen's loss rates considered prospectively. In respect of the period from 2 to 5 January 2011, Dr Nathan initially conceded that there was insufficient rainfall and flow to justify his chosen loss rates and baseflow rates as he lacked the necessary amount of data to calibrate to.[626] To an extent, he subsequently resiled from those concessions and instead asserted they might have "some defensibility"[627] or were "weakly defensible"[628]. Having heard Dr Nathan's evidence and considered the material that he was shown, I consider that his initial concessions were well founded.

9.00pm 6 January 2011 Loss Rates

259 As submitted by the plaintiff,[629] after 5 January 2011 the closest comparison to Dr Christensen's midnight RTFM runs was Dr Nathan's 9.00pm runs from 6 January 2011 onwards and concerning the Wivenhoe catchment. For the reasons explained above, his adopted continuing loss rate of 3.2mm/hr calibrated well to time "now" but calibrated poorly to upstream catchments, meaning his modelling would underestimate future flows at Gregors Creek.[630]

260 Seqwater submitted that Dr Nathan's calibrated hydrograph for Gregors Creek at 3.00am on 7 January 2011, ie, six hours after the 9.00pm 6 January 2011

[624] EXP.SEQ.014.0013 at .0076, [154].
[625] EXP.SEQ.014.0013 at .0075 (Figure 6.3).
[626] T 3799.41, T 3803.36, T 3804.19, T 3804.35, T 3807.3, T 3814.9, T 3814.31, T 3818.41, T 3821.17, T 3822.37, T 3824.40, T 3825.8; see also Plaintiff subs at [1629].
[627] T 3830.34; T 3831.3.
[628] Eg T 3827.23; T 3828.6; T 3843.13.
[629] Plaintiff subs at [1629].
[630] T 3857.14; T 3857.23.

run, still produced a modelled flow within 50m^3/s of the observed flow.[631] It also cited Dr Nathan's evidence in re-examination when he pointed to the fact that he did not adjust his calibrated rates until much later as suggestive of the fact that "we wouldn't have changed [loss rates] had we given more attention to upstream gauges".[632] I do not agree. As at 9.00pm on 6 January 2011, using an initial loss of 40mm and a continuing loss of 3.2mm/hr, Dr Nathan's modelled flows at Gregors Creek was 150m^3/s *in excess of* the observed flows.[633] At 3.00am on 7 January 2011, using a reduced initial loss rate of 35mm and the same continuing loss rate of 3.2mm/hr, Dr Nathan modelled a flow rate that was approximately 120m^3/s *below* the observed flows.[634] By 9.00am on the same day, the modelled flow was just under 200m^3/s *below* the observed flow.[635] Otherwise, after observing Dr Nathan's evidence in person, I give little weight to his evidence on this topic after he made the initial concession noted above (at [258]).

261 In relation to the Somerset catchment, Dr Nathan agreed that there was "very weak" support for his modelled flow at 9.00pm on 6 January 2011 at the Stanley River gauge.[636]

9.00pm 7 January 2011 Loss Rates

262 In relation to Gregors Creek and other sub-catchment upstream loss rates, this issue has been addressed above. Dr Nathan agreed that if he was calibrating continuing loss rates for the purpose of modelling rain on the ground inflows after time "now" then he would have adopted rates of 0.5mm/hr.[637] They accord with or are less than Dr Christensen's adopted rates for those sub-catchments at that time.[638] Dr Nathan's rates for SDI and WDI on 7 (and 6) January 2011 were 1.5mm/hr, which was greater than Dr Christensen's adopted rate but less than the flood engineers'. However,

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631 Seqwater subs at [2093(b)]; MSC.010.221.0001 at .0002.
632 T 4662.23; Seqwater subs at [2095].
633 MSC.010.220.0001 at .0014.
634 Ibid at .0002.
635 Ibid at .0006.
636 T 3864.33; MSC.010.220.0001 at .0015.
637 T 3882.21 - .36.
638 Dr Christensen adopted 0.8mm/hr for CRE and 0.5mm/hr for all other upstream sub-catchments (see above at [247]).

these rates were affected by his baseflow assumption. At least so far as SDI is concerned, Dr Nathan increased the baseflow assumption from 25m^3/s to 45m^3/s from the 3.00pm to the 9.00pm calibration on 7 January 2011.[639] Dr Nathan agreed that instead of increasing baseflow he could have reduced the continuing loss rate.[640]

9.00pm 8 January 2011 and 9.00pm 9 January 2011

263 As noted above, for these periods Dr Nathan's calibrated continuing loss rates in the Upper Brisbane sub-catchments were less than or equal to the rates applied by Dr Christensen. As noted above, with SDI the rate was calibrated against Somerset Dam levels and the rate of modelled inflows for both runs was lower than the observed rate at time "now", with this addressed by adjusting initial loss rates and baseflow rates.[641] Dr Nathan agreed that his Somerset continuing loss rate was a "fraction too high" at 9.00pm.[642]

9.00pm 10 January 2011

264 Dr Nathan adopted increased continuing loss rates for the upper Brisbane sub-catchments in the 3.00am 10 January 2011 run (0.5mm/hr increased to 1.2mm/hr) but reduced the WDI sub-catchment rates from 1.5mm/hr to 0.5mm/hr and increased his baseflow assumption as the day progressed.[643] Dr Nathan accepted these changes were interrelated and that they were both made in an endeavour to produce a better calibration to time "now".[644] All this illustrates is that these rates cannot be used to undermine Dr Christensen's rates for that day. There is no prospect whatsoever, in light of the actual rainfall experienced to that time, that continuing loss rates in the Upper Brisbane catchments increased on 10 January 2011.

265 Across the Somerset catchment, Dr Nathan adopted a continuing loss rate of 0.7mm/hr from 3.00am on 10 January 2011, a figure which was only slightly

[639] MSC.010.221.0001 at .0012 and .0016.
[640] T 3887.19.
[641] MSC.010.222.0001 at .0016; MSC.010.223.0001 at .0016.
[642] T 3897.33.
[643] EXP.SEQ.002.0227; MSC.010.227.0001 at .0008.
[644] T 3901.10; T 3901.42.

higher than Dr Christensen's rate of 0.5mm/hr. As noted, Dr Nathan accepted the rate of 0.7mm/hr was "too high" and he was only able to calibrate it by increasing baseflow.[645] He also accepted his modelling necessarily over-estimated flows early but then underestimated the rate of inflow in the day and half prior to time "now".[646]

9.00pm 11 January 2011

266 In the 3.00pm 11 January 2011 run, Dr Nathan reversed the changes made to the continuing loss rates for the WDI sub-catchments on 11 January 2011.[647] I repeat the observation made at the end of [264]. This loss rate was then decreased to 0.9mm/hr from 1.5mm/hr for the 9.00pm run.

267 Dr Nathan maintained the rate 0.7mm/hr for SDI throughout 11 January 2011. He agreed that his modelling had missed the peak at the Stanley River gauge[648] and that his means of calibrating to it at Somerset Dam was by increasing the baseflow assumption[649] from $100m^3/s$[650] to $125m^3/s$.[651]

Conclusion in Respect of Dr Nathan's Evidence on Loss Rates

268 Four matters follow from Dr Nathan's evidence. First, considered with hindsight, Dr Nathan's analysis suggests that Dr Christensen's rain on the ground continuing loss rates for the Wivenhoe catchments were reasonable and for the Somerset catchment were marginally too high.

269 Second, Dr Nathan's adopted continuing loss rates for each time period up to 9.00pm on 5 January 2011 were devoid of information against which they could be calibrated. They neither support nor undermine Dr Christensen's initial and continuing loss rates for that period. The same observation applies in relation to the loss rates for the Somerset catchment on 6 January 2011.

[645] T 3909.15; MSC.010.227.0001 at .0008, .0016.
[646] T 3911.14.
[647] EXP.SEQ.002.0227, tab "C_CL".
[648] MSC.010.228.0001 at .0015.
[649] T 3911.44 to T 3912.14.
[650] MSC.010.228.0001 at .0004.
[651] Ibid at .0016.

Similarly, given the objective of Dr Nathan's modelling and that he only calibrated to the Gregors Creek gauge, his loss rates for GRE, LIN, COO and EMU on 6 and 7 January 2011 neither support nor undermine Dr Christensen's loss rates for those sub-catchments for those days

270 Third, Dr Nathan's continuing loss rates for all Wivenhoe upstream sub-catchments for the period from 3.00am on 8 January 2011 to 9.00pm on 9 January 2011 strongly support Dr Christensen's loss rates for those sub-catchments in that period (and throughout 10 and 11 January 2011).

271 Fourth, Dr Nathan's continuing loss rate for WDI and SDI of 1.5mm/hr (which he adopted until 3.00am on 10 January 2011) for the period from around 6 to 7 January 2011 provides significant support for Dr Christensen's (lower) continuing loss rates for WDI and SDI from 7 January 2011. Dr Nathan's rate was less than the flood engineers' rate for WDI and SDI until 8 January 2011 and his calibration was undertaken from a different perspective with a different baseflow assumption.

Mr Ickert

272 Mr Ickert addressed Dr Christensen's rain on the ground and 24-hour loss rates in his first report.[652] He did not determine his own loss rates. In his report he disagreed with Dr Christensen's assumption that there was no initial loss for the period 2 to 4 January 2011 for two reasons. First he noted that:[653]

> "… according to Rob Ayre's Affidavit, paragraph 504, the Antecedent Precipitation Index (API) went from 132.8 mm on 28 December 2010 to 71.3 mm on 05 January 2011 and the initial loss estimates went from 4.2 mm to 31.2 mm during this period. This would indicate that the basin did dry out over this period and Dr. Christensen's assumption of an initial loss of 0 mm from 02 January to 04 January was not accurate. Actual rainfall depths shown in Table 2 show the limited rainfall that actually fell from late December through the first few days of January 2011 which would support this drying trend"

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[652] EXP.SUN.008.0001_OBJ at [32] to [44].
[653] Ibid at [34].

273 Second, he noted Dr Christensen's observation in his own Response Report, "that there had been some drying out of the catchment in the 4 days prior to January 5".[654]

274 Mr Ickert was cross-examined on the Antecedent Precipitation Index ("API") spreadsheet.[655] This spreadsheet constitutes a chart mapping the daily level of precipitation across the Wivenhoe Dam catchments and a corresponding level of initial losses.[656] Generally, as the daily rainfall depths increase the corresponding initial loss rate lowers. For each day from 2 January 2011 to 7 January 2011, the initial loss rate specified in the API spreadsheet was 23.5mm, 27.2mm, 27.7mm, 31.2mm, 23.4mm and 11.4mm respectively. However, Mr Ickert explained that the satisfaction of that rate depends on when the modelling period commenced.[657] For example, if the modelling was undertaken on 5 January 2011, but with a modelling period that started prior to then, the initial losses could be satisfied by rain that fell prior to that time.[658] He stated that whether or not that was so would depend on whether there was reasonable calibration or justification for adopting initial loss rates of 0mm.[659] Mr Ickert was taken to the last RTFM run conducted by the flood engineers prior to the conclusion of flood operations for the Late December Flood Event undertaken at 6.00pm on 1 January 2011.[660] By reference to a comparison of the flood engineers' predictions of rain on the ground inflows for 2 to 4 January 2011 with Dr Christensen's modelling of no rain inflows in that period and allowing for a small amount of rain in the catchment, Mr Ickert accepted that Dr Christensen's modelling appeared reasonable.[661] He agreed that the setting of an initial loss rate above 6mm would not accord with the observed inflows from the minimal rain that was received.[662] In effect, Dr Christensen was not assuming that there was no initial loss, just that any

[654] EXP.SUN.008.0001_OBJ at [35].
[655] SUN.016.001.0273.
[656] Ibid, tab "Chart 1".
[657] T 8192.34.
[658] T 8192.43 to T 8193.7.
[659] T 8193.11; T 8194.10.
[660] QLD.001.001.1955; T 8194.16.
[661] T 8196.46.
[662] T 8197.24.

initial loss was satisfied prior to the time he undertook his modelling.[663] As noted, for 5 and 6 January 2011, Dr Christensen used the same initial loss values as the flood engineers used from 6 January 2011.

275 In relation to Dr Christensen's continuing loss rates, Mr Ickert stated that he had no criticism of Dr Christensen's rain on the ground loss rates used after 8 January 2011.[664] However, he was critical of the lack of calibration, arguing that it should have been used to justify the application of the loss rates adopted by the flood engineers and Dr Christensen from 8 January 2011 to the period prior to then (ie, 2 to 8 January 2011) and to justify the different loss rates applied for WDI and CRE from 8 January 2011 onwards.[665] He agreed that it was not possible to calibrate to individual gauges but stated that calibration could be done to dam levels.[666] However, he had not reviewed Dr Nathan's calibration to dam levels,[667] which supports Dr Christensen's adopted continuing loss rates. He agreed that, in circumstances where it was difficult to calibrate loss rates, it was a "more reasonable approach" to take the Late December Flood Event loss rates and modify them to account for any change in catchment conditions rather than using a default rate for (Eastern) Queensland as the flood engineers did.[668]

Mr Giles

276 In his third report, Mr Giles stated that he considered that "the initial loss and continuing loss values derived by the Flood Engineers are reasonable with respect to the consideration of catchment runoff from recorded rainfall."[669] He did not accept the lower initial loss rates "adopted by Dr Christensen until 7 January [2011]" could be justified. He stated that he derived his initial loss and continuing loss values for the period prior to 6 January 2011 using the API spreadsheets maintained by the Flood Engineers for Wivenhoe Dam[670]

[663] T 8201.18.
[664] T 8204.18.
[665] EXP.SUN.008.0001_OBJ at [42] to [44].
[666] T 8205.46.
[667] T 8206.13.
[668] T 8209.33 to T 8210.7.
[669] EXP.QLD.001.1359 at .1372.
[670] SUN.016.001.0273.

and Somerset Dam.[671] The loss rates he derived compare to Dr Christensen were as follows:[672]

Initial Loss Values

	Jan 2-Jan 4		Jan-05		Jan-06		Jan-07		Jan-08		Jan 9-Jan 10		Jan 11-	
	My Val.	Dr Chr	My Val.	Dr Chr	My Val.	Dr Chr	My Val.	Dr Chr	My Val.	Dr Chr	My Val.	Dr Chr	My Val.	Dr Chr
Upper Brisbane														
COO	15	0	15	10	30	10	30	10	30	30	30	30	30	30
LIN	25	0	25	10	30	10	30	15	30	30	30	30	30	30
EMU	10	0	10	10	30	10	30	30	30	30	30	30	30	30
GRE	10	0	10	10	40	10	40	10	40	40	40	40	40	40
CRE	10	0	10	10	10	10	10	10	10	10	10	10	10	10
Middle Brisbane River														
WDI	10	0	10	10	0	10	0	0	0	0	0	0	0	0
Somerset Dam														
SDI	10	0	10	10	15	10	15	0	15	15	15	15	15	15

Continuing Loss Rates- Recorded Rainfall

	Jan 2-Jan 5		Jan 6-Jan8		Jan 9-Jan 10		Jan 11-	
	My Val.	Dr Chr	My Val.	Dr Chr	My Val.	Dr Chr	My Val.	Dr Chr
Upper Brisbane								
COO	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
LIN	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
EMU	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
GRE	1.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
CRE	0.8	0.8	2.5	0.8	2.5	0.8	2.5	0.8
Middle Brisbane River								
WDI	0.75	0.8	2.5	0.8	2.5	0.8	2.5	0.8
Somerset Dam								
SDI	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table 9-7: Mr Giles' Initial and Continuing Rain on the Ground Loss Rates

277 In relation to initial losses, it can be seen that the principal difference between Mr Giles and Dr Christensen concerns the period 2 to 4 January 2011. The different rates applicable from around 6 January 2011 would matter little to estimating future inflows as they would have already been satisfied. In relation to 2 January 2011, Mr Giles accepted that initial losses were all satisfied in

[671] SUN.016.001.0272.
[672] EXP.QLD.001.1359 at .1373 to .1374.

the RTFM run undertaken at 6.00pm on 1 January 2011 and that there was no relevant change in the following six hours.[673] Mr Giles agreed that if Dr Christensen had adopted his initial loss rate of 10mm then there would have been no observed inflow until 5 January 2011[674] and the fact that inflow was observed could only have been addressed to generate a reasonable match by adjusting the baseflow assumption.[675] He ultimately accepted that the adoption of an initial loss rate of 10mm by Dr Christensen at that time "would not have been reasonable".[676]

278 In relation to the continuing loss rates for the period 2 to 5 January 2011, the only material difference between the two sets of rates concerned SDI and GRE (0.8mm/hr v 0.5mm/hr and 1.5mm/hr v .5mm/hr).[677] Mr Giles said both rates were established by three RTFM runs he undertook,[678] however, he agreed that the results of those runs did not justify the above rates.[679] He also posited that the runs he undertook were overwritten.[680] Mr Giles maintained that the 2.5mm/hr rate for WDI and CRE after 6 January 2011 was appropriate. He maintained that the "calibration bears them out".[681] In re-examination, he was referred to Mr Ayre's evidence noted in Chapter 6[682] about the dams in CRE not spilling until 10 January 2011.[683] However, the obvious difficulty with those rates is that on his figures they involve a substantial increase in rates from 5 January 2011 to 6 January 2011 despite substantial rainfall occurring on 5 January 2011.

Submissions

279 The State attacked Dr Christensen's credit on the basis that he supposedly made "pejorative" assertions about the flood engineers' loss rates in his

[673] T 8875.42.
[674] T 8879.5 - .12.
[675] T 8879.30.
[676] T 8884.32.
[677] T 8884.46.
[678] MSC.010.496.0001.
[679] T 8886.47 to T 8889.45.
[680] T 8890.4.
[681] T 8890.33.
[682] Chapter 6 at [309].
[683] T 8937.6 to T 8938.4;

Supplementary Report when he later acknowledged that he used incorrect error rates in that report.[684] This appears to be a reference to his conclusion in that report that "[t]he engineers also failed to update and input reasonable rainfall initial losses and continuing loss rates into the Flood-Ops hydrologic model" and that the "engineers specified rainfall losses and loss rates that were orders of magnitude too high".[685] Dr Christensen stated that those criticisms flowed from his conclusion about the appropriate loss rates.[686] He otherwise maintained these criticisms as his loss rates were "only partly" erroneous and his Response Report bore the criticisms out.[687] These submissions attempt to elevate a mistake by Dr Christensen into a matter that reflects upon his honesty. I do not accept the submissions and consider this to be a distraction from an evaluation of his substantive opinions and his simulations.

280 SunWater's submissions concerning rain on the ground loss rates were directed to their lack of calibration to the Gregors Creek gauge,[688] which has already been addressed above. The balance of its submissions on loss rates concerned four-day and eight-day forecast loss rates.[689]

281 Seqwater was critical of Dr Christensen for setting initial loss rates at zero for 2 to 5 January 2011 when the API index was indicating that initial loss rates should be set above that.[690] This has also been addressed above. In short, Dr Christensen did not set initial rates at zero. Due to the constraints of his dealings with the RTFM, his modelling assumed that initial losses were satisfied prior to 2 January 2011. That approach was consistent with the flood engineers' modelling on the evening of 1 January 2011 which would have suggested to a flood engineer that initial losses were already satisfied. That understanding would have been reinforced as inflows were observed in the following days. In relation to continuing loss rates, Seqwater referred to the

[684] State subs at [460].
[685] Supplemental Report, EXP.ROD.002.0005 at .0010, [2(2)(b)-(c)]; T 1875.22 to T 1876.12.
[686] T 1875.19.
[687] T 1876.33 - .41.
[688] SunWater subs at [1020] to [1025].
[689] Ibid at [1026] to [1040].
[690] Seqwater subs at [2081] to [2084].

poor calibration of Dr Christensen's rates to Gregors Creek and Dr Nathan's evidence,[691] the material concerning the source of the figure of 2.5mm/hr and Seqwater's post-event calibration report,[692] all of which have been addressed.

Conclusion

282 The plaintiff submitted that all of Dr Christensen's rain on the ground loss rates were reasonable and none of the criticisms were substantiated.[693] I accept that submission. In particular, having regard to the above analysis I am satisfied that Dr Christensen's initial and continuing loss rates for rain on the ground and 24-hour forecast inflows for the period 2 to 5 January 2011 were reasonable. His rates were consistent with the flood engineers' own modelling during the Late December Flood Event, including on 1 January 2011, observed inflows, and what was known about the state of the catchments at the time. Further, I am satisfied that his continuing loss rates from 6 January 2011 were reasonable. In the end result, to the extent that there was a difference between the flood engineers' continuing loss rates and Dr Christensen's from 6 January 2011, it concerned the former's use of the default rate of 2.5mm/hr and the latter's use of adjusted rates from the Late December Flood Event. In light of the origins of the default rate, the prevailing conditions at the time and Mr Ickert's concession referred to above at [275], I am satisfied that Dr Christensen's approach is to be preferred.

283 Seqwater's ultimate submission on this topic was not so much directed to Dr Christensen's loss rates but to those adopted by the flood engineers. It submitted that the plaintiff did not establish that the flood engineers' rain on the ground loss rates were "unreasonable, nor that reasonably competent real-time operations required the adoption of Dr Christensen's continuing loss rates".[694] This submission does not engage with the period from 2 to 5 January 2011 inclusive when the flood engineers did not undertake RTFM modelling. In the absence of any defendable alternative rates, Dr

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[691] Seqwater subs at [2085] to [2095].
[692] Ibid at [2098] to [2104].
[693] Plaintiff's submissions at [1644].
[694] Seqwater subs at [2105].

Christensen's modelling is the only reasonable option for this timeframe. However, for the period from mid-6 January 2011 onwards, while I prefer Dr Christensen's rates, I also accept that it has not been established that the flood engineers' rain on the ground loss rates were unreasonable for the purpose of modelling rain on the ground inflows.

284 However, in light of the analysis in Chapter 10, nothing turns on the difference between those rates for that period. This is so because all relevant estimates of forecast inflows for periods of 24 hours and beyond, including those that I do not consider to be reasonable, support the modelled operations in SIM F and SIM H (which commence on 8 January 2011).[695] Further, all reasonable four-day inflow estimates support the modelled operations in SIM C.[696] It is true that the reasonable four-day inflow estimates include both Dr Christensen's estimates, which are the sum of his four-day forecast estimate and his rain on the ground estimate,[697] and Mr Giles' adjustment of those estimates to account for his assessment of the inflows for the Late December Flood Event. However, the differences between Dr Christensen's rain on the ground inflow estimates and the flood engineers' rain on the ground inflow estimates are ultimately immaterial to the reasoning in Chapter 10 concerning SIM F, SIM H and SIM C so far as they concern the four-day inflow estimates. The flood engineers did not commence inflow modelling until midday on 6 January 2011.[698] Dr Christensen's rain on the ground estimates were referable to the period beginning at midnight each night. For midnight on 7, 8, 9 and 10 January 2011, his rain on the ground estimates were 155,000ML, 168,000ML, 79,000ML and 615,000ML respectively.[699] Operational spreadsheets for the same times are not available but, taking the operational spreadsheet prepared closest in time prior to those times and using its forward estimate from the same time as Dr Christensen's modelling commences, the corresponding figures are 127,000ML,[700] 138,000ML,[701]

[695] See Chapter 10 at [7] to [8] and Appendix E to this judgment.
[696] See Chapter 10 at [60ff] and Appendix F to this judgment.
[697] Chapter 8 at [69].
[698] Chapter 6 at [164].
[699] Response Report Vol 2, EXP.ROD.015.0261 at .0276 to .0280; see [235].
[700] 6 Jan 21:00 ROG run, input data tab, SUM [H119:H488] * 3.6; QLD.001.001.2299.
[701] 7 Jan 18:00 ROG run, input data tab, SUM [H143:H488] * 3.6; QLD.001.001.2409.

62,000ML[702] and 655,000ML[703] respectively. For midnight on 7, 8 and 9 January 2011, those differences in estimates represent a maximum projected height differential of no more than approximately 23cm. This is immaterial. The same applies to Mr Giles' rain on the ground inflow estimates for that period (see [235]).[704]

9.6: Revised 24-Hour Inflow Volumes

285 In determining rain on the ground and 24-hour inflow volumes using the RTFM there are three parameters: loss rates; rainfall depth and temporal patterns. The first has been addressed above and the second is specified by the QPF forecast. As noted in Chapter 8, the temporal pattern used by Dr Christensen for modelling 24-hour forecast rainfall upstream and downstream was the same temporal pattern used in the Appendix A "with forecast" runs, namely the ARI 1-30.[705] Mr Giles described it as "quite aggressive" in that it assumed that 57% of the daily total rainfall fell within the first six hours.[706] To an extent, that pattern addresses the issue that was discussed in Chapter 6[707] concerning the use of rain on the ground loss rates calibrated to past spasmodic rainfall to assumptions of future continuous rainfall. Otherwise, as that temporal pattern was also applied to downstream flows, it promoted caution in assessing the effect of current releases on downstream conditions. In any event, none of the defendants' submissions took issue with the temporal pattern used in Dr Christensen's modelling of rain on the ground and 24-hour QPF forecasts.[708] As noted below at [294], Dr Christensen used the higher bound of the QPF forecast (save that where the forecast was for "falls in excess of 100mm" on 11 January 2011 he used 100mm for his modelling).[709]

[702] 8 Jan 15:00 ROG run, input data tab, SUM [H167:H488] * 3.6; QLD.001.001.2543.
[703] 9 Jan 22:00 ROG run, input data tab, SUM [H191:H488] * 3.6; QLD.001.001.2826.
[704] See Appendix E to this judgment; fn 10 to 14; Appendix F to this judgment; fn 61, 62, 70, 71, 79 and 80.
[705] See EXP.QLD.001.0813 at .0834.
[706] Ibid.
[707] Chapter 6 at [299] to [319].
[708] Mr Malone's analysis of temporal patterns in his report did not assess 24-hour forecasts: SEQ.004.046.0291 at .0292.
[709] Response Report, EXP.ROD.015.0005 at .0250 to .0252; Chapter 7 at [355]; QLD.002.002.1670.

286 At this point, it is appropriate to quantify the differences in estimates of inflow volumes based on QPFs. Three permutations were presented. The first was Dr Christensen's 24-hour inflow volumes. However, they were affected by the error noted in Chapter 8[710] in that he "double counted" the inflows between midnight and the time of the forecast. The second permutation was provided by Mr Pokarier who corrected for that error.[711] The third permutation is derived from Mr Giles' modelling of inflows using the loss rates he determined (see [276]). A number of errors were encountered in ascertaining those figures.[712] Ultimately, the parties provided different figures for Mr Giles' analysis.[713] The three sets of volume figures are set out in the table below. As noted, to the extent necessary the significance of the difference will be addressed in the context of each simulation. At this point it suffices to state that I have significant misgivings about Mr Giles' estimates, especially in the period up to 6 January 2011. I am not satisfied those estimates fell within a reasonable range of estimates of inflow volumes based on QPFs. I am satisfied that Mr Pokarier's corrected inflow volumes do fall within that range.

Revised Wivenhoe Dam One-Day Inflow Volumes[714]

Forecast Date/Time[715]	Christensen (ML)[716]	Pokarier (ML) (correcting for double counting error)[717]	Giles (ML)[718]
2 Jan 11:00 (Less than 5 to 10mm)[719]	51,000	45,537	18,500 (18,405)
2 Jan 17:00 (5 to 10mm)[720]	53,000	45,324	8,300 (16,854)

[710] Chapter 8 at [27].
[711] EXP.SEQ.016.0012 at .0150 to .0151.
[712] See Chapter 8 at [28] an email from the Court on 23 April 2019: MSC.010.560.0001.
[713] See Plaintiff's submissions dated 30 April 2019 in response to Court's email of 23 April (SBM.010.018.0001); See the State's supplementary version of Table 4-1 dated 30 April 2019 (SBM.040.007.0001).
[714] Including rain on the ground inflows.
[715] Note that QPF times varied anywhere up to one hour before the designated time, but for the sake of consistency they are denoted as these times and dates.
[716] Derived from EXP.SEQ.016.0012 at .0149 to .0150.
[717] Derived from EXP.SEQ.016.0012 at .0150 to .0151.
[718] Figures taken from the State's emailed submission: SBM.040.007.0001; Figures in brackets calculated by the Plaintiff from Mr Giles' spreadsheets (SBM.010.018.0001).
[719] SEQ.001.019.6808.
[720] SEQ.001.019.6811.

3 Jan 11:00 (5 to 10mm)[721]	42,000	36,674	13,200 (12,535)
3 Jan 17:00 (10 to 20mm)[722]	99,000	91,437	36,700 (39,697)
4 Jan 11:00 (10 to 20mm)[723]	89,000	84,426	52,300 (51,357)
4 Jan 17:00 (5 to 15mm)[724]	66,000	59,018	30,448 (32,084)
5 Jan 11:00 (20 to 30mm)[725]	112,000	106, 762	96,400 (95,845)
5 Jan 17:00 (30 to 50mm)[726]	238,000	230,752	210,000
6 Jan 11:00 (30 to 50mm)[727]	338,000	326,730	206,900
6 Jan 17:00 (20 to 30mm)[728]	330,000	301,671	216,900
7 Jan 11:00 (20 to 30mm)[729]	340,000	274,866	219,000
7 Jan 17:00 (20 to 30mm)[730]	433,000	324,839	286,000
8 Jan 11:00 (30 to 50mm)[731]	383,000	319,471	288,000
8 Jan 17:00 (30 to 50mm)[732]	399,000	307,425	265,000
9 Jan 11:00 (40 to 60mm)[733]	443,000	418,881	355,000
9 Jan 17:00 (50 to 80mm)[734]	888,000	836,748	678,000
10 Jan 11:00 (50 to 100mm)[735]	1,160,000	854,498	810,000 (810,027)
10 Jan 17:00 (25 to 50mm, with isolated falls up to 100mm)[736]	1,007,000	563,496	518,000

[721] SEQ.001.019.6814.
[722] SEQ.001.019.6831.
[723] SEQ.001.019.6842.
[724] SEQ.001.019.6859.
[725] SEQ.001.019.6861.
[726] SEQ.001.018.7970.
[727] SEQ.001.019.6916.
[728] SEQ.001.019.6977.
[729] SEQ.016.047.9578.
[730] QLD.001.001.2389.
[731] SEQ.001.019.7014.
[732] QLD.001.001.2546.
[733] SEQ.001.019.5593.
[734] SEQ.001.019.5605.
[735] SEQ.001.018.8509.
[736] QLD.002.002.1737.

11 Jan 11:00 (in excess of 100mm)[737]	1,233,000	1,073,450	972,000
11 Jan 17:00 (50 to 100mm, easing to 30mm on 12 Jan)[738]	1,332,000	1,001,806	911,000
12 Jan 11:00 (10mm)[739]	335,000	182,068	N/A
12 Jan 17:00 (5mm)[740]	332,000	125,031	N/A

Table 9-8: Range of Estimated Volumes Based on QPF Forecasts

287 The plaintiff submitted that "nothing has been introduced or [was] put to Dr Christensen to suggest that [his] use of slightly different continuing loss rates for the WDI and CRE sub-catchments, for rain on [the] ground modelling and 24-hour modelling, would make any material difference in terms of modelled inflows or subsequent operating strategy".[741] I have already addressed this submission so far as it concerns the flood engineers' rain on the ground modelling and SIM C, SIM F and SIM H.[742] In Chapter 10 I address the effect of variations in the 24-hour inflow estimates that were presented in evidence on Dr Christensen's simulations to the extent that it is necessary. It suffices to state that none of the variations affect my acceptance of SIM C, SIM F and SIM H.[743]

9.7: Flood Operations Approaching and Above EL 74.0m AHD

288 The release strategy adopted by Dr Christensen in his various simulations throughout 11 and 12 January 2011 was heavily criticised by the defendants. In essence, they contended that all of the simulated operations conducted on that day were affected by, or even constructed by reference to, hindsight. [744] This is a contention that I reject. Further, to the extent that some of the

[737] SEQ.016.047.9664.
[738] SUN.002.003.6266.
[739] QLD.002.002.1602.
[740] QLD.002.002.1571.
[741] Plaintiff subs at [1620].
[742] See [284] above.
[743] In particular see Appendix E and Appendix F to this judgment.
[744] SunWater subs at [938] to [955]; State subs at [537]; T 1668.35; T 1677.4 (hindsight suggestion put to Dr Christensen by Senior Counsel for Seqwater).

simulations involved maintaining gate openings even when Wivenhoe Dam was above EL 74.0m AHD, it was submitted that Dr Christensen's approach was irresponsible and contrary to the Manual. For the reasons that follow, I reject aspects of that submission, although I do accept that aspects of Dr Christensen's simulated operation above EL 74.0m AHD at Wivenhoe Dam were not those required of a reasonably competent flood engineer.

289 Dr Christensen's simulations can be conveniently separated into two categories: those that never take Wivenhoe Dam above EL 74.0m AHD (SIM A, C, E and I; "category one"), and those that do (SIM B, D, F, G, H and J; "category two"). The defendants' criticisms can be addressed by reference to one simulation from each category, namely SIM C and SIM F (noting that SIM H is relevantly identical to SIM F).

Circumstances on 11 and 12 January 2011

290 I have described the circumstances prevailing on 11 and 12 January 2011 in Chapter 7.[745] I will not repeat that discussion save to note five matters.

291 First, there was a rapid increase in inflows throughout 11 January 2011. As at 2.00am on 11 January 2011, actual inflows into Wivenhoe Dam were $3594m^3/s$. By 7.00am they were $6802m^3/s$.[746] By midnight on 12 January 2011, inflows into Wivenhoe Dam were $5052m^3/s$. They steadily decreased throughout 12 January 2011. By midnight on 13 January 2011, inflows were $2143m^3/s$.[747]

292 Second, there was a corresponding increase in the rain on the ground[748] and "with forecast" estimate of downstream flows (excluding dam outflows) throughout 11 January 2011. As at 4.00am, the Appendix A "with forecast" predicted peak of natural downstream flows was $1810m^3/s$. This increased to $3000m^3/s$ at 8.00am and crucially to $5770m^3/s$ at 1.00pm, meaning that urban

[745] Chapter 7; sections 7.6 and 7.7.
[746] Simulation Analysis, EXP.ROD.015.0461 at .0932 (these figures include Somerset Dam outflows and thereafter inflows increased as per the table set out in Table 7-4 in Chapter 7 at [378]).
[747] Simulation Analysis, EXP.ROD.015.0461 at .0933 (this figures includes Somerset Dam outflows of $1231m^3/s$; see Table 7-4 in Chapter 7 at [378].
[748] LAY.SUN.001.0001 at .0772 (Annexure C4).

flooding downstream could not be avoided.[749] The Appendix A "with forecast" analysis predicted those peaks occurring at 5.00 and 4.00am respectively on 12 January 2011.[750]

293 Third, as noted in Chapter 7,[751] in light of the amount of rain falling directly onto Wivenhoe Dam, the RTFM was not able to model inflows accurately and the flood engineers resorted to reverse routing, (ie, determining the rate of inflow from rises in actual lake levels and gate settings).[752]

294 Fourth, just after 10.00am on 11 January 2011, the 24-hour QPF forecast was issued. It predicted in excess of 100mm of rain.[753] Based on that, Dr Christensen modelled 100mm of rain and produced an estimated inflow volume of 1,233,000ML.[754] The afternoon QPF predicted "50 to 100mm this evening and overnight, easing to less than 30mm during" the following day.[755] Dr Christensen's modelling of that rainfall produced an estimated inflow volume of 1,332,000 ML.[756] Mr Pokarier corrected those volumes to 1,073,450ML and 1,001,806ML respectively.[757]

295 Fifth, Table 7-4 in Chapter 7[758] shows the flood engineers gate openings from the evening of 10 January 2011 to midnight on 12 January 2011. It is notable that, while the height of Wivenhoe Dam rose through EL 72m AHD and EL 73m AHD, gate increments were maintained at 45 and they only increased once EL 74m AHD was about to be exceeded.

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[749] AID.500.021.0001 at .0002; for an explanation of the Appendix A run, see Chapter 6 at [23] to [31].
[750] AID.500.021.0001 at .0002.
[751] Chapter 7 at [375].
[752] LAY.SUN.001.0001_OBJ at [2512].
[753] QLD.002.002.1670.
[754] See above at [286]; see, for example, Response Report Vol 2, EXP.ROD.015.0261 at .0337.
[755] SUN.002.003.6266.
[756] See above at [286]; see, for example, Response Report Vol 2, EXP.ROD.015.0261 at .0337.
[757] EXP.SEQ.016.0012 at .0151; see above at [286].
[758] Chapter 7 at [378].

Category One: SIM C on 11 and 12 January 2011

296 The parameters and governing assumptions of SIM C are described in Chapter 8.[759] In SIM C, as at midnight on 11 January 2011, Wivenhoe Dam would have been at EL 69.03m AHD and releasing 1860m^3/s with gates open to 36 increments. [760] Somerset Dam would have been at EL 103.24m AHD and releasing 965m^3/s into Wivenhoe Dam[761] via two open sluice gates.[762]

297 Under SIM C, Dr Christensen would have closed Wivenhoe's gates by one increment at 1.00am on 11 January 2011 and then closed gates by a further 17 increments between 7.00am and 4.00pm on 11 January 2011, leaving gates open at 18 increments at that time[763] with an outflow of approximately 1070m^3/s.[764] Between 1.00pm and 3.00pm, both remaining sluice gates at Somerset Dam would have been closed. This outflow was maintained until around 4.00pm on 12 January 2011 when Wivenhoe gates were raised by thirteen increments to a total of 31 by 2.00am on 13 January 2011.[765]

298 The effect of reducing outflows from Wivenhoe Dan and Somerset Dam through 11 January 2011 was that the Wivenhoe Dam storage level would have increased from EL 69.03m AHD at midnight on 11 January 2011 to a peak of EL 73.86m AHD at midnight on 13 January 2011. The storage level of Somerset Dam would have increased from EL 103.24m AHD at midnight on 11 January 2011 to a peak of EL 105.07m AHD at 5.00am on 12 January 2011.

299 In his day-by-day release rates explanation for SIM C, Dr Christensen explained the rationale for this approach. In light of Seqwater's criticisms it is

[759] Chapter 8 at [146] to [147].
[760] Simulation Analysis, EXP.ROD.015.0461 at .0630 and .0653.
[761] Ibid at .0639 and .0653.
[762] Ibid at .0653.
[763] Ibid at .0653.
[764] Ibid at .0631.
[765] Ibid at .0653 to .0654.

necessary to set out most of the explanation for his modelled releases on 11 January 2011 in full:[766]

> "At 11:00am, the predicted 7.9 m no release rise from 70.46 m to 78.36 m continued to indicate a potential fuse plug breach, requiring continuing the W4B strategy. At this stage, given the dam level is continuing to exceed dam protection level, the releases are fully determined by minimum gate opening settings at Wivenhoe Dam. The Manual provides that while the radial gates can withstand overtopping, it should be avoided if possible.
>
> In order to prevent overtopping of the gates (at 73.0m when the gates are closed), it is necessary to raise the gates to ensure that the top of the spillway gates remain above water. With that 11am forecast rise, at a minimum, all spillway gates would have to be up at least 0.5 m – 1.0m when the dam level reaches 73.0 m to 73.5 m.
>
> When the lake level is above 73.0 m at Wivenhoe Dam, all the spillway gates would need to be raised with all gates up at least 0.5 m to 1.0m. *Those gate settings would cause a release of 850 m³/s to 1,100 m³/s.* Releases were made just under 1,500 m³/s with an aim to avoid overtopping the gates while trying to minimize flows as possible downstream.
>
> At 13:00, the Moggill 1-day forecast run indicated a Moggill peak flow of 5,770 m³/s indicating it was no longer possible to keep Moggill from rising above 4,000 m³/s. The main consideration for the engineer is therefore whether and how much to release being aware that any release will add to the peak at Moggill.
>
> In the simulated operations, at 13:00, the water level in Wivenhoe was 70.98 m. With the peak at Moggill exceeding 4,000, the engineer would need to determine whether and how much to release from Wivenhoe Dam.
>
> *The flood engineers' no rain RTFM run at 13:00 showed that the total inflow volume into Wivenhoe Dam in the next 24 hours was 576,000 ML. That inflow would cause a rise of 3.9 m in Wivenhoe Dam from the current water level at 13:00 of 70.98 to 74.88. That rise exceeds dam protection level by more than 0.5 m requiring the gates to be raised to avoid overtopping the gates.*
>
> The strategy is to aim to keep the lake level in Wivenhoe Dam from rising above 73.0 m, but if that cannot be achieved, the engineer would aim to keep the lake level from rising above the dam protection level of 74.0 m. The engineer would consider that a release of 1,100 m³/s to 1,150 m³/s would be necessary given the minimum gate release settings. The same release rate was maintained at 19:00 when the Moggill forecast increased to 6,910 m³/s.
>
> The engineer would always plan to raise the gates as needed to prevent gate overtopping, avoid a fuse plug breach, and protect the dam from overtopping. *At 13:00, the 24-hour QPF forecast rain is indicating 100 mm of rain, which if the rain does come would require the gates to be opened quickly in a W4 dam protection strategy. The engineer would be ready and on the alert to raise the gates as needed per the W4 Strategy to prevent a fuse plug breach.*

[766] Response Report Vol 2, EXP.ROD.015.0261 at .0345 to .0346.

However, overtopping of the dam was not a reasonable concern based on the best available 1-day to 8-day forecasts which showed the heavy rain ending by January 13. The gates could release 10,400 m³/s at 75.5 m before a fuse plug breach and 13,500 m³/s at the 80.0 m top of dam level. The forecast peak inflow of 8,678 m³/s (Run 39 with rain) was less than the 75.5 m spillway capacity without using any of the large amount of available remaining storage to 75.5 m and above to 80.0 m." (emphasis added)

300 Dr Christensen's explanation for the modelled approach to releases on 12 January 2011 in SIM C was as follows:[767]

"The objective became to keep Wivenhoe Dam below 74.0m.

At 11:00, the lake level was at 73.55m, but inflows were rapidly declining. *The gate settings would have been continued and then raised as needed to prevent gate overtopping*. As the water level rose, and as downstream flows decreased through the day, I started to raise the gates at 16:00pm, increasing the releases towards 1,500 m³/s once the downstream peak had passed. By 20:00, the downstream tributary gages and the gages on the Brisbane River showed that downstream peak flow was over and had declined sufficiently to gradually increase releases and stop the rise of the Wivenhoe water level." (emphasis added)

301 Two matters should be noted about these passages at this point.

302 First, much of the above discussion addresses the minimum level of gate openings at Wivenhoe Dam that must be undertaken to allow the gates to be opened rapidly should that be necessary to avoid the top of those gates becoming submerged. Dr Christensen's analysis yields a conclusion that in SIM C the gates had to be open at least to a level that allowed outflows of 1100m^3/s to 1150m^3/s.

303 It is necessary to explain the arithmetic that underlies this calculation, especially his calculation of the range 850m^3/s to 1100m^3/s in the extract at [299]. In the above passage, Dr Christensen sought to protect the structural integrity of Wivenhoe Dam by ensuring that, if necessary, the gates could be raised rapidly to allow a large discharge and avoid a fuse plug breach. One impediment to that is a possible malfunction if the gates are fully submerged in water. As at 1.00pm on 11 January 2011, in SIM C Wivenhoe Dam would

[767] Ibid at 0346 to .0347.

have been at EL 70.98m AHD.[768] By reference to the flood engineers' rain on the ground loss inflows, Dr Christensen determined that, at a minimum, SIM C would rise above EL 73.0m AHD and would most likely rise higher. The Manual states that, if a crest gate is fully closed, the top of the gate is at EL 73.00m AHD. If a gate is open to 0.5m AHD then the top of the gate is somewhere between EL 73.34m AHD and 73.50m AHD. If it is open to 1.0m then the top of the gate is at EL 73.83m AHD.[769] Dr Christensen determined that he had to raise each gate out of the water by between 0.5m to 1.0m AHD (in fact 1.0m AHD), although if the water level went higher they would need to be raised further to avoid overtopping. The gate opening sequences specified in the Manual are such that for every gate to be opened by at least 1.0m, Gate 1 and Gate 5 must be opened by 1.0m, Gates 2 and Gate 4 must be opened by 1.5m and Gate 3 must be opened by 4.0m.[770] A rating table for individual Wivenhoe crest gates in the Manual specifies that, if those gates are open to that extent at EL 73.0m AHD, then the dam will release 1100m^3/s.[771] Application of the same analysis yields a conclusion that, if all gates are open by at least 0.5m, then the rate of outflow at EL 73.0m AHD is 854m^3/s (which is the basis for Dr Christensen's figure of 850m^3/s).[772]

304 Consistent with this analysis, in SIM C Dr Christensen states that he would have reduced gate openings from 1.00pm to settings reflecting all gates being open by at least 1.0m by 4.00pm on 11 January 2011, by which time Wivenhoe Dam would have been at EL 71.45m AHD[773] and releasing 1043m^3/s.[774] Those openings would have been maintained until 3.00pm on 12 January 2011 when Wivenhoe Dam would have been at EL 73.66m AHD and releasing 1123m^3/s. As explained in the passage in [300], as the dam level on 12 January 2011 would have been approaching the overtopping level for two of the gates (ie, EL 73.83m AHD), Dr Christensen would have opened

768 Simulation Analysis, EXP.ROD.015.0461 at .0631.
769 Manual at 57.
770 Ibid at 3.
771 Ibid at 55: Gates 1 and 2: 124m^3/s each; Gates 2 and 4: 185m^3/s each; and Gate 3: 482m^3/s.
772 Gate 1: 0.5m (62m^3/s), Gate 2: 1.0m (124m^3/s), Gate 3: 4.0m (482m^3/s); Gate 4: 1.0m (124m^3/s) and Gate 5: 0.5m (62m^3/s): Manual at 35 and 55.
773 Simulation Analysis, EXP.ROD.015.0461 at .0653.
774 The difference between 1100m^3/s and 1043m^3/s is referable to the different water pressure at EL 71.45m AHD compared to EL 73.0m AHD.

the gates by two more increments between 3.00pm and 4.00pm and a further four increments between 6.00pm and 7.00pm prior to Gates 1 and 2 being overtopped at EL 73.83m AHD.[775] This increased releases towards a discharge rate of 1500m^3/s but that would have been well after the downstream peak had passed.[776] In fact, consistent with the analysis in Chapter 7[777] the gauges were indicating that the peak flow had passed through Moggill by early in the afternoon of 12 January 2011.[778] These openings meant that the crest gates were open by at least 1.5m AHD and could not be overtopped until the water level was above somewhere between EL 74.15m and EL 74.31m AHD[779] which would not have been reached in SIM C. In any event, in SIM C there would have been further gate openings at 1.00am on 13 January 2011.[780]

305 Second, parts of the extract in [299] focus on the position at 1.00pm on 11 January 2011. The significance of that time to Dr Christensen is that is when the modelling of downstream flows indicated that avoiding flows causing urban damage downstream was no longer possible.

Category Two: SIM F and SIM H on 11 and 12 January 2011

306 The parameters of SIM F and SIM H are addressed in Chapter 8.[781] In summary, SIM F commenced at midnight on 8 January 2011 and operates by reference to four and eight-day forecasts. SIM H operates by reference to one-day forecasts. Both simulations assume that the Somerset Dam crest gates had to remain open. The various issues raised with both simulations are addressed in Chapter 10.[782] As explained there, the prevailing circumstances from 8 January 2011 were such that the difference in assumptions and approaches for the two simulations did not lead to any relevantly different gate operations.

[775] Simulation Analysis, EXP.ROD.015.0461 at .0654.
[776] Response Report Vol 2, EXP.ROD.015.0261 at .0346.
[777] Chapter 7; section 7.9.
[778] January FER at .1263.
[779] Manual at 57.
[780] Simulation Analysis, EXP.ROD.015.0461 at .0654.
[781] Chapter 8 at [158] to [163].
[782] Section 10.1.

307 As at midnight on 11 January 2011, in SIM F and SIM H Wivenhoe Dam would have been at EL 71.15m AHD and releasing 1870m^3/s.[783] In SIM F, at midnight the projected height of Wivenhoe Dam on a "no release" basis would have been EL 75.82m AHD which was sufficient to engage a fuse plug and Strategy W4B.[784] The adjusted four-day volume based on Mr Giles' analysis leads to a similar result.[785] Dr Christensen described the strategy engaged as "W4B/Fill to below 74.0m at first then protect the dam while minimising Moggill".[786] This is a reference to utilising the dam storage space up to EL 74.0m AHD given the very strong likelihood of downstream flooding.

308 Dr Christensen's hourly analysis of SIM H states that, as at 2.00am on 11 January 2011, the operative strategy was W3.[787] However, his analysis of the 10.00am QPF indicated that the projected height would result in a fuse plug initiation. Further, the projected height based on Mr Pokarier's adjusted one day volumes well exceeds EL 74.0m AHD.[788] In any event, by reason of the morning QPF predicting "in excess of 100mm" of rainfall, all projected heights based on one-day QPF forecasts were well above the height necessary to case a fuse plug breach. Dr Christensen recorded that he would have adopted W4B.[789]

309 So far as the category two simulations are concerned, the defendants' criticisms can best be addressed by reference to the following table for SIM F (and SIM H) which sets out Dr Christensen's simulated gate openings and simulated heights and gate openings and the simulated heights and gate openings prepared by Mr Ickert for operations above EL 74.0m AHD. Mr Ickert contended that his simulated gate opening pattern was consistent with

[783] Simulation Analysis, EXP.ROD.015.0461 at .0847 and at .0932.
[784] Ibid at .0847; Response Report Vol 2, EXP.ROD.015.0261 at .0393.
[785] See Appendix F to this judgment.
[786] Response Report Vol 2, EXP.ROD.015.0261 at .0393 to .0394.
[787] Simulation Analysis, EXP.ROD.015.0461 at .0932.
[788] See Appendix E to this judgment and Simulation Analysis, EXP.ROD.015.0461 at .0932.
[789] Simulation Analysis, EXP.ROD.0461 at .0933; T 2575.36.

Strategy W4.[790] Mr Ickert prepared similar tables for each of Simulations B, D, G and J.

Date and Time	Wivenhoe Inflow (m^3/s)	Christensen Simulation F			Revisions to Simulation F Above EL 74.0m AHD		
		No of Gate Increments Open	Wivenhoe Release (m^3/s)	Wivenhoe Pool Elevation (m AHD)[791]	No. of Gate Increments Open	Wivenhoe Release (m^3/s)	Wivenhoe Pool Elevation (m AHD)
11 Jan 0000	4,284	33	1,869	71.08	As per Christensen Simulation F data		
11 Jan 0100	3,809	33	1,874	71.15	As per Christensen Simulation F data		
11 Jan 0200	3,238	33	1,878	71.20	As per Christensen Simulation F data		
11 Jan 0300	4,036	33	1,881	71.25	As per Christensen Simulation F data		
11 Jan 0400	4,634	32	1,830	71.30	As per Christensen Simulation F data		
11 Jan 0500	5,747	32	1,834	71.36	As per Christensen Simulation F data		
11 Jan 0600	6,925	32	1,840	71.45	As per Christensen Simulation F data		
11 Jan 0700	7,132	32	1,848	71.57	As per Christensen Simulation F data		
11 Jan 0800	8,604	32	1,857	71.71	As per Christensen Simulation F data		
11 Jan 0900	9,920	32	1,868	71.86	As per Christensen Simulation F data		
11 Jan 1000	11,120	31	1,824	72.05	As per Christensen Simulation F data		
11 Jan 1100	10,334	31	1,839	72.28	As per Christensen Simulation F data		
11 Jan 1200	10,843	31	1,853	72.50	As per Christensen Simulation F data		
11 Jan 1300	12,267	36	2,156	72.72	As per Christensen Simulation F data		
11 Jan 1400	10,440	36	2,174	72.96	As per Christensen Simulation F data		
11 Jan 1500	9,749	36	2,190	73.18	36	2,190	73.18
11 Jan 1600	9,623	36	2,204	73.38	36	2,204	73.38
11 Jan 1700	8,869	36	2,217	73.56	36	2,217	73.56
11 Jan 1800	7,800	36	2,229	73.72	36	2,229	73.72
11 Jan 1900	7,526	36	2,239	73.87	36	2,239	73.87
11 Jan 2000	7,702	36	2,248	74.00	36	2,248	74.00
11 Jan 2100	7,435	36	2,257	74.12	36	2,257	74.12
11 Jan 2200	6,856	36	2,266	74.25	40	2,507	74.25
11 Jan 2300	6,587	36	2,274	74.36	44	2,753	74.36
12 Jan 0000	5,657	36	2,281	74.47	48	2,996	74.45
12 Jan 0100	5,350	36	2,287	74.55	52	3,237	74.53
12 Jan 0200	4,679	36	2,292	74.63	56	3,474	74.58
12 Jan 0300	5,208	36	2,296	74.69	60	3,709	74.62
12 Jan 0400	4,745	36	2,301	74.75	64	3,943	74.65
12 Jan 0500	4,624	36	2,305	74.81	68	4,176	74.68
12 Jan 0600	4,507	36	2,309	74.87	72	4,408	74.69
12 Jan 0700	4,202	36	2,312	74.92	76	4,640	74.70
12 Jan 0800	2,963	36	2,315	74.96	73	4,466	74.70
12 Jan 0900	2,985	36	2,317	74.99	70	4,290	74.67
12 Jan 1000	3,259	36	2,318	75.01	67	4,114	74.64
12 Jan 1100	2,950	36	2,319	75.02	64	3,938	74.62
12 Jan 1200	3,231	36	2,321	75.04	61	3,764	74.60
12 Jan 1300	3,300	36	2,322	75.06	58	3,589	74.58
12 Jan 1400	2,342	36	2,323	75.08	55	3,415	74.57

[790] EXP.SUN.009.0001 at .0292.
[791] Data for the simulated lake level of Wivenhoe Dam was taken from the gate constraints table .0862 of Dr Christensen's Simulation Analysis (EXP.ROD.015.0461).

12 Jan 1500	3,071	36	2,324	75.09	52	3,239	74.55
12 Jan 1600	2,695	39	2,508	75.10	49	3,063	74.54
12 Jan 1700	2,656	42	2,693	75.11	46	2,886	74.53
12 Jan 1800	3,309	44	2,816	75.11	46	2,886	74.53

Table 9-9: Dr Christensen's Simulation F with Revised Operations above EL 74.0m AHD[792]

310 Like the above extract from the SIM C day-by-day explanation quoted at [299], in his equivalent analysis for SIM F, Dr Christensen referred to the need to be able to raise the Wivenhoe gates quickly to "avoid a fuse plug breach, and protect the dam from overtopping".[793] To enable this to occur, Dr Christensen calculated the necessary level of openings for the Wivenhoe Dam gates based on its expected height (accounting for releases). In SIM F and SIM H, he assessed that level of releases to be around 2200 to 2300m^3/s[794] based on raising the gates to a minimum of 3.0m.[795] The balance of his explanation stated:

> "At 13:00, the Moggill 1-day forecast run indicated a Moggill peak flow of 5,770 m³/s confirming that it was no longer possible to keep Moggill from rising above 4,000 m³/s. Given the W4B Strategy, the engineer's main priority is the protection of the dam. With the rising lake levels and increasing inflows, it is necessary to continue releases from the dams. The releases are fully determined by minimum gate opening settings at Wivenhoe Dam.
>
> Given the W4B Strategy, the operation is aimed at preventing a breach of the initial fuse plug, the engineer would have to make release at least above 2,200 m³/s because of the minimum gate settings [necessary to allow the gates to be opened quickly]. The strategy is to aim to keep the lake level in Wivenhoe Dam from rising above 74.0 m dam protection level, but if as here, that cannot be achieved, the engineer would aim to keep the lake level from rising above the fuse plug protection level of 75.5 m. The strategy would be to stop the rise of Wivenhoe Dam near 75.0 m.
>
> …
>
> The engineer would always plan to raise the gates as needed to prevent gate overtopping, avoid a fuse plug breach, and protect the dam from overtopping. At 13:00, the 24-hour QPF forecast rain is indicating 100 mm of rain, which if the rain does come would require the gates to be opened quickly in a W4 dam protection strategy. The engineer would be ready and on the alert to

792 Taken from EXP.SUN.009.0001 at .0292 with SIM F gate operations for period prior to 3.00pm on 11 January 2011 taken from EXP.ROD.015.0461 at .0862 (gate constraint table).
793 Response Report Vol 2, EXP.ROD.015.0261 at .0401.
794 Id.
795 Manual at 35 and 55; Gates 1 and 5: 390m^3/s; Gates 2 and 4: 452m^3/s and Gate 3: 574m^3/s = 2258m^3/s.

> raise the gates as needed per the W4 Strategy to prevent a fuse plug breach. However, overtopping of the dam was not a reasonable concern based on the best available 1-day to 8-day forecasts which showed the heavy rain ending by January 13. The gates could release 10,400 m³/s at 75.5 m before a fuse plug breach and 13,500 m³/s at the 80.0 m top of dam level."

Flood Operations Below EL 74.0m AHD on 11 January 2011

311 Dr Christensen's simulated gate operations can be conveniently separated into the period before the actual dam level reaches EL 74.0m AHD and after. In respect of the former period, his simulations either maintain (SIM F), or in some cases reduce (SIM C), gate openings and allow the dam to fill. This is a similar approach to that adopted by the flood engineers, with the crucial difference being that in these simulations Wivenhoe Dam would have filled later than in the actual events.

312 In respect of all simulations, Seqwater submitted that Dr Christensen "chang[ed] his approach at 1300 on 11 January so as to make operational decisions on the Appendix A rain on the ground model run".[796] In relation to SIM C and SIM H, which make operational decisions based on QPFs, Seqwater submitted that Dr Christensen "chang[ed] his methodology" so as not to "respond" to the QPFs issued on that day, presumably by making releases in advance of rain falling.[797] It noted Dr Christensen's modelling of the morning and afternoon QPFs and contended that they "should have caused Dr Christensen concern".[798] Further, by reference to Mr Pokarier's evidence, it submitted that there was no explanation for how in SIM C Dr Christensen could lower the release rate when QPFs were to be used to decide upon strategies and releases and the 11.00am QPF provided a "dire prediction".[799]

313 These criticisms, and the evidence of Mr Pokarier upon which they are based, mischaracterise Dr Christensen's simulated gate operations on 11 January 2011 as a "change" in his methodology because he does not "respond" to

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[796] Seqwater subs at [2171].
[797] Ibid at [2170]; Seqwater subs at [2434].
[798] Seqwater subs at [2179] to [2180] and [2190] to [2191].
[799] Seqwater subs at [2195] citing T 7150.23 (Pokarier).

forecasts of further rainfall by increasing releases. Dr Christensen described his methodology in his Reply Report, which is summarised in Chapter 8.[800] As noted, his first step was to determine the applicable strategy by reference to the predicted maximum water levels. Dr Christensen did not depart from this step in his simulated operations on 11 January 2011. However, in his Reply Report Dr Christensen did not state that a reasonably competent flood engineer would always "respond" to forecasts of large amounts of rainfall by increasing outflows. Instead, he stated that the second step in applying the Manual was to determine whether to fill the reservoir or create storage by lowering water levels.[801] If it was determined to lower water levels then, depending on downstream flows and other constraints dictated by the Manual, then that would be undertaken by reference to forecast inflows and other factors. However, Dr Christensen determined that on 11 January 2011 a reasonably competent flood engineer would, if they could, allow the flood pool of the dams to fill. This approach was explained in the following passage in his Reply Report:[802]

> "215. *The engineer would decide to allow the reservoirs to fill if the flood flows are forecast to begin to rise near 3,500m^{3}s at Lowood or 4,000m^{3}s at Moggill, and to do so would not compromise the structural safety of the dams. It may not be possible to retain water in Wivenhoe Dam or Somerset Dam if the forecasts indicate that there would be a risk to the structural safety of one or both of the dams if they continued to fill.* The engineer may decide to fill Somerset Dam even earlier in the circumstances described in paragraph 217 below.
>
> 216. The engineer would also decide to allow the reservoirs to fill if the forecasts indicated that heavy rainfall would be ending and would not overfill the remaining flood storage.
>
> 217. The engineer may decide to allow Somerset Dam to fill if the forecasts indicate that the water level in Wivenhoe Dam will rise to above the top of Wivenhoe Dam's spillway gates (73.0m), while Somerset Dam is not at risk of failure or overtopping at 107.46m or 109.70m(depending on which is the correct failure level)." (emphasis added)

314 The emphasised portion of this extract is directly applicable to the circumstances that would have prevailed in Dr Christensen's simulated flood

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800 Chapter 8; section 8.2.
801 See Chapter 8 at [54] to [58].
802 Reply Report, EXP.ROD.004.0005_OBJ at [215] to [217].

operations on 11 January 2011, especially from 1.00pm when the Appendix A "with forecast" estimate of downstream flows predicted a peak flow rate at Moggill well in excess of 4000m^3/s. In their submissions on this topic, all of the defendants addressed and emphasised the prevailing conditions on 11 January 2011.[803] However, it is notable that in doing so none of them referred to the various predictions of downstream flows, especially that prediction. Yet in the above passage, and repeatedly in his cross-examination, Dr Christensen emphasised that it was the estimate of downstream flows, especially the 1.00pm Appendix A "with forecast" estimate of downstream flows above 4000m^3/s, that led him to either hold or even reduce release rates depending on other considerations.[804] This was not a "change" in his stated methodology. Instead, it was an application of his stated methodology, namely that once downstream flows were predicted at that level then, provided dam safety concerns could be addressed, a reasonably competent flood engineer would let the dams fill up to EL 74.0m AHD (and in some simulations beyond that, as addressed below).[805]

315 Many of Seqwater's attempts to contrast Dr Christensen's approach with that of the flood engineers on 11 January 2011 overlooked the difference in storage levels between the simulations and the actual events. In fact, as noted, to a large extent Dr Christensen's approach prior to the storage level exceeding EL 74.0m AHD was consistent with the approach of the flood engineers. They also let the dam fill to EL 74.0m AHD through the evening of 10 January 2011 and the morning of 11 January 2011. The critical difference was that, in Dr Christensen's simulations, during the morning and afternoon of 11 January 2011 there would have been storage space below EL 74.0m AHD available in all of his simulations to allow a fill to that point to occur. Put another way, according to Dr Christensen the entire point of using forecasts as a basis to evacuate water to create storage space is to use that storage space to hold flood waters when downstream flows are damaging.[806] This is subject to concerns about dam safety, which Dr Christensen addresses in the

[803] Seqwater subs at [2172] to [2192], SunWater subs at [814] to [849]; State subs at [532] to [534].
[804] T 1174.4 to .22.
[805] T 1808.46 to T 1810.8.
[806] T 1655.38.

above extracts by reference to the forecasts, likely outflows and raising Wivenhoe Dam crest gates high enough to allow for rapid opening if necessary.

316 Seqwater placed particular weight on the emphasised extract regarding SIM C at [299] which refers to the flood engineers' 1.00pm RTFM modelling of rain on the ground inflows which used different loss rates for WDI and CRE to Dr Christensen's rain on the ground loss rates.[807] By 1.00pm, Dr Christensen would have already modelled the most recent (ie, morning) QPF using his loss rates. However, Seqwater noted that after that QPF was issued the inflow rates already exceeded the modelled inflow rates and Dr Christensen did not (hypothetically) redo his modelling at 1.00pm. Seqwater submitted that the difference between Dr Christensen's forecast modelling with his selected loss rates and the flood engineers' rain on the ground modelling with their selected two higher loss rates was "material because the assessment at [1.00pm] is used to determine whether there are risks to the safety of the dams that would require larger releases".[808]

317 This submission is premised on a misunderstanding of the use Dr Christensen made of the flood engineers' rain on the ground modelling in the above extract. Dr Christensen did not use that modelling to determine strategies or the release rates within strategies in attempting to create storage.[809] Instead, Dr Christensen used the RTFM "without forecast" modelling as an estimate of the *minimum* level of anticipated flows that could be expected.[810] As explained, he used that figure for the purposes of determining the minimum height he had to raise the gates to address the risk of overtopping.[811] Dr Christensen explained the approach as follows:[812]

> "…what this calculation [ie by reference to the flood engineers' ROG modelling] is, is, "No, I'm not going to be able to shut my gates entirely. It looks like if I shut my gates partway, I'm going to be able to minimise the

[807] Seqwater subs at [2186].
[808] Id.
[809] Cf Seqwater subs at [2196].
[810] T 1808.34 to T 1809.10.
[811] T 1809.43 to T 1810.8.
[812] T 1653.2 - .12.

> release downstream. *So what's my minimum gate setting? What do I think - or what do I calculate is the minimum I'm going to have to have my gates up*?" That's what you're doing on 1300, is deciding, "It looks like I'm going to have to have my gates up some. What's the minimum setting that I can - I forecast that forces me, basically, to open the gates and flood people downstream?" (emphasis added)

318 Dr Christensen explained that during this phase of simulated flood operations gates are being raised in response to observed inflows to minimise downstream impacts.[813] He explained that the last passage in the above extract at [299] is directed to the steps to be taken to protect against overtopping of the dams.[814] Subject to considering whether his actions above EL 74.0m AHD were compliant with Strategy W4, I accept his explanation.

319 Each of the day-by-day release strategy explanations for the category one simulations contain a similar reference to the flood engineers' 1.00pm RTFM "without forecast" run.[815] However, there is no such reference in the equivalent explanations for the category two simulations (see [310]). This was not explored in the evidence. I suspect that this was because, as at 1.00pm on 11 January 2011, each of those simulations would have been above EL 73.0m AHD and it was otherwise obvious they would exceed EL 74.00m AHD (ie, it was not necessary to use the minimum rain on the ground inflows to determine how far out of the water the Wivenhoe gates had to be lifted).

320 Seqwater also submitted that the concern about overtopping Wivenhoe Dam was not adequately addressed by Dr Christensen.[816] Seqwater submitted that Dr Christensen satisfied himself that this concern was addressed by:[817] inspecting the modelled hydrograph of inflows to determine whether a fuse plug might breach[818] to which an estimate of Somerset Dam outflows could be added;[819] assessing the current rate of rise of the reservoir;[820] assessing that

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[813] T 1654.8.
[814] T 1653.45 to T 1654.10.
[815] EXP.ROD.015.1107; Response Report Vol 2, EXP.ROD.015.0261 at .0385, .0430.
[816] Seqwater subs at [2198] to [2206].
[817] Ibid at [2198].
[818] T 1800.45, T 1802.13.
[819] T 1801.1 - .17.
[820] T 1803.18.

radar showed rain was clearing[821] (although that was incorrect[822]) and, according to Seqwater, "assuming that if further rainfall continued it would be an extreme set of circumstances as that rainfall would have been outside of the forecast".[823] I take the last element of the submission to be a reference to rainfall continuing *beyond* that which was forecast. This is not a complete description of what Dr Christensen relied on. As stated in the above passages from his Response Report and in his oral evidence,[824] his principal reason for being confident that he could address the risk of overtopping Wivenhoe Dam, or avoiding a fuse plug breach, was the ability to raise the gates quickly and his assessment of the spillway capacity. To utilise that capacity, he sought to ensure the crest gates were sufficiently raised out of the water to allow that to occur.[825]

321 Otherwise, another part of Seqwater's submissions on this point concerned Dr Christensen's approach when the storage level was above EL 74.0m AHD of maintaining gate openings in category two simulations.[826] This is a matter I address next and the resolution of which I am satisfied resolves any residual concern over this aspect of Dr Christensen's approach.

322 In its submissions, the State contended that, in his simulation analyses, Dr Christensen included the comment that at 11:00 on 11 January rainfall *"should ease tomorrow*".[827] It contended that there was no factual basis for that statement at that time. It is submitted that Dr Christensen had used the benefit of hindsight to maintain or reduce his gate openings during 11 January 2011 because he knew that on 12 January 2011 the rain had abated.[828]

323 In cross-examination, Dr Christensen said that the "main factual basis [for the statement] is the PME [issued] beforehand at 0000 hours"[829] which was to the

[821] T 1175.1 - .33.
[822] T 1663.42 to T 1664. 8.
[823] Citing T 1803.34.
[824] T 1802.28 - .43.
[825] Cf Seqwater subs at [2201].
[826] Seqwater subs at [2202].
[827] EXP.ROD.015.0461 at .0471, .0552, .0631, .0710, .0788, .0894, .0933, .0984, .1061.
[828] State subs at [536] to [539].
[829] T 2774.46.

effect "that the forecasts for the 12th and the 13th were small".[830] I accept that answer. In his first report, Mr Giles provided a breakdown of the 00UTC daily PMEs available from 6.00pm on 10 January 2011 and available as a four-day forecast from midnight on 11 January 2011.[831] According to that breakdown, the PMEs predicted substantial rain above the dam on 11 January 2011 which the plaintiff estimated as being in the range 25 to 100mm and the defendant estimated as being in the range 15 to 100mm[832] as well as modest falls on 12 January 2011 of around 5mm and no rain on 13 and 14 January 2011.[833] Dr Nathan's georeferencing report includes the 1200UTC PME forecasts available from 5.41am on 11 January 2011 which are not relevantly different.[834]

Flood Operations Above EL 74.0m AHD in Category Two Simulations on 11 January 2011

324 There remains to consider Dr Christensen's simulated flood operations when Wivenhoe Dam was above EL 74.0m AHD. Unlike the flood engineers, it can be seen from the first column in Table 11-9 that, even when Wivenhoe Dam is above EL 74.0m AHD and rising, in SIM F Dr Christensen would have maintained the existing level of gate increments until the Dam exceeded EL 75.0m AHD. A similar approach was adopted in all category two simulations. Mr Ickert sought to address this issue by commencing gate openings after the dam levels exceeded EL 74.12m AHD at 9.00pm on 11 January 2011 and thereafter opening the gates at four increments an hour until he arrested the rise of the water level at 7.00am on 12 January 2011. He says that he then would have closed gates at the target minimum rate stated in the Manual: three increments an hour.[835] Although Mr Ickert's variation is only addressed to SIM F, it appears to be equally applicable to SIM H given that the only apparent difference between SIM F and SIM H is the timing of some gate

[830] T 2775.1.
[831] EXP.QLD.001.0611 at .0794.
[832] AID.500.035.0001 at .0005.
[833] EXP.QLD.001.0611 at .0794; see also EXP.SEQ.014.0219 at .0425, .0426, .0427, .0428 and .0430.
[834] EXP.SEQ.014.0219 at .0433, .0434, .0435, .0436, .0438.
[835] Manual at 33.

openings on the afternoon of 12 January 2011,[836] which is after the point at which Mr Ickert's variation in gate openings would have commenced and thus would supersede that difference.

325 All of the defendants submitted that Dr Christensen's maintenance of existing gate increments while Wivenhoe Dam storage level reached above EL 74.0m AHD and continued to rise was contrary to Strategy W4.[837]

326 SunWater noted that by 5.00pm on 11 January 2011, when SIM G reaches EL 74.0m AHD, there had been large to massive rainfalls in the areas upstream of the dam, prolonged difficulties in modelling the rate of inflow and the prospect of further rain.[838] They also submitted that, just prior to 6.00am on 12 January 2011 when Mr Ickert's varied operations are at or near their peak levels, Mr Ayre's situation report was advising that "[n]o significant rain has fallen over the catchments in the past twelve hours" with "[l]ess than 10 to 15 millimetres of rainfall … expected over the next 24–48 hours".[839] The State made similar submissions.[840]

327 The plaintiff noted[841] that inflow rates were reducing during the evening of 11 January 2011,[842] that the radar indicated little rain above the catchment at that time,[843] and modelling undertaken through that evening indicated that inflows were projected to decrease.[844] The plaintiff also noted that, by the evening of 11 January 2011 when Mr Ickert suggested opening gates, the flood engineers commenced closing them.[845] Mr Tibaldi stated that they commenced closing gates that evening once they were "confident that the rain had cleared the catchment".[846]

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[836] Simulation Analysis, EXP.ROD.015.0461 at .0863 and .0948.
[837] Seqwater subs at [2202] to [2203]; State subs at [542]; SunWater subs at [1433] to [1442].
[838] SunWater subs at [845].
[839] Ibid at [841].
[840] State subs at [534] to [543].
[841] Plaintiff subs at [1874].
[842] T 8348.14 (Ickert).
[843] T 8349.43 (Ickert); ROD.529.001.5070.
[844] QLD.001.001.3392; QLD.001.001.3455.
[845] Plaintiff subs at [1879].
[846] T 5585.6.

328 I have addressed the requirements of Strategy W4 in Chapter 3[847] and the approach adopted by the flood engineers above EL 74.0m AHD on 11 January 2011 in Chapter 7.[848] At all times the outflows in Dr Christensen's simulations were less than 4000m^3/s. Mr Ickert's suggested rate of gate openings from EL 74.12m AHD was slightly in excess of that adopted by the flood engineers when Wivenhoe Dam was rising above EL 74.0m AHD and outflows were less than 4000m^3/s.[849] However, the critical difference between the category two simulations and the actual events of 11 January 2011 is that, in the category two simulations, the rise above EL 74.0m AHD occurs much later on 11 January 2011. Under Dr Christensen's simulations, the rise above EL 74.0m AHD would have been occurring when the rate of inflows was decreasing and via reverse routing would have been seen to be decreasing. By around 9.00pm on 11 January 2011, the rain had stopped falling. At that time the flood engineers had access to the daily PMEs which suggested rain the following day that was consistent with the afternoon QPF ("rain easing to 30mm") and, most importantly, a forecast of the weather being clear thereafter.[850] However, that said, anything more than minimal rain was still significant given the saturated state of the catchment and the height of both dams.

329 Nevertheless, given the wording of Strategy W4 and the priorities of the Manual, I am not satisfied that a reasonably competent flood engineer would or must have held gate openings while Wivenhoe Dam above EL 74.0m AHD in the manner proposed by Dr Christensen in SIM F and SIM H. Given the circumstances prevailing on the evening of 11 January 2011, especially the observable drop in inflows due to the cessation of rain and the more positive forecasts, Mr Ickert's proposed flood operations represent a very conservative approach to addressing dam safety (and in that sense represent an approach of a reasonably competent flood engineer that is the most favourable to the defendants). However, it is still one that a reasonably competent flood

[847] Chapter 3; section 3.3.11.
[848] Chapter 7 at [378] to [386].
[849] See Table 7-4 in Chapter 7 at [378]: flood engineers raised gates 11 increments over 3 hours = 3.67 increments/hr; Ickert raised gates 32 increments over 8 hours = 4 increments/hr.
[850] See Chapter 7 at [387] to [388].

engineer could have reasonably adopted in the circumstances. I accept SunWater's submission to that effect.[851] The same reasoning applies in relation to each of the other simulations that take Wivenhoe Dam's water levels substantially above EL 74.0m AHD.[852]

330 Seqwater submitted that Mr Ickert incorrectly asserted that his gate opening sequences were based on the flood engineers' approach, which in fact involved making gate openings of approximately eight increments per hour (when outflows are above 4000m^3/s). [853] Seqwater is correct in submitting that Mr Ickert was incorrect in that respect but it does not matter. All of Dr Christensen's simulations involve outflows of less than 4000m^3/s and only three hours of Mr Ickert's releases involve outflow rates above 4000m^3/s whilst Wivenhoe Dam was rising (and that occurred while inflow rates were falling).[854] In contrast, most of the flood engineers' releases during the relevant period exceeded 4000m^3/s[855] such that any comparisons are inapposite. The relevant comparison is with the flood engineers' first three sets of hourly openings while the dam was above EL 74.0m AHD (ie, 3 per hour, 5 per hour and 3 per hour)[856]. I have already rejected Seqwater's contention that gate openings at the rate of six increments per hour were required when the rate of releases was less than 4000m^3/s.[857] Otherwise, I note that Mr Ickert's varied gate openings above EL 74.0m AHD involved raising the gates higher than suggested by Dr Christensen and thus further reducing the risk of overtopping. By midnight on 12 January 2011, with his variation all gates are at least 4.5m open.[858]

331 The plaintiff contended that, even if the dams had been operated in Dr Christensen's Simulations B, D, F, G, H and J as varied in the manner suggested by Mr Ickert, a better flood outcome would have eventuated than the outcome of the January 2011 Flood Event. To that end they adduced

[851] SunWater subs at [848].
[852] Ie, SIM B, SIM D, SIM H, SIM G and SIM J.
[853] Seqwater subs at [2207].
[854] See above at [309].
[855] Table 7-4; Chapter 7 at [378] to [379].
[856] Chapter 7 at [381].
[857] Chapter 3 at [302].
[858] 48 increments; See Manual at 35.

evidence from Dr Altinakar as to areas of downstream flooding that would result from the adoption of those variations.[859] That evidence is addressed in Chapter 13.

332 Each of Seqwater and SunWater contended that it was not open on the pleadings for the plaintiff to contend for counterfactual operation of the dams that reflect Mr Ickert's variations as such operations would not be "substantially in accordance" with Dr Christensen's simulations,[860] being the relevant phrase used in the pleadings.[861]

333 I do not agree. Mr Ickert's variations alter the gate operations for approximately 20 hours over a simulation that occupies many days. They were set out in a report filed on behalf of SunWater in November 2017. His approach reflected a long-standing dispute between the parties as to the proper construction of Strategy W4, a dispute that was largely resolved in the defendants' favour. Mr Ickert's modification to Dr Christensen's simulations means that the simulated flood operations on 11 January 2011 in the category two simulations would have been broadly similar to the flood engineers' operations, namely allowing the flood pool to fill when downstream flows were very high then evacuating water above EL 74.0m AHD in compliance with the Manual's dam safety concerns. All of the defendants had the opportunity to cross-examine Dr Altinakar on the causation aspect of the adoption of Mr Ickert's variations.[862] A counterfactual based on Mr Ickert's variations to Dr Christensen's simulated operations is within the pleaded case.

9.8: Closing the Somerset Dam Crest Gates

334 As noted in Chapter 8, two of Dr Christensen's simulations assume that the Somerset Dam crest gates can be closed: SIM I and SIM J. In SIM I, the crest gates would have commenced being closed at 1.00am on 10 January 2011

[859] See *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 20)* [2019] NSWSC 287.
[860] SunWater subs at [751].
[861] See for example PLE.010.001.0001 at [211], particular D.
[862] See Chapter 13.

with Somerset Dam at EL 101.73m AHD and with one sluice gate open.[863] By 8.00am, all eight crest gates would have been fully closed with two sluice gates remaining open.[864] The last crest gate closure would have occurred when Somerset Dam was at EL 102.58m AHD, being almost two metres above the fixed crest level of EL 100.45m AHD. Thereafter the crest gates would have remained closed and flow from Somerset Dam would have been controlled through the sluice gates.[865] In SIM I, Somerset Dam would have peaked at EL 106.95m AHD.[866]

335 In SIM J, which commenced at midnight on 8 January 2011, closure of the crest gates would have begun as soon as the simulation started, with all gates closed by 8.00am on 8 January 2011 and with three sluice gates remaining open.[867] At the time of the last gate closure, Somerset Dam would have been well below the crest level, sitting at EL 100.24m AHD.[868] The gates would have remained closed thereafter. In SIM J, Somerset Dam would have peaked at EL 106.93m AHD.[869]

336 Seqwater raised two challenges to the closure of the Somerset Dam crest gates in these simulations. First, it contended that Dr Christensen's evidence was inconsistent in that he simulated flood operations with the Somerset Dam crest gates closed when in Strategy W3 or W4A but agreed that the Manual stated that they could only be closed when Strategies W4B and S3 were engaged.[870] Second, it contended that the safety risks associated with the uncertainty surrounding the dam failure level with the gates closed are such that the Court could not be satisfied that a reasonably competent flood engineer would have closed the gates at all.[871]

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863 Simulation Analysis, EXP.ROD.015.0461 at .1007.
864 Id.
865 Simulation Analysis, EXP.ROD.015.0461 at .1007 to .1015.
866 Ibid at .1009.
867 Simulation Analysis, EXP.ROD.015.0461 at .1074.
868 Id.
869 Simulation Analysis, EXP.ROD.015.0461 at .1077.
870 Seqwater subs at [2240] to [2248].
871 Ibid at [2268] to [2291].

337 Given that I accept the second submission, it is not necessary to address the first submission in any detail. However, it suffices to state that having reviewed the passages of transcript relied upon I do not accept it. In his oral evidence, Dr Christensen endeavoured to explained that in SIM I he closed the gates when the no release rises were sufficient to invoke Strategy W4B/S3, even though with the gates closed he chose to orientate towards the Operating Target Line consistent with an S2 strategy.[872]

338 In relation to Seqwater's second submission, the starting point is the Manual. Section 3.2 of the Manual provides that the "structural safety of Somerset Dam … is of paramount importance".[873] The Manual notes that Somerset Dam can withstand limited overtopping to a point of "at least 2.2 metres of overtopping without failure, provided all radial gates are open" (ie, EL 109.70m AHD).[874] In section 9.3, the Manual notes that the "failure level of 109.70m AHD for Somerset Dam assumes all radial gates are fully open and this failure level will be reduced if this cannot be achieved".[875] Thus, Seqwater noted that a failure level in the case of the gates being closed is not specified.[876] Otherwise, the Manual refers to keeping the crest gates open at least in Strategy S1 and S2.[877] The gate opening sequence description in section 9.5 of the Manual does not specify any minimum intervals for opening crest gates at Somerset Dam. Instead, it simply states that the crest "[g]ates are normally open".[878] Appendix F to the Manual, which describes the Somerset Dam Auxiliary Equipment, provides that the "[t]he normal operating procedure for Somerset Dam in the event of a flood requires the spillway gates to be raised to provide an uncontrolled spillway followed by opening of the low level outlets some time later".[879]

339 In his report, Mr Christopher Dann identified two "key risks" from operating the Somerset Dam crest gates during a flood event in the manner proposed by Dr

[872] T 1834.42; T 1836.30.
[873] Manual at 9.
[874] Ibid at 10.
[875] Ibid at 41.
[876] Seqwater subs at [2273(a) and (b)].
[877] Manual at 40 to 41.
[878] Ibid at 43.
[879] Manual at 66.

Christensen.[880] The first was that closing the gates stores more water in Somerset Dam and subsequently increases the risk of overtopping the dam. Mr Dann stated that "[i]f the reservoir level exceeds EL 107.46m this is likely to cause erosion of the abutments, potentially undermining the toe of the monoliths leading to failure of the dam". The second was the potential for one or more gates to fail to open which "would reduce the spillway discharge capacity and hence raise the reservoir level."[881] In relation to the second risk, in 2004 a report by the Snowy Mountain Engineering Corporation included a gate reliability assessment which "indicates the most likely gate operation scenarios are for all gates to open (86.6%), or 1 gate fail[ing] to open (13%)" with "multiple gate failure[s] … relatively unlikely, and virtually dependent on a common cause event".[882]

340 In relation to the first risk, numerous historical assessments of Somerset Dam were tendered.[883] They provided various assessments of the potential failure level of Somerset Dam. The plaintiff referred to a report prepared in 2000 entitled "South East Queensland Water Board: Safety Review, Report on Somerset Dam"[884] which noted that "[u]nder PMF [probable maximum flood] conditions with the gates closed the dam is stable with the exception of the non-overflow blocks above RL100.5 [Reservoir level] where failure is likely when the reservoir level exceeds 109.7m".[885] The plaintiff noted that a number of other reports "did not consider the failure level with the gates closed in any detail let alone quantify what that level may be",[886] although two of them raised concerns about closing the gates into substantial flow.[887]

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880 EXP.SEQ.003.0113 at .0120 (Dann).
881 Id.
882 SEQ.006.002.0261 at .0261.
883 See LAY.SEQ.002.0001 at [77] (Maher).
884 SEQ.004.036.6673.
885 Ibid at .6684; Plaintiff subs at [954].
886 Plaintiff subs at [954], referring to: Preliminary Risk Assessment Wivenhoe, Somerset and North Pine Dams - Final Report, Appendix B (March 2000), SEQ.004.036.7154; Somerset Dam - Detailed Risk Assessment of Project (August 2004), SEQ.006.002.0261; Somerset and North Pine Dams: Dam Safety Review (December 2004), SEQ.006.001.7576; Somerset Dam: Stability of Abutment Monoliths (May 2005), SEQ.006.001.7498.
887 SEQ.006.001.7576 at .7591; SEQ.006.001.7498 at .7524.

341 Seqwater placed particular emphasis on an earlier safety review undertaken in 1995 (the "1995 Safety Report")[888] which included the following statement:[889]

> "On the basis of the assumed 'normal' parameters, the dam meets the current structural guidelines with the reservoir at FSL however, if the radial gates are closed during a flood (as is allowed by the current flood operational rules) the upper section of the Monoliths are likely to fail through overturing. *Assuming zero tensile strength at the upper gallery level (as a result of the cracking), the imminent failure flood level (IFF) with the radial gates closed is RL 105.7* and the IFF with the radial gates open is RL 109.1. There is insufficient data available to define the loss of strength in the dam caused by the cracking. If lower bound strength parameters are adopted the dam would not meet current structural guideline requirements." (emphasis added)

342 In 1996, a consulting engineer, Mr Ben Russo, reviewed the 1995 Safety Report.[890] He noted that this conclusion was based on a "very conservative assumption" as to tensile strength[891] but, given its conclusion, added:[892]

> "2(a): The IFF water levels have been calculated by the reviewers as EL 105.7 with the radial gates closed and EL 109.1 with the gates open. It is unusual to combine an extreme load case such as the PMF with gates closed, but the reason given is that the existing flood manual states that although the gates are to be normally open during a large flood they can be closed to endeavour to prevent overtopping of Wivenhoe Dam if such an eventuality were to arise.
>
> The writer's comment on the above is that with the above IFF it would be too dangerous to close the gates for water levels above 105.7 and this should be written into the flood manual. Better still, it would be preferable to lock the gates open to prevent them being lowered."

343 Since 2008, Mr Tibaldi has been the Principal Engineer – Dam Safety and Flood Operations for Seqwater.[893] In September 2010, he completed the "Somerset Dam: Five Year Comprehensive Dam Safety Report" (the "Somerset 2010 Report"). The Report "noted that recent structural reports calculate that the dam is over stressed if the radial gates are closed when the dam lake level exceeds 105.7 metres AHD and this issue should be noted in

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888 SEQ.006.002.0001; Seqwater subs at [2277(b)].
889 Ibid at .0008.
890 SEQ.004.036.0982.
891 Ibid at .0984.
892 Id.
893 LAY.SEQ.004.0001_2 at .0007, [1] to [2].

the flood operations procedures."[894] It also recommended that "appropriate arrangements [be inserted] into the … Flood Operations Procedures to account for the dam becoming over stressed if the radial gates are closed when dam water levels exceed 105.7 m AHD."[895]

344 The reference section to the Somerset 2010 Report lists the reports it relied on.[896] Most, if not all of them, were tendered in these proceedings. Even so, it is not clear what the "recent structural reports" were that Mr Tibaldi was referring to, unless it was the 1995 Safety Report and Mr Russo's 1996 report.

345 On any view, the Manual contemplates that, generally, during flood operations the Somerset Dam crest gates should not be closed. It also appears to allow for the possibility of their being closed when S3 is invoked but leaves the flood engineer in a state of uncertainty about what the revised failure level is, or might be, in the event that gate closing occurs. Perhaps the Manual allowed for the possibility that more evidence of a definitive maximum height to operate the crest gates might emerge which would enable the flood engineer to make a judgment accordingly. However, this evidence did not emerge. To the contrary, at least as late as 2010, Mr Tibaldi was still (apparently) affording weight to the assessment undertaken in 1995 that the failure level may be as low as EL 105.7m AHD. Accepting that the Manual allows for the possibility that in W4B/S3 the gates might be closed, I do not accept that a reasonably competent flood engineer would have to take such a step in the face of the uncertainty about the dam's failure level suggested by the combination of the Manual and the various reports, notwithstanding the obvious flood mitigation benefits that would derive from the far greater control that closing gates would confer over Somerset Dam outflows. I note that, when assumptions were put to Dr Christensen that were said to reflect at least some of the material relied on by Seqwater, he accepted that a reasonably competent flood engineer would determine not to close the crest gates.[897]

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894 SEQ.001.001.6895 at .6924.
895 Ibid at .6925 and .6931.
896 Ibid at .6933.
897 T 1775.14.

346 It follows that I do not accept that a reasonably competent flood engineer confronted with the circumstances prevailing as at midnight on 2 January 2011 would have conducted flood operations in accordance with so much of SIM I that involved the closure of the crest gates at Somerset Dam. Similarly, I do not accept that a reasonably competent flood engineer confronted with the circumstances prevailing as at midnight on 8 January 2011 would have conducted flood operations in accordance with so much of Dr Christensen's SIM J that involved the closure of the crest gates at Somerset Dam.

9.9: Dr Christensen's Somerset Dam Operations

347 Dr Christensen's approach to Somerset Dam flood operations in his various simulations is outlined in Chapter 8. Again, there were numerous criticisms of his approach made by the defendants.

His Own S2 Target Line

348 Seqwater's submissions characterised Dr Christensen's approach as involving him determining "his own S2 target line".[898] Similarly, the State cited Mr Fagot's evidence and contended that Dr Christensen created his "own balancing target line[s]" to abide by during a flood event.[899] Save for one exception, these submissions mischaracterise Dr Christensen's approach.

349 The approach described in section 8.6 of Chapter 8 simply involves Dr Christensen explaining his approach to either progressing towards the Operating Target Line or conducting flood operations in Strategies W4B/S3. When Strategies W4B/S3 are engaged, the Manual provides express permission to temporarily depart from the "operating protocols"[900] and "[r]etain water in Somerset Dam"[901] to prevent a fuse plug initiation. The only guidance provided is to protect the safety of Somerset Dam and not let it exceed EL 109.7m AHD.[902] Dr Christensen explained that his approach simply involved a

[898] Seqwater subs at [2219].
[899] State subs at [558].
[900] Manual at 42.
[901] Ibid at 31.
[902] Ibid at 42.

"diagrammatic representation of the Manual's permission to depart from the S2 operating target line".[903] This is yet another instance of the contrast between this Manual and the highly prescriptive water control manuals which experts such as Mr Fagot are familiar with and relied upon. In those circumstances, there is no basis for criticising Dr Christensen for enunciating an approach to adopt on a matter which the Manual said could occur but was silent as to how.

350 The exception to this concerns a statement in Dr Christensen's February 2015 Report that the orange line in Figure 38 of that report "should have been used whether in S2 or S3 operations to maximise the flood mitigation capabilities of both dams operated in tandem so long as overtopping of either dam was not a likely concern".[904] In his Reply Report[905] and in cross-examination,[906] Dr Christensen confirmed that this line was only applicable to the circumstance where the Somerset Dam crest gates could be closed during flood operations.

Equating Wivenhoe EL 74.0m AHD With Overtopping At Somerset Dam

351 Seqwater also submitted that Dr Christensen equated overtopping Somerset Dam at EL 107.46m AHD with an equivalent lake level of EL 73.0m or 74.0m AHD in Wivenhoe Dam[907] and referred to Mr Fagot's evidence to that effect.[908]

352 Dr Christensen did not adopt this approach. Instead, he nominated those levels as significant for maximising the flood mitigation benefits of the dam and protecting dam safety. In his February 2015 Report, he explained that "if there is no 'best available forecast' chance of overtopping the 107.46m Somerset Dam crest level, a reasonably competent flood operations engineer would recognise that flood water could reasonably be stored behind Somerset Dam to prevent a water level rise to 74.0m at Wivenhoe Dam and maximise

[903] See Chapter 8 at [123]; Reply Report, EXP.ROD.004.0005 at [193].
[904] February 2015 Report, EXP.ROD.001.0016 at [352].
[905] Reply Report, EXP.ROD.004.0001 at [194].
[906] T 1203.19 and T 1203.37.
[907] Seqwater subs at [2217].
[908] Ibid at [2227] to [2230].

urban flood mitigation".[909] As noted, in his oral evidence Dr Christensen emphasised the importance of choosing a target point below EL 107.46m AHD.[910] Otherwise, I note that Mr Fagot's evidence was addressed in Chapter 3.

The Target Point Is To Be Avoided

353 I have described Dr Christensen's approach to the selection of the target point in Chapter 8.[911] Both Seqwater[912] and the State[913] were critical of one part of Dr Christensen's evidence in which he stated that the selected target point was a point to be "avoided". In its submissions,[914] the State extracted the following questions and answers from Dr Christensen's cross-examination:[915]

> A. That is - you're not trying to hit that target point. You're trying to keep it from getting there. All right? You're –
>
> Q. So the target point is something to be avoided by setting releases from Somerset?
> A. The target point on the S2 line is where you go if you have to.
>
> Q. It's an undesirable end position, or something, is it?
> A. That's incorrect. It's desirable for a flood - for a dam overtopping position. But if you are trying to do both, dam overtopping protection and releases, and minimise downstream impacts, it's undesirable under the second criteria to head directly for that target line, because it doesn't meet the second criteria. You're still not - your dams are still above - your forecast tells you that your dams are not going to overtop at 109.7 and 80, and given that information, even with the no release rise, then the next part - then with the no release rise, you've taken care of the dam safety concern. You know what the dam safety concern is, at the very highest. And then you say, but if I go to that level on the dam - that line - on the S2 line, I need to trend toward it to continue to protect my dam, but I should - but to protect people downstream, I should temper that and not go directly toward it, or not go directly straight up to the S2 line and not do my best to get to the S2 line and then follow it."

[909] February 2015 Report, EXP.ROD.001.0016 at [355].
[910] See Chapter 8 at [119]; T 1194.18.
[911] Chapter 8 at [118] to [121].
[912] Seqwater subs at [2209(a)].
[913] State subs at [547].
[914] Id.
[915] T 1798.16.

354 The State submitted that this answer was "nonsensical" and that Dr Christensen's "approach is fundamentally inconsistent with the fundamental aim of the target line".[916]

355 I do not agree. Insofar as Dr Christensen stated that the target point is a point that you are trying to "keep it [the Dam water levels] from getting there" and is a point "where you go if you have to", Dr Christensen was merely emphasising that orientating tandem flood operations towards a target point was a necessary aspect of ensuring dam safety but that tempering the approach of travelling directly towards the Operating Target Line before that point allowed for a better flood outcome in terms of downstream effects. This reflects the statement in the Manual that the "intent" of Strategy S2 "is to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dam".[917]

356 This can be illustrated by considering the tandem dam operations lines for each of SIM G and SIM E. The SIM G line is the green line in the following graph:[918]

[916] State subs at [548].
[917] Manual at 40.
[918] Simulation Analysis, EXP.ROD.015.0461 at .0914.

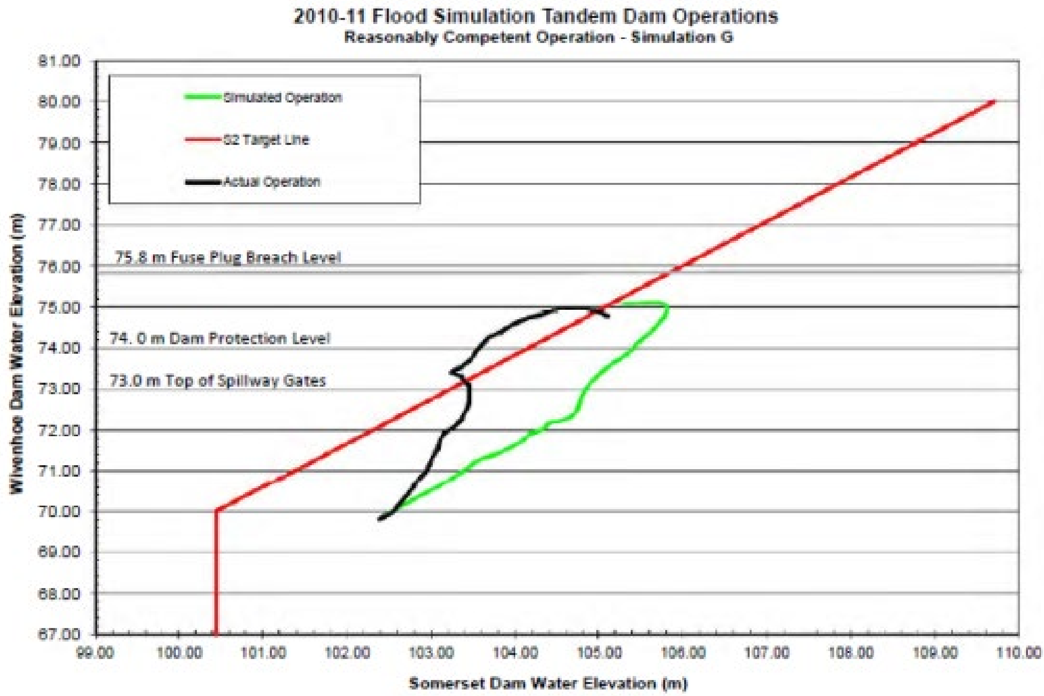

Figure 9-5: Tandem Dam Operations Line for Dr Christensen's Simulation G

357 In SIM G, with that part of flood operations in which Wivenhoe Dam is above EL 73.0m AHD until the green line evens out when Wivenhoe Dam is around EL 75.0m AHD, it can be seen that that line is orientating towards a point on the Operations Target Line below the overtopping level for Somerset Dam of EL 107.46m AHD.[919] Even though the forecast levels in both dams would enable a movement to Strategies W4B/S3 (ie, the green line moving to the right) no more water can be stored in Somerset Dam given that from one hour after SIM G commenced, all sluice gates were closed[920] and the operating assumption was that the crest gates had to remain open. Once the rainfall clears and Wivenhoe Dam inflows ease, then the sluice gates in Somerset Dam are opened and the simulated operations line trends sharply back to the Operating Target Line. Thus, consistent with the above answer, the target point was a point to *avoid* as a fuse plug breach would most likely have occurred in the course of getting there. However it was a point "*where you go if you have to"*, namely, if large inflows persisted. The utility of the target point was that it was a guide to making sure that either Somerset Dam would not be

[919] Most likely around EL 106.50m AHD to EL 106.80m AHD.
[920] Simulation Analysis, EXP.ROD.015.0461 at .0905.

overtopped, or at the very least that the target line would be reached before Somerset Dam was overtopped with the risk of dam failure thus equalised. As soon as the forecasts and actual conditions, including downstream operations, permitted, flood operations returned sharply to the Operating Target Line by the opening of the sluice gates at Somerset Dam.

358 The SIM E tandem dam operations line is the green line in the following graph:[921]

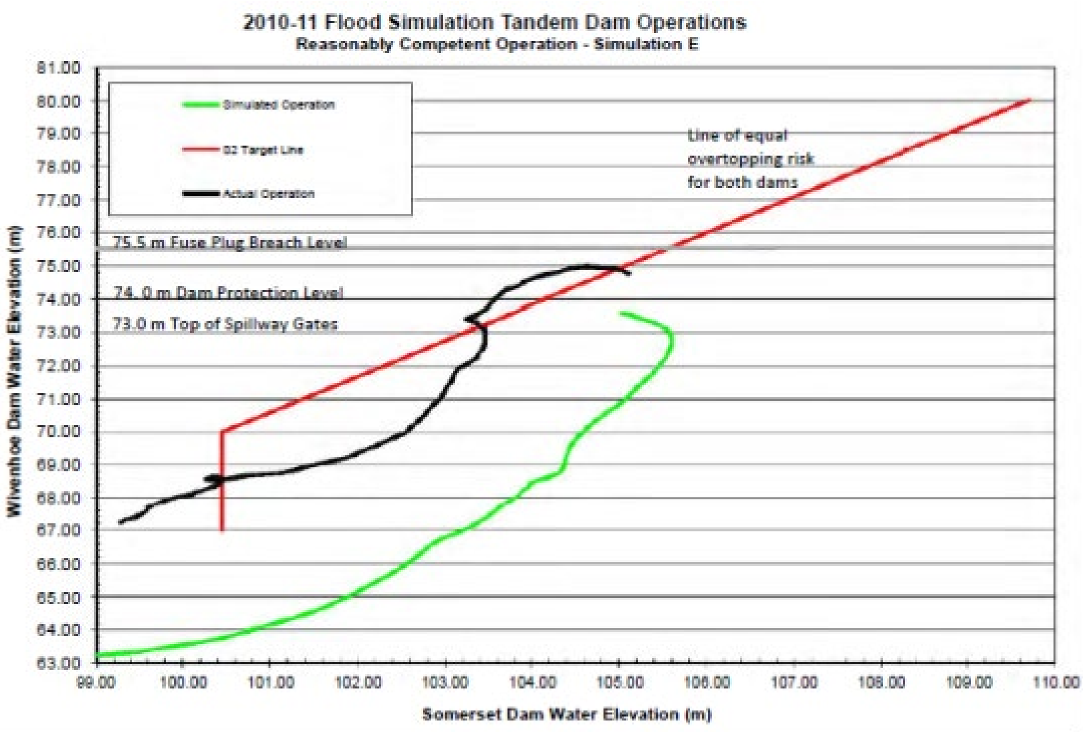

Figure 9-6: Tandem Dam Operations Line for Dr Christensen's Simulation E

359 In SIM E, Somerset Dam does not exceed EL 100.45m AHD until around 8.00 to 9.00pm on 9 January 2011[922] and from that time until 9.00pm on 13 January 2011 all of the sluice gates remain closed.[923] After 9.00pm on 13 January 2011 the sluice gates are progressively opened, which corresponds with the sharp turn towards the operating target line at the end of the green line.[924] Until that time, it can be seen that with all the sluice gates

[921] Simulation Analysis, EXP.ROD.015.0461 at .0814.
[922] Ibid at .0795.
[923] Ibid at .0804.
[924] Ibid at .0807.

closed the green line is still trending towards a point on the Operating Target Line that is below EL 107.46m AHD.

Suggested Proper Approach

360 During Dr Christensen’s cross-examination by Senior Counsel for Seqwater, it was suggested that the proper approach to tandem dam operations involved four steps, namely:[925]

> “… step 1, you address Wivenhoe Dam first. You model predicted inflows to Wivenhoe and predicted releases from Wivenhoe and, from that, you identify a predicted peak level of Wivenhoe. Step 2, you plot that predicted Wivenhoe peak level on the operating target line. Step 3, you identify what's the corresponding level on that graph for Somerset. Step 4, you take the predicted inflows to Somerset and you devise a release plan for Somerset which will have Somerset peak at that corresponding peak level”.

361 It is not clear whether this truly encapsulates the flood engineers’ approach. However, in its submissions, Seqwater contended that it was the correct approach required by the Manual.[926]

362 Dr Christensen criticised the approach suggested in [360] as not maximising the storage capacity of Somerset Dam to avoid flooding downstream.[927] In addition to the point made by Dr Christensen, this suggested approach has a number of other difficulties. First, to comply with the Manual, the first step would have to involve the predicted peak level being determined by, or at least based on, forecast rainfall,[928] a step the flood engineers did not perform and the defendants did not advocate for. Second, in any event, this approach is inconsistent with the Manual because it excludes any role for the estimated maximum storage level at Somerset Dam where the Manual provides that the target point is to be “based on this maximum storage level” as well.[929] Instead, it appears to make the maximum storage level of Somerset Dam solely dependent on the maximum storage level of Wivenhoe Dam. Third, the combination of the first and fourth steps will lead to circularity because the

[925] T 1398.13.
[926] Seqwater subs at [2225].
[927] T 1399.6.
[928] See Manual at 42.
[929] Id.

predicted maximum storage level of Wivenhoe Dam will in part depend on the volume of outflows from Somerset Dam. Fourth, in any event, unless inflows using forecasts as well as rain on the ground at Somerset Dam are modelled it will not be known whether a release plan for Somerset Dam can be devised which will bring it to a point on the Operating Target Line given that uncontrolled releases occur above EL 100.45m AHD.

363 Thus, the difference between Dr Christensen's approach and that advocated by Seqwater appears to be, as just explained, that the latter construes the Manual as requiring the conduct of flood operations along the Operating Target Line where, on Dr Christensen's approach, the Manual does not necessarily require that. Instead, consistent with the object of maximising the flood mitigation benefits of the dam, Dr Christensen construed the first two points on page 42 of the Manual as allowing movements towards the line in a progressive manner and at times a deviation away. As noted in Chapter 3,[930] Mr Ickert accepted that the Manual does not necessarily require flood operations be conducted along the operating target line.[931]

Flood Operations When Somerset Dam Below EL 100.45m AHD or Wivenhoe Dam Not Rising

364 One matter that arises out of the parties' submissions concerns flood operations at Somerset Dam when the dam is below is EL 100.45m AHD or Wivenhoe Dam is not rising. The Manual is clear in that its statement relating to Strategy S2 that the Operating Target Line is "generally [to] be followed" is not engaged unless both Wivenhoe Dam is rising and Somerset Dam is above EL 100.45m AHD.[932] Mr Ayre's directive sent on the morning of 8 January 2011 is consistent with this.[933]

365 A related issue is the approach to be adopted when Wivenhoe Dam is rising and the level of Somerset Dam is below EL 100.45m AHD.[934] The first box in

[930] Chapter 3 at [88].
[931] T 8463.40.
[932] Manual at 40; cf Seqwater subs at [2237].
[933] SEQ.001.018.4107; Chapter 7 at [47].
[934] See Seqwater subs at [2235] and Plaintiff subs at [1837].

S2 provides that in those circumstances the crest gates are to be raised and the "low level regulators and sluices are *generally* [to be] kept closed".[935] In his evidence, Mr Pokarier asserted that the keeping of the sluice gates closed was one aspect of "an effort to move towards the interaction line".[936] The plaintiff submitted that this was incorrect and that this box corresponded to section 9.2 of the Manual as an initial flood control action.[937] Seqwater submitted that it is a general prohibition[938] and referred to a statement by Dr Christensen that to the best of his recollection "there were no simulations when the regulators and sluices were kept closed, in circumstances when Wivenhoe Dam was rising and Somerset Dam was below EL 100.45m AHD".[939]

366 I do not accept that the first box in S2 amounts to a general "prohibition" as contended for by Seqwater. A statement that they are "generally [to be] kept closed" does not support that approach. Mr Ickert agreed that "if an engineer was of the view that making releases through the low level regulators or sluices was desirable for achieving one of the objectives in the manual, they would be entitled to do so". He also agreed that Dr Christensen's simulations are not in contravention of the Manual by reason of opening sluice gates and regulators.[940]

367 The flood engineers did not treat this part of the Manual as a prohibition. They opened sluice gates at Somerset Dam at 7.00pm on 7 January 2011 when it was at EL 100.15m AHD.[941] Somerset Dam did not exceed EL 100.45m AHD until after 1.00pm on 9 January 2011.[942] Wivenhoe Dam was rising from 7.00pm on 7 January 2011 until 11.00pm on 8 January 2011 and then from 10.00am to 11.00am on 9 January 2011 onwards.[943]

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[935] Manual at 40.
[936] EXP.SEQ.016.0012 at [310].
[937] Plaintiff subs at [1840].
[938] Seqwater subs at [2235].
[939] Ibid at [2238] citing T 1821.17.
[940] T 8466.12 - .22.
[941] January FER at .0464.
[942] Ibid at .0466.
[943] Ibid at .0450 to .0452.

368 When he was cross-examined on this topic, Dr Christensen sought to explain his approach but the questioning did not elicit it.[944] In fact, no regulators or sluice gates at Somerset Dam would have been opened below EL 100.45m AHD in any of SIM F,[945] SIM G or SIM H. In SIM B and SIM D, regulators and sluice gates would have been open below EL 100.45m AHD, but only when Wivenhoe Dam was either slightly rising, steady or slightly falling.[946]

369 In SIM A, two regulators would have been opened while Somerset Dam was under EL 100.45m AHD and Wivenhoe Dam was rising for seven hours between 2.00pm and 9.00pm on 9 January 2011.[947] In SIM C, two sluice gates would have been open while Somerset Dam was under EL 100.45m AHD when Wivenhoe Dam was rising for an eight and a half-hour period between 2.00pm and 10.30pm on 9 January 2011.[948] In SIM E, one sluice would have been open while Somerset Dam was under EL 100.45m AHD when Wivenhoe Dam was rising for a six-hour period between 3.00pm and 9.00pm on 9 January 2011.[949] At least so far as the afternoon and evening of 9 January 2011 are concerned, the increase in inflows, especially at Somerset Dam,[950] and the prevailing dire forecasts, warranted the departure from the general statement provided in the first box of S2.

S3 Operations

370 Seqwater's submissions were critical of Dr Christensen for "unreasonably selecting Strategy S3".[951] To the extent necessary, those criticisms will be addressed in relation to each simulation.

371 At this point it suffices to note that Dr Christensen's invocation of Strategy W4B is only of significance to those simulations in which he closes the Somerset Dam crest gates (ie, SIM I and SIM J). In all of his other

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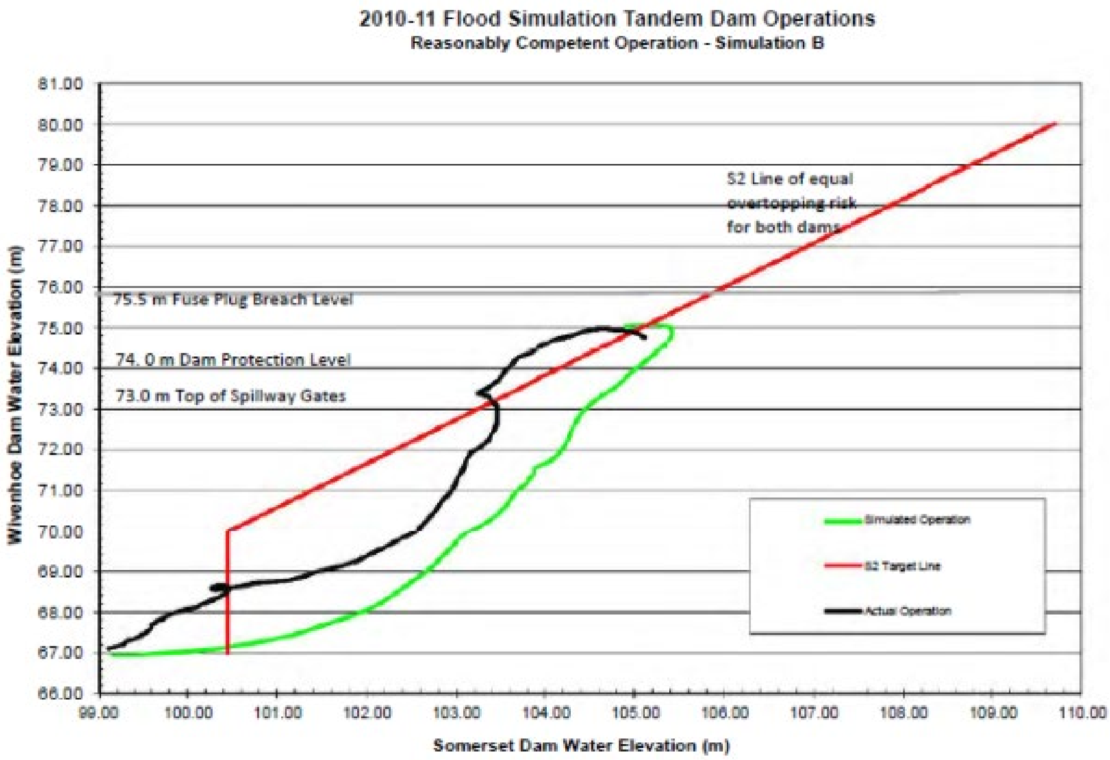
944 T 1821.17.
945 Except at commencement: Simulation Analysis, EXP.ROD.015.0461 at .0860.
946 Simulation Analysis, EXP.ROD.015.0461 at .0570 to .0575 and .0729 to .0731.
947 Ibid at .0493.
948 Ibid at .0652.
949 Ibid at .0804.
950 At 4.00pm they were 5108m^3/s: Simulation Analysis, EXP.ROD.015.0461 at .0639.
951 Seqwater subs at [2249] to [2267].

simulations in which W4B was invoked by a forecast height, in the latter part of the simulated flood event as Somerset Dam's height climbs above EL 104.0m AHD, the respective water levels trend towards, and not away from, the Operating Target Line.[952] The reason for this is relatively simple, namely that in the latter part of the event in these simulations the sluice gates were already either fully or nearly fully closed so that there was no further step, or only limited steps, that could be taken to retain water in Somerset Dam as part of the invocation of Strategy S3. Instead, uncontrolled spillage would have been occurring above EL 100.45m AHD at a rate that increased with the height of the water level in Somerset Dam and which moved dam heights towards the Operating Target Line.

372 This is evident in following tandem dam operations line for SIM B:[953]



[952] SIM B: Simulation Analysis, EXP.ROD.015.0461 at .0586; Response Report Vol 2, EXP.ROD.015.0261 at .0313 re W4B; SIM C: Simulation Analysis, EXP.ROD.015.0461 at .0664, Response Report Vol 2, EXP.ROD.015.0261 at .0337 to .0338 re W4B; SIM D: Simulation Analysis, EXP.ROD.015.0461 at .0744; Response Report Vol 2, EXP.ROD.015.0261 at .0356 re W4B; SIM F: Simulation Analysis, EXP.ROD.015.0461 at .0871, Response Report Vol 2, EXP.ROD.015.0261 at .0392 re W4B; SIM G: Simulation Analysis, EXP.ROD.015.0461 at .0914, Response Report Vol 2, EXP.ROD.015.0261 at .0406 to .0407 re W4B; SIM H: Simulation Analysis, EXP.ROD.015.0461 at .0933 re W4B, at .0956 re Operating Target Line.
[953] Simulation Analysis, EXP.ROD.015.0461 at .0586.

Figure 9-7: Tandem Dam Operations Line for Dr Christensen's Simulation B

373 In SIM B, W4B would not have been engaged until 2.00pm on 11 January 2011.[954] Two sluice gates were open at that point and one would have been closed at 6.00pm on 10 January 2011 and the other at 7.00pm the following night.[955] Dr Christensen noted that, even with these gate closures, water levels still trend towards the Operating Target Line.[956] The reduction in the height of Somerset Dam evident from the flat part of the green line would have commenced before the sluice gates would have been opened on 13 January 2011 and would have occurred by reason of the uncontrolled spillage above EL 100.45m AHD.[957]

374 In SIM C, Strategy W4B is invoked on the morning of 10 January 2011 when two sluice gates are open but Somerset Dam is only at EL 102.52m AHD, so that the combined outflow is only 686m^3/s.[958] Those sluice gates are not closed until 3.00pm the following afternoon, reducing the outflow from Somerset Dam from 1171m^3/s to 831m^3/s before it climbs again because of the increasing height of Somerset Dam and the resulting uncontrolled spillage over EL 100.45m AHD.[959] The tandem operations line continues towards and not away from the Operating Target Line before Somerset Dam levels drop sharply on the morning of 12 January 2011.[960]

375 SIM D is similar. In SIM D, Strategy W4B would have been invoked at midnight on 10 January 2011 when two sluice gates were open and Somerset Dam would have been at EL 102.55m AHD.[961] Those sluice gates remained open until 11 January 2011 and the reduction in releases when they were closed was balanced by the increase in discharge above EL 100.45m AHD.[962]

[954] Ibid at .0552.
[955] Ibid at .0575 to .0577.
[956] Response Report Vol 2, EXP.ROD.015.0261 at .0323.
[957] The height of Somerset Dam drops after 5.00am on 12 January 2011: Simulation Analysis, EXP.ROD.015.0461 at .0576.
[958] Simulation Analysis, EXP.ROD.015.0461 at .0630, .0639 and .0652.
[959] Ibid at .0653.
[960] Ibid at .0564; Response Report Vol 2, EXP.ROD.015.0261 at .0345; cf Seqwater subs at [2261(a)].
[961] Simulation Analysis, EXP.ROD.015.0461 at .0709 and .0732.
[962] Ibid at .0733.

Throughout this, dam water levels trended towards the Operating Target Line.[963]

376 SIM F and SIM H are addressed in section 10.1 of Chapter 10. In SIM G, Strategy W4B was engaged from the outset and all five sluice gates were closed immediately and remained closed until 14 January 2011.[964] Dr Christensen noted that uncontrolled discharge from above EL 100.45m AHD would have trended water levels towards the Operating Target Line.[965]

Approach When Crest Gates are Closed

377 I have noted above an aspect of Dr Christensen's approach to the Operating Target Line when the crest gates are closed. As I do not accept that a reasonably competent flood engineer confronted with the January 2011 Flood Event would necessarily have closed the crest gates at Somerset Dam it is unnecessary to consider the balance of the defendant's criticisms of this aspect of Dr Christensen's simulated flood operations.

9.10: Defendants' Other Criticisms

Releases Below FSL

378 All of the defendants were critical of Dr Christensen for making releases below FSL during the simulated January 2011 Flood Event.[966] This is largely addressed in Chapter 5. The only remaining issue is whether the approach in each simulation properly addresses the flood mitigation objective of retaining the storage at FSL at the conclusion of the flood event.[967] This is addressed in Chapter 10 in relation to each simulation as is necessary.

Impact of Downstream Flows

379 Dr Christensen's approach to assessing the impact of simulated releases on downstream flows is described in section 8.5 of Chapter 8. Both the State and

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963 Response Report Vol 2, EXP.ROD.015.0261 at .0365; cf Seqwater subs at [2261(b)].
964 Simulation Analysis, EXP.ROD.015.0461 at .0905 to .0907.
965 Response Report Vol 2, EXP.ROD.015.0261 at .0414; cf Seqwater subs at [2261(c)].
966 Seqwater subs at [2016]; State subs at [494] to [506].
967 Manual at 9.

SunWater disputed his approach to mitigating the risk of flooding from releases based on forecasts combining with downstream flows.[968]

Modelling Downstream Flows

380 The State's submissions were critical of Dr Christensen for supposedly using "one set of data to determine his inflows above the dams and a different set of data downstream of the dam". It contended that the "PME forecasts he relied upon for calculating inflows above the dams typically forecast much heavier rainfall to occur below the dams" and cited Mr Giles' georeferenced breakdown of the PME forecasts on a daily basis for the catchments above and below the dams in support.[969] The State contended that there was an inconsistency between Dr Christensen using the four-day and eight-day PME forecasts for inflows above the dams to set strategy and to determine releases, compared to his exclusive usage of the Appendix A "with forecast" runs to model downstream effects. It also contended that Dr Christensen's simulated dam operations could not "have been achieved consistently with the Flood Manual directions concerning the maximum flows at Moggill if he had assumed the PME forecast rain would also fall below the dams".[970] It cited a statement by Mr Giles in his first report to the effect that a consistent approach should have been used for all catchments above and below the dams[971] and referred to this report in support of a submission that Dr Christensen "consistently underestimate[d] the combined flow likely to occur at Moggill, both with and without discharge from Wivenhoe Dam".[972]

381 I reject these submissions. Three matters should be noted.

382 First, there is no inconsistency in Dr Christensen's use of four-day and eight-day PME forecasts to model inflows and 24-hour QPF forecasts to

[968] State subs at [474] to [493]; SunWater subs at [1049] to [1074].
[969] State subs at [474]; see Appendix A to Mr Giles first report, EXP.QLD.001.0611 at .0735 and Appendix B to Mr Giles' third report, EXP.QLD.001.1359 at .1427.
[970] State subs at [478].
[971] Ibid at [479]; EXP.QLD.001.0611 at .0704.
[972] Ibid at [482] to [483].

model the effect of the current level of outflows. The rationale for that approach is explained in Chapter 8.[973]

383 Second, a comparison of the QPF forecasts with Mr Giles' one-day PME estimates for the Lockyer Creek and Bremer River catchments does not support the contention that the use of the former underestimated downstream flows compared to the latter. For all days other than 9 and 10 January 2011, the upper bound of the QPF, which was the basis for the Appendix A modelling used by Dr Christensen, substantially exceeded the one-day PME forecast determined by Mr Giles for the Lockyer Creek and Bremer River catchments.[974]

384 For 9 January 2011, Mr Giles' breakdown of the one-day PME forecast for Lockyer and Bremer yielded rainfall forecasts of 69mm and 109mm respectively.[975] The morning QPF forecast was 40 to 60mm and the afternoon was 50 to 80mm. The upper limit of the morning QPF forecast was only marginally less than the Lockyer forecast and the upper limit of the afternoon QPF forecast exceeded it. For 10 January 2011, Mr Giles' breakdown of the one-day PME forecast for Lockyer and Bremer yielded predictions of 98 and 131mm of rain respectively.[976] The morning QPF forecast predicted 50 to 100mm of rain. Thus, the only integers that were potentially underestimated in the modelling that used the QPFs compared to the one-day PMEs were the rainfall depths for the Bremer River on 9 and 10 January 2011. However, the scope for any such underestimation reduces considerably when it is recalled that the Appendix A "with forecast" runs did not adjust the QPF rainfall

[973] Chapter 8 at [107] to [110].
[974] See T 10162.39 to T 10168.3 and Giles one-day PME sub-catchment breakdown – EXP.QLD.001.1359 at .1469 to .1473: 2 Jan: PME (Lockyer and Bremer) – 1 and 7mm v QPF – 5 to 10mm; 3 Jan: PME (Lockyer and Bremer) – 2 to 2mm v QPF – 5 to 10mm and 10 to 20mm; 4 Jan: PME (Lockyer and Bremer) – 1 and 7mm v QPF – 10 to 20mm and 5 to 15mm; 5 Jan: PME (Lockyer and Bremer) – 11 and 9mm v QPF – 20 to 30mm and 30 to 50mm; 6 Jan – PME (Lockyer and Bremer) – 27mm and 36mm v QPF – 30 to 50mm and 20 to 30mm; then EXP.QLD.001.0611 at .0790 to .0794; 7 Jan – PME (Lockyer and Bremer) – 20 and 25mm – QPF – 20 to 30mm; 8 Jan – PME (Lockyer and Bremer) – 13 and 21mm v QPF – 30 to 50mm; 9 Jan – PME (Lockyer and Bremer) – 69 and 109mm v QPF – 40 to 60mm and 50 to 80mm; 10 Jan – PME (Lockyer and Bremer) – 98 and 131mm v morning QPF – 50 to 100mm and afternoon of 25 to 50mm with isolated falls up to 100mm; 11 Jan – PME (Lockyer and Bremer) – 67 and 95mm v QPF – (in excess of) 100mm.
[975] EXP.QLD.001.0611 at .0792.
[976] Ibid at .0793.

forecast applied to the RTFM to allow for the amount of rain that had already fallen prior to the time of the RTFM run on the relevant day and the aggressive temporal pattern that was assumed by the modelling.[977]

385 Third, as noted above, the evidentiary basis for the submissions made by the State concerning Dr Christensen's modelling was Mr Giles' first report. However, Mr Giles effectively withdrew that criticism in light of the change in approach of Dr Christensen to the flood engineers' rain on the ground and 24-hour loss rates over the course of the preparation of his various reports:[978]

> "Q Mr Giles, in your report in particular you might recall that you made a detailed set of criticisms of Dr Christensen about the fact that he didn't use his own modelling for the downstream flows. Do you remember that?
> A. Yes.
>
> Q. Is that a criticism that you maintain now?
> A. *Not to any significant degree*. The modelling that was completed by Dr Christensen for the earlier report was based on very low loss rates, and he then used the flood engineers' results downstream of the dam which were based on higher loss rates. *The loss rates that Dr Christensen subsequently adopted were far closer to the flood engineers' ones, and so the majority of that criticism would be removed*.
>
> Q. Of course, it is no criticism of Dr Christensen or anyone else that they used different loss rates for the downstream catchments and the upstream catchments is it?
> A. Not as long as the two marry together, no.
>
> Q. You certainly don't say that there is anything wrong with the flood engineers' modelling of the downstream catchments, do you?
> A. No." (emphasis added)

386 The extent to which any criticism of Dr Christensen's methodology was maintained was not elaborated upon. In any event, I am not satisfied that any of the criticism that Mr Giles made of this aspect of Dr Christensen's approach survived this concession.

[977] See Chapter 6 at [24].
[978] T 8800.25.

16-Hour Travel Time Window

387 The State noted that portion of Dr Christensen's evidence that provided that (only) approximately 13% of the Brisbane basin has a travel time of 16 hours or less to Moggill[979] and that the "downstream travel times [are such] that there is an opportunity … to respond by reducing or if possible ceasing releases".[980] The State submitted that Dr Christensen's assertions were "erroneous and fail[ed] to engage with the reality of real time operations".[981]

388 The State made five points in support of that contention.

389 First, the State described the risk, supposedly acknowledged by Dr Christensen, that if "releases are made on the basis of forecast rain falling above the dams and that rainfall does not occur, then it is likely that the operations proposed by Dr Christensen will have made the downstream flooding worse than it would have been without the dams".[982] However, to merely state the existence of a risk of that kind adds nothing in the context of a dam where it is acknowledged, as it was by Mr Malone,[983] that the combination of dam capacity and the characteristics of the catchment area above the dam are such that both rain on the ground operations and operations conducted by reference to 24-hour forecasts represent too short a planning horizon to maximise flood storage capacity.[984] Thus, accompanying the risk described by the State is the risk that by not making releases flood storage capacity will be lost. These risks are not necessarily symmetrical and the question posed by the Manual is how should they be addressed by considering forecasts? Otherwise the State's submission presupposes there is "downstream flooding". The concept of "downstream flooding" in the context of the Manual means firstly exceeding the threshold for urban damage and secondly inundating bridges in that order of priority. Generally, Dr Christensen's approach applies the 24-hour QPF forecasts to downstream

[979] Ie, the purple area in the map which is Figure 8-1 in Chapter 8 at [102].
[980] Reply Report, EXP.ROD.004.0005 at .0024; State subs at [485].
[981] State subs at [486].
[982] Ibid at [487].
[983] Chapter 3 at [184] to [185].
[984] See [128] above; Reply Report, EXP.ROD.004.0005 at [71] to [72].

catchments to propose releases when there is none of the former and to minimise the latter.

390 Second, the State submitted that "Dr Christensen assert[ed] that the probability of significant rain occurring sufficient to cause Lowood or Moggill to get close to 3,500 m^3/s and 4000 m^3/s without warning was negligible" and pointed to extreme flash flooding that occurred on evening of 10 January 2011.[985] This is a reference to a statement made by Dr Christensen in his Reply Report[986] but it is taken out of context. Dr Christensen noted that the flood engineers had possession of the PME probability of exceedance maps and that it took three days of heavy rainfall during the January 2011 Flood Event to cause the Moggill flows to exceed 4000m^3/s.[987] All that Dr Christensen stated was that, with the benefit of forecasts (as well as radar), there was a relatively small chance that there would be insufficient notice of rainfall occurring that was markedly above the forecast amounts so as to cause downstream flooding and prevent the flood engineers from responding by reducing outflows. Further, the extreme flooding on the evening of 10 January 2011 in the Toowoomba Valley commenced in an area outside the 16-hour window that could be affected by existing releases. The flood engineers received enough notice of that flooding to allow them to reduce releases that would have otherwise coincided with those flows. However, because of the rapid increase in inflows and the level of the dams, which was a product of their rain on the ground operations to that time, they could not reduce releases.[988] In contrast, Dr Christensen's simulations maintained that storage capacity for such use if it was necessary.

391 Third, the State identified various matters affecting the 16-hour time period that Dr Christensen identified as providing a warning to reduce releases, namely:

[985] State subs at [488] and [492].
[986] Reply Report, EXP.ROD.004.0005 at [67].
[987] Id.
[988] See Chapter 7 at [359] and [364].

> "[1] the time it takes for the additional rainfall to work its way from hitting the ground into the watercourses that had their travel times measured in that map …; [2] the time it takes for that rain to be recognised or registered at stream gauges; [3] the time it takes to be assessed; [4] the time it takes to understand the catchment response and remodel inflows and redo gate operations spreadsheets in order to calculate the reductions to be made to releases; [5] the time it takes to implement such release reductions."[989]

392 The State noted Mr Pokarier stated that the resulting impact of sudden, very significant rainfall may not be easily identified for "*a number of hours*".[990]

393 The first matter noted by the State supports Dr Christensen's approach. The longer the period that rain takes to enter the watercourse the longer the period the flood engineers have to respond, as the 16-hour figure is a measurement of flow time (ie, it pushes more of the purple area in the map in Figure 8-1 in Chapter 8[991] into the brown area). The second matter overlooks the presence of rain gauges and the use of radar. The third and fourth matters overlook the context in which this issue is being considered, namely significant amounts of rain falling *beyond that which was forecast* that could cause significant downstream flooding. At the very least, flood engineers could quickly recognise when rainfall upstream was so extreme compared to what was forecast as to create a concern that the downstream threshold for urban flooding would be exceeded. As for the fifth matter, if necessary, the Manual allows for rapid gate closure to ameliorate downstream flooding.[992]

394 Fourth, the State pointed out[993] that the travel times could vary depending on the size of the flow, the nature of the channel[994] and whether water has broken out of channels,[995] although the latter issue only arises in the context of extreme flooding that has already occurred. The State also asserted that both Mr Malone[996] and Mr Pokarier[997] "disputed" one part of Dr Christensen's

[989] State subs at [489].
[990] T 6929.45.
[991] Chapter 8 at [102].
[992] Manual at 33.
[993] State subs at [490].
[994] T 7999.39 (Ayre).
[995] T 8001.24 (Ayre).
[996] Citing T 5099.2.
[997] Citing T 6928.44.

map that is Figure 8-1 in Chapter 8[998] namely that the "*top right*" portion of rust colour "*above the blue*" was more than 16 hours to Moggill. The State contended that Mr Malone otherwise did not accept the accuracy of the map.[999] In fact, when questioned about Dr Christensen's map, Mr Pokarier said "in general terms I agree".[1000] All Mr Malone said was that "I'm just not quite sure what that little brown spot is up above the blue"[1001] and "I don't know how this [map] was derived".[1002] These are relatively minor quibbles. Dr Christensen published his colour coded map and the explanation for its use in his Reply Report of December 2016. There was more than sufficient time for the defendants to either verify it or properly dispute it. I accept its accuracy.

395 Fifth, the State noted the plaintiff's assertion that the risk of unexpected downstream rain applies to all releases from Wivenhoe Dam and was not peculiar to pre-releases made on the basis of forecasts.[1003] However, it submitted that "as pointed out in the USACE Tulsa video, the risk is not whether rain forecast downstream will or will not happen but whether rainfall which is forecast upstream and which warrants releases are made will or will not happen and that in the event [it] do[es] not happen downstream conditions are made worse than would have occurred if the dam was not in place." The "USACE Tulsa video" was a short video shown in the State's opening that explained that, at a particular dam in the USA, releases were not made based on forecast rain upstream because it might fall downstream and coincide with releases. The video contained no discussion of the factors that might inform a decision to operate that way, namely the dam capacity, flow times from upstream catchments, flow times to downstream catchments and urban areas, local forecast products and stability of seasonal conditions. The discussion of the practice at dams in the USA in section 9.1 above illustrates the potential significance of those matters. Otherwise, the State's contention does not engage with the plaintiff's point that the risk of downstream flows coinciding with releases to cause flooding pertains to all forms of flood

[998] Chapter 8 at [102].
[999] T 5099.35.
[1000] T 6929.4.
[1001] T 5099.2.
[1002] T 5099.35.
[1003] State subs at [493].

operations, not just pre-releases. As it happened, that risk in fact materialised in that the flood engineers' releases largely coincided with downstream peaks in circumstances where the flood engineers operated based on rain on the ground. Their commitment to rain on the ground flood operations effectively forced them to make releases at a time that coincided with the largest downstream flows.

396 SunWater submitted that it "is not to the point" that only 13% of the entire Brisbane River drainage basin has a peak flood travel time of 16 hours or less to Moggill given the risk of rain falling within that area.[1004] It contended that, with respect to rain falling in that zone the flood engineer does not have the ability to recall the water that has already been released.[1005] It instanced the example of rain falling directly over the Brisbane River downstream of the dam within a short period of time which would leave the flood engineers unable to effectively respond.[1006] However, it is very much "to the point" to identify the catchment area that is within the 16-hour travel time of released flows to Moggill because it allows one to define the scope of the risk that already released water will combine with downstream flows before there is the chance to reduce releases. If, say for example, the travel time for releases from the dam to Moggill was four days and 70% of the entire catchment area had a flood travel time of four days or less to Moggill then that would increase the risk of releases combining with downstream flows from rain beyond that which was forecast and might reduce the justification for releasing water in advance of forecasts.

397 Otherwise there are three related difficulties with SunWater's submission and example.

398 First, the risk of sufficient rain falling directly onto the Brisbane River itself to cause an unforeseen sudden rise in flow levels was extremely low given the width of the Brisbane River.

[1004] SunWater subs at [1060].
[1005] Ibid at [1063]
[1006] Ibid at [1065] to [1069]; it cited Mr Keller's evidence in support of that having occurred on 11 January 2011.

399 Second, as noted, the risk that SunWater identified pertains with all forms of flood operations, including those actually conducted by the flood engineers. SunWater does not identify how Dr Christensen's approach materially increased that risk.

400 Third, Dr Christensen sought to mitigate the risk of water falling within the 16-hour window by modelling downstream flows using the upper range of the QPF forecast (and by paying regard to the PME forecasts). The flood engineers did not. In that regard, SunWater contended that a "forecast of 100mm below the dams could result in 150mm of actual rainfall" and that there is greater uncertainty associated with PME forecasts because, unlike the QPFs, they are not catchment specific.[1007] It can be accepted that there remains a risk that downstream rainfall will exceed the upper range of the QPF forecast (and even the modelled flows that use the aggressive temporal distribution in the Appendix A "with forecast" modelling). However, the uncertainty in that forecast can be addressed by reference to the probability of exceedance forecasts provided with the PMEs and by allowing for a buffer between the combined release rate and the downstream flow prediction on the one hand and the next inundation threshold flow level on the other. It is certainly not accounted for by making releases that only address downstream flows calculated by rain on the ground modelling.

The Manual and Downstream Flows

401 SunWater submitted that "there [was] a certain irony in the plaintiff's mantra that the *Manual required the use of forecasts"*.[1008] It contended that "a decision to hold off increasing releases due to forecast rain downstream (and the potential for more rain than forecast) is using forecasts, at least qualitatively, to inform release decisions" and that "there is a choice: increase releases to increase flood storage to guard against forecast rain in the catchments, or maintain releases to guard against the risk of forecast (and unforecast) rain potentially combining with increased releases and

[1007] SunWater subs at [1070].
[1008] Ibid at [1073].

exacerbating downstream flooding".[1009] By reference to Mr Fagot's approach, it contended that it was reasonably open to the flood engineers to adopt the approach of "not risk[ing] making things worse downstream than if the dams had not been in place".[1010]

402 The Manual unambiguously requires the use of forecasts to determine "maximum storage levels" in the dams *and* the "peak flow rate … excluding Wivenhoe Dam releases…" at Lowood and Moggill.[1011] The use described by SunWater of forecasts does neither. The flood engineers did neither. Dr Christensen's approach does both. Otherwise, to exercise the choice referred to by SunWater, a reasonably competent flood engineer had to weigh up the relative risks of taking either course of action, rather than refusing to countenance the first, which the flood engineers did. As for Mr Fagot's approach, the approach dictated by the Manual was to generally assume the risk of making downstream flows worse in terms of inundating bridges to pursue the flood mitigation objective of minimising the risk of urban inundation. His approach was to the contrary and was therefore inconsistent with the Manual.

Peak Outflow v Peak Inflow

403 Seqwater contended that Dr Christensen's simulations made releases at rates that exceeded current inflows[1012] and that he therefore breached the "constraints in the Manual regarding peak outflows and peak inflows if regard is had to the contemporaneous modelling of inflow rates".[1013]

404 I addressed the scope of this statement in section 3.3.9 of Chapter 3. I found that the reference to peak inflow was to the peak inflow over the course of the flood event and thus included predicted peak inflow. However, even if the relevant statement in the Manual was confined to comparing planned outflows to past inflows then, as the Late December Flood Event did not cease on

[1009] Ibid at [1073].
[1010] SunWater subs at [1074].
[1011] Manual at 23.
[1012] Seqwater subs at [2147].
[1013] Ibid at [2148].

2 January 2011, the relevant comparator was the maximum peak rate of inflow during that event, namely, 2200m^3/s.[1014]

405 Against the contingency that the relevant comparator for outflows was predicted inflows over the course of the flood event, Seqwater contended that Dr Christensen did not comply with this “constraint”.[1015] In support of that contention it noted three aspects of his inflow modelling. First, due to his approach to the temporal distribution of future inflows, Dr Christensen’s inflow modelling was said not to produce a “reliable inflow series”. Second, his approach of conducting two separate model runs and combining the result was said to “disrupt the principle of non-linear routing storage” in the RTFM adverted in Chapter 8.[1016] In particular, Mr Giles said that “it is not correct to add hydrographs that have been separately routed through a catchment”.[1017] Third, Seqwater noted that, as Dr Christensen does not use the gate operations spreadsheet in the RTFM, he does not “assess the outflow rates that will be required beyond the next 24 hours”.[1018]

406 In relation to the first point, Dr Christensen’s approach to forecast modelling means that he does not produce a reliable estimate of the timing of the peak inflow. However, to address the peak outflow and peak inflow statement in the Manual it is only necessary to assess the peak flow over the course of the event, not the timing of any past or future peak. In that regard, Dr Nathan concluded that “the introduction of temporal uncertainty has only a small impact on the peak and volume of the inflow floods, but crucially it has a material impact on the timing of the flood peak”.[1019] This is evident from scenario F in the middle of the “tornado” diagram, which is Figure 9-1 above.

407 In support of its contention, Seqwater referred to Mr Malone’s “Temporal Pattern Analysis”.[1020] In that analysis, Mr Malone compared and contrasted

[1014] ROD.650.003.6506 at .6606.
[1015] Seqwater subs at [2150] to [2152].
[1016] Chapter 8 at [98] to [99].
[1017] EXP.QLD.001.0611 at .0664.
[1018] Seqwater subs at [2152].
[1019] EXP.SEQ.014.0013 at [30].
[1020] SEQ.004.046.0291.

the predicted peak flows and the timing of the peak as derived from Dr Christensen's modelling of the no rain scenario, the four-day PME forecast, the average of the eight-day PME forecast and the high end of the range of the eight-day PME forecast for each of 2 January 2011 to 11 January 2011. In relation to the size and timing of the peak inflow, Mr Malone stated that using Dr Christensen's approach to modelling inflow volumes meant that "[t]here also would be no reliable way of determining whether your peak outflow would exceed the peak inflow … because your peak inflow rate and the expected time when it may occur would likely vary between forecasts on the same day".[1021] Mr Malone did not undertake an analysis of the kind undertaken by Dr Nathan, namely varying the same forecast by different parameters that included temporal distribution. Nevertheless, Mr Malone's analysis is consistent with Dr Nathan's in that where the four-day and eight-day average forecasts predicted rainfall similar depths, his analysis yields very little difference in the predicted size of the peak flow although it does yield differences in the timing of its arrival.[1022] In any event, the issue presented by Mr Malone's analysis is simply one of resolving potentially inconsistent forecasts. Given the findings that have been made, to the extent that there is conflict between the four-day and eight-day PME forecasts on this topic, generally the reasonably competent flood engineer would rely on the former.

408 In relation to Seqwater's second point, the difficulties in combing hydrographs in assessing peak rates are addressed in relation to each simulation.

409 In relation to Seqwater's third point, a consideration of the Manual's statement concerning peak outflow and peak inflow only requires an assessment of the currently proposed releases. If in 24 hours' time or earlier Dr Christensen proposes to alter his release pattern then the principle can be reconsidered then in light of the prevailing forecasts and what is known about past inflows.

[1021] SEQ.004.046.0291 at .0363.
[1022] See SEQ.004.046.0291 at .0311 .0314, .0315, .0320, .0323, .0324, .0335.

410 Otherwise, the peak outflow and peak inflow statement in the Manual will be considered in relation to each simulation as necessary. At present it suffices to state that Seqwater's points do not mean that Dr Christensen's methodology prevents the flood engineer from properly applying this part of the Manual.

No Release Rises

411 All of the defendants contended that Dr Christensen's use of a no release rise to determine strategies was contrary to the Manual.[1023] This was addressed in Chapter 3.[1024]

Incorrect QPF Volumes

412 Seqwater contended that the error made by Dr Christensen in modelling 24-hour inflows described in Chapter 8[1025] was fatal to the Court being satisfied the gate operations and release rates in SIM C or SIM H would have been adopted by a reasonably competent flood engineer.[1026] The effect of that error on those simulations is addressed in relation to each relevant simulation in Chapter 10. Mr Pokarier's corrected inflow volumes for each QPF are set out above at [286].

Incorrect Inflows Between 2 and 6 January 2011

413 Seqwater contended that Dr Christensen's use of incorrect inflow figures for the period 2 to 6 January 2011 materially affected his simulations that start on those days.[1027] This error is addressed in section 6.5 of Chapter 6 and, where relevant, in Chapter 10.

1023 State subs at [560] to [562]; Seqwater subs at [2153] to [2154]; SunWater subs at [1116] to [1132].
1024 Chapter 3 at [221] to [237].
1025 Chapter 8 at [27].
1026 Seqwater subs at [2298].
1027 Ibid at [2293] to [2294].

Target Level Approach

414 All of the defendants were critical of Dr Christensen's formulation and application of a target level approach to releases as described in Chapter 8.[1028] As explained in Chapter 10, these criticisms are only relevant to some of the days simulated in SIM A and SIM E. SIM I utilised a target level approach but it is rejected for other reasons. It is not relevant to SIM F, SIM G, SIM H, and, as explained in Chapter 10,[1029] not material to SIM C. The defendants' criticisms will be addressed in the context of each simulation.

Hindsight

415 As noted, one of the defendants' criticisms was that Dr Christensen's simulations were consciously or subconsciously constructed with the benefit of hindsight to produce a better flood outcome than the events that happened, especially with his modelled operations on 11 and 12 January 2011.[1030] The suggestion that he contrived the simulations with the benefit of hindsight was repeatedly put to Dr Christensen in cross-examination.[1031] I have rejected the suggestion that he deliberately acted in that way and sought to address the charge of using subconscious hindsight by addressing the simulations based on the information known or available to a reasonably competent flood engineer at the relevant time.

416 At this point, I note that an aspect of two of Dr Christensen's simulations support the rejection of the accusation of deploying hindsight levelled against him. As explained in Chapter 10, in SIM C Dr Christensen modelled releases in Strategy W3 on 6 January 2011 and 7 January 2011 which would have inundated all the downstream bridges.[1032] However, as Dr Christensen modelled SIM C on the assumption that strategies were determined by 24-hour inflow estimates, the effect of those releases was that on 8 January

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[1028] Chapter 8 at [55] to [58]; State subs at [563] to [568]; SunWater subs at [1000] to [1010]; Seqwater subs at [2155] to [2167].
[1029] Chapter 10 at [169].
[1030] SunWater subs at [953]; State subs at [536] to [539]; See above at [288] and [322].
[1031] T 1804.3 - .26; T 1685.3 to T 1686.17; T 1697.24; T 1711.2 - .36; T 2502.30; T 2506.6 - .40; T 2759.27.
[1032] Chapter 10 at [109] to [125].

2011 and for part of 9 January 2011, SIM C would have no longer been in Strategy W3 but instead subject to Strategies W1D and W1E which imposed limits on releases of 1900m^3/s.[1033] Similarly, in SIM B, which selected strategies and made releases by reference to rain on the ground inflows with forecasts only used for "situational awareness", the releases made by Dr Christensen from 2 January onwards resulted in modelled gate operations ending on 5 January 2011. Modelled releases did not resume until 4.00am on 7 January 2011.[1034] These aspects of the simulations tend against a suggestion that they were constructed with hindsight. Considered retrospectively, it would have been relatively easy to reconstruct both simulations so that they made lesser releases earlier so as to keep them above the relevant strategy threshold until later when rain on the ground inflows increased dramatically in SIM B and one-day inflow estimates did likewise in SIM C.

A New Methodology?

417 Seqwater also contended that, without sufficient research and verification, a reasonably competent flood engineer "would not have assumed the risks inherent in Dr Christensen's methodology".[1035] It referred to Mr Pokarier's evidence to the effect that "[m]aking operational release decisions on the basis of forecast rainfall would represent a shift in the decision making paradigm in the Flood Operations Centre"[1036] which could only have been adopted if various research and pilot studies had been undertaken.[1037]

418 The relevant "paradigm" shift that took place was not the promulgation of Dr Christensen's methodology but the approval of a Manual that required the use of forecasts in flood operations, prioritised flood mitigation objectives and required the flood engineers to adopt a risk assessment approach. It follows from the discussion in Chapter 4 that, despite the deep involvement of its own staff in the redrafting of the Manual, Seqwater apparently took little or no

[1033] See Appendix F to this judgment.
[1034] Simulation Analysis, EXP.ROD.015.0461 at .0548 to .0549.
[1035] Seqwater subs at [1999].
[1036] EXP.SEQ.016.0012 at [162]; Seqwater subs at [2002].
[1037] Ibid at [163].

steps to implement what was required of the Manual. If it is the fact that sufficient research and scientific validation of an approach that conformed with the Manual was not undertaken, it is Seqwater's responsibility, not the plaintiff's. The plaintiff, via Dr Christensen, put forward a methodology and some simulations that applied it or a variation of it which, subject to the analysis in this Chapter and Chapter 10, generally conformed with the Manual. The defendants did not. Instead, they attacked Dr Christensen's methodology (and its application) as either inconsistent with the Manual or incompetent. In most respects they failed, leaving open the prospect of the Court accepting that it was what was required of a reasonably competent flood engineer. Otherwise, to invite the Court to reject Dr Christensen's approach on the basis that some unspecified process of research and verification, such as that suggested by Mr Pokarier, might have led to its rejection is pure speculation.

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CHAPTER 10: DR CHRISTENSEN'S SIMULATIONS

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CHAPTER 10: DR CHRISTENSEN'S SIMULATIONS

1 As noted in Chapter 9,[1] it is necessary to address each of Dr Christensen's simulations and, in particular, determine whether a reasonably competent flood engineer *would have* made flood releases substantially in accordance with one or more of them. This issue is addressed in accordance with the analysis in Chapters 11 and 12 of the relevant standard of care applicable to the flood engineers and the allegations of breach of duty made against them.

2 It follows from the finding in Chapter 9[2] that, as both of SIM I and SIM J involve the closing of the Somerset Dam crest gates under high rates of inflow, I do not accept that either of them represent a form of flood operations that a reasonably competent flood engineer would or must have engaged in during the January 2011 Flood Event.

3 Of the remaining simulations, it is convenient to commence with SIM F and SIM H and then address SIM C. With these simulations many of the defendants' objections to Dr Christensen's primary methodology and modelling either do not arise or, if they do, upon closer analysis they are not sufficiently material to invalidate them. In the end result, I am satisfied that, with those simulations, any scope for legitimate disagreement as to the interpretation of a particular PME forecast, the appropriate continuing loss rates, estimation of inflow volumes, concerns over the capacity of Wivenhoe Dam to refill to FSL and the use of the "target" approach or some other "quantitative" use of four-day PMEs to set releases are all immaterial to their acceptance. In particular, my acceptance of SIM F and SIM H[3] only requires an acceptance that QPF forecasts are to be used to select strategy and that longer forecasts are to be used only as a form of "situational awareness", although I am satisfied that they can be used beyond that. Similarly, my acceptance of SIM C only requires an acceptance that four-day PMEs be used to select strategy and not that they, or QPFs, be used to determine a volume of water to be evacuated pursuant to a "target approach". The

[1] Chapter 9 at [2].
[2] Chapter 9 at [346].
[3] As varied by Mr Ickert's proposed operations above EL 74.0m AHD.

reasoning that supports SIM C also supports SIM F. The only difference is the start dates and thus the commencing reservoir levels.

10.1: Simulations F and H – 8 January 2011 Start

4 Each of SIM F, H and J are described in Chapter 8. They all commence at midnight on 8 January 2011. As they commence then it was common ground that they were not affected by Dr Christensen's erroneous calculation of inflows for the period 2 to 6 January 2011.[4] Although I do not accept that SIM J represents a form of flood operations that a reasonably competent flood engineer commencing around midnight on 8 January 2011 would have engaged in, it is necessary to refer to it in that some of the defendants' witnesses contrasted its releases from Somerset Dam with those undertaken in SIM F and SIM H.

5 While, to an extent SIM F utilises Dr Christensen's primary methodology, its acceptance is not dependent on complete acceptance of that methodology. Dr Christensen's primary methodology involves the selection of strategy by reference to eight-day forecasts and the determination of releases by reference to a target informed by the four-day forecast volume subject to relevant constraints. However, in SIM F the prevailing water levels and magnitude of forecasts are such that Dr Christensen determined to release as much water as possible subject to the limits imposed by strategies and downstream considerations rather than any amount set by a target approach. SIM H does not utilise a "target" approach either. It uses 24-hour QPF forecasts to select strategies and relies on four and eight-day forecasts for so called "situational awareness" and, to the extent necessary, for ascertaining peak inflow over the course of the event.

6 Both SIM F and SIM H are relevantly identical. This is so for three interrelated reasons.[5] First, because whichever forecast was used, from 8 January 2011 flood operations would have always been conducted within Strategy W3 or higher while actual levels were below EL 74.0m AHD. Second, because even

[4] SBM.010.019.0001 at [1(b)]; SBM.020.021.0001 at [2].
[5] cf Sunwater subs at [1500].

if only 24-hour QPF forecasts are used quantitatively to determine strategies, then any form of consideration of the longer term forecasts demanded the highest level of releases be made subject to downstream flow thresholds and other constraints. Third, because from the time they commenced until 11 January 2011, in both SIM F and SIM H the relevant constraint on releases was the downstream threshold for non-damaging flows, namely 4000m^3/s at Moggill. Any debate about the possibility of making higher releases in either simulation is moot because it would not have led to that threshold being exceeded.

7 The first two of these points is illustrated by the table in Appendix E to this judgment. This table sets out the various dam levels in both SIM F and SIM H at the time the four-day PME and one-day QPF forecasts were available to a flood engineer during the period from late on 7 January 2011 to 12 January 2011. It includes projected dam heights based on all the permutations of inflow volumes provided by the various witnesses derived from the one and four-day forecasts. The lowest estimate of four-day and one-day inflow volumes was provided by Mr Giles. Under all of his 24-hour forecast inflow estimates, the maximum height of Wivenhoe Dam exceeded the W3 threshold of EL 68.5m AHD, even when operations in SIM F and SIM H reduced the level of Wivenhoe Dam (marginally) below FSL on 9 January 2011.[6] With Mr Giles' four-day PME inflow estimates, the projected height of the dam is not less than EL 72.0m AHD, even though I consider that the loss rates he utilised to derive his four-day inflow estimates were unreasonable.[7] The same result applies even if the adopted four-day inflow estimates utilised the flood engineers' estimate of rain on the ground inflows[8] (and none of the following reasoning in relation to release rates is affected by considering those estimates). Thus, regardless of which forecast was used to estimate inflows and choose strategy, at most the only limit imposed by any strategy on the maximum release rate was 4000m^3/s. Releases in both simulations never

[6] cf Seqwater subs at [2300].
[7] See Chapter 9 at [234].
[8] See Chapter 9 at [284] and Appendix E to this judgment; footnotes 10, 11, 13 and 14 to that Appendix.

exceeded that rate and, as I will explain, the rate of releases was determined by downstream constraints.

8 Appendix E to this judgement also illustrates that the findings in Chapter 9[9] about the utility of eight-day forecasts have no bearing on either simulation. In particular, in SIM F the choice of strategy would still have been the same if Dr Christensen's four-day inflow volumes were utilised. Further, while the use of four-day volumes based on Mr Giles "corrected" loss rates derived from the Late December Flood Event, or even his four-day volumes based on the use of his own loss rates, would have yielded lower projected heights and strategies at some points, they would not have affected the release rates driven as they were by downstream considerations. The position of Somerset Dam is addressed below, but in short because all sluice gates would have been closed from the outset no different outcome was possible regardless of whether Strategy S2 or S3 was invoked.

9 A consideration of SIM F and SIM H together provides a useful perspective to consider the position of a reasonably competent flood engineer. As found in Chapter 9, the use of a 24-hour period as the relevant forecast period to determine "maximum storage levels" represents too short a planning period, notwithstanding that the QPF is considered the most accurate of the relevant forecast products.[10] It follows that, in so far as SIM H utilises 24-hour QPF forecasts to determine strategies, it represents an (overly) liberal approach to flood operations, in the sense of applying too little caution to guard against urban flooding. Otherwise, these simulations provide a simple illustration of what is yielded by an approach that considers all forecasts, namely, by this stage of the January 2011 Flood Event they all pointed to the need to dramatically increase releases to guard against an ever-increasing risk of urban flooding.

[9] Chapter 9 at [61(ii)].
[10] See Chapter 9 at [128].

Wivenhoe Dam Operations

8 January 2011

10 In his SIM F simulation analysis, Dr Christensen noted that his analysis of the eight-day forecast at the commencement of the simulation yielded a maximum storage height of EL 76.12m AHD and thus warranted the adoption of Strategy W4B.[11] As Appendix E to this judgment demonstrates, the same result would follow from utilising Dr Christensen's four-day forecast estimate. Using Mr Giles' adjustment of his four-day inflow estimates yields a predicted height in excess of EL 75.0m AHD. In his explanation of strategies, Dr Christensen describes the "Strategy/Target" as keeping the dams "[a]s low as possible [while] keeping Moggill < 4000";[12] ie, no target level or volume was selected. Dr Christensen's day-by-day explanation for SIM F explained his approach to releases on 8 January 2011 as follows:[13]

> "The engineer would need to empty as much storage as possible given current inflows and forecast inflows while reducing the releases as possible during peak downstream flows at Moggill. The primary objective is to protect the safety of the dam as required in a W4B Strategy. The engineer would also strive to provide urban flood mitigation if possible and as a secondary objective by doing what is possible to prevent or minimise flows in excess of 4,000m^3/s at Moggill. The releases are increased to a maximum of 2,800m^3/s to reduce the rise of Wivenhoe Dam given dam protection is of primary importance. That release rate would also keep Moggill below 4,000m^3/s and Lowood below 3,500m^3/s (as per lower priority W2). The engineer would try to achieve as practical urban flood mitigation while first achieving the W4 dam protection strategy."

11 Dr Christensen recorded that the authorities should be notified to close the downstream bridges and that an increase in releases should be staggered to allow that to occur.[14] His hour-by-hour breakdown noted predictions made at 1.00am of peak downstream flow at Moggill of 1040m^3/s, and a prediction made at 3.00pm on 8 January 2011 of a peak downstream flow at Moggill of 940m^3/s.[15] Consistent with those predictions and the above explanation,

[11] Response Report Vol 2, EXP.ROD.015.0261 at .0398.
[12] Ibid at .0389.
[13] Ibid at .0398.
[14] Id.
[15] Simulation Analysis, EXP.ROD.015.0461 at .0846.

releases in SIM F would have been increased to around 2700m^3/s by 11.00am and would have remained at that level for the balance of the day.[16]

12 Dr Christensen's hour-by-hour breakdown for SIM H noted the effect of all the upstream and downstream forecasts but would have adopted Strategy W3 given the governing assumption that strategies are determined by one-day QPF forecasts.[17] Having regard to the four-day forecasts (as well as the 6.00am situation report) Dr Christensen noted that a "large flood [was] imminent".[18] He modelled inundating the remaining bridges and increasing releases up to the point that they do not combine with downstream flows to exceed the 4000m^3/s threshold for non-damaging flows at Moggill.[19]

13 Even though Dr Christensen's approach in SIM F invokes Strategy W4 (including W4B) by a prediction that Wivenhoe Dam would exceed EL 74.0m AHD, he does not treat that as requiring an immediate opening of gates to arrest rising levels as the actual level does not exceed EL 74.0m AHD. Thus, the circumstances prevailing as at midnight on 8 January 2011 in SIM F are an example of those discussed in Chapter 7[20] (and Chapter 3[21]) namely, that just because W4 is invoked based on a predicted height, that does not necessarily lead to an immediate increase in releases from a W3 Strategy.

14 In Chapter 6,[22] I noted that, at midnight on 8 January 2011, the principal difference between the flood engineers' approach on the one hand and Dr Christensen on the other was whether the circumstances warranted inundating the remaining bridges to optimise protection against potential urban inundation from increased inflows if the forecast rain (or worse) fell. The range of forecasts available to a flood engineer as at midnight on 8 January 2011 are described in Chapter 6.[23] The situation report issued at around 6.00pm on 7 January 2011 listed forecast rainfall of between 140mm and

[16] Id.
[17] Ibid at .0931.
[18] Id.
[19] Id.
[20] Chapter 7 at [108].
[21] Chapter 3 at [318].
[22] Chapter 6 at [267].
[23] Chapter 6 at [241] to [243].

300mm over the following four days.[24] Mr Giles' breakdown of the four-day PMEs suggested over 200mm in each of the Middle Brisbane and Somerset catchments.[25] A visual inspection of the PMEs conducted by the parties generated a range of predictions of between a lower bound of either 50mm or 100mm and an upper bound of 300mm above the dams and 400mm below the dams.[26] The potential for that heavier rain to fall upstream instead of or in addition to downstream, as well as the potential for higher rainfall, was manifestly obvious.

15 The one-day PMEs available from 6.00pm on 7 January 2011 predicted very heavy rain for Sunday, 9 January 2011 and Monday, 10 January 2011,[27] which was consistent with all of the most recent forecasts.[28] Both the one-day PME for 8 January 2011 and the QPF forecast published on the afternoon of 7 January 2011 (20mm to 30mm) suggested some rain for 8 January 2011, but much less than what the PMEs predicted over four days. An Appendix A "with forecast" RTFM run referable to 3.00pm on 7 January 2011 predicted a peak flow at Moggill of around 1040m^3/s at midday on 8 January 2011.[29] That prediction and those forecasts suggested there was little scope for immediately increasing releases if Fernvale and Mt Crosby Weir Bridges were to remain open but substantial scope for increasing releases if they were not, given the next threshold in the Manual were downstream flow rates of 3500m^3/s at Lowood and 4000m^3/s at Moggill. The forecasts and situation reports that became available throughout 8 January 2011 would have only reinforced that analysis,[30] even allowing for the possibility that a three-day SILO meteogram available from 6.00am on 8 January 2011 might have suggested a slight reduction of the forecast rain over the coming days.[31]

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[24] QLD.001.001.2406.
[25] Chapter 6 at [242].
[26] Chapter 6 at [242].
[27] Chapter 6 at [242].
[28] EXP.SEQ.014.0219: see 5 January 6.00pm PME: SEQ.013.004.1286; 6 January 6.00am PMEs: SEQ.013.005.0462 and SEQ.013.005.0464; 6 January 6.00pm PMEs: SEQ.013.004.1297 and SEQ.013.004.1299; and 7 January 6.00am PMEs: SEQ.013.005.0475 and SEQ.013.005.0477.
[29] AID.500.021.0001 at .0002; SUN.002.002.2796.
[30] Chapter 7 at [1] to [2], [5], [52], [68] and [77] to [82].
[31] Chapter 7 at [59] to [60].

16 In its submissions concerning SIM F, SunWater contended that the use of an eight-day no release rise "predicts alarmingly high levels", that if releases were taken into account lower lake levels would have been predicted and that it was only the use of such longer range forecasts that could have justified an increase in releases on 8 January 2011.[32] I disagree. All the forecasts required the adoption of a W3 strategy at a minimum and, irrespective of whether they were considered "quantitatively" or only as a form of situational awareness, all the forecasts for beyond a 24-hour period required a sharp increase in releases sufficient to inundate the remaining bridges.

17 In its supplementary submissions on causation,[33] the State made a number of submissions concerning the operations in SIM F and SIM H on 8 January 2011. First, it was submitted that the release rates from midnight were dependent on a contested interpretation of the PME forecasts.[34] For the reasons stated above, they were not. This is exemplified by the identical level of releases modelled in SIM H which are based on the QPF forecasts. Second, they pointed to Mr Giles' evidence of the appropriate loss rates,[35] a matter that has already been addressed in Chapter 9.[36] Third, it pointed to Professor Manton's evidence that the four-day and eight-day PMEs were not available until midnight.[37] I addressed that evidence in Chapter 2 and accepted it.[38] However, it makes no difference because of the estimate of the time taken to undertake an RTFM run and the fact that the constituent one-day PMEs for the 4-day PME were available from 6.00pm on 7 January 2011. Fourth, it contended that Dr Christensen's spreadsheets supposedly indicated he started releases at 11.00pm on 7 January 2011 rather than midnight.[39] No pinpoint evidentiary reference was provided for this contention. It was not taken up with Dr Christensen in cross-examination and is not

[32] SunWater subs at [1445] to [1456].
[33] SBM.040.005.0001.
[34] Ibid at [22].
[35] Ibid at [27].
[36] Section 9.3 and section 9.5.
[37] SBM.040.005.0001 at [28].
[38] Chapter 2; section 2.10.
[39] SBM.040.055.0001 at [30].

supported by the gate operations spreadsheet for SIM F.[40] In any event, as noted the one-day PMEs were available from 6.00pm on 7 January 2011.

18 Subject to considering the balance of the issues raised in relation to SIM F and SIM H, I am satisfied that a reasonably competent flood engineer acting consistently with the Manual who inherited the circumstances prevailing at midnight on 8 January 2011 would have made releases throughout 8 January 2011 substantially in accordance with the rates adopted in those simulations.

9 January 2011

19 By midnight on 9 January 2011 the actual storage level of Wivenhoe Dam was EL 68.64m AHD.[41] In Chapter 7[42] I found that, having regard to the actual level of the dam and projected inflows, flood operations should have at the very least been conducted in Strategy W3. I also found that, if the engagement of strategy was undertaken based on three-day forecasts, then W4 would have been engaged.[43] Further, having regard to actual dam levels and the developing rainfall forecasts, I concluded that the remaining bridges had to be inundated in the short term.[44]

20 In SIM F and SIM H, as at midnight Wivenhoe Dam would have been at EL 67.47m AHD.[45] Depending on which estimate of the four-day inflow volume is used, the projected height of Wivenhoe dam from that time was above EL 72.44m AHD and any reasonable estimate was well above it.[46] (It was EL 75.07m AHD using Dr Christensen's estimate of inflows using the eight-day PME forecast[47]).

21 In his explanation of strategies for SIM H, Dr Christensen repeated the statement that the "Strategy/Target" was to keep the dams as low as possible

[40] Simulation Analysis, EXP.ROD.015.0461 at .0860.
[41] Ibid at .0931.
[42] Chapter 7 at [94].
[43] Chapter 7 at [124].
[44] Chapter 7 at [124].
[45] Simulation Analysis, EXP.ROD.015.0461 at .0931.
[46] See Appendix E to this judgment at "09 Jan 00" row.
[47] Response Report Vol 2, EXP.ROD.015.0261 at .0399.

while “keeping Moggill < 4000”;[48] ie, no target level or volume was selected. In his simulation analysis for SIM F, Dr Christensen also noted a “large flood [was] imminent” and adopted of a W4A strategy.[49] At 1.00am on 9 January 2011, the predicted peak downstream flows at Moggill were 840m^3/s. At 8.00am the predicted peak was 780m^3/s but by 2.00pm the predicted peak had increased to 1210m^3/s. By 7.00pm it had increased again to 1940m^3/s.[50] Dr Christensen’s day-by-day simulated release rates explanation stated that the early downstream forecasts warranted an increase in releases to a “maximum target of 2900m^3/s”[51] but that this target would have been scaled back as the downstream forecasts worsened. By 7.00pm, the target maximum release rate was 1940m^3/s. Consistent with these figures, Dr Christensen’s simulated gate openings at Wivenhoe Dam increased from 61 increments at midnight to 66 increments by 9.00am, before gate closing commenced at 2.00pm, leaving gates open to 39 increments at midnight on 10 January 2011.[52] Releases would have peaked at 2868m^3/s at 5.00am on 9 January 2011 before reducing to 1844m^3/s at midnight on 10 January 2011.[53]

22 In SIM H, all of Dr Christensen’s modelling of a “no release” rise based on the one-day QPFs available through 8 January 2011 projected dam heights above EL 70m AHD. The same results are attained with Mr Pokarier’s corrected one-day inflows and Mr Giles one-day estimates.[54] Based on the QPF issued on the afternoon of 8 January 2011, Dr Christensen continued with a W3 strategy[55] and all iterations of the 24-hour inflow modelling at that time and thereafter for 9 January 2011 projected dam storage levels well above EL 68.5m AHD.[56] Having regard to the longer-term forecasts, Dr Christensen maintained the release strategy from the previous day. Given that Strategy W3 limits outflows to 4000m^3/s and given the predicted peak

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[48] Response Report Vol 2, EXP.ROD.015.0261 at .0390.
[49] Simulation Analysis, EXP.ROD.015.0461 at .0846.
[50] Ibid at .0846 to .0847.
[51] Response Report Vol 2, EXP.ROD.015.0261 at .0399.
[52] Simulation Analysis, EXP.ROD.015.0461 at .0860 to .0861.
[53] Ibid at .0846 to .0847.
[54] See Appendix E to this judgment.
[55] Simulation Analysis, EXP.ROD.015.0461 at .0931 to .0932.
[56] See Appendix E to this judgment.

downstream flows, I accept his reasoning that releases in SIM H would have been and should have been the same as in SIM F.

23 Again, subject to considering the balance of the issues raised in relation to SIM F and SIM H, I am satisfied that a reasonably competent flood engineer acting consistently with the Manual who inherited the circumstances prevailing at midnight on 8 January 2011 would have made releases throughout 9 January 2011 substantially in accordance with the rates adopted in those simulations.

10 January 2011

24 In SIM F, as at midnight on 10 January 2011 all of the permutations of the four-day forecast inflow volumes lead to a projected dam height at or above EL 74.87m AHD.[57] Dr Christensen's modelling (and Mr Giles' adjustment of the loss rates based on the Late December Flood Event) projected a height sufficient to initiate a fuse plug breach and thus engage W4B in SIM F.[58] Dr Christensen's Simulation H analysis also records the adoption of Strategy W4B at midnight on 10 January 2011,[59] however this was not justified by the most recent QPF and could only have been engaged by the QPF issued later that morning. In any event, and leaving aside Somerset Dam operations, it does not matter because in both simulations Dr Christensen determined not to make releases that caused flows at Moggill to exceeded $4000m^3/s$ and thus releases made on 10 January 2011 in SIM F and SIM H would have been governed exclusively by downstream constraints. Consistent with this, in his explanation of strategies, Dr Christensen described the "Strategy/Target" as filling the dams below EL 74.00m AHD and "keeping Moggill < 4000";[60] ie, again no target volume or water level was selected.

[57] See Appendix E to this judgment.
[58] Simulation Analysis, EXP.ROD.015.0461 at .0847; Response Report Vol 2, EXP.ROD.015.0261 at .0392.
[59] Simulation Analysis, EXP.ROD.015.0461 at .0932.
[60] Response Report Vol 2, EXP.ROD.015.0261 at .0392.

25 In his day-by-day release rates explanation for SIM F, which is also applicable to SIM H, Dr Christensen explained the position as follows:[61]

> "Wivenhoe releases are fully determined and controlled by the 1-day flood engineers' forecasts at Moggill. Gates were moved as needed to preserve storage in response to the forecasts, remain near the targeted release rate and keep Moggill below 4,000m³/s if possible.
>
> At first, the January 9 operation is continued being Moggill forecast to peak at 1,940m³/s with a maximum release rate of about 1,900m³/s was targeted.
>
> At 1:00, the forecast peak at Moggill was slightly increased to 2,000m³/s. A maximum release rate of about 1,900m³/s was continued.
>
> At 9:00, the forecast peak at Moggill was increased to 2,090m³/s. A maximum release rate of about 1,800m³/s was targeted.
>
> At 15:00, the forecast peak at Moggill was increased to 2,570m³/s. A maximum release rate of less than 1,400m³/s was targeted and releases decreased accordingly.
>
> At 20:00, the forecast peak at Moggill decreased to 1,810m³/s. A maximum release rate was increased accordingly to a target of about 1,900m³/s and continued for the remainder of the day."

26 Subject to considering the balance of the issues raised in relation to SIM F and SIM H, I am satisfied that a reasonably competent flood engineer acting consistently with the Manual who inherited the circumstances prevailing at midnight on 8 January 2011 would have made releases throughout 10 January 2011 substantially in accordance with the rates nominated by those simulations.

11 and 12 January 2011

27 The flood operations simulated in SIM F and SIM H on 11 and 12 January 2011 are addressed in section 9.7 of Chapter 9. Dr Christensen's explanation of strategies describes the approach on this day as "fill to below [FSL] at first, then protect the dam while minimising Moggill".[62] Subject to considering the balance of the issues raised in relation to SIM F and SIM H, I am satisfied that a reasonably competent flood engineer acting consistently with the Manual who inherited the circumstances prevailing at midnight on 8 January 2011

[61] Response Report Vol 2, EXP.ROD.015.0261 at .0399.
[62] Ibid at .0393 to .0394.

would have made releases throughout 11 and 12 January 2011 (and thereafter) substantially in accordance with the rates adopted in those simulations as varied by Table 18 to Mr Ickert's Response Report dated 30 November 2017.[63]

Refill to FSL

28 In SIM F and SIM H the simulated level of Wivenhoe Dam drops below FSL between 7.00am and 8.00pm on 9 January 2011. Its lowest level is EL 66.54m AHD at 3.00pm on 9 January 2011.[64] As noted above, it was accepted that, throughout that period, Wivenhoe Dam could be refilled by the amount of water that Somerset Dam was above FSL.[65] At no stage in SIM F did Somerset Dam drop below FSL. It follows from the findings in Chapter 5[66] that the simulated flood operations in SIM F and SIM H do not compromise the Manual's objective of retaining storage at FSL at the conclusion of the flood event.

Peak Outflow and Peak Inflow

29 Attached to Seqwater's submissions was a table for each of Dr Christensen's simulations comparing their peak rate of outflow at any given time to the maximum inflow rate recorded up to that time and the peak inflow rate predicted at that time in the flood engineers' rain on the ground operational spreadsheets.[67] Seqwater relied on the table as demonstrating that, at various times, each simulation violated the statement in the Manual that "peak outflow should generally not exceed peak inflow".[68] Mr Fagot was critical of SIM F on the basis that outflow on 8 and 9 January 2011 exceeded peak inflow to date.[69]

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[63] Set out in Table 9-8 in Chapter 9; Chapter 9 at [309]; EXP.SUN.009.0001 at .0292.
[64] Simulation Analysis, EXP.ROD.015.0461 at .0932.
[65] SunWater subs at [1430]; SBM.020.014.0001 (Seqwater).
[66] Chapter 5 at [200].
[67] Seqwater subs at .0595 to .0602.
[68] Manual at 23.
[69] EXP.QLD.001.1311 at [117].

30 In relation to SIM F and SIM H, at 11.00pm on 7 January 2011 Seqwater's table identified the peak inflow to time now (and as far as 8.00am on 8 January 2011) as being 1688m^3/s.[70] That figure was derived from the flood engineers' 6.00pm rain on the ground RTFM model run, which utilised the rate of inflows as at midday that day.[71] In fact, by reference to Dr Christensen's figures that he derived from the January FER, it can be determined that, by use of reverse routing, it could have been ascertained that at around 11.00am on 7 January 2011 the rate of inflows into Wivenhoe Dam (excluding Somerset outflows) was 2190m^3/s.[72] Further the maximum rate of inflows during the Late December Flood Event was 2200m^3/s on 27 December 2011.[73] Given that neither dam had fallen below FSL since that time, and that rainfall had effectively been ongoing, the Late December Flood Event was very much continuing since then.

31 I have already rejected the contention that the references to peak inflow in the phrase "peak outflow should generally not exceed peak inflow" are restricted to past peak inflow or peak inflow confined to a rain on the ground prediction. Instead, it includes the predicted peak over the course of the event.[74] When pressed on the rate of outflows in SIM C on 6 and 7 January 2011, Dr Christensen explained that a reasonably competent flood engineer who knew that 86mm of rain had produced a peak inflow rate of 2200m^3/s in the Late December Flood Event would comfortably expect the larger amounts of rain that were forecast to produce a much higher peak rate of inflow.[75]

32 A similar conclusion follows from considering the response of the catchments since 2 January 2011. The inflow rate of 2225m^3/s at Wivenhoe Dam at 11.00am on 7 January 2011 had been produced by less than approximately 80mm of rain over 5, 6 and part of 7 January 2011.[76] Dr Christensen's four-day RTFM run referable to midnight on 8 January 2011 predicted a peak

[70] Seqwater subs at .0598.
[71] QLD.001.001.2409; input data table, cell H131.
[72] Simulation Analysis, EXP.ROD.015.0461 at .0786 and .0794.
[73] 2010 FER at .6606.
[74] See Chapter 3, section 3.3.9.
[75] T 1647.5.
[76] T 8834.1 (Giles); see Table 6-1 in Chapter 6 at [3].

inflow rate into Wivenhoe Dam of 3155m^3/s.[77] This did not include any consideration of rain on the ground flows, which even on the flood engineers' modelling was between 100 and 300m^3/s over the following two days. Even allowing for the various complaints about the use of Dr Christensen's forecast modelling to derive peak flow and timing,[78] a predicted peak rate over the course of the flood event of say at least 3000m^3/s was more than realistic given recent inflows, the assessments of the four-day PME forecast, the state of the catchment and its response during the Late December Flood Event. The maximum rate of discharge in SIM F and SIM H on 8 January 2011 was 2780m^3/s at 8.00pm.[79] Having regard to the proper construction of this part of the Manual as explained in section 3.3.9 of Chapter 3, maintaining a rate of outflow that is less than a realistic assessment of peak inflow over the following four days, where all of the forecasts predicted substantial rain over those days, is consistent with this part of the Manual.

33 The same position applies as at midnight on 9 January 2011. The maximum modelled release rate on 9 January 2011 in SIM F and SIM H was 2868m^3/s occurring at 5.00am.[80] Dr Christensen's four-day volume assessment as at midnight on 9 January 2011 predicted a peak rate of 3157m^3/s[81] and the PMEs were suggesting that the rain predicted by the four-day forecast would fall over three days.[82] By 11.00am, Dr Christensen's 24-hour forecast runs were predicting a peak inflow of 3114m^3/s.[83] Otherwise, by 2.00pm actual inflows ascertainable by reverse routing were 2414^3/s excluding Somerset Dam outflows. By 3.00pm, actual inflows ascertainable by reverse routing were 3098m^3/s excluding Somerset Dam outflows, both figures of which exceeded all previous and subsequent Wivenhoe outflows in SIM F and SIM H until 14 January 2011.[84]

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[77] MSC.010.080.0001.
[78] See Chapter 8 at [98] to [99]; Chapter 9 at [403ff].
[79] Simulation Analysis, EXP.ROD.015.0461 at .0846.
[80] Ibid at .0931.
[81] MSC.010.084.0001.
[82] Chapter 7 at [143].
[83] MSC.010.172.0001.
[84] Simulation Analysis, EXP.ROD.015.0461 at .0847, .0853.

Somerset Dam Operations

34 In the events that happened, at midnight on 8 January 2011 Somerset Dam was at EL 100.31m AHD and rising.[85] It had one sluice gate open and was releasing 206m^3/s into Wivenhoe Dam.[86] As noted, this aspect of the flood engineers' flood operations was inconsistent with the first box in S2 of the Manual (if that is construed as a prohibition).[87] By 2.00pm on 9 January 2011, five sluice gates were open releasing 1034m^3/s into Wivenhoe Dam. They were all closed between 4.00am and 8.00am on the morning of 11 January 2011.[88]

35 In his day-by-day release rate explanation for SIM F, Dr Christensen stated that from the commencement of the simulation he would have closed the remaining sluice gate to "store as much water as possible in Somerset [Dam] given that the spillway gates must remain wide open" and thus uncontrolled spillage above EL 100.45m AHD would have resulted.[89] Dr Christensen maintained these settings until midnight on 14 January 2011.[90] Given that uncontrolled spillage occurs above EL 100.45m AHD, the effect of these settings was that the rate of spillage of water from Somerset Dam into Wivenhoe Dam was purely a function of the height of Somerset Dam. SIM H adopted the same gate settings for Somerset Dam.[91] In SIM F, Somerset Dam would have peaked at EL 106.25m AHD at 1.00am on 12 January 2011.[92] The levels in Somerset Dam would have dropped before any sluice gates were opened.[93]

36 As noted, SIM J had the same governing assumptions as SIM F save that it assumed that the Somerset Dam crest gates could be closed. Dr Christensen stated that in SIM J he would have closed the crest gates at midnight on

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[85] Simulation Analysis, EXP.ROD.015.0461 at .0853.
[86] January FER at .0465.
[87] Manual at 40; see Chapter 9 at [364ff].
[88] January FER at .0466 to .0467.
[89] Response Report Vol 2, EXP.ROD.015.0261 at .0398.
[90] Ibid at .0403.
[91] Simulation Analysis, EXP.ROD.015.0461 at .0945.
[92] Ibid at .0885.
[93] Id.

8 January 2011 and opened three sluice gates.[94] He said that he would have maintained those settings until 7.00am on 12 January 2011 when he would have opened a further sluice gate, causing Somerset Dam to crest shortly afterwards at EL 106.93m AHD.[95] He stated that he would have opened one further sluice gate on each of the two following days.[96]

37 Mr Pokarier mapped the respective heights of Wivenhoe Dam and Somerset Dam against the Operating Target Line in both SIM F (which is the same as SIM H) and SIM J as follows:[97]

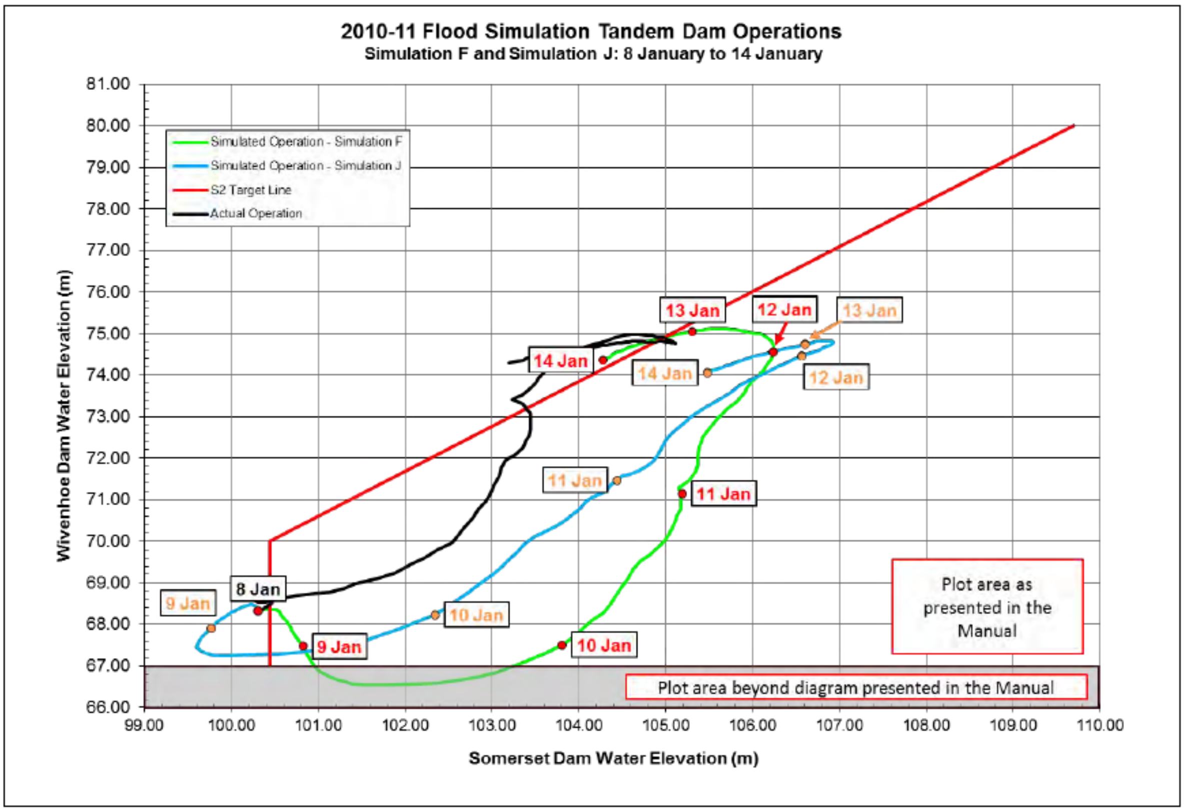

Figure 10-1: Tandem Dam Operations Line for Simulations F, J and H

38 Four particular criticisms emerged of Dr Christensen's hypothetical operation of Somerset Dam in SIM F (green), SIM H (green) and SIM J (blue).

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[94] Response Report Vol 2, EXP.ROD.015.0261 at .0444 to .0445.
[95] Ibid at .0448.
[96] Ibid at .0448 to .0449.
[97] EXP.SEQ.016.0012 at 0169; Mr Ayre reproduced a similar graph: LAY.SUN.006.0001 at .0191 and .0221.

39 The first criticism concerned the trajectory of so much of the green line in the above diagram which moves away from the Operating Target Line, principally the time between 8 January 2011 and 10 January 2011.[98] Seqwater noted one part of Dr Christensen's oral evidence in which he stated that on 8 January 2011 he was using the S2 Operating Target Line.[99] However, he immediately clarified that the S2 Operating Target Line was not engaged on that day as Somerset Dam was initially at EL 100.31m AHD and throughout the day Wivenhoe Dam was falling.[100]

40 I have already found that the relevant part of S2 that engages the Operating Target Line is not invoked unless both Wivenhoe Dam is rising and Somerset is above the level of EL 100.45m AHD.[101] Under SIM F and SIM H, that point was not reached until around 4.00pm on 9 January 2011 when Somerset Dam would have been at EL 102.14m AHD.[102] At that point, both rain on the ground inflows and forecast inflows for both dams were increasing. As noted, the provisions in the Manual concerning the Operating Target Line allow temporary movement away from the target line. As the simulated inflows into Somerset Dam increased, the rate of uncontrolled spillage from Somerset Dam above EL 100.45m AHD would have increased rapidly, causing the line to angle upwards as it did. In those circumstances, I am satisfied that a reasonably competent flood engineer would continue to store water in Somerset Dam via keeping the sluice gates closed in the knowledge that uncontrolled spillage above EL 100.45m AHD would align dam levels with the Operating Target Line as the flood event progressed.

41 The second criticism concerned the differences between operations in SIM F and SIM H on the one hand and SIM J on the other.[103] The above graph indicates that more water was stored in Somerset Dam in SIM F compared to

[98] State subs at [206] and [552]; State supplementary subs on causation, SBM.040.005.0001 at [31]; EXP.SEQ.016.0012 at .0177 to .0178; LAY.SUN.006.0001 at [780]; EXP.QLD.001.1311 at [118] and [131].
[99] T 2566.17 to .33; Seqwater subs at [2264].
[100] T 2668.35 to T 2669.8.
[101] Manual at 40.
[102] Simulation Analysis, EXP.ROD.015.0461 at .0931 to .0932, .0938.
[103] Seqwater subs at [2262] and [2263].

SIM J until 7.00pm on 11 January 2011.[104] Mr Pokarier contended that this was "counter intuitive" given that there is a greater capacity to store water in SIM J as it assumes the crest gates can be closed.[105] However, in cross-examination, Dr Christensen explained that this reflected the lack of control over the storage capacity that would have existed under SIM F (and SIM H) given its operative assumption that the crest gates at Somerset Dam had to remain open.[106] He stated that in SIM J there was greater control over Somerset Dam releases and storage than in SIM F (and SIM H).[107] According to Dr Christensen, this meant that, in SIM J, the better approach was to release from Somerset Dam immediately because of the capacity to store inflows later, whereas in SIM F the better approach was to store inflows immediately because there was much less capacity to store them later.[108] I accept this explanation. In effect it means that, in SIM F and SIM H, Dr Christensen is taking the opportunity during the weekend of 8 and 9 January 2011 while he has control over Somerset Dam releases to build up storage space in Wivenhoe Dam over which he has a high level of control in the knowledge that he will have far less control over releases from Somerset Dam if the predicted amounts of forecast rain eventuate. Hence, at 2.00pm on 9 January 2011 in SIM F, Wivenhoe Dam is at EL 66.54m AHD[109] whereas in SIM J Wivenhoe Dam would not have fallen below FSL.[110] At its peak, Somerset Dam in SIM J would have risen to EL 106.93m AHD,[111] whereas in SIM F it would not have exceeded EL 106.25m AHD.[112]

42 The third criticism concerned what was said to be an apparent inconsistency between SIM F and SIM H in that, in the former, S3 was engaged from 8 January 2011 based on longer term forecasts, whereas in the latter, one-day forecasts would have only engaged S2,[113] yet their gate operations

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[104] Compare Simulation Analysis EXP.ROD.015.0461 at .0940 with .1069.
[105] EXP.SEQ.016.0012 at .0171, [489].
[106] T 1844.35 to T 1846.31.
[107] T 1844.40 to T 1845.4.
[108] T 8145.6 - .16.
[109] Simulation Analysis, EXP.ROD.015.0461 at .0847.
[110] Ibid at .1060.
[111] Ibid at .1069.
[112] Ibid at .0855.
[113] See for example Appendix E to this judgment.

at Somerset Dam were identical.[114] This is just another instance of the matter noted in Chapter 9[115] namely that if all sluice gates are closed in S2 and the crest gates at Somerset Dam remain open then there is no further step that can be undertaken to implement S3. In SIM H, on 8 January 2011 Dr Christensen adopted Strategy W3 and S2. He determined to close the sluice gates at Somerset Dam on 8 January 2011 to create (controllable) storage space at Wivenhoe Dam. That position pertained thereafter until 14 January 2011. The one-day forecasts in SIM H on 10 January 2011 warranted the adoption of W4B/S3. However, as all the sluice gates were closed, no further step could be taken to store water in Somerset Dam. In SIM F, the sluice gates were all closed from the commencement of the simulation. Strategy W4B/S3 was engaged on 8, 10 and 11 January 2011,[116] but again no further step could have been taken to store water in Somerset Dam because all the sluice gates were closed.

43 Mr Pokarier noted that in SIM F on 9 January 2011 the eight-day forecast prompted a change to Strategy W4A from W4B but that there was no change to Somerset gate operations.[117] However, the rationale that drove the closing of the sluice gates in both SIM F and SIM H still pertained at that time. Mr Ayre contended that, in SIM H, Dr Christensen provided no explanation of when strategy at Somerset Dam in SIM H transitioned from S2 to S3.[118] However, as explained above, given that all five sluice gates were closed, that transition made no practical difference to gate operations.[119]

44 The fourth criticism concerns Dr Christensen's assessment of the risk of Somerset Dam being overtopped.

45 In his explanation of strategies for SIM F for each day, Dr Christensen included a passage addressing the risk of overtopping at Somerset Dam.[120]

[114] Seqwater subs at [2264].
[115] Chapter 9 at [371ff].
[116] Simulation Analysis, EXP.ROD.015.0461 at .0846 to .0847, .0853 to .0854.
[117] EXP.SEQ.016.0012 at .0177.
[118] LAY.SUN.006.0001 at [792].
[119] Plaintiff subs at [1986].
[120] Response Report Vol 2, EXP.ROD.015.0261 at .0389 to .0395.

For example, on 10 January 2011 in SIM F (and SIM H), Somerset Dam would have been at EL 103.81m AHD with both the four and eight-day average forecast no release rises predicting an increase of 5.6m (to 109.41m AHD) and the eight-day high range predicting an increase of 5.8m.[121] Dr Christensen noted:[122]

> "With the available storage (267,000 ML to 107.46m) and spill through the Somerset spillway gates and the available sluice gate and regulator release capacity (up to 4,650m^3/s at 107.5), the 8 day high range inflow and the 4 day inflow do not indicate a concern for Somerset overtopping its crest at 107.46m."

46 A footnote to the explanation included a calculation to the effect that the average daily spill rate for the eight-day high forecast inflow volume in excess of EL 107.46m AHD was 282m^3/s (over eight days) and for the four-day average inflow volume the spill rate was 506m^3/s (over four days). As at midday on 10 January 2011, in SIM F Somerset Dam was at EL 104.92m AHD and would have been spilling over the crest gates at a rate of approximately 1131m^3/s.[123]

47 Mr Pokarier was critical of this reasoning. He contended that the four-day forecast volume should have been assessed on the basis that it would fall in two days, yielding a rate of 1128m^3/s. He noted that, at midnight on 10 January 2011 the release rate from Somerset Dam was 671m^3/s.[124] This criticism was not put to Dr Christensen but, accepting the possibility of the four-day forecast of rain falling and flowing into the dam within two days, Mr Pokarier's calculations overlook the fact that the release rate from uncontrollable spillage increases dramatically as the height of Somerset Dam increases[125] and the sluice gates could be opened to release at least a further 1600m^3/s if necessary.

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[121] Response Report Vol 2, EXP.ROD.015.0261 at .0392.
[122] Ibid at .0393.
[123] Ibid at .0854.
[124] EXP.SEQ.016.0012 at .0180.
[125] In Dr Christensen's simulations: 408m^3/s at EL 103.06m AHD, 777m^3/s at EL 104.04m AHD, 1206m^3/s at EL 105.04m AHD, 1689m^3/s at EL 106.08m AHD: Simulation Analysis, EXP.ROD.015.0461 at .0939 to .0940. These figures appear consistent with the spillway discharge figures in the Manual at 60 (multiply discharge per spillway bay figure x 8).

48 Both Mr Pokarier[126] and Mr Ayre[127] were critical of an apparent inconsistency in Dr Christensen taking into account releases for the purposes of his overtopping analysis yet using a "no release" rise for determining Wivenhoe strategies. I do not accept that there is any inconsistency. As explained in Chapter 8[128], Dr Christensen used the "no release" rises at Somerset Dam as a component of his determination of the relevant duty point but it was not the sole determinant. Otherwise, for both Wivenhoe Dam and Somerset Dam Dr Christensen did not state that he would ignore the effect of releases in assessing the risks of overtopping[129] as opposed to selecting strategies. There is no "inconsistency" in using different methodologies to calculate different figures for different purposes.

49 Otherwise, I note that if Mr Ickert's proposed variation to gate operations in SIM F had been implemented[130] then the rise of Wivenhoe Dam between EL 74m AHD and EL 75.10m AHD that would have occurred between 9.00pm on 11 January 2011 and 4.00pm on 12 January 2011 would have instead only been a rise to EL 74.70m AHD by 7.00am on 12 January 2011, with Wivenhoe Dam levels falling thereafter. On this approach, the equivalent line to the green line in Figure 10-1 would be virtually identical up to the point marked "12 Jan", which is just one hour prior to the simulated peak of Somerset Dam. At this point, the varied green line would trend towards the Operating Target Line even more sharply than the original green line, before reaching a plateau for Wivenhoe Dam 0.4m below the original green line. At that point, both Somerset Dam and Wivenhoe Dam levels would start to drop such that the line would trend towards the Operating Target Line in a slightly downward slope rather than horizontally as shown in the diagram. The end result is that Mr Ickert's variation to the gate opening strategy above EL 74.0m AHD for SIM F and SIM H do not add to any concerns about the correlation of the operation of both dams to the Operating Target Line.

[126] EXP.SEQ.016.0012 at .0180 to .0181.
[127] LAY.SUN.006.0001 at [678].
[128] Chapter 8 at [119] to [120].
[129] T 1303.32.
[130] Table 9-8; Chapter 9 at [309].

Other Matters

50 SunWater submitted that SIM F (and presumably SIM H) involved the release of water from below the gate trigger level of EL 67.25m AHD.[131] I have rejected the construction of the Manual that is the premise of this contention.[132]

51 SunWater was critical of Dr Christensen's release rate of 2740m^3/s at 3.00pm on 8 January 2011 when the 24-hour QPF forecast provided a peak downstream flow estimate of 940m^3/s.[133] It was also critical of his release rate of 2405m^3/s at 7.00pm on 9 January 2011 when a revised forecast of downstream flows predicted a peak of 1940m^3/s, which would have prompted Dr Christensen to reduce outflows to a rate of approximately 1800m^3/s give hours later.[134] In part, this is addressed by the caution built into the downstream flow estimates noted in Chapter 6.[135] Further, Dr Christensen explained that he would examine the hydrographs of downstream flows to determine the timing of the predicted peaks to "mak[e] sure that you are reducing releases within the time frame needed to keep Moggill" below the appropriate rate.[136]

52 SunWater submitted that there remained the risk of rain falling directly onto the Brisbane River, being a matter that the flood engineer has "no control and no knowledge" of.[137] Given the width of the Brisbane River, there would have to have been an extremely large volume of rainfall directly onto the river to make a significant difference to flow rates. Otherwise, the risk identified by SunWater pertains with all forms of flood operations and it was heightened in the events that transpired.

[131] SunWater subs at [1458] to [1459].
[132] Chapter 3 at [146], Chapter 5 at [79].
[133] SunWater subs at [1489]; Simulation Analysis, EXP.ROD.015.0461 at .0846; State supplementary submissions on causation, SBM.040.005.0001 at [33].
[134] Simulation Analysis, EXP.ROD.015.0461 at .0847.
[135] Chapter 6 at [24].
[136] T 2439.38.
[137] SunWater subs at [1198].

53 The same observations apply in relation to a criticism SunWater made of the size of releases in SIM C on the afternoon of 10 January 2011.[138] As the relevant release was virtually identical to that modelled in SIM F at the same time (because releases in both simulations were at this time governed by downstream conditions),[139] it is convenient to deal with it at this point. Dr Christensen's simulation analysis for SIM C records a release rate of 1658m^3/s from Wivenhoe Dam at 4.00pm on 10 January 2011 and the receipt of a forecast of a natural peak of 2570m^3/s at Moggill.[140] This peak was forecast to occur at 11.00am the following morning.[141] SunWater noted that this had the potential to combine with the releases made at or around 4.00pm on 10 January 2011 to exceed 4000m^3/s.[142] However, Dr Christensen modelled an immediate reduction in releases to avoid that outcome before receiving a lower downstream forecast four hours later. Otherwise, for the reasons already stated, his downstream modelling had a strong element of caution attached to them. It is notable that the flood engineers who did not use forecast modelling to monitor downstream flows released at a much higher rate throughout 10 January 2011 than SIM F.

54 SunWater submitted that Dr Christensen's SIM F (and presumably SIM H) operations are subject to an "optimum protection fallacy".[143] They contrast his operations in SIM F on 8 January 2011 with the circumstances prevailing on 26 December 2010, when significant rainfall was predicted but did not eventuate in predicted quantities. It submitted that the adoption of Dr Christensen's approach would have led to a record release of around 2800m^3/s at that time, inundating all bridges and causing some damage.[144]

55 The premise of SunWater's submission that similar levels of releases would have been made at that time is doubtful. As at 26 December 2010, Wivenhoe Dam level was at EL 67.33m AHD which is almost a metre less than the

[138] SunWater subs at [1312].
[139] Simulation Analysis, EXP.ROD.015.0461 at .0630, .0847.
[140] Ibid at .0630 and .0847.
[141] AID.500.021.0001 at .0002 citing SUN.002.002.2676.
[142] SunWater subs at [1312].
[143] Ibid at [1464].
[144] Ibid at [1464] to [1475].

commencement height of SIM F (and SIM H). While, according to SunWater, the eight-day “no release” rise would have exceeded EL 75.5m AHD, the four-day forecast as at 26 December 2010 was 100 to 200mm compared to 100 to 300mm on 8 January 2011.[145] The one-day forecast on 8 January 2011 was 25 to 50mm.[146] If SIM F was applied to these circumstances, but using the four-day PME to select strategy, it is likely that W3 would have been engaged but not inevitable that the release rate would have inundated all downstream bridges. If the approach in SIM H was applied it is not clear whether Strategy W3 would have been engaged. In any event, these submissions only return attention to the Manual with its priority of objectives and emphasis on rainfall forecasts. As discussed in Chapter 3, its wording reflects an assessment that, if the cost of optimising protection against urban inundation,[147] is the inundation of bridges which, with the benefit of hindsight proves to have been unnecessary, then so be it.[148]

Conclusion

56 I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing as at midnight on 8 January 2011 would have made releases substantially in accordance with SIM F and SIM H as varied by Table 18 to Mr Ickert’s Response Report dated 30 November 2017.[149]

10.2: Simulation C – 2 January 2011 Start

57 An overview of SIM C is set out in Chapter 8[150]. It involved an adaptation of Dr Christensen’s primary methodology so that strategies and, to an extent, releases were determined by modelling based on one-day QPFs. To that end, in SIM C Dr Christensen reconsidered the position at 11.00am and 5.00pm on each day by reference to modelling undertaken on the most recently released QPF forecast.[151] The modelling of that forecast on the RTFM uses Dr

[145] February 2015 Report, EXP.ROD.001.0016 at [660] to [662].
[146] Id.
[147] Determined by a flow rate of 4000m^3/s at Moggill.
[148] Chapter 3 at [194].
[149] EXP.SUN.009.0001 at .0292.
[150] Chapter 8 at [146] to [149].
[151] Response Report Vol 2, EXP.ROD.015.0261 at .0342 to .0347.

Christensen's one-day and rain on the ground loss rates which in some respects differed from those adopted by the flood engineers.[152] Dr Christensen stated that the selection of strategy was dictated by a "no release" rise as determined by the modelling of the QPF forecast.[153] However, he also explained that, in SIM C, release rates were "influenced" by the four-day and eight-day forecasts.[154] He said that he used them for "situational awareness".[155] In SIM C, the modelled flood operations would have taken both dams below FSL[156] but only if the amount below FSL was exceeded by the predicted one-day forecast volume[157] (the "refill condition"). Dr Christensen also explained that he used the one-day forecast as the basis upon which to end flood operations.[158]

QPF Error and 4-Day PME Justification

58 One of the difficulties facing so much of the plaintiff's case that sought an acceptance of SIM C was the error that Dr Christensen made in calculating the volume of one-day inflows noted in Chapter 8.[159] Mr Pokarier recalculated the volume of those inflows.[160] Appendix F to this judgment sets out a table of the various estimates of one-day flows that were produced in the proceedings and the corresponding projected dam heights. It also includes estimates of the four-day inflows based on the four-day PMEs made available at midnight (ie, the 00UTC PMEs, with the constituent one-day PMEs available four hours earlier). Each projected height is accompanied by a footnote which sets out the revised height that accounts for Dr Christensen's overestimation of inflows for the period 2 to 6 January 2011 based on the figures provided by

[152] T 2656.46; see section 9.4 of Chapter 9.
[153] T 2658.31.
[154] T 2658.9, T 2659.27.
[155] T 2655.23.
[156] T 2659.32.
[157] T 2657.38; T 2658.9.
[158] T 2660.27 to T 2661.43; T 2661.11; see Response Report Vol 2, EXP.ROD.015.0261 at .0328 and .0342 which selects the target to end flood operations by reference to one-day "no release" rise (ie, 0.5m) when the eight-day high "no release" rise was 0.9m.
[159] Chapter 8 at [27].
[160] See Chapter 9 at [286]; Table 9-8.

Seqwater.[161] The modelled release rates from Wivenhoe Dam and Somerset Dam at the corresponding time in SIM C are set out in the last two columns.

59 It is apparent from Appendix F to this judgment that the correction of Dr Christensen's one-day volumetric estimates creates a particular difficulty with the releases in SIM C from 7 January 2011 to the morning of 9 January 2011.[162] On those days, Dr Christensen's modelling of the QPF forecasts lead him to project a height for Wivenhoe Dam on a "no release" basis sufficient to place him in Strategy W3 on 7 January 2011 and W1E on 8 January 2011. In turn, this facilitated the making of releases at levels permitted by those strategies, namely at around 2400m^3/s on 7 January 2011[163] and at around 1870m^3/s on the afternoon of 8 January 2011.[164] Dr Christensen otherwise supported the need to make releases at those levels by reason of the dire four-day and eight-day forecasts. However, the revised volumes provided by Mr Pokarier meant that Strategies W1C, W1E and W1B would have been engaged in SIM C on 7 and 8 January 2011 into the morning of 9 January 2011, which limited releases to 500m^3/s, 1900m^3/s and 380m^3/s respectively.[165] The plaintiff sought to counter this point by contending that the reduction in releases occasioned by these limits would have pushed later water levels higher and led SIM C back into Strategy W3, therefore generating higher releases at a later time with no overall difference in result. The submissions and counter submissions on that contention were extensive.[166]

60 However, the plaintiff also submitted that the flood operations could be supported by reference to longer term forecasts in that SIM C "operations represent an exceptionally conservative operation of the dams on the basis of Strategy selection using the 4-day or 8-day forecasts".[167]

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[161] SBM.020.021.0001 at .0004; see for example Appendix F; footnote 13.
[162] Plaintiff subs at [1898].
[163] Simulation Analysis, EXP.ROD.015.0461 at .0629.
[164] Ibid at .0630.
[165] Manual at 26 to 27.
[166] Plaintiff subs at [1896] to [1901]; Seqwater subs at [2413] to [2430]; SunWater subs at [1285] to [1295]; SBM.010.12.0001 at [19] to [28]; MSC.010.552.0001; SBM.020.015.0001.
[167] Plaintiff subs at [1902]; AID.010.003.0001; T 10188.

61 One foundation for this submission is that the four-day PME forecasts are suitable for use in selecting strategies under the Manual, a proposition I have accepted. As noted, the various four-day inflow estimates are set out in Appendix F to this judgment. They will be considered in the context of each day of SIM C. At this point it suffices to state that from 3 January 2011 onwards, both Dr Christensen's estimates of the four-day volumes and Mr Giles' "correction" of those estimates to account for his analysis of the Late December Flood Event are more than sufficient to engage a strategy that enables releases at the rates modelled at any point in SIM C. Further, given the findings I have made about the range of rainfall depths that can be ascertained from the four-day PME forecasts and given the wide margin between each four-day inflow projected height and EL 68.5m AHD, I am satisfied that this conclusion extends to all reasonable estimates of the four-day inflows (including any such estimates that use the flood engineers' rain on the ground estimates from midnight on 7 January 2011 onwards).[168] The relevance of the four-day PME forecast to the position on 2 January 2011 (and each day of the simulation) is addressed below.

62 Seqwater contended that it was not open on the pleading for the plaintiff to attempt to establish that flood operations substantially in accordance with SIM C constituted "reasonably prudent flood operations" whilst justifying the selection of strategies and releases by reference to four-day PME forecasts.[169] The basis for this assertion was that throughout the 5ASOC, the plaintiff identified particulars or pleads as follows:[170]

> "In the alternative, the plaintiff contends that operations substantially in accordance with Simulations A, B, C and D in the Christensen Response Report would have constituted "reasonably prudent Flood Operations" on *the assumptions relevant to each simulation*".

63 Seqwater contended that, in the case of SIM C, the "assumptions relevant to each simulation" are those identified by Dr Christensen, which relevantly included the use of 24-hour QPF's for the selection of strategies and the

[168] Appendix F to this judgment at footnotes 60, 61, 69, 70, 78 and 79.
[169] Seqwater subs at [2432]; SBM.020.015.0001 at [22].
[170] Eg PLE.010.001.0001 at .0118, [245B], Particular D.

determination of releases and that could not embrace some other more generous assumption regarding the four and eight-day PMEs that would favour the plaintiff.[171]

64 The relationship between the plaintiff's pleading of breach and Dr Christensen's simulations is addressed in Chapter 12. At this stage, it suffices to state that I do not accept that, in so far as the plaintiff's case seeks the Court to accept SIM C as constituting "reasonably prudent flood operations", it is confined as Seqwater contended. It would be an unusual construction of a pleading that confined a party to pleading what a defendant should have done whilst precluding it from contending why they should have so acted. In this case, such a construction of the pleading would sit uneasily with the statement of Garling J in *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority t/as Seqwater (No 1)* [2014] NSWSC 1565 at [63] to the effect that allegations which relate to the thought processes contributing to a judgment of a flood engineer are not be pleaded as breaches (or otherwise) compared with acts or failures to act. Further, it was not suggested that any particulars exchanged between the parties limited the plaintiff to only being able to support SIM C by reference to some assumptions and not others.

65 In any event, Seqwater's contention misconstrues the 5ASOC. SIM C is first introduced into the pleading in the particulars to paragraph 211 as follows:[172]

> "Further, by reason of the matters pleaded at paragraphs 192-204 and 209, a reasonably prudent flood engineer responsible for Flood Operations at Somerset Dam and Wivenhoe Dam on 2 January 2011:
>
> a) would have complied with the Flood Mitigation Manual;
> b) would have recommenced or continued Flood Operations and releases at Somerset Dam and Wivenhoe Dam on 2 January 2011;
> c) would have implemented Strategy ~~W1~~ W3 at Wivenhoe Dam;
> d) would have implemented Strategy S2 at Somerset Dam;
> e) would have caused Somerset Dam and Wivenhoe Dam to release water at rates substantially exceeding the rate of inflow;
> f) …
>
> PARTICULARS

[171] Seqwater subs at [2432].
[172] 5ASOC, PLE.010.001.0001 at .0092 to .0094, [211].

A. A reasonably prudent flood engineer would have complied with the Flood Mitigation Manual by taking the actions pleaded in paragraphs 211(b)-(h).

B. Flood Mitigation Manual, sections 1.1, 3.1, 8.4, 8.5, 9.3, 9.4.

C. ~~Christensen Report, Chapter VIII, [771] - [797].~~ Christensen Reply Report, Volume 1, pp 73-74, [253].

D. ~~Christensen Report, Chapter X, [1194] - [1214]~~ The plaintiff's primary case is that in operating the dams in accordance with the Flood Mitigation Manual a reasonably prudent flood engineer would have adopted release rates and gate operations on and from 2 January 2011 substantially in accordance with Simulation I in the Christensen Response Report.

E. ~~Christensen Supplemental Report, Volume 2, pp 4-5.~~ In the alternative, the plaintiff contends that operations substantially in accordance with Simulations A, B, C, and D in the Christensen Response Report would have constituted reasonably prudent Flood Operations *on assumptions reflecting different findings that the Court may make concerning which of the matters pleaded in paragraph 211 were required for reasonably prudent Flood Operations on 2 January 2011*." (italicised emphasis added, strikethrough as in original)

66 The portion of the pleading that Seqwater relies on is first found as a particular to paragraph 211B(b) which pleads the various water levels that Wivenhoe Dam would have reached "having first commenced reasonably prudent Flood Operations on 2 January 2011 (by taking the actions pleaded in paragraph 211 above)". Considered in context, the reference to the "assumptions relevant to each simulation" in the particular relied on by Seqwater is a reference to the "assumptions reflecting different *findings that the Court may make* … of the matters pleaded in paragraph 211" in Particular E to [211], which includes what is required by the Manual ([211(a)]. This is sufficient to enable the plaintiff to seek to justify a simulation such as SIM C by reference to the Court's findings as to the Manual's requirements regarding the utilisation of rainfall forecasts, specifically forecasts for periods longer than the one-day QPF (including the four-day PMEs). The reliability and utility of forecasts for that period was a significant issue in the proceedings.

67 Seqwater also submitted that the purported use of four-day PME forecasts and volumes did not address the fact that SIM C was determined by a methodology that determined a target level by reference to the one-day QPF forecasts. It contended that "just to say that the 4 day PMEs generally calculate a larger volume of future inflows may be factually accurate, but does

not take into account the application of Dr Christensen's methodology to the particular forecast product being used in the simulation in order to produce the releases made in that simulation".[173] Seqwater makes reference to the releases on 2 and 5 January 2011 to support this contention. Those particular points are addressed below in relation to each specific day.[174]

68 Seqwater's submissions do not accurately reflect how releases were modelled in SIM C. Each day of the simulation is addressed below. However, at this point it suffices to state that, for 2 to 4 January 2011 in SIM C, Dr Christensen modelled a draindown to end flood operations having regard to the one-day QPF forecast. For part of 5 January 2011 and for all of 6 January 2011, Dr Christensen determined a target level below FSL based on the one-day QPF in a manner akin to SIM A,[175] but due to downstream flow limits and strategy constraints the simulated levels did not come within 1.0m of achieving those target levels.[176] Thereafter, releases were not governed by any "target" but by a necessity to draindown as much as possible given the longer-term forecasts while remaining subject to the constraints imposed by the release limits for strategies and downstream conditions. As explained below, the various criticisms of the target approach made by the defendants are immaterial to SIM C.[177]

69 In any event, from at least 3 January 2011 a consideration of the four- and eight-day forecasts always warranted higher releases being modelled in SIM C. However, releases in SIM C were constrained by an inter-related combination of the governing assumptions,[178] the refill condition, release limits imposed by strategies, downstream conditions and potentially maximum discharge limits. It follows that, if the limits on flow rates imposed by strategies are determined by four-day PME forecasts (as set out in Appendix F to this judgment), or if four-day inflow estimates are used in some qualitative fashion

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173 SBM.020.015.0001 at [21]; see also Seqwater subs at [2433].
174 See [81] to [83] and [97].
175 See [194ff].
176 EXP.ROD.015.0261 at .0330 to .0331.
177 SunWater did not submit that SIM C was affected by any alleged error in the adoption of a target approach: SunWater subs at [1278]; cf SunWater subs at [1107](c) re SIM A.
178 See Chapter 8 at [146].

to determine release rates, or both, then until 11 January 2011 releases would never have been less than those adopted in SIM C. Otherwise, this analysis strongly supports the conclusion that a reasonably competent flood engineer would at the very least have made releases in accordance with SIM C, if such releases are otherwise justified.

Actual Inflow Calculation Error for 2 to 6 January 2011

70 The flood operations modelled in SIM C are potentially affected by Dr Christensen's error in calculating actual inflow volumes during the period 2 to 6 January 2011 (the "inflow error").[179] Following an inquiry by the Court in an email dated 12 June 2019, both the plaintiff and Seqwater provided submissions concerning the effect on the simulation of differences between the volumes Dr Christensen modelled and the correct volumes.[180] The simulation analysis prepared by Dr Christensen for each simulation commenced with the actual volume of water in the two dams and then recalculated that volume and corresponding height at each hour using the actual inflows and modelled outflows. The error in actual inflows caused the inflow rates, inflow volumes and reservoir heights to be overstated in his simulation analysis for SIM C, as well as the other simulations that commence on 2 and 5 January 2011. The degree of overstatement varies between simulations and within a simulation at different times. This is so because, for a given set of gate openings at Wivenhoe Dam, the rate of release will vary depending on the height of the dam and, in addition, the rate of release at Somerset Dam will vary depending on how far above EL 100.45m AHD the relevant height of the dam is.

71 Seqwater provided the following table indicating the level of overstatement[181] of retained volumes in Wivenhoe Dam and Somerset Dam in SIM C during the course of the January 2011 Flood Event:[182]

[179] See Chapter 6 at [32] to [34].
[180] SBM.010.019.0001; SBM.020.021.0001.
[181] And in the case of midday on 2 January 2011, understatement.
[182] SBM.020.021.0001 at .0004.

	SIMULATION C					
	Original Dr Christensen		**With Corrected Inflows**			
	Wivenhoe Stored Volume (ML)	Wivenhoe Lake Level (m AHD)	Wivenhoe Stored Volume (ML)	Change in Stored Volume (ML)	Wivenhoe Lake Level (m AHD)	Change in Wivenhoe Lake Level (m)
2/01/2011 0:00	1,180,998	67.15	1,180,998	0	67.15	0
2/01/2011 12:00	1,172,734	67.07	1,173,811	+1,077	67.08	+0.01
3/01/2011 0:00	1,166,874	67.02	1,164,250	-2,624	66.99	-0.02
3/01/2011 12:00	1,156,338	66.92	1,151,862	-4,476	66.87	-0.04
4/01/2011: 0:00	1,149,140	66.85	1,142,000	-7,140	66.78	-0.07
4/01/2011 12:00	1,140,429	66.77	1,132,743	-7,686	66.69	-0.07
5/01/2011 0:00	1,130,128	66.67	1,123,095	-7,032	66.60	-0.07
5/01/2011 12:00	1,118,548	66.56	1,113,317	-5,231	66.51	-0.05
6/01/2011 0:00	1,109,316	66.47	1,101.197	-8,120	66.39	-0.08
6/01/2011 12:00	1,082.455	66.21	1,070.428	-12,027	66.09	-0.12
7/01/2011 0:00	1,030,945	65.69	1,019,614	-11,331	65.58	-0.12
7/01/2011 12:00	1,000,056	65.37	989,618	-10,438	65.26	-0.11
8/01/2011 0:00	956,938	64.91	947,502	-9,436	64.81	-0.10
8/01/2011 12:00	924,177	64.55	916,409	-7,768	64.46	-0.09
9/01/2011 0:00	894,785	64.21	887,643	-7,142	64.12	-0.08
9/01/2011 12:00	859,941	63.80	853,384	-6,557	63.72	-0.08
10/01/2011 0:00	983,529	65.20	977,487	-6042	65.13	-0.06
10/01/2011 12:00	1,246,533	67.74	1,240,364	-6,169	67.68	-0.06
11/01/2011 0:00	1,396,956	69.03	1,390,461	-6,495	68.98	-0.05
11/01/2011 12:00	1,608,518	70.71	1,601,759	-6,759	70.66	-0.05
12/01/2011 0:00	1,904,173	72.85	1,897,132	-7,042	72.80	-0.05

Table 10-1: Corrected Inflows and Levels for SIM C

72 In relation to Wivenhoe Dam it can be seen that the maximum amount of the overstatement of retained volumes in SIM C is around 12000ML (around 12cm in dam levels) and by 11 to 12 January 2011 the overstatement is

around 7000ML (or around 5cm in dam levels). The effect of these overestimates on the selection of strategies is addressed in the footnotes to Appendix F to this judgment which contain amended projected heights for all volumetric estimates that take into account these inflow figures. The figures relating to the morning QPF use the midday corrected inflow figures in the above table and the figures relating to the afternoon QPF use a figure that is the average of the preceding midday and proceeding midnight figure in the above table. The revised figures make no difference to the selection of strategy based on the four-day PMEs, although it has the potential to affect the selection of strategies based on Mr Pokarier's corrected calculation of the one-day inflows.[183]

73 Another issue that arises is whether, by itself, the inflow error was capable of effecting Dr Christensen's approach to releases on 11 and 12 January 2011. In Chapter 9,[184] I outlined Dr Christensen's approach, including the arithmetic underlying his selection of a target release of around 1100m^3/s during the afternoon and evening of 11 January 2011.

74 I am satisfied that the inflow error does not affect Dr Christensen's modelled gate operations on 11 and 12 January 2011. As at midnight on 11 January 2011, releases from Wivenhoe Dam in SIM C would have been 1860m^3/s and the dam level would have been at EL 69.03m AHD,[185] or EL 68.98m AHD accounting for the inflow error. As at 1.00pm on 11 January 2011 which, as explained in Chapter 9[186], was a critical time for Dr Christensen's analysis given the revised estimate of downstream flows at that time, in SIM C Wivenhoe Dam would have been at EL 70.98m AHD,[187] or approximately EL 70.93m AHD accounting for the inflow error.[188] That corrected height would not make any difference to Dr Christensen's determination of the height at which the Wivenhoe Dam gates had to be lifted out of the water to avoid

[183] See Appendix F to this judgment, at 11.00am on 7 January 2011, 5.00pm on 7 January 2011, 11.00am on 8 January 2011, 5.00pm on 8 January 2011, 11.00am on 10 January 2011 and 5.00pm on 10 January 2011.
[184] Chapter 9 at [302] to [304].
[185] Simulation Analysis, EXP.ROD.015.0461 at .0630.
[186] Chapter 9 at [305] and [314].
[187] Simulation Analysis, EXP.ROD.015.0461 at .0630.
[188] Reflecting the 5cm difference shown in the above table for midday on 11 January 2011.

overtopping, which in turn determines the modelled peak outflow from SIM C during the critical period.[189] The same applies for the 5cm height difference at midnight on 12 January 2011. During the following day, the only possible difference that a reduction in the dam level of around 5cm could possibly have made to SIM C was to *delay* the raising of the gates on the afternoon of 12 January 2011 to avoid the risk of overtopping by possibly an hour to two.[190] If anything, this would reduce the downstream flooding, not exacerbate it.

Day by Day Consideration of Wivenhoe Releases

2 January 2011

75 SIM C commences at midnight on 2 January 2011.[191] Dr Christensen assumed that at that time Twins Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge were all closed.[192] This accords with Mr Ayre's situation report issued at 5.59am that morning,[193] save that at some point the road had been resurfaced at Kholo Bridge but it was damaged due to the Late December Flood Event and remained closed.[194]

76 Dr Christensen explained that the modelled strategy in SIM C on 2 January 2011 was to continue the Late December Flood Event by draining down Wivenhoe Dam (and Somerset Dam) to approximately 0.5m below FSL, which accorded with his estimate of the one day "no release" rise that was issued on 2 January 2011.[195] He determined a release rate of 470m^3/s which would allow that stored volume to be released in two days and which would return the dams to FSL in one day. This rate would also allow Kholo Bridge to reopen that day and Burtons Bridge the following day (if releases were reduced). The fact that Kholo Bridge was unusable was not taken up with Dr Christensen. If it had, it may have led him to adopt a higher release rate given

[189] See Chapter 9 at [303].
[190] See Chapter 9 at [304].
[191] Reflecting the 5cm difference shown in the above table for midday on 11 January 2011.
[192] Response Report Vol 2, EXP.ROD.015.0261 at .0328.
[193] SEQ.001.018.4207; Chapter 6 at [54].
[194] LAY.SUN.001.0001_OBJ at [1964].
[195] Response Report Vol 2, EXP.ROD.015.0261 at .0328.

that, after Kholo Bridge, the next bridge to inundate is Mt Crosby Weir Bridge at 1900m^3/s.[196] At 2.00am in SIM C, Dr Christensen would have opened one sluice gate at Somerset Dam.[197]

77 Dr Christensen's simulation analysis describes the applicable strategy on 2 January 2011 as a "W3 strategy drain down".[198] There is no such strategy expressly provided for in the Manual but Dr Christensen was simply referring to draining down from the W3 strategy that was applicable during the Late December Flood Event.[199] SunWater's submissions asserted that Dr Christensen admitted that on 2 January 2011 he released "more than [was] permitted" because he should have been in W1B, which had a maximum release of 380m^3/s.[200] In fact, the relevant evidence of Dr Christensen concerned 3 January 2011 and the questioning was premised on an assumption, which I do not accept, that flood operations necessarily ended when the dam reached FSL.[201]

78 Given the terms of the Manual, the flood engineers had no choice but to continue the flood event on 2 January 2011.[202] The provisions of the Manual that address draindown and the conclusion of a flood event are directed to freeing up flood storage space before the onset of another flood event. Given the volatility of the weather in Brisbane at that time of year, what was known about the La Niña event,[203] the state of the catchment, and the high runoff experienced in late December,[204] such a draindown was necessary. According to the Manual, at the very least, a draindown to FSL should have been completed by 4.00pm on 3 January 2011 at the latest, that being seven days after the peak inflow during the Late December Flood Event.[205]

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[196] Manual at 27.
[197] Response Report Vol 2, EXP.ROD.015.0261 at .0342; Simulation Analysis, EXP.ROD.015.0461 at .0645.
[198] Simulation Analysis, EXP.ROD.015.0461 at .0627.
[199] T 1827.47 to T 1828.10.
[200] SunWater subs at [1306] citing T 1832.26 – .44.
[201] See T 1831.41 to T 1832.5.
[202] See Chapter 3 at [142].
[203] See Chapter 2 at [53] to [57].
[204] T 1590.15 (Christensen).
[205] 2010 FER at 6606; Manual at 10.

79 Seqwater contended that the releases on 2 January 2011 which kept Burtons Bridge inundated were unduly aggressive bearing in mind the large amount of flood storage available.[206] However, the only real choice facing a flood engineer operating in accordance with the Manual who inherited the circumstances as at midnight on 2 January 2011 was whether to draindown at a rate that kept Burtons Bridge closed or at a rate of say 375m^3/s that kept the bridge open. The next flow level below that necessary to inundate a bridge was 175m^3/s, which would inundate Colleges Crossing. Without considering the effect of natural downstream flows, outflows to allow that bridge to be kept open could not have returned Wivenhoe Dam to FSL by 4.00pm on 3 January 2011.[207]

80 I have described Dr Christensen's calculations that support his release rates of around 473m^3/s on 2 January 2011. He determined to adopt a higher release rate with a view to lowering it to allow Burtons Bridge to reopen the following day and have the dam below FSL to allow refill by projected inflows from the QPF forecast. On Dr Christensen's figures, the adoption of a release rate of 327m^3/s on 2 January 2011 would have resulted in Wivenhoe Dam not reaching EL 66.5m AHD until more than three days hence.[208] Given the volatility of the weather and recent events, his more cautious approach to creating flood storage space was required. His approach of releasing to below FSL relative to the one-day "no release" rise was consistent with the findings in Chapter 3[209] concerning the circumstances in which flood operations may end and the flood objective of retaining storage in Wivenhoe Dam at FSL at the conclusion of the flood event. In any event, simulated

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[206] Seqwater subs at [2311] to [2313].

[207] According to Dr Christensen's revised reverse routed figures (MSC.010.146.0001), as at 4.00pm on 3 January 2011 Wivenhoe Dam was at EL 67.16m AHD being 15833ML above FSL. For that extra volume of water to be released over the 34 hours and since the release rate dropped from 209m^3/s to 161m^3/s at 6.00am on 2 Jan 2011, an extra release of 129m^3/s was required (15833 ÷ 34 ÷ 3.6). Thus releases could not have been less than 179m^3/s as 50m^3/s was the minimum release actually made in that period.

[208] Response Report Vol 2, EXP.ROD.015.0261 at .0342.

[209] Chapter 3 at [139] and [140].

releases on 2 January 2011 would have only caused SIM C to fall below FSL by 1cm on that day.[210]

81 Seqwater also noted that on 2 January 2011 Dr Christensen's four-day PME forecast was less than his one day forecast from which he calculated his "no release" rise of 0.5m. It contended that, if he had applied his methodology by reference to the four-day PME, then he would have selected a lower "target" volume to release.[211] Dr Christensen's four-day average PME inflow volume was 33,000ML, whereas his one-day average forecast inflow volume was 51,000ML and his no-rain inflows were 30,000ML. [212] The no-rain inflows produced a no release rise of 0.3m. His four-day PME modelling was based on an average rainfall depth of 6mm,[213] whereas his one-day QPF modelling used the high end of a range of 5mm to 10mm. Hence, this outcome is the product of modelling small rainfall depths from (slightly) inconsistent forecasts. Faced with those forecasts and volume estimates, a reasonably competent flood engineer would for that day operate from the QPF given its greater accuracy. However, it is not necessary to consider this further for two reasons.

82 First, because for 2 January 2011 in SIM C, Dr Christensen did not utilise the QPF forecast to select a target volume to release in the same manner as he used the four-day forecast for 3 January 2011 onwards in SIM A.[214] As noted, the flood operations modelled in SIM C on 2 January 2011 concerned draindown. They did not involve the application of any of Strategy W1 to W4. Dr Christensen was seeking to end flood operations by releasing below FSL to the point where it could be refilled by the one-day QPF forecast. That approach is not affected by using the four-day PME strategy to determine

[210] See above at [71].
[211] SBM.020.015.0001 at [20(a)].
[212] Response Report Vol 2, EXP.ROD.015.0261 at .0317; Table 9-6 in Chapter 9 at [235]; and Table 9-8 in Chapter 1 at [286].
[213] Table 9-2 in Chapter 9 at [138].
[214] See below at [194].

which of Strategies W1 to W4 are applicable as was done in other simulations.[215]

83 Second, even if Dr Christensen had reduced outflows from 2.00am on 2 January 2011 to 375m^3/s to open Burtons Bridge, as he did in SIM B (which used only rain on the ground inflows),[216] it would not make any material difference to SIM C. For 2 January 2011 in SIM B, Dr Christensen modelled a reduction in releases to 379m^3/s, which was maintained into 3 January 2011.[217] If that had occurred in SIM C, then the difference in retained water to midnight on 3 January 2011 would have been approximately 7,400ML.[218] On the issue of the four-day PME forecast at midnight on 3 January 2011 (and possibly the constituent one day PMEs at 6.00pm that evening) which showed around a tenfold increase in the predicted four-day inflow volumes,[219] a reasonably competent flood engineer would have increased outflows to inundate Burtons Bridge much earlier than Dr Christensen would have on 5 January 2011 in SIM C. Such releases might have been moderated by the refill condition but the amount of extra volume of water retained on 2 January 2011 would have easily been released by midday on 5 January 2011.

84 At midnight on 3 January 2011 in SIM C, Wivenhoe Dam would have been at EL 67.02m AHD, or EL 66.99m AHD accounting for the inflow error. Somerset Dam would have been at EL 98.79m AHD, or EL 98.78m AHD accounting for the inflow error.[220] I am satisfied that neither of those differences are material.

3 and 4 January 2011

85 The circumstances prevailing on 3 and 4 January 2011, including the relevant forecasts, were outlined in sections 6.8 and 6.9 of Chapter 6. Dr Christensen's explanation for strategies used in SIM C on 3 and 4 January 2011 stated that

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[215] In SIM A on 2 January 2011, which is governed by eight-day forecasts, Dr Christensen also models a draindown.
[216] Response Report Vol 2, EXP.ROD.015.0261 at .0317.
[217] Simulation Analysis, EXP.ROD.015.0461 at .0547.
[218] 22 hours x (473 – 379) x 3.6 = 7441ML.
[219] See Appendix F to this judgment.
[220] SBM.020.022.0001.

he continued to model a draindown on those days.[221] His day-by-day release explanation for these days stated that he would have continued releasing 470m^3/s on 3 January 2011 but would have reduced the release rate to 330m^3/s on the same day after the morning QPF to allow Burtons Bridge to re-open.[222] The morning QPF predicted 5 to 10mm of rain.[223] Dr Christensen stated that he would still have been in draindown from Strategy W3 at this time.[224] The afternoon QPF forecast increased to 10 to 20mm. However, Dr Christensen maintained the same gate settings as Burtons Bridge had only just been reopened.

86 As at midnight on 4 January 2011, under SIM C Wivenhoe Dam would have been at EL 66.85m AHD, or EL 66.78m AHD accounting for the inflow error. Dr Christensen maintained the same release rate throughout 4 January 2011, even though the one-day QPF forecasts were beginning to decrease.[225]

87 Given the volumetric estimates of the four-day forecasts over both of these days, as well at the outlook presented by the eight-day forecasts, I am satisfied that, at the very least, if Dr Christensen and any reasonably competent flood engineer were utilising the four-day forecasts to select strategy and/or determine releases, they would have (at least) made releases at the level that Dr Christensen modelled in SIM C, and most likely higher, subject to any concerns over the refill condition. Given those estimates and the findings in Chapter 9 about the use of four-day PMEs to select strategy,[226] such an engineer would no longer operate in “draindown”.

88 By reference to Mr Ickert’s evidence, SunWater noted that, if Dr Christensen had applied his modelling at the start of each day then he would have been in Strategy W1 from 2 to 5 January 2011, during which time he would have been required to minimise the impacts on downstream bridges.[227] It contended that

[221] Response Report Vol 2, EXP.ROD.015.0261 at .0329 to .0330.
[222] Ibid at .0342.
[223] SEQ.001.019.6814.
[224] Response Report Vol 2, EXP.ROD.015.0261 at .0329.
[225] See Appendix F to this judgment; Chapter 6 at [92].
[226] Chapter 9 at [61] and [128].
[227] SunWater subs at [1304].

there was no explanation for why Dr Christensen "calculates his 1-day no release rise lake levels at 11:00 and 17:00" when he makes those calculations at midnight in SIM A and SIM B.[228] It also contended that between "2 and 4 January, when he is supposed [to be] operating in W1, he is unnecessarily inundating" Savages Creek, Colleges Crossing and, depending on the size of Lockyer Creek flows at any given point, Burtons Bridge. In that regard, they enquired how, as Dr Christensen did not have information on downstream flows in the Lockyer, "can he safely open Burton's Bridge without knowing the combined flow at Lowood"?[229]

89 Five matters should be noted about these submissions. First, in SIM C Dr Christensen recalculated "no release" rises at 11.00am and 5.00pm each day to coincide with the publication of the relevant QPF forecast. Second, as noted, throughout this period Dr Christensen was operating in draindown from the Late December Flood Event, meaning that the release limits in W1A were not applicable. Third, even so, with effect from the afternoon of 3 January 2011, Mr Pokarier's corrected one-day inflow volumes were sufficient to engage W1B, which enabled the adopted release pattern from that time. Fourth, in any event and as noted, the "no release" rise based on the four-day PME forecasts was sufficient from 3 January 2011 to invoke a strategy that would justify the releases and, as noted, those forecasts would have prompted a move out of draindown. Fifth, the absence of downstream modelling during the period 2 to 4 January 2011 was not taken up with Dr Christensen during cross-examination.[230]

90 However, the flood engineers' rain on the ground modelling as at 6.00pm on 1 January 2011 predicted relatively small downstream flows at Lowood and Moggill on 3 January 2011 and there was little rain in the ensuing period.[231] Mr Malone's "Observed Rainfall Analysis" report reveals that there was 1mm of rain in the 24 hours to 9.00am on 3 January 2011 and 3mm of rain in the

[228] SunWater subs at [1305].
[229] Id.
[230] Dr Christensen was asked about downstream modelling for 6 January 2011 at T 1976.30.
[231] QLD.001.001.1955.

following 24 hours.[232] After the morning QPF on 3 January 2011, in SIM C, Dr Christensen modelled releases between 323m^3/s and 327m^3/s to maintain Burtons Bridge as open, which has a submergence flow rate of 430m^3/s. This appears to be more than a sufficient buffer to account for the rain that fell and that was predicted to fall.

91 Seqwater's submissions were critical of the level of releases on 3 and 4 January 2011 having regard to the prevailing one-day forecasts.[233] In fact, the releases modelled in SIM C on those days were relatively modest even before regard is had to the four-day PME forecast. One part of Seqwater's submissions asserts that Dr Christensen acknowledged that "his modelling based on the 8-day PME on 3 January [2011] showed no rain for the first four days".[234] This is not an accurate statement of his evidence. In cross-examination, Dr Christensen was shown a document prepared by Mr Pokarier which extracted the temporal distribution used in his eight-day modelling and which allocated the predicted rainfall across the last four days.[235] The temporal distributions used in Dr Christensen's forecast modelling are addressed in Chapter 9.[236] In his Response Report, Dr Christensen stated that the temporal pattern for modelling this forecast was "incidental" as it was selected with a view to producing a runoff volume at least consistent with the percentage derived from the Late December Flood Event.[237] There is no basis for taking that distribution and asserting or implying that Dr Christensen was conducting flood operations on the basis that no rain would fall for four days. In fact, Dr Christensen's four-day modelling was conducted on the basis that substantial rain would fall within that period (as it did). Mr Pokarier's own analysis of both the 3 January 2011 and the 4 January 2011 four-day PMEs was not materially different from Dr

[232] SEQ.004.046.0230 at .0267 to .0268.
[233] Seqwater subs at [2339] to [2340].
[234] Ibid at [2339].
[235] T 1599.42 to T 1600.16.
[236] Chapter 9 at [218ff].
[237] Response Report, EXP.ROD.015.0005 at .0167.

Christensen's.[238] Otherwise, Mr Pokarier described the rate of release on 3 and 4 January 2011 as being "low".[239]

92 As at midnight on 5 January 2011, in SIM C Wivenhoe Dam would have been at EL 66.67m AHD, or EL 66.60m AHD accounting for the inflow error. Somerset Dam would have been at EL 98.66m AHD, irrespective of whether the inflow error is accounted for.[240] I am satisfied that the difference in levels at Wivenhoe Dam is not material.

93 Subject to considering the balance of the issues raised in relation to SIM C, I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing at midnight on 2 January 2011, would have, at a minimum, made releases from Wivenhoe Dam throughout 2 to 4 January 2011 substantially in accordance with the rates nominated by that simulation.

5 January 2011

94 In SIM C, Dr Christensen modelled releasing between $321m^3/s$ and $323m^3/s$ from midnight to 4.00pm from Wivenhoe Dam and $34m^3/s$ between midnight and 10.00am from Somerset Dam.

95 At 11.00am on 5 January 2011, in his simulated operations Dr Christensen modelled the morning QPF which predicted 20mm to 30mm of rain. His modelling predicted an inflow of 112,000ML, yielding a projected height of EL 67.60m AHD on a "no release" basis, sufficient to invoke W1B.[241] Mr Pokarier's adjusted volume was not materially different.[242] Dr Christensen's modelling of the four and eight-day PME forecasts as at midnight on 5 January 2011 yielded "no release" volumes sufficient to take Wivenhoe Dam to EL 69.82m AHD and EL 71.37m AHD respectively.[243] The adjustment of his forecast loss rates for the four-day volumes as per Mr Giles' analysis of

[238] Table 9-2 in Chapter 9 at [138].
[239] EXP.SEQ.016.0012 at [456].
[240] SBM.020.022.0001.
[241] Appendix F to this judgment.
[242] 106,672ML yielding a projected height of EL 67.56m AHD; see Appendix F to this judgment.
[243] See Appendix F to this judgment and Response Report Vol 2, EXP.ROD.015.0261 at .0331.

the Late December Flood Event does not yield a materially different figure,[244] nor does the adjustment of any of the figures to account for the inflow error.

96 In light of the four and eight-day PME forecasts, and bearing in mind the constraint imposed by Strategy W1B of releasing at a rate no greater than 380m^3/s, Dr Christensen modelled maintaining his existing release rate of 321m^3/s, which would have been sufficient to keep Burtons Bridge open.[245] As stated, if the strategies or releases (or both) had been determined by reference to the four-day inflows, then the releases would certainly not have been less than that rate.

97 In support of its submission that the flood operations in SIM C could not justified by reference to the four-day PME forecasts and associated estimates of inflow volumes, Seqwater noted that the four-day forecast available at midnight on 5 January 2011 would have placed flood operations well within Strategy W3 from that time, whereas Dr Christensen prepared SIM C on the basis that Strategy W1B was engaged. It submitted that "[i]t is far from obvious that if W3 had been selected, that Dr Christensen's releases on 5 January would have been the same as those in SIM C that were selected under W1B".[246] That may be so, but what is "obvious" is that the releases would not (and should not) have been less than those selected under W1B, and that is sufficient.

98 The afternoon QPF predicted 30mm to 50mm of rain. This caused all the estimates of the one-day inflows, including that produced by Mr Giles' loss rates, to more than double.[247] With Dr Christensen's estimate and Mr Pokarier's corrected estimate, the projected height based on the afternoon QPF was sufficient to invoke W3.[248] Leaving aside Mr Giles' four-day volumetric estimates that use his loss rates (which I have rejected as

[244] Appendix F to this judgment, EL 69.55m AHD.
[245] Simulation Analysis, EXP.ROD.015.0461 at .0628; Response Report Vol 2, EXP.ROD.015.0261 at .0331.
[246] SBM.020.015.0005 at [20(b)].
[247] See Appendix F to this judgment.
[248] Simulation Analysis, EXP.ROD.015.0461 at .0628; Response Report Vol 2, EXP.ROD.015.0261 at .0331, .0343; Appendix F to this judgment.

unreasonable), the invocation of W3 was more than justified by the inflow volumes calculated from the four-day PME available at midnight on 5 January 2011 and even more so at midnight on 6 January 2011,[249] bearing in mind that the daily PMEs that comprise that four-day estimate would have been available from 6.00pm on the evening of 5 January 2011. Again, none of these figures were materially affected by the inflow error.

99 As W3 was invoked, and given the four and eight-day outlook, Dr Christensen modelled an increase in releases on the afternoon of 5 January 2011 to around 1370m^3/s, which would have inundated Burtons Bridge and Kholo Bridge.[250] He identified the rate of 1400m^3/s as being appropriate to reduce Wivenhoe Dam to 2.1m below FSL (which was the new refill condition limit in light of the afternoon QPF) in more than a day and as being less than the peak rate of releases from the Late December Flood Event.[251] As stated, it does not appear that Dr Christensen was aware that Kholo Bridge was damaged during this period so that once Burtons Bridge was closed via a flow rate of around 430m^3/s,[252] the next bridge to be inundated was Mt Crosby Weir Bridge which had a submergence flow rate of 1900m^3/s.[253]

100 So far as refill is concerned, the lowest level that Wivenhoe Dam would have reached on 5 January 2011 was EL 66.49m AHD at 11.00pm[254] (or 6cm less accounting for the inflow error).[255] The lowest level Somerset Dam would have reached was EL 98.54m AHD at the same time[256] (or 1cm less accounting for the inflow error).[257] Throughout 5 January 2011, all of the

[249] See Appendix F to this judgment.
[250] Simulation Analysis, EXP.ROD.015.0461 at .0628; Response Report Vol 2, EXP.ROD.015.0261 at .0331, .0343.
[251] Ibid at .0331, .0343.
[252] Manual at 26.
[253] Ibid at 27.
[254] Simulation Analysis, EXP.ROD.015.0461 at .0628.
[255] Dr Christensen's simulation analysis which does not correct for the error in calculating inflows records Wivenhoe Dam at EL 66.49m AHD at 11.00pm and at EL 66.47m AHD at 12.00am (Simulation Analysis, EXP.ROD.015.0461 at .0628). This is a difference of 1.02m. Maintaining this difference means at 11.00pm, SIM C (with corrected inflow figures) would have Wivenhoe Dam at EL 66.41m AHD (see above at [71]). This is a difference of 0.06m.
[256] Simulation Analysis, EXP.ROD.015.0461 at .0637.
[257] SBM.020.022.0001: SIM C with uncorrected inflows models Somerset Dam at EL 98.54m AHD at 11.00pm on 5 January 2011 and EL 98.51m AHD at 12.00am on 6 January 2011 (Simulation Analysis, EXP.ROD.015.0461 at .0637). This is a difference of 3cm. Maintaining this difference and

one-day forecast estimates of inflows were more than sufficient to return those levels to FSL.[258] Those estimates were provided in the context of the longer term forecasts all pointing to substantially more rainfall. I am satisfied that the flood operations in SIM C on 5 January 2011, if undertaken, would have been consistent with the fourth of the flood mitigation objectives.

101 In relation to the Manual's statement that peak outflow should generally not exceed peak inflow, it suffices to note that the simulated outflows on 5 January 2011 did not exceed the maximum rate of inflow during the Late December Flood Event, which was 2200m^3/s on 27 December 2011.[259]

102 Seqwater was critical of the level of releases in SIM C on 5 January 2011. It pointed to the absence of any substantial rain in the catchments on 2, 3 and 4 January 2011 and the relatively large storage capacity of the dams in light of the one-day forecast values.[260] Given the state of Kholo Bridge, the critical decision for a flood engineer operating in accordance with the Manual on 5 January 2011 was whether to inundate Burtons Bridge or not. If it was decided to inundate Burtons Bridge then, subject to refill concerns, the (only) logical step would have been to then increase releases to the point below that which would have resulted in Mt Crosby Weir Bridge being inundated by a combination of releases and downstream flows. This is exactly what Dr Christensen modelled.

103 Given the state of the dams and the prevailing circumstances, especially the forecasts available on the afternoon of 5 January 2011, I am satisfied that a reasonably competent flood engineer operating in SIM C was required to inundate Burtons Bridge on 5 January 2011. The decision to inundate involved a consideration of the relative inconvenience caused by that bridge's closure compared[261] to the potential advantages in creating storage space to minimise the potential of exceeding EL 74.0m AHD. The Manual directs that

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using the Somerset revised inflow figures means at 11.00pm on 5 January 2011, Somerset Dam level would have been at EL 98.53m AHD in SIM C.

[258] See Appendix F to this judgment.
[259] 2010 FER at .6606.
[260] Seqwater subs at [2341] to [2342].
[261] See Chapter 2; section 2.7.

priority be afforded to the latter, especially in Strategy W3, which the four-day PME forecasts had engaged. The prevailing circumstances, including the state of all of the forecasts on 5 January 2011, are set out in section 6.10 of Chapter 6. Not only did the four and eight-day PMEs available at midnight on 5 and 6 January 2011 point to significant rain in the catchment,[262] the 1200UTC PMEs available from 6.00am on 5 January 2011 for the South East Queensland area pointed to a very realistic possibility of much higher depth of rain falling in the catchments above and below the dam,[263] a matter that was recognised at the time by the flood engineers and within Seqwater.[264] A consideration of the PMEs and the current levels of the dams indicated that the suitable, indeed optimal, time to increase releases was immediately.

104 Mr Malone's "Observed Rainfall Analysis" report, described in Chapter 6, indicated that on the morning of 5 January 2011, runoff of 157mm would have caused Wivenhoe Dam levels to increase above EL 74.0m AHD from the dam levels then prevailing, which were approximately 68cm above the levels that were modelled in SIM C for that time (this difference being approximately 72,000ML in Wivenhoe Dam).[265] Adjusting for Dr Christensen's estimate of rain on the ground[266] and taking Mr Malone's calculation of a rainfall to runoff ratio of 77% from the Late December Flood Event, that amount of runoff could be produced by approximately 217mm of further rain;[267] noting that 77% is a lower ratio than what Dr Christensen utilised and slightly above what Mr Giles utilised for the forecast on 5 January 2011.[268] If Dr Christensen's figure for the

[262] See Chapter 6 at [103] and [149]; Table 9-2 and Table 9-3 in Chapter 9.
[263] Chapter 6 at [105] to [106].
[264] Chapter 6 at [109] to [111].
[265] Using the simulated figures at 6.00am for SIM C: Simulation Analysis, EXP.ROD.015.0461 at .0628 reduced by around 6000ML to account for the inflow error (see [71]). Thus, simulated level = 1124188ML – 6000ML = 1118188. Actual = 1190056ML (MSC.010.146.001) Diff = 71868ML; LAY.SEQ.007.0001 at .0153 to .0154.
[266] See Chapter 6 at [133] to [134]; 14000ML as at midnight on 5 January 2011: MSC.010.070.0001; Table 9-6 in Chapter 9 at [235].
[267] Rainfall needed to meet EL 74.0m AHD = (storage needed to meet EL 74.0m AHD + difference in Wivenhoe storage with revised inflows – ROG inflows) / (area of upstream catchment x runoff to rainfall ratio); (157mm x 5673km^2 + 72,000ML -14000ML)/(5673km^2 x .77) = 217.2mm.
[268] Table 8-2; Chapter 8 at [95]; Table 9-5 in Chapter 9 at [193].

Late December Event is used, then the figure needed to reach EL 74.0m AHD is 194mm of further rain.[269]

105 As noted in Chapter 6,[270] the prospect of rainfall eventuating in that amount and a runoff response similar to the Late December Flood Event was very much a realistic possibility to a flood engineer receiving the forecast information throughout 5 January 2011. This is especially so in light of the fact that the FPM required the engineer to model twice the forecast amount of rain. As at midnight on 5 January 2011, the range of interpretations of the four-day PME forecast was 61mm to 83mm and the range of interpretations of the eight-day PME forecast was 106mm to 127mm.[271] As at midnight on 6 January 2011, the range of interpretations of the four-day PME forecast was 76mm to 88mm and the range of interpretations of the eight-day PME forecast was 125mm to 150mm.[272] Most importantly, in terms of potential rainfall, Mr Malone's breakdown of the 1200UTC PMEs available from 6.00am on 5 January 2011 provided an eight-day total of up to 300mm of rain.[273]

106 Seqwater noted a criticism made by Mr Pokarier about the rate of gate openings modelled by Dr Christensen.[274] In his report, Mr Pokarier stated that "[o]n 5 January releases are increased rapidly … by increasing gate settings by 5 to 6 increments per hour for several hours".[275] In fact, the modelled gate openings in SIM C were increased by five increments between 8.00pm and 9.00pm, by six increments between 9.00pm and 10.00pm, by five increments between 10.00pm and 11.00pm and by four increments between 11.00pm and midnight.[276] None of these exceeded the maximum rate for opening gates below outflow rates of 4000m^3/s of six per hour specified in the Manual.[277] Mr Pokarier did not elaborate on the safety risk that was posed by this rate of opening, although it appears to be related to the rapid rise in downstream

[269] (157mm x 5673km^2 + 72000ML – 14000ML)/(5673km^2 x .86).
[270] Chapter 6 at [136].
[271] Table 9-2 and Table 9-3 in Chapter 9 at [138], [161].
[272] Id.
[273] Chapter 6 at [105]; Malone 1, LAY.SEQ.007.0001 at [532].
[274] Seqwater subs at [2346].
[275] EXP.SEQ.016.0012 at [459].
[276] Simulation Analysis, EXP.ROD.015.0461 at .0648.
[277] Manual at 32 to 33.

flows it would cause, especially at the bridges.[278] In the absence of the risk being elaborated on and the point being taken up with Dr Christensen, I cannot take the issue any further, other than to note that a moderated increase in releases would cause little difference in the amount of water retained.[279]

107 Finally, so far as "target" volumes and heights are concerned, I note that Dr Christensen's explanation of strategies for SIM C on 5 January 2011 records "Strategy/Target W3/W3 drain down then W1B and then W3 2.1m below FSL".[280] The first part of this refers to the prevailing strategy from the time of the morning QPF up to the time of the afternoon QPF (ie, W1B). The latter part refers to the invocation of Strategy W3 from that time. His calculated rate of 1400m^3/s appears to have been based on reducing the modelled dam level at 5.00pm on 5 January 2011 to 2.1m below FSL.[281] Releases at this rate would not result in the reservoir reaching that level until 32 hours later.[282] Consistent with this, by midnight on 6 January 2011 the modelled level of SIM C was well above the target height of 2.1m below FSL. As the modelled release rate for the afternoon of 5 January 2011 in SIM C was more than justified by reference to either a qualitative or quantitative consideration of the four-day PME forecasts, it is unnecessary to address the various criticisms of the "target" approach at this point.

108 Subject to considering the balance of the issues raised in relation to SIM C, I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing at midnight on 2 January 2011, would have, at a minimum, made releases from Wivenhoe Dam throughout 5 January 2011

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278 EXP.SEQ.016.0012 at [459].

279 For example, compare where the increase in releases from 457m^3/s to 1370m^3/s was staggered over 8 hours to 4.00am on 6 January 2011 instead of over 4 hours: With gate openings occurring over 4 hours then the average rate of releases to midnight is (1370 + 457)/2 = 913.5m^3/s and for the 4 hours to 4.00am the rate = 1370m^3/s. In that case, Wivenhoe releases an extra 19,721ML = (913.5m^3/s x 4 + 1370m^3/s x 4 – (457m^3/s x 8)) x 3.6) compared to a continuation of the 457m^3/s rate. With gate openings occurring over 8 hours, the average release rate = 913.5m^3/s. The extra amount released over 8 hours compared to the rate of 457m^3/s = 13,147ML (= (913.5 – 457) x 8 x 3.6). Difference = 6574ML.

280 Response Report Vol 2, EXP.ROD.015.0261 at .0331.

281 Ibid at .0331.

282 5 Jan 17:00 volume: 1,115,213ML (Simulation Analysis, EXP.ROD.015.0461 at .0628); 2.1m below FSL = 956,000. (1,115,213 – 956,000)/(1400/3.6) = 31 hours 35 minutes.

substantially in accordance with the release rates nominated by that simulation.

6 January 2011

109 As at midnight on 6 January 2011 the modelled releases in SIM C from Wivenhoe Dam would have been 1379m^3/s and the dam level would have been at EL 66.47m AHD,[283] or EL 66.39m AHD accounting for the inflow error. The various estimates of the four-day PME rainfall available at midnight on 6 January 2011 are set out in Table 9-2 in Chapter 9.[284] Dr Christensen modelled an average rainfall depth of 88m and the lowest interpretation of the average four-day PME figures was 76mm. Dr Christensen identified the range of the eight-day forecast as 100 to 200m.[285] In his simulation analysis for SIM C at this time, Dr Christensen noted that due to assumption constraints he would "only watch [the] 4-day and 8-day forecasts" but that "[g]iven [the] rainfall received and wet conditions, [a] major flood [is] likely imminent".[286]

110 In SIM C, Dr Christensen would have maintained the outflow rate of around 1379m^3/s until around 11.00am on 6 January 2011 when the morning QPF of 30mm to 50mm become available, which he modelled as producing a "no release" rise of 3.0m.[287] In his explanation of strategies, Dr Christensen identified the "Strategy/Target" as "W3/Lower to 2.5m below FSL".[288] Dr Christensen noted that the probability of "downstream 1-day large flood producing rain is 0 to 10 per cent" and concluded that there was "no reasonable chance" of the Lowood or Moggill flows exceeding 3500m^3/s or 4000m^3/s respectively.[289] He concluded that "based on 1-day and monitoring of 4-day and 8-day inflows" he would "increase release[s] to lower about 2.5m below FSL".[290] He modelled the afternoon QPF of 20mm to 30mm as

[283] Simulation Analysis, EXP.ROD.015.0461 at .0628.
[284] Table 9-2 in Chapter 9 at [138] and see also Chapter 6 at [149].
[285] Table 9-3 in Chapter 9 at [161].
[286] Simulation Analysis, EXP.ROD.015.0461 at .0628.
[287] Response Report Vol 2, EXP.ROD.015.0261 at .0332; Appendix F to this judgment.
[288] Response Report Vol 2, EXP.ROD.015.0261 at .0332.
[289] Id.
[290] Id.

producing a similar rise. Bearing in mind that rain had fallen in the meantime, he maintained the same approach to releases and water level target.[291]

111 In his day-by-day releases explanation, Dr Christensen explained the approach for the balance of that day as follows:[292]

> "At Wivenhoe, the increase to a release rate of just under 1,400 m³/s that commenced on the previous day was reached by January 6, and was maintained, until 11:00 am when the increased forecast was received. The releases were then increased towards 2,000 m³/s, and then after 17:00 to just over 2,400 m³/s (which was about one third greater than the historic maximum) and would keep Lowood below 3,500 as per the lower W2 strategy objective. That release would release the *combined target volume in about 2 days*. The engineer would monitor the Dam and adjust releases if necessary.
>
> Somerset releases of more than 500 m³/s were continued throughout the day, which would release the target volume in over a day. The engineer would monitor the Dam and adjust releases if necessary." (emphasis added)

112 Thus, from 11.00am on 6 January 2011, in SIM C Dr Christensen would have increased the releases to inundate all downstream bridges and then monitored releases to avoid breaching the thresholds for urban damage. To effect this, Dr Christensen modelled increasing gate openings from thirty increments at 11.00am to sixty increments by midnight on 7 January 2011.[293] The modelled gate openings would have increased outflows to 2136m^3/s at 5.00pm and then to a peak of 2439m^3/s at 11.00pm.[294] The former rate did not exceed the peak inflow during the Late December Flood Event and neither of these two rates exceeded his predicted peak. His modelling of the morning QPF forecast produced a peak inflow rate of 2316m^3/s.[295] His modelling of the afternoon QPF forecast produced a peak inflow rate of 2518m^3/s.[296] At 11.00am on 7 January 2011, SIM C modelled inflows were 2646m^3/s, or 2190m^3/s excluding Somerset outflows.[297]

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[291] Id.
[292] Response Report Vol 2, EXP.ROD.015.0261 at .0343.
[293] Simulation Analysis, EXP.ROD.015.0461 at .0648 to .0649.
[294] Ibid at .0629.
[295] MSC.010.166.0001.
[296] MSC.010.167.0001.
[297] Simulation Analysis, EXP.ROD.015.0461 at .0629 and .0638.

113 In the above extract, Dr Christensen refers to the "combined target volume". Unlike SIM A and SIM E considered below, Dr Christensen did not include the figures explaining the calculation of the combined target volume or the release rates in this part of his day-by-day release rates explanation.[298]

114 I find it difficult to reconcile his calculations. In his explanation of strategies, Dr Christensen stated that the target level for making releases at Wivenhoe Dam was 2.5m below FSL (and that he would lower Somerset Dam in tandem with Wivenhoe Dam).[299] Using the modelled level of Wivenhoe Dam in SIM C at 11.00am, (ie, EL 66.23m AHD[300]) and Somerset Dam at the same time (ie, EL 98.13m AHD[301]), and assuming both are to be released to 2.5m below FSL, then the volume to release is 223,586ML.[302] This yields a release rate of 1293m^3/s[303] over two days. This suggests that the reference to "2 days" in the above extract might be a typographical error. In any event, this supports the analysis at [144] to [154] below.

115 Mr Pokarier undertook an analysis of the release rates and release periods for the target volumes supposedly adopted in SIM C up to 6 January 2011.[304] Using the release rates in SIM C, he calculated backwards to determine the release periods "required to … create airspace equal to the 24-hour volume QPF inflow volume". His analysis produced periods between 1.2 days and 3.9 days during the period 2 to 6 January 2011. However, this analysis is of no assistance for three reasons. First, because, as already explained, for most of that period SIM C was in draindown or confined by strategy limits so the use of targets was not in play. Second, because as is apparent from the discussion below in relation to SIM A and SIM E and the above discussion of SIM C on 6 January 2011, the target to release to below FSL was always *less* than the "no release" rise volume estimate produced by the relevant

[298] Response Report Vol 2, EXP.ROD.015.0261 at .0343 (cf .0381).
[299] Ibid at .0332.
[300] 1,084,739ML: Simulation Analysis, EXP.ROD.015.0461 at .0629.
[301] 344447ML: Simulation Analysis, EXP.ROD.015.0461 at .0637.
[302] Wivenhoe Dam (Manual at 53): 1,084,739 – 920000 = 164,739ML. Somerset Dam (Manual at 59): 344,447 – 285,600 = 58,847.
[303] 223,586 / (48 x 3.6).
[304] See EXP.SEQ.016.0012 at [452].

forecast[305] so that Mr Pokarier's calculations use the wrong numerator. Third, even where a target volume was used, the calculated rate was always adjusted after considering other factors such as downstream considerations.

116 At this point, I note that any debate about the effect of the error in the calculation of Dr Christensen's one-day inflows does not impact on the strategies and releases that would have been adopted in SIM C on 6 January 2011. Even on Mr Pokarier's corrected one-day inflow volumes, Strategy W3 would still have been engaged and the "no release" rises would have been only marginally lower, causing no adjustment to the release target.[306] Mr Giles' one-day modelling might not have engaged W3. However, I have expressed my doubts about the value of his inflow modelling.[307] In any event, as I consider that it was incumbent upon a reasonably competent flood engineer to use a longer forecast (specifically, the four-day PME forecast) any debate about the issue at this point falls away.

117 As at midnight on 7 January 2011, releases from Wivenhoe Dam in SIM C would have been 2429m^3/s and the dam level would have been EL 65.69m AHD,[308] or EL 65.58m AHD accounting for the inflow error. Somerset Dam would have been at EL 97.68m AHD or EL 97.59m AHD accounting for the inflow error.[309] None of those differences are material.

7 January 2011

118 The range of forecast and other data available as at midnight and throughout 7 January 2011 is set out in section 6.12 of Chapter 6. As Table 6-1[310] makes clear, by midnight on 7 January 2011 substantial rain had fallen on 6 January 2011 and was continuing to fall.[311] In his Simulation Analysis, Dr Christensen's entry for midnight on 7 January 2011 was "4-day forecast 50–

[305] In SIM C, on 6 January 2011 the one-day no release rise was 3.0m but the target level below FSL was 2.5m: Response Report Vol 2, EXP.ROD.015.0261 at .0332.
[306] See Appendix F to this judgment.
[307] Chapter 9 at [285] to [286]; Chapter 6 at [314] and [322] to [323].
[308] Simulation Analysis, EXP.ROD.015.0461 at .0629.
[309] SBM.020.022.0001.
[310] Chapter 6 at [3].
[311] See Chapter 6 at [181].

150mm; 8 day 75-200mm, large flood imminent but use 1-day".[312] The various estimates of the four-day PME inflow volumes are set out in Appendix F to this judgment. In addition, Dr Christensen's modelling of the eight-day PME produced an average eight-day inflow volume of 769,000ML and the high range produced 1,178,000ML[313] with "no release" rises of 6.4m and 9.2m respectively. Of particular significance is that the eight-day PME for the area downstream of the dam predicted rain in the range of 100mm to 300mm.[314]

119 Dr Christensen's modelling of the four-day PME inflow volume represented a substantial increase from the previous day (608,000ML v 460,000ML)[315] and a large portion of the difference was referable to the increase in predicted rain on the ground inflows (154,988ML[316] v 79,126ML[317]). His modelling of the morning and afternoon QPFs, both of which predicted falls of 20mm to 30mm, continued to produce substantial inflows, as did Mr Pokarier's correction of his calculations.[318] However, one potential difference between their predicted volumes is that Dr Christensen's modelling was sufficient to engage Strategy W3, whereas Mr Pokarier's did not.[319] This issue was adverted to above at [59]. In light of my findings concerning the utility of the four-day PME forecasts and the lack of utility of Mr Giles' modelling of those forecasts using the flood engineer's loss rates, this difference is immaterial (even if those estimates used the flood engineers' rain on the ground estimates).[320]

120 Dr Christensen's explanation of strategies in his Response Report contains entries similar to those noted above in relation to downstream conditions.[321] It also states that the "Strategy/Target [was] W3/Moggill <4000m^3/s". In his day-by-day release rate explanation he stated:[322]

[312] Simulation Analysis, EXP.ROD.015.0461 at .0629.
[313] Response Report Vol 2, EXP.ROD.015.0261 at .0333.
[314] SEQ.013.004.1302.
[315] Table 9-6.
[316] MSC.010.079.0001; see Table 9-6.
[317] MSC.010.075.0001; see Table 9-6.
[318] See Appendix F to this judgment.
[319] Id.
[320] Chapter 9 at [284]; see Appendix F to this judgment.
[321] Response Report Vol 2, EXP.ROD.015.0261 at .0333.
[322] Ibid at .0343.

> "The releases from Wivenhoe were controlled by the 1-day forecast and the forecast flows at Moggill, which was forecast to peak at 1040m^3/s… At first, existing releases of over 2,400 m^3/s were maintained, until the increased 11:00 am forecast was received, and releases were increased to over 2,500 m^3/s. After the 17:00 forecast was received, which predicted even greater inflow, releases were increased further to over 2,600 m^3/s, allowing releases to reduce as the water level decreased. These releases were able to be made without exceeding the 4,000 m^3/s maximum at Moggill and kept Lowood below 3,500 m/s as per the lower W2 strategy objective.
>
> At Somerset, existing releases of over 500m^3/s were maintained during the early part of the day, until the 11:00am forecast, when they were reduced (by closing the regulator valves) to assist in lowering Wivenhoe."

121 Thus, no target volume or water level was adopted for 7 January 2011. Instead, releases were increased up to the limit necessary to avoid exceeding the 4000m^3/s threshold for downstream inundation.

122 Consistent with the above, Dr Christensen modelled opening gates a further five increments at 11.00am on 7 January 2011 which would have increased the release rate to approximately 2521m^3/s and another five increments at 6.00pm which would have increased the release rate to approximately 2631m^3/s.[323] Two matters should be noted about those releases.

123 First, as noted above, based on reverse routing Dr Christensen modelled an inflow into Wivenhoe Dam of 2646m^3/s at 11.00am on 7 January 2011.[324] Excluding Somerset Dam outflows, inflows were 2190m^3/s.

124 Second, the second round of increases coincided with the publication of the one-day PMEs for the forecast periods beginning at 10.00pm that evening. They showed a very large increase in the three to four-day catchment rainfall (as reflected in Appendix F to this judgment).[325] The analysis in relation to SIM F suggests that the outflow rates in that simulation on 8 January 2011 of around 2800m^3/s would not exceed the predicted peak inflow.[326] That analysis is equally applicable to SIM C for the period from 6.00pm on 7 January 2011 onwards.

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[323] Simulation Analysis, EXP.ROD.015.0461 at .0649 to .0650.
[324] Ibid at .0629.
[325] See also Chapter 6 at [241] to [244].
[326] Above at [32].

125 As at midnight on 8 January 2011, releases from Wivenhoe Dam in SIM C would have been 2575m^3/s and the dam level would have been EL 64.91m AHD,[327] or EL 64.81m AHD accounting for the inflow error. Somerset Dam would have been at EL 97.79m AHD, or EL 97.71m AHD accounting for the inflow error.[328] I am satisfied that those differences are not material.

8 January 2011

126 The range of forecast information and other data available as at midnight and throughout 8 January 2011 is set out in section 7.1 of Chapter 7. Again, substantial rain had fallen throughout 7 January 2011.[329] In his Simulation Analysis, Dr Christensen's entry for midnight on 8 January 2011 was "4-day forecast 100-300mm; 8 day 100-320mm, large flood imminent, W3 strategy".[330] His annotation for six hours later notes the effect of the situation report issued around that time, which in turn appears to be based on the 1200UTC PMEs published around then.[331] Thus, Dr Christensen recorded "inflow+4 day 130-300mm, large flood imminent, but use 1 day".

127 Appendix F to this judgment indicates that both Dr Christensen's four-day inflow estimate and Mr Giles' adjustment of that estimate are very large figures and produce "no release" rises close to EL 74.0m AHD (even if the flood engineers' rain on the ground estimate is used). A comparison of both the 00UTC and 1200UTC four-day PME with the eight-day PME suggests most of that rain was expected within the four-day period.[332]

128 Dr Christensen's explanation of the adopted strategies for 8 January 2011 in SIM C again describes the downstream conditions in terms that allow for releases that would not cause flows in excess of 3500m^3/s at Lowood and

[327] Simulation Analysis, EXP.ROD.015.0461 at .0629.
[328] Ibid at .0638; SBM.020.022.0001.
[329] See Table 6-1 in Chapter 6 at [3]; Table 9-1 in Chapter 9 at [138] and Table 9-2 in Chapter 9 at [161].
[330] Simulation Analysis, EXP.ROD.015.0461 at .0629.
[331] See Chapter 7 at [5]; EXP.SEQ.014.0219 at .0243; SEQ.013.005.0484; SEQ.013.005.0486.
[332] Compare SEQ.013.005.0492 (four-day PME) to SEQ.013.005.0493 (eight-day PME).

4000m^3/s at Moggill.[333] He identified the Strategy/Target as "W1E/1900m^3/s release".[334] His day-by-day release rate explanation states:[335]

> "On January 8, the 1-day forecast at 11:00 am indicated a 3.7 m rise from 64.59 m, resulting in a W1E strategy. As a result, releases were reduced down to below 1,900 m^3/s.
>
> At 17:00 pm, the 1-day forecast was for a 3.9 m rise. The water level was at 64.42 m, resulting in a rise 68.32 which continued to indicate a W1E strategy. Releases were maintained below 1,900 m^3/s.
>
> At Wivenhoe, releases were maintained below 1,900 m^3/s for the rest of the day in accordance with the W1E strategy.
>
> Existing gate settings were maintained at Somerset, continuing to release just under 400 m^3/s. That lower release rate helped in lowering Wivenhoe."

129 Again, it follows that no target volume or height was set in SIM C for 8 January 2011. Instead, releases were governed by the various constraints imposed by the Manual. As indicated by this passage and Appendix F to this judgment, as SIM C was governed by volume estimates based on the one-day QPF forecasts and given the amount that had been released in previous days, the "no release" rise figures obtained using Dr Christensen's estimates engaged Strategy W1E and placed a limit on releases of 1900m^3/s from around 11.00am. Two matters should be noted about this.

130 First, for so long as the simulation is governed by an assumption that strategies are determined by 24-hour QPF forecasts, the validity of the invocation of W1E on 8 January 2011 is dependent on an acceptance of Dr Christensen's modelling of those forecasts. Mr Pokarier's corrected forecast would have placed flood operations at that time in Strategy W1B, with a consequential flow limit of just 380m^3/s.[336] This led to the debate in the submissions noted above.

131 However, I have already accepted that the determination of strategies is not limited to modelling based on 24-hour QPF forecasts and had to extend to the

[333] Response Report Vol 2, EXP.ROD.015.0261 at .0334.
[334] Id.
[335] Ibid at .0344.
[336] See Appendix F to this judgment; Manual at 26.

four-day PME forecasts. On any view of the four-day estimates, including Mr Giles' figures based on the flood engineers' loss rates, at the very least Strategy W3 would have been engaged in SIM C as of midnight on 8 January 2011 (and throughout the day).

132 Second, it is self-evident that, subject to the matters considered next, if Strategy W3 was engaged in SIM C then Dr Christensen would have increased releases on 8 January 2011 and not reduced them. Dr Christensen modelled releases of just below 1900m^3/s in SIM C on 8 January 2011. Even though strategy W1E was engaged, that rate would not have led to any downstream bridges reopening because when combined with downstream flows that level of releases would still have inundated all bridges. All of Dr Christensen's commentary for 8 and 9 January 2011 in SIM C and all the other simulations[337] refer to the effect of the four-day and eight-day PME forecasts and that a "large flood [was] imminent".[338] The "Strategy/Target" engaged for SIM E on 8 January 2011 was "W3/[to keep Wivenhoe Dam] as low as possible".[339] At this point, SIM E was lower than SIM C but, as it used four and eight-day forecasts, W3 was engaged. Thus, it is clear that Dr Christensen's approach in SIM C on 8 January 2011 was to release as much as possible in Strategy W1E because of the effect of the longer-term forecasts.

133 However, even if Strategy W3 or higher was engaged, there were three operative restrictions on the rate that Dr Christensen could have released at. The first constraint is the effect of releases on downstream conditions. To account for this, it can be expected that Dr Christensen would have addressed them in a similar way to SIM F. As described above, in SIM F, releases on 8 and 9 January 2011 were exclusively governed by his modelling of downstream flows.

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[337] Except SIM G which commences on 10 January 2011.
[338] Simulation Analysis, EXP.ROD.015.0461 at .0469, .0560, .0629 to .0630, .0708, .0786, .0846, .0931, .0982, .1060.
[339] Response Report Vol 2, EXP.ROD.015.0261 at .0372.

134 The second constraint is the refill condition, namely the obligation to be satisfied that the estimated one-day inflows could refill SIM C to FSL. Appendix F to this judgment confirms that this was met in relation to releases made in SIM C on 8 January 2011 (and 9 January 2011), even when notionally refilled based on Mr Giles' "corrected" inflow estimates, which I have already expressed misgivings about.[340]

135 The third operative constraint is the limit on discharges relative to the various lake levels of Wivenhoe Dam as set out in the Manual.[341] Thus, for example, when Wivenhoe Dam is at EL 67.0m AHD, the maximum available discharge is 3885m^3/s. It was not suggested that the releases in SIM C exceeded those rates but they could potentially have been engaged had Dr Christensen been able to increase releases by reason of Strategy W3 being engaged.

136 SunWater noted that in SIM C at 11.00am on 8 January 2011, when Dr Christensen's predicted level based on QPF forecasts was EL 68.29m AHD and Strategy W1 was engaged with an actual level of EL 64.59m AHD, he modelled releasing around 1800m^3/s, which would have inundated all the relevant bridges.[342] Two matters should be noted. First, one issue presented by the W1 sub-strategies imposing limits on releases is that a limit may be imposed with the apparent purpose of keeping a downstream bridge open when downstream flows have already submerged the bridge. It is entirely consistent with the Manual to observe those limits but still inundate the relevant bridge if necessary to give effect to higher objectives, as "[w]ithin any strategy, consideration is always given to [the flood] objectives in [their] order [of priority]".[343] Second, based on the four-day PME forecasts, Strategy W3 would have been engaged at this point.

137 As at midnight on 9 January 2011, releases from Wivenhoe Dam in SIM C would have been made at 1855m^3/s and the dam level would have been EL

[340] Chapter 9 at [286].
[341] Manual at 53 to 54.
[342] SunWater subs at [1307] to [1309].
[343] Manual at 23.

64.21m AHD,[344] or EL 64.12m AHD accounting for the inflow error.[345] Somerset Dam would have been at EL 97.59m AHD, or EL 97.51m AHD accounting for the inflow error.[346] Subject to what follows I am satisfied that those differences are not material.

9 January 2011

138 The range of forecast information and other data available as at midnight and throughout 9 January 2011 is set out in sections 7.2 and 7.3 of Chapter 7. In his Simulation Analysis, Dr Christensen's entry for midnight on 9 January 2011 was "4-day forecast 75-300mm; 8 day 100-320mm, large flood imminent, W1E strategy".[347] The analysis is annotated with the forecast estimate of naturally occurring downstream flows, this being 530m^3/s at Lowood and 840m^3/s at Moggill.

139 The modelling of the four-day PME inflow volumes undertaken by Dr Christensen is set out in Appendix F to this judgment. Both his volumes and Mr Giles' adjustment of his volumes are still very large and produce no release rises close to EL 74.0m AHD (even if the flood engineers' rain on the ground estimates are used). As noted in Chapter 7,[348] the daily PME forecasts suggested that the bulk of the four-day forecast would fall within three days, as it did. Rain commenced falling in the upstream catchments at 4.00am.[349] The 1200UTC PME forecasts available from 6.00am highlighted that an extremely bad situation was becoming worse.[350] Dr Christensen's modelling of the morning QPF produced an increase in the volumetric assessment of Wivenhoe Dam inflows to 444,000ML. By mid-afternoon the inflows were increasing rapidly and the modelling of the afternoon QPF forecast closely matched the overnight four-day PME forecast. By around

[344] Simulation Analysis, EXP.ROD.015.0461 at .0630.
[345] Above at [71].
[346] Simulation Analysis, EXP.ROD.015.0461 at .0638; SBM.020.022.0001.
[347] Ibid at .0630.
[348] Chapter 7 at [143].
[349] Chapter 7 at [146].
[350] Chapter 7 at [147].

7.00pm, the flood engineers' peak downstream flow at Moggill was predicted to be 1940m^3/s.[351]

140 In SIM C, Dr Christensen modelled releases at a constant rate of around 1850m^3/s throughout the day.[352] In his day-by-day release explanation,[353] he stated that operations continued in Strategy W1E until the morning QPF was made available. The modelling of this forecast yielded a predicted height of EL 68.21m AHD, thus requiring the adoption of Strategy W1D. However, the maximum release rate in W1D is also 1900m^3/s, so this did not result in any change in releases. The afternoon QPF yielded a projected height that engaged Strategy W3. Later that day, the modelling of downstream flows yielded a predicted peak flow at Moggill of 1940m^3/s, which required outflows to remain constant in order to avoid the flow at Moggill exceeding 4000m^3/s; ie the same position that pertained with SIM F.

141 SunWater was also critical of the level of releases at around 7.00pm on 9 January 2011 when the forecast of downstream flows had increased dramatically.[354] That contention is addressed above at [51] in relation to SIM F, which saw Dr Christensen lower releases to around 1850m^3/s to protect against downstream effects, this being the rate of releases maintained from 7.00pm on 9 January in SIM C.

142 In his explanation of the adopted strategies on 9 January 2011, Dr Christensen stated "Strategy/Target W1D/W3/As low as can be achieved then fill to below 73.0m with Moggill < 4,000m^3/s".[355] Thus, simulated operations in SIM C on 9 January 2011 did not involve the selection of a target or level below FSL to release to.

143 As at midnight on 10 January 2011, releases from Wivenhoe Dam in SIM C would have been made at a rate of 1841m^3/s and the dam level would have

[351] Response Report Vol 2, EXP.ROD.015.0261 at .0364.
[352] Simulation Analysis, EXP.ROD.015.0461 at .0630.
[353] Response Report Vol 2, EXP.ROD.015.0261 at .0344.
[354] SunWater subs at [1310].
[355] Response Report Vol 2, EXP.ROD.015.0261 at .0335.

been EL 65.20m AHD,[356] or EL 65.13m AHD accounting for the inflow error. Somerset Dam would have been EL 101.04m AHD, or EL 100.98m AHD accounting for the inflow error.[357] Again, subject to what follows, I am satisfied that those differences are not material.

Inundating Bridges Between 6 and 9 January 2011 in SIM C

144 Given the prevailing circumstances from 6 to 9 January 2011, the finding above at [103] and the finding that the determination of strategies and releases in flood operations should be governed by forecasts of longer than a day, and in this case, by the four-day PME, then it follows that reasonably prudent flood operations throughout 6 to 9 January 2011 required releases to be made at least at a level that kept Kholo Bridge submerged along with all bridges with a lower inundation level. Moreover the analysis above at [14] to [18] overwhelmingly points to the necessity, if otherwise permitted by the Manual, to make releases from midnight on 8 January 2011 that would have the effect of inundating the remaining bridges. This is so even allowing for the height differential between SIM C on the one hand and SIM F and actual operations on the other, which at that time was 3.41m or 355,000ML.[358] The forecasts were all pointing to an imminent large flood and that the window to make releases before downstream flows worsened was closing. Given that the constituent one-day PMEs were available from 6.00pm on 7 January 2011,[359] a decision to inundate bridges in SIM C could and should have been made then, if it had not been made earlier.

145 The remaining issue is whether a reasonably competent flood engineer operating in SIM C, working on the basis that strategy and releases could be determined by four-day forecasts and applying the Manual was obliged to inundate the remaining bridges before then and, if so, when? As noted, Dr Christensen stated that such a flood engineer would have inundated those

[356] Simulation Analysis, EXP.ROD.015.0461 at .0630.
[357] Ibid at .0639; SBM.020.022.0001.
[358] Simulation Analysis, EXP.ROD.015.0461 at .0629, .0846: EL 68.32m AHD (SIM F) – EL 64.91m AHD (SIM C) = 3.41m; Manual at 53.
[359] EXP.SEQ.014.0219 at .0242; SEQ.013.004.1304; SEQ.013.004.1306; SEQ.013.004.1308; SEQ.013.004.1310.

bridges by increasing releases on the morning of 6 January 2011. In justifying the level of releases, Dr Christensen stated that he was seeking to increase releases to a point just below the combined flows crossing the downstream thresholds of 3,500m^3/s at Lowood and 4,000m^3/s at Moggill so that the bridges could be reopened earlier.[360]

146 Seqwater was critical of Dr Christensen for not testing the effect that different releases would have had on the predicted Wivenhoe Dam lake level.[361] It contended that a reasonably competent flood engineer would have "model[led] the projected rate of inflows to the dams for at least one day in order to decide the releases to make and whether a release in the order of 2400m^3/s would actually be required". In cross-examination, it was suggested that he should have recorded an analysis considering a release decision of, "say, 600 or 700m^3/s from Wivenhoe and [see] what would be the effect of that on the dam levels or the flows downstream".[362] Two matters should be noted about that contention.

147 First, Dr Christensen's Simulation Analysis adjusts modelled releases in light of predictions of downstream flows based on the modelling of the 24-hour QPF. However, beyond that, any analysis that seeks to model the precise timing of expected future flow rates based on forecasts risks placing too much reliance on a factor that Dr Nathan's stochastic analysis revealed to be one of the most uncertain aspects of modelling based on rainfall forecasts, namely the impact of temporal variations in rainfall on the timing of peak flow.[363] Thus, Dr Christensen could quickly gauge the *potential* (worst case) effect of a release decision of 700m^3/s by reference to the forecast maximum peak rate at Moggill and Lowood.

148 Second, for Dr Christensen the critical downstream effect to address depends on the relevant threshold that is in play. He explained that once bridges had been inundated the best course was to increase flows as much as possible

[360] T 1641.34.
[361] Seqwater subs at [2345].
[362] T 1642.9.
[363] See Chapter 9 at [63], [69].

without risking breaching the next threshold for downstream flow limits because that maximised the possibility of opening the bridges again as quickly as possible.[364]

149 As noted in Chapter 6,[365] in his first affidavit Mr Malone calculated that, as at 6.30am on 6 January 2011, in actual operations the available storage space in Wivenhoe Dam to a level of EL 74.0m AHD was equivalent to 156mm of excess rainfall (ie, runoff) and the available space up to the trigger of a fuse plug was equivalent of 203mm of excess rainfall.[366] To adapt those figures to the circumstances of SIM C at that time it is first necessary to take into account the height differential between SIM C and the actual level of Wivenhoe Dam as at 6.00am on 6 January 2011[367] and to allow for rain on the ground inflows, which Dr Christensen calculated at midnight on 6 January 2011 to be 79,000ML.[368] Using Mr Malone's estimate of the rainfall-to-runoff catchment response from the Late December Flood Event (77%), the amount of runoff necessary to fill the dam to EL 74.0m AHD would have been produced by approximately 210mm of further rainfall[369] and a further 271mm of rainfall would trigger a fuse plug.[370] The figures would be less if Dr Christensen's estimate of the catchment response during the Late December Flood Event (ie 86%) was used, namely 186mm and 241mm of further rainfall respectively.

150 The (reasonable) volumetric estimates of the "no release" rise as at midnight on 6 January 2011 based on the four-day average PME inflow figure were not approaching EL 74.0m AHD, although they were slightly above EL 70.0m AHD.[371] However, the two permutations of the eight-day PME forecast and its

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364 T 1641.20 to .36; T 1643.11.
365 Chapter 6 at [204].
366 LAY.SEQ.007.0001 at [589(b)].
367 EL 67.31m AHD – EL 66.34m AHD = 97cm = 102,657ML + 10,000ML (allowing for inflow error: see [71]) = 112,657; Simulation Analysis, EXP.ROD.015.0461 at .0628.
368 MSC.010.075.0001.
369 Rainfall needed to meet EL 74.0m AHD = (storage needed to meet EL 74.0m AHD + difference in Wivenhoe storage under SIM C – ROG inflows) / (area of upstream catchment x runoff to rainfall ratio) = (156mm x 5673km^2 + 112657ML – 79000ML)/(5673km^2 x .77) = 210.3mm.
370 = (203mm x 5673km^2 + 112657ML – 79000ML)/(5673km^2 x .77) = 271.34mm.
371 See Appendix F to this judgment.

modelling were very much in that range.[372] Dr Christensen's eight-day average "no release" rise in SIM C was to EL 72.27m AHD and his eight-day high range reached a height of EL 74.57m AHD.[373] Against these figures was the potential to make releases in the meantime but the timing of the forecast rainfall as predicted in the PMEs necessitated making higher releases immediately before downstream flow limits curtailed the capacity to increase releases.[374]

151 Further, there was also the potential for much higher rainfall than these forecasts predicted. As noted, the FPM required the flood engineers to be on guard for this by requiring they model the effects of 200% of forecast rain. This was reinforced by one known characteristic of the forecasts, namely their capacity to under estimate heavy rainfall events.[375] Most significantly, the potential for much higher rainfall was very real as at 6 January 2011. As noted in Chapter 6,[376] Mr Malone's analysis of the 1200UTC PMEs available from 6.00am on 6 January 2011 described the potential for rainfall of "up to or even more than" 400mm[377] in areas downstream of the dam, which could have fallen upstream of the dam and which in fact did so. His analysis of the falls in the surrounding areas as suggested by the PMEs yielded even higher figures.[378]

152 The position as at midnight on 7 January 2011 has already been addressed. Save for six matters, all of the conditions that presented risk on 6 January 2011 still prevailed at that point in time but the risk of flood storage space proving insufficient had materially increased. The first was the difference in water levels in SIM C, as Wivenhoe Dam would have been at EL 65.69m AHD at midnight on 7 January 2011 (or EL 65.58m AHD allowing for the inflow error) if the bridges had been inundated, compared to a lake level of EL 66.47m AHD (or EL 66.39m AHD accounting for the inflow error) at midnight

[372] Dr Christensen interpreted the 8-day PME as being in the range 100 to 200mm, Table 6 -1 in Chapter 6 at [3]; Table 9-2 in Chapter 9 at [161].
[373] Response Report Vol 2, EXP.ROD.016.0261 at .0332.
[374] See the PME breakdown at Chapter 6 at [155].
[375] See Chapter 9 at [85] to [86], [96], Chapter 4 at [5] and [35], paragraph 8.
[376] Chapter 6 at [155] to [158].
[377] T 5151.22.
[378] See Chapter 6 at [155].

on 6 January 2011.[379] However, if the bridges had not been inundated then, as at midnight on 7 January 2011 Wivenhoe Dam would have been at approximately EL 66.02m AHD (or EL 65.91m accounting for the inflow error) in SIM C.[380] The second was that substantial rain had continued to fall throughout 6 January 2011[381] and, as noted above, the estimate of rain on the ground inflows had grown dramatically. The third was that the four-day and eight-day volumetric assessments had now increased, only partly due to the increased rain on the ground estimates. The fourth is that the catchment was clearly getting wetter, increasing the runoff response. The fifth was that the "window" to make releases uninhibited by any potential of combined flows exceeding thresholds for urban damage was reducing. The one-day PMEs suggested scope to make releases on 7 and 8 January 2011,[382] with the one-day PMEs for 9 and 10 January 2011 indicating that this window was likely to close then.[383] The sixth was the PME forecasts were still predicting much larger rainfall downstream and just outside of the catchment, with the concomitant risk that that rain would fall above the dams.[384] Mr Malone's analysis of the 1200UTC PMEs issued at 6.00am on 7 January 2011 again suggested larger falls in areas near the dam catchment.[385] Thus, there was an (ominous) consistency in the entire suite of forecasts.

153 A decision to inundate either and especially both of Mt Crosby Weir and Fernvale Bridges was not to be made lightly. Neither of those bridges was inundated during the October 2010 Flood Event or the mid-December 2010 Flood Events.[386] The inconvenience caused would have been considerable.[387] A rate of release sufficient to inundate the bridges was the largest release rate to that time ever recorded (a "historic release").[388] These

[379] Simulation Analysis, EXP.ROD.015.0461 at .0628.
[380] Lake level at midnight in SIM C = cumulative volume difference with limit on releases – corrected inflows at midnight = EL 65.69m AHD + 32,340ML – 11,331ML = EL 65.91m AHD; see Appendix G to this judgment and [71].
[381] See Table 6-1 in Chapter 6 at [3].
[382] EXP.SEQ.014.0219; SEQ.013.005.0471.
[383] SEQ.013.005.0473; SEQ.013.005.0475.
[384] EXP.SEQ.014.0219; SEQ.013.005.0479.
[385] LAY.SEQ.007.0001 at [637].
[386] See Chapter 4 at [209].
[387] Chapter 2 at [90] and [91].
[388] T 1974.9.

factors could justifiably have warranted extended notice being provided to stakeholders of the closure of those bridges. However, against these matters are the priorities in the Manual. The actual events of the evening of 9 January 2011 indicate that the logistics of a safe closure of the bridges could have been arranged in a relatively short period.

154 The end result is that I am satisfied that a reasonably competent flood engineer conducting flood operations in SIM C but using four-day PMEs to determine strategy and releases (at least qualitatively) and acting in accordance with the Manual *could* justifiably have decided on the morning of 6 January 2011 to close the bridges based on the prevailing circumstances. I am also satisfied that by midnight on 7 January 2011 such a flood engineer *would have been obliged* to take that step. The forecasts that were issued throughout 7 January 2011, especially the PMEs at 6.00pm, would not have caused this course of action to be reconsidered.

Effect of Delaying Inundation of Bridges

155 These findings raise a question as to whether the impact of any delay in the inundation of Fernvale and Mt Crosby Weir Bridges in SIM C on 6 January 2011 to midnight on 7 January 2011 is sufficiently material to warrant a rejection of the simulation in its entirety? For two separate reasons, I am satisfied that the answer to that question is ‘no’.

156 First, the position can be assessed on the basis that the volumetric difference in releases would have been retained in Wivenhoe Dam over the balance of SIM C, that is, without any change in gate openings.

157 Appendix G to this judgment sets out the calculation of the approximate difference in outflows between releases proposed in SIM C and the releases in SIM C had the remaining bridges not been inundated from late on the morning of 6 January 2011 but instead where a decision to inundate those bridges was made at midnight on 7 January 2011. It sets out the outflows used in SIM C for early on 6 January 2011 to keep those bridges open on

6 January 2011 (ie, < 1400m^3/s).[389] This figure is relatively low given the small actual and modelled flow downstream on 6 January 2011. Appendix G to this judgment then models a gate opening sequence initiated at midnight on 7 January 2011 using the increase in flow rates that Dr Christensen modelled in SIM C on 6 January 2011. Appendix G to this judgment reveals that had the bridges not been inundated until early on the morning of 7 January 2011, then approximately 43,940ML of extra water would have been retained in Wivenhoe Dam as at 6.00am on 7 January 2011. Allowing for the inflow error, which at 6.00am on 7 January 2011 appears to overstate retained volumes by around 10,884ML,[390] the result is that the volume retained in Wivenhoe Dam in SIM C at around midday on 7 January 2011 would have been approximately 33,000ML more than that modelled by Dr Christensen at that time.[391]

158 If that extra volume is retained in SIM C until 11 and 12 January 2011 with the same gate settings and releases applied, then this volumetric difference would diminish as the releases would be slightly higher with the same settings due to the higher water level. However, assuming in the defendants' favour, that as at midnight on 11 January 2011 that volume of water had been retained, then the modelled height of Wivenhoe Dam would be EL 69.30m AHD instead of a modelled EL 69.03m AHD, at 1.00pm on 11 January 2011 it would be EL 71.22m AHD instead of EL 70.98m AHD, and at midnight on 12 January 2011 it would be at EL 73.07m AHD instead of a modelled EL 72.85m AHD. Subject to what follows, those differences in water levels are not material.

159 One potential effect of retaining such a volume of water concerns the gate openings on 12 January 2011. In Chapter 9,[392] I explained the basis upon which Dr Christensen chose the minimum gate settings upon considering the projection of downstream flows made as at 1.00pm on 11 January 2011.

[389] Simulation Analysis, EXP.ROD.015.0461 at .0628.
[390] Taking the average of the corrected inflows at midnight and midday on 7 January 2011 provides an approximate corrected inflow volume for 6.00am of 10,884ML.
[391] 43,940ML – 10,884ML = 33,056ML.
[392] Chapter 9 at [301] to [304].

While Wivenhoe Dam was at a modelled height of EL 70.98m AHD he modelled raising all crest gates by at least 1.0m to avoid them being overtopped. This 1.0m rise offers protection up to EL 73.83m AHD. If in SIM C at that time Wivenhoe Dam was at a revised height of EL 71.22m AHD then, all other matters being equal, I do not accept that a reasonably competent flood engineer would have raised all gates by at least 1.5m to avoid being overtopped, which would have provided protection up to about EL 74.23m AHD.[393] Instead, at most, the extra height could have necessitated the bringing forward of the gate openings that occurred at 3.00pm (two increments) and 6.00pm (four increments) on 12 January 2011,[394] to ensure that the gates would not be overtopped at EL 73.83m AHD.[395] If these releases were brought forward to say, 11.00am on 12 January 2011, the crest level of EL 73.83m AHD would not be exceeded.[396] At that time, inflows had reduced rapidly and the flow gauges would have indicated that the peak downstream had passed through Lowood hours before indicating that a small increase in releases could then be made.[397] Otherwise, I note that, without any such adjustment, on 12 January 2011 if SIM C retained an extra 33,000ML, it would cause Wivenhoe Dam to reach EL 74.0m AHD sometime between 6.00pm and 7.00pm on 12 January 2011 and it would have peaked at EL 74.07m AHD at midnight on 13 January 2011. Given that between those times outflows were increasing, inflow rates were dropping markedly and the other prevailing circumstances I am satisfied that this would have had no effect on modelled gate operations.

160 Further, I note that, if an extra 33,000ML of water had been retained in Wivenhoe Dam from 6.00am on 7 January 2011, then the tandem operations line for SIM C noted below would have been slightly closer to the Operating Target Line.

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[393] Manual at 57.
[394] Simulation Analysis, EXP.ROD.015.0461 at .0654.
[395] See Chapter 9 at [302].
[396] 11.00am volume = 2,007,277ML + 33,000ML = 2,040,277ML = EL 73.76m AHD.
[397] January FER at .1263.

161 The second reason arises from considering the likely effect of retaining that extra volume on the modelled releases on 8 and 9 January 2011 in SIM C, having regard to the finding concerning the determination of strategy and the conduct of flood operations by reference to four-day PME forecasts on modelled flood operations on 8 and 9 January 2011.

162 As already noted, the effect of the modelled releases that would have been made in SIM C on 6 and 7 January 2011 also meant that on 8 January 2011 and for most of 9 January 2011, the releases that would have been made in SIM C were impacted by the constraint imposed by Strategy W1D (and W1E), namely that they not exceed 1900m^3/s.[398] This constraint operated because the releases that would have been made in SIM C on 6 and 7 January 2011 would have reduced SIM C to EL 64.91m AHD at midnight on 8 January 2011 and because Dr Christensen's modelled operations were restricted by his assumption that one-day QPF forecasts were to be used for selecting strategies. As noted above, if that assumption was maintained, then the limit on releases was even greater when regard is had to Mr Pokarier's corrected volumes as they meant that, for a period, Dr Christensen was confined to Strategy W1B.

163 As noted, it is clear that, if he had not been constrained by the operative strategies capping releases at 1900m^3/s, then Dr Christensen would have modelled larger releases on 8 and 9 January 2011 because of the size of the flood indicated by the four-day and eight-day forecasts. Dr Christensen's day-by-day commentary for SIM C for 8 and 9 January 2011 repeatedly refers to the effect of the four-day and eight-day forecasts and that a "large flood [was] imminent".[399] His day-by-day release explanation pointed to the constraints imposed by W1D and W1E on those days.[400] His other simulations, especially SIM E and SIM F, make higher releases on that day. SIM E does so even though its water level is lower. Given the above analysis of the state of the forecasts as at 8 January 2011, I am satisfied that, subject

398 See Appendix F to this judgment.
399 Simulation Analysis, EXP.ROD.015.0461 at .0629 to .0630.
400 Response Report Vol 2, EXP.ROD.015.0261 at .0344.

to the limits imposed by the Manual, the reasonably competent flood engineer operating in SIM C would have sought to make the maximum releases available on 8 and 9 January 2011 provided that the downstream thresholds of 3500m^3/s at Lowood and at 4000m^3/s at Moggill were not exceeded.

164 The maximum level that such releases might have been is discernible from Appendix H to this judgment which compares the outflows in SIM C with SIM F over the weekend of 8 and 9 January 2011. In SIM F, there is no strategy constraint on releases and, due to the level of Wivenhoe Dam, there is no operative maximum discharge rate. By the evening of 9 January 2011 and thereafter until the morning of 11 January 2011, the modelled release rates in SIM C and SIM F are virtually identical because both sets of releases are governed exclusively by the objective of keeping downstream flows below 4000m^3/s. From Appendix H to this judgment, it is apparent that the differences in the amount released under the two simulations during 8 and 9 January 2011 was approximately 100,000ML; ie approximately 100,000ML more was released in SIM F and H than in SIM C over that period.

165 The end result is that the releases modelled by Dr Christensen in SIM F on 8 and 9 January 2011 are a reasonable guide to the releases that would have been modelled in SIM C had it not be constrained or potentially constrained by three matters: the release limits imposed by strategies selected by reference to 24-hour QPFs, the refill condition, and the maximum discharge limits.

166 As just explained, Appendix G to this judgment reveals that, had the bridges not been inundated until early on the morning of 7 January 2011, then allowing for the inflow error, approximately 33,000ML of extra water would have been retained in Wivenhoe Dam as at 6.00am on 7 January 2011. If that amount had been retained then, as at midnight on 8 January 2011, Wivenhoe Dam would have been at EL 65.27m AHD[401] (and the projected heights in

[401] EL 64.91m AHD + 33,000ML = 989,938ML = EL 65.27 AHD.

Appendix F to this judgment for the four-day PME would have increased by approximately 25 cm).[402]

167 Appendix I to this judgment is an analysis setting out an approximate estimate of the extra releases that would have occurred on 8 and 9 January 2011 in SIM C if it had been unconstrained by the condition that strategies are determined by one-day QPF forecasts and an extra 33,000ML of water had been retained in Wivenhoe Dam. The analysis includes an allowance for the maximum discharge rates applicable at the water levels that would have resulted from the retention of an extra 33,000ML and their corresponding higher releases. The analysis reveals that, if in SIM C the decision to inundate the remaining bridges had been deferred until midnight on 7 January 2011, then by 6.00pm on 9 January 2011, the extra volume that would have been retained in Wivenhoe Dam would have been released while still acting in accordance with the constraints of the Manual.

168 This analysis is not undertaken to postulate an alternative simulation to simulation C. Instead, it has been undertaken to address whether, even if I was not satisfied that a reasonably competent flood engineer must have decided to inundate the remaining bridges on 6 January 2011, that would invalidate the conclusion that a reasonably competent flood engineer should have undertaken flood operations substantially in accordance with SIM C. If, as part of that inquiry, I am not satisfied that a reasonably competent flood engineer must have inundated the bridges at a particular time but am satisfied they must have done so later and am also satisfied that any such delay was not material to the outflows in the simulation overall, especially on 11 and 12 January 2011, then the simulation will not have been invalidated. I am so satisfied.

169 Finally, I note that this conclusion means that the various criticisms of Dr Christensen's "target" approach to flood operations[403] are not relevant to an assessment of SIM C. At most, the only day of SIM C operations governed by

[402] Dr Christensen = 0.22m increase; Giles = 0.23m increase; Giles with flood engineers' ROG loss rates = 0.27m increase.
[403] Described in Chapter 8 at [57ff] and below at [194], [200] to [213].

an approach of releasing to a target below FSL determined by, or informed by, a forecast, is 6 January 2011 and I have concluded, based on the above reasoning, that concerns about that release rate on that day do not invalidate the simulation overall. Otherwise, the above analysis reveals that the releases in SIM C up to and including 9 January 2011 are, at a minimum, what was required by an approach that uses four-day inflow estimates to specify strategies and that sets releases by, in effect, a “qualitative” approach that considers all the forecasts and, inter alia, downstream constraints.

Conclusion in Relation to 6 to 9 January 2011

170 Subject to considering the balance of the issues raised in relation to SIM C, I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing at midnight on 2 January 2011, would have (at least) made flood releases across the period of 6 to 9 January 2011 substantially in accordance with that simulation.

10 January 2011

171 The range of forecast and other data available as at midnight and throughout 10 January 2011 is set out in section 7.3 of Chapter 7. In his Simulation Analysis, Dr Christensen’s entry for midnight on 10 January 2011 was “4-day 75–225mm; 8 day 75-225mm, large flood *occurring*, W3 strategy”.[404] Again, his analysis for that day is annotated with the forecast estimate of peak downstream flows.

172 The various estimates of the four-day PME volumes and one-day QPF volumes for 10 January 2011 are set out in Appendix F to this judgement. All of them place Wivenhoe Dam in Strategy W3 or higher, even allowing for the inflow error (and even with the use of the flood engineers’ rain on the ground inflow estimates). So far as Wivenhoe Dam is concerned, the differences between them are immaterial because, as was the case with SIM F, all of Dr Christensen’s releases from Wivenhoe Dam on this day were driven by concerns about downstream effects, specifically avoiding exceeding the

[404] Simulation Analysis, EXP.ROD.015.0461 at .0630.

downstream flow threshold of 4000m^3/s at Moggill. Dr Christensen's explanation of releases described the "Strategy/Target" as "W4B/Dam protection and minimise Moggill as possible"[405] (ie, no target volume or height was selected). Dr Christensen's day-by-day release rates explanation for Wivenhoe Dam for 10 January 2011 for SIM C is identical to that set out above for SIM F.[406] I have already accepted that aspect of SIM F and accompanying explanation and this applies equally to a consideration of the modelled releases in SIM C from Wivenhoe Dam for this day. As its modelled water level was lower than SIM F, SIM C had a greater capacity to suspend releases than SIM F. Given the extremely dire conditions, there was no justification for reopening any downstream bridge.

173 Subject to considering the balance of the issues raised in relation to SIM C, I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing at midnight on 2 January 2011, would have made flood releases throughout 10 January 2011 substantially in accordance with the rates nominated by the simulation.

11 and 12 January 2011

174 The flood operations for 11 January 2011 and 12 January 2011 modelled in SIM C are addressed in section 9.7 of Chapter 9.

175 Subject to considering the balance of the issues raised in relation to SIM C, I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing at midnight on 2 January 2011, would have made releases from Wivenhoe Dam throughout 11 and 12 January 2011 (and thereafter) substantially in accordance with the rates nominated by the simulation.

[405] Response Report Vol 2, EXP.ROD.015.0261 at .0336.
[406] Ibid at .0344.

SIM C: Refill

176 Each of Seqwater and SunWater contended that SIM C violated a constraint in the Manual on making releases below FSL.[407] SunWater pointed out that Wivenhoe Dam in SIM C was below FSL from around 2.00am on 3 January 2011 to 8.00am on 10 January 2011.

177 In Chapter 5, I concluded that releases should be made below FSL if they are necessary to give effect to the Manual's objectives including the admonition that there should be no reason why the dam should not return to FSL at the conclusion of a flood event.[408] In SIM C, Dr Christensen stated that he used the 24-hour QPF forecast as the limiting condition on how far to release below FSL and that the "4 and 8 day forecasts were used simply to provide some additional confidence that the reservoirs were likely to refill to FSL".[409] Mr Giles accepted that the corrected QPF estimates were sufficient to refill to FSL,[410] although he noted that in some cases the temporal pattern of actual inflows did not match the modelled pattern of the 24-hour inflows.[411] In any event, the defendants' submissions did not contend that Dr Christensen's reductions below FSL violated his own approach. This approach appears to be borne out by all of the permutations of the one-day inflows estimates in Appendix F to this judgment, including Mr Giles' estimates. (It was not suggested that the flood engineers' "with forecast" modelling was insufficient to refill Wivenhoe Dam to FSL in SIM C.) SIM C would have fallen below EL 64.0m AHD during 9 January 2011 but only at a time when all predictions of inflows, including the flood engineers' rain on the ground inflows, were rising rapidly.

178 The adoption of a mechanistic approach that always takes Wivenhoe Dam below FSL by an amount representing the one-day QPF forecast may not always satisfy the fourth flood objective of retaining the dam at FSL at the conclusion of a flood event. However, the use of inflow estimates based on a

[407] SunWater subs at [1279] to [1284]; Seqwater subs at [2016].
[408] Chapter 5 at [200].
[409] Reply Report, EXP.ROD.004.0005 at .0074, [245(b)].
[410] T 8785.17.
[411] T 8788.37 to T 8789.8.

QPF as a limit on releases below FSL in circumstances where the four and eight-day forecasts were pointing to much larger inflows, and at a time that was only part way through a rainfall season influenced by a La Niña event, is a very different circumstance.[412] In the circumstances faced by a flood engineer during the January 2011 Flood Event, the use of the 24-hour QPFs as a limit on the reduction of reservoir levels below FSL conformed with the Manual and its objectives.

SIM C: Peak Outflow v Peak Inflow

179 SunWater contended that SIM C breached the Manual by adopting a release pattern from Wivenhoe Dam in excess of inflows to date, especially from 11.00pm on 5 January 2011 to 10.00am 7 January 2011.[413] Seqwater made a similar contention in respect of the period between midnight on 2 January 2011 and midnight on 7 January 2011.[414]

180 I have already rejected the construction of the Manual that is the premise of both of these contentions and have addressed the statement in the above discussion of the day-to-day releases for Wivenhoe Dam, as well as SIM F.[415]

SIM C: Somerset Dam Operations

181 In SIM C, Dr Christensen modelled opening one sluice gate early on the morning of 2 January 2011 to release 201m^3/s for the balance of the day.[416] The sluice gate would have been closed in SIM C on 3 January 2011, with releases being made through a regulator at a rate of either 34m^3/s or 68m^3/s until 5 January 2011.[417] Dr Christensen then modelled increasing releases to around 534m^3/s via two regulators and two sluice gates on that day until around 11.00am on 7 January 2011, when the regulators would have been closed and releases of around 390m^3/s through two sluice gates were

[412] EXP.ROD.011.0011_OBJ at [121] to [127]; EXP.ROD.014.0034 at [3.2].
[413] SunWater subs at [1301].
[414] Seqwater subs at [2370] to [2371].
[415] See above at [29] to [33], [101], [112] and [124].
[416] Simulation Analysis, EXP.ROD.015.0461 at .0645.
[417] Ibid at .0646 to .0648.

modelled.[418] Those settings were not altered until 2.00pm on 11 January 2011, when both sluice gates were closed.

182 In SIM C, Somerset Dam would not have exceeded EL 100.45m AHD until around 9.30pm on 9 January 2011.[419] By the time the sluice gates would have been closed on 11 January 2011, Somerset Dam would have been at EL 104.08m AHD. The sluice gates would have remained closed until 7.00pm on 13 January 2011, when Somerset Dam would have been at EL 103.98m AHD.[420] In SIM C, Somerset Dam would have peaked at EL 105.07m AHD at 8.00am on 12 January 2011.

183 The tandem dam operations line for the entirety of SIM C is the green line in the following:[421]

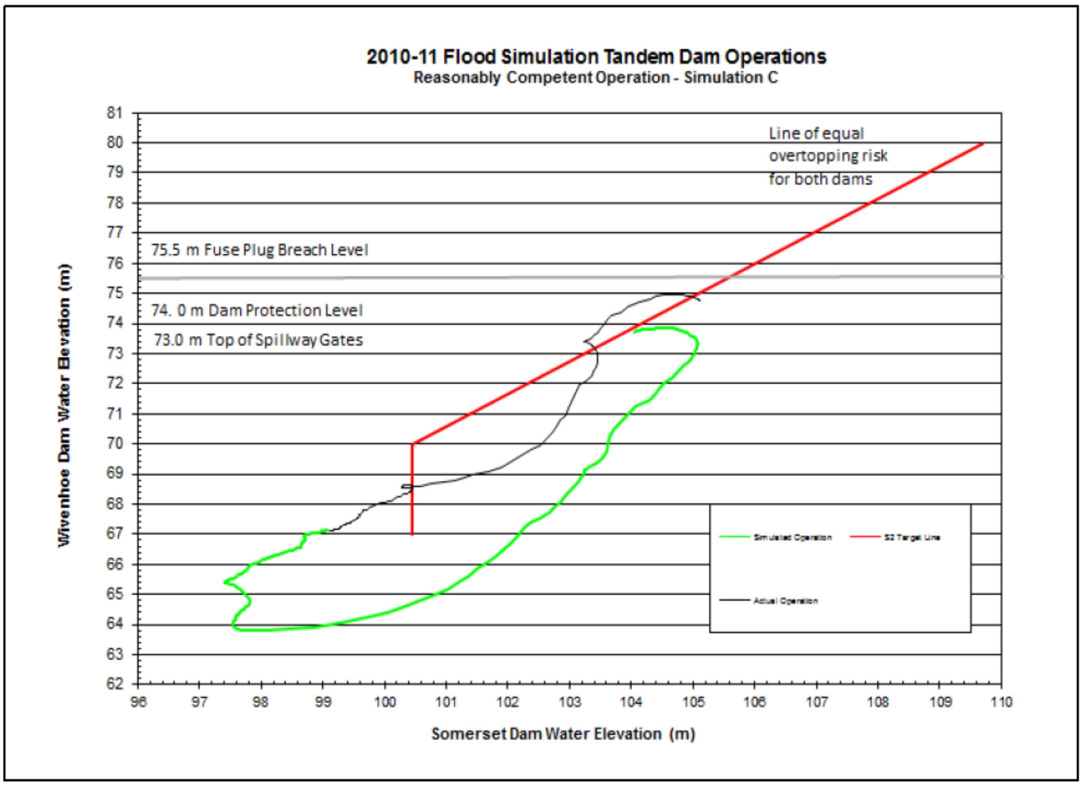

Figure 10-2: Tandem Dam Operations Line for SIM C

[418] Simulation Analysis, EXP.ROD.015.0461 at .0649.
[419] Ibid at .0652.
[420] Ibid at .0655.
[421] LAY.SUN.006.0001_2 at [426].

184 The discussion in section 9.9, and above in relation to SIM F addresses the various issues that arise with the modelled operation of Somerset Dam in SIM C. The above diagram makes it clear that, even with the sluice gates closed, the uncontrolled discharge above EL 100.45m AHD would have directed the tandem operations line to a point on the Operating Target Line well before EL 107.46m AHD.[422] As noted in Chapter 9,[423] in SIM C there would have been an eight and a half hour period between 2.00pm and 10.30pm on 9 January 2011 when (two) sluice gates were open, Somerset Dam was below EL 100.45m AHD and Wivenhoe Dam was rising (although this coincided with a large increase in inflows to Somerset Dam).[424] Correcting for the inflow error extends that period by around 20 minutes.[425] The rate of inflows into Somerset Dam and low levels of Wivenhoe Dam in SIM C more than justify that approach. Even though Strategy W4B was engaged by Dr Christensen's modelling on 10 January 2011, he maintained Somerset operations in S2 throughout the entirety of the flood event.[426] This accords with Mr Pokarier's corrected one-day volumes and the reasonable range of four-day volumes.[427] In any event, at that time only two sluice gates remained to be closed and, even when all sluice gates were closed on 11 January 2011, the tandem operations line would have trended strongly towards the Operating Target Line.

185 I have addressed the variation in Somerset Dam heights occasioned by the inflow error. The range of variations is between 1cm and 9cm.[428] None of them are material.

[422] cf EXP.QLD.001.1311 at [97].
[423] Chapter 9 at [369].
[424] Simulation Analysis, EXP.ROD.015.0461 at .0651 to .0652.
[425] In SIM C Somerset Dam would have been rising by around 25cm an hour at that point and the inflow error caused an overestimation of Somerset Dam levels by about 8cm at this time: SBM.020.022.0001.
[426] Simulation Analysis, EXP.ROD.015.0461 at .0637 to .0640.
[427] See Appendix F to this judgment.
[428] SBM.020.022.0001.

Other Matters

186 SunWater again contended that SIM C breached the Manual by making releases below the gate trigger level of EL 67.25m AHD.[429] As already noted, I reject the construction of the Manual that is the premise of this contention.[430]

187 Seqwater relied on much of Mr Fagot's evidence concerning Method A reservoirs to rebut the simulated flood operations in SIM C.[431] His evidence on that topic was addressed in section 3.4 of Chapter 3. It also referred to Mr Swain's evidence.[432] His evidence was also addressed in Chapter 3.[433]

Conclusion

188 I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing as at midnight on 2 January 2011 would have, at a minimum, made flood releases substantially in accordance with SIM C up to and including 9 January 2011 and made flood releases substantially in accordance with the simulation thereafter.

10.3: Simulation A: 2 January 2011 Start

189 The releases modelled in SIM A are described in Chapter 8.[434] For the period from 3 to 7 January 2011 inclusive, SIM A uses the average eight-day forecast for the purposes of determining strategy and, if the reservoir is to be lowered, releases are determined by reference to a target informed by the estimate of the volume of inflows derived from the four-day PME using the approach outlined in Chapter 8 and further discussed below.[435] For 2 January 2011, Dr Christensen modelled a draindown with a view to ending flood operations. For that day, he used the eight-day high PME forecast to determine a target volume to release upon which flood operations would end

[429] SunWater subs at [1296] to [1300]; EXP.QLD.001.1311 at [94].
[430] Chapter 3 at [146], Chapter 5 at [81].
[431] Seqwater subs at [2374] to [2381].
[432] Ibid at [2382].
[433] Chapter 3 at [198] to [200].
[434] Chapter 8 at [135] to [142].
[435] Chapter 8 at [56] to [58].

(0.9m below FSL for Wivenhoe Dam, 0.8m below FSL for Somerset Dam).[436] For the weekend of 8 and 9 January 2011, SIM A adopts the approach of releasing as much as possible subject to the relevant constraints, including keeping Fernvale Bridge open (which was maintained until the end of 9 January 2011). Thereafter, releases were controlled by downstream considerations in a manner similar to that described in SIM F and SIM C.

190 Compared to the other simulations that commence on 2 January 2011, SIM A makes relatively high releases in the period to the end of 5 January 2011, maintains releases below the rate necessary to keep Mt Crosby Weir Bridge open until 7 January 2011 and to keep Fernvale Bridge open until 9 January 2011. The modelled rate of outflows does not exceed 1900m^3/s until 5.00am on 11 January 2011 and never exceeds 2000m^3/s until 4.00pm on 13 January 2011. As the January 2011 Flood Event was properly to be regarded as a continuation of the Late December Flood Event, this means that peak outflows during SIM A never exceeded past peak inflows at any point.[437]

191 SIM A models making releases well below FSL during the period up to 10 January 2011. The defendants' criticisms were primarily directed to the high level of releases in the period up to and including 7 January 2011, the consequential water level below FSL they caused, and the target approach that produced those outcomes.[438] Thus, Seqwater contended that Dr Christensen's releases in this period were "unreasonably aggressive"[439] and were made "while Wivenhoe Dam was below its FSL and refill to FSL could not be guaranteed".[440] To address the defendants' critique, which in part I accept, it is necessary to explain Dr Christensen's modelled releases and their rationale in SIM A during the period 3 to 7 January 2011 inclusive. The following also illustrates the application of the target approach he adopts, which is described in Chapter 8.[441]

[436] Response Report Vol 2, EXP.ROD.015.0261 at .0286 to .0287.
[437] Cf Sunwater subs at [1155] to [1162].
[438] Seqwater subs at [2319] to [2327]; SunWater subs at [1108] to [1112].
[439] Seqwater subs at [2324].
[440] Ibid at [2327].
[441] Chapter 8 at [56] to [58].

2 January 2011 Releases

192 In SIM A on 2 January 2011, Dr Christensen was seeking to model an end to flood operations.[442] To that end, he determined to release to 0.9m below FSL for Wivenhoe Dam, a level which corresponded with the "no release" rise based on the high range of the eight-day PME forecast.[443] This target corresponded to a release rate of 1678m^3/s, which would release that volume in one day.[444] For both dams, Dr Christensen determined to release at 1400m^3/s, consistent with the rates of release on or around 31 December 2010.[445]

193 The basis for this approach was the notion that, to end flood operations, there must have been no possibility that the water levels would rise above FSL, with this to be determined based on the high end of the range of rainfall depths given by the eight-day PME.[446] I do not accept that the first limb of this proposition is the correct construction of the Manual. Instead, it is sufficient if the flood engineer does not (reasonably) expect the water level to rise above FSL.[447] I also do not accept that the second limb involves a correct application of that construction. Given the skill possessed by the eight-day PME forecast, to make refill to FSL dependent on its high range estimate coming to pass gives too little weight to the objective of "retain[ing] … storage at [FSL] at the conclusion of the Flood Event".[448] The high end of the range of rainfall depths given by the eight-day PME forecast provides the flood engineer with an insufficient basis to conclude that this will occur, bearing in mind that in most cases at the end of the flood event the three higher flood objectives will often be of less significance or not engaged at all.[449] The position is different with any consideration of allowing gate closure but not ending the flood event when sitting at between EL 67m AHD and EL 67.5m AHD on account of a

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[442] Response Report Vol 2, EXP.ROD.015.0261 at .0286.
[443] Id.
[444] Id.
[445] QLD.001.001.1871 at .1874 to .1875.
[446] Reply Report, EXP.ROD.004.0005 at [237].
[447] Chapter 3 at [139] to [140].
[448] Manual at 1; cf SIM C: see [78] to [80].
[449] Chapter 5 at [87].

"favourable weather outlook".[450] In that circumstance, as the dam is above FSL, there is no possibility of compromising the objective of retaining the Dam at FSL and the relevant concern is evacuating remaining floodwater.[451]

3 to 7 January 2011 Releases

194 For 3 January 2011, simulated operations at Wivenhoe Dam commence at EL 66.55m AHD. The modelled four-day inflow volume is 361,000ML, yielding a "no release" rise of 3.1m (ie, to EL 69.65m AHD).[452] Dr Christensen's simulation analysis records the adoption of a W3 strategy.[453] Dr Christensen targeted making releases from Wivenhoe Dam to a level that is 2.5m or 245,000ML below FSL, which would require releases of 197,180ML from Wivenhoe Dam and 45,059ML from Somerset Dam and which, if evacuated in two days, would require a release rate of approximately 1400m^3/s.[454] As releases were already being made at that rate, Dr Christensen modelled continuing releases at that rate.

195 As at midnight on 4 January 2011, Wivenhoe Dam would have been at EL 65.77m AHD. Dr Christensen's four-day PME forecast inflow volume was 517,000ML, which produced a "no release" rise of 4.5m (ie, to EL 70.27m AHD).[455] By reference to the eight-day PME forecast, Dr Christensen recorded the adoption of Strategy W3.[456] Dr Christensen identified a target level of 3.0m (or 288,000ML) below FSL, which required the release of a further 161,615ML.[457] Dr Christensen determined that he could release that amount in two days by releasing at 1322m^3/s.[458] He therefore continued releases during that day at the existing rate of around 1400m^3/s.[459]

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[450] Manual at 32.
[451] See Chapter 6 at [78].
[452] Response Report Vol 2, EXP.ROD.015.0261 at .0287.
[453] Simulation Analysis, EXP.ROD.015.0461 at .0466.
[454] Response Report Vol 2, EXP.ROD.015.0261 at .0287 to .0288.
[455] Ibid at .0288.
[456] Simulation Analysis, EXP.ROD.015.0461 at .0467.
[457] Response Report Vol 2, EXP.ROD.015.0261 at .0228.
[458] Ibid at .0289.
[459] Id.

196 By midnight on 5 January 2011 in SIM A, Wivenhoe Dam would have been at EL 64.96m AHD. Dr Christensen's four-day PME forecast inflow volume had reduced to 364,000ML, producing a "no release" rise of 3.5m (ie, to EL 68.46m AHD).[460] By reference to the eight-day PME forecast, Dr Christensen selected Strategy W3.[461] He again determined a target level of 3.0m (or 288,000ML) below FSL at Wivenhoe Dam, which required the release of a further 84,203ML and which could be achieved in one day at a release rate of 1135m^3/s. Nevertheless, Dr Christensen determined to make the releases in a day at around 1200m^3/s "to avoid unduly prolonging downstream bridge inundation"[462] (ie, by releasing greater amounts earlier to allow bridges to open sooner if possible). Seqwater was critical of this aspect of his operations and contended that, in effect, Dr Christensen determined to release "79% of the total 4-day forecast inflow volume to Wivenhoe… in one day".[463] This is incorrect. In fact, Dr Christensen's target volume below FSL was 79% of his four-day forecast[464] and he exceeded that target on that day but not by releases in one day. In any event, Seqwater contended that "a reasonable alternative would have been to cease flood releases and wait to see if and how rainfall ultimately occurred",[465] a proposition I do not accept. In circumstances where downstream conditions are favourable, 5 January 2011 was the ideal time to release water, although whether it was at the rate simulated from the reservoir level simulated is a different matter.

197 As at midnight on 6 January 2011, the modelled level of Wivenhoe Dam was EL 64.03m AHD[466] and the modelled level of releases was 1205m^3/s. Dr Christensen's four-day PME forecast inflow volume was 460,000ML, which produced a "no release" rise of 4.5m.[467] By reference to the eight-day forecast Dr Christensen selected Strategy W3.[468] He determined a target level of 4.0m (or 370,000ML) below FSL at Wivenhoe Dam, which required the release of a

[460] Response Report Vol 2, EXP.ROD.015.0261 at .0290.
[461] Simulation Analysis, EXP.ROD.015.0461 at .0467.
[462] Response Report Vol 2, EXP.ROD.015.0261 at .0290.
[463] Seqwater subs at [2322].
[464] 288,000/364,000 = 79.12%.
[465] Seqwater subs at [2325].
[466] Simulation Analysis, EXP.ROD.015.0461 at .0468.
[467] Response Report Vol 2, EXP.ROD.015.0261 at .0291.
[468] Simulation Analysis, EXP.ROD.015.0461 at .0468.

further 84,698ML.[469] He calculated that this could be achieved by releases of just over 1000m^3/s in just over a day.[470] Dr Christensen calculated that, at the modelled release rate as at midnight, "slightly more than the target volume would be released in a day". However, he concluded that the "reasonably competent flood operations engineer" would not be concerned because the "target was equivalent to only 370,000ML of [the] 460,000ML forecast 4-day inflow into Wivenhoe," without accounting for Somerset Dam inflows.[471] He concluded that a reasonably competent flood engineer would continue to release at around 1200m^3/s.[472]

198 In SIM A, by midnight on 7 January 2011 the modelled level of Wivenhoe Dam was EL 63.26m AHD or just under 349,000ML below FSL.[473] The modelled releases rate was 1189m^3/s. Dr Christensen's estimate of the four-day PME forecast inflow volume was 608,000ML which produced a "no release" rise of 6.0m (to EL 69.26m AHD). By reference to the eight-day PME forecast the selected strategy was W3.[474] Dr Christensen determined to release to a target level of 4.5m below FSL which required the release of an additional volume of 60,008ML and which could be released over one day at a rate of 695m^3/s (and 820m^3/s including Somerset Dam outflows). Nevertheless, Dr Christensen considered that a higher rate was warranted given the PME forecasts were showing greater rainfall downstream and the potential for that rain to fall upstream. Having regard to the downstream estimate of naturally occurring peak flows, he determined to release at no more than 1280m^3/s to keep Fernvale Bridge open (but close Mt Crosby Weir Bridge based on forecast flows downstream).[475] Again, Seqwater contended that the modelled releases in SIM A were unreasonably high, especially as they exceeded the rate necessary to meet his target level in one day.[476] SunWater contended that Dr Christensen left too little margin for error

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469 Response Report Vol 2, EXP.ROD.015.0261 at .0291.
470 980m^3/s + 41m^3/s: Response Report Vol 2, EXP.ROD.015.0261 at .0291 to .0292.
471 Response Report Vol 2, EXP.ROD.015.0261 at .0292.
472 Id.
473 Response Report Vol 2, EXP.ROD.015.0261 at .0292.
474 Simulation Analysis, EXP.ROD.015.0461 at .0468.
475 Response Report Vol 2, EXP.ROD.015.0261 at .0293; Simulation Analysis, EXP.ROD.015.0461 at .0468.
476 Seqwater subs at [2398] to [2399].

between his outflow rate and the predicted peak at Moggill to keep Fernvale Bridge open.[477]

199 By midnight on 8 January 2011, the modelled level of Wivenhoe Dam in SIM A was EL 63.39m AHD. The approach on subsequent days has already been described. It suffices to state that, given the significant deterioration in the forecasts, modelled releases from this point were largely governed by downstream considerations. For each of 8 to 10 January 2011, Dr Christensen did not identify a target level or volume below FSL to release to. Instead, he simply endeavoured to keep the dams as low as possible subject to downstream constraints.[478] In light of the analysis below, it is unnecessary to address the defendants' submissions concerning those releases.[479] On 11 January 2011, Dr Christensen determined the minimum gate openings in a manner consistent with that outlined in section 9.7 of Chapter 9[480] (allowing for the difference in reservoir levels).[481]

Target Approach

200 Thus, for the period 3 to 7 January 2011, the target volume below FSL that Dr Christensen used to guide modelled release rates was always less than the four-day inflow estimate and usually by at least a metre.[482] The selected target and the potential release periods would produce an initial calculation of a release rate for one day and two days which would then be assessed having regard to, inter alia, downstream conditions. On 5, 6 and 7 January 2011, Dr Christensen determined to release to the target in one day and therefore adopted a release rate that meant that (marginally) more than the remaining volume that needed to be released to reach the target was actually released.[483] The rationale for that approach was that the extra water that was released was relatively small and did not infringe on the capacity to refill

[477] SunWater subs at [1176] to [1183].
[478] Response Report Vol 2, EXP.ROD.015.0261 at .0278 to .0281.
[479] Eg Seqwater subs at [2400] to [2406]; SunWater subs at [1185] to [1195].
[480] Chapter 9 at [302] to [304].
[481] Response Report Vol 2, EXP.ROD.015.0261 at .0299 to .0300.
[482] 3 Jan: 361,000ML v 245,000ML; 4 Jan: 517,000ML v 288,000ML; 5 Jan: 364,000ML v 288,000ML; 6 Jan: 460,000ML v 370,000ML; 7 Jan: 608,000ML v 490,000ML.
[483] Response Report Vol 2, EXP.ROD.015.0261 at .0289 to .0293.

based on inflows from the four-day PME forecast, that there was little to be gained in reducing releases as it would not open any extra bridge and that there was likely to be a potential benefit in reopening more bridges earlier from slightly over releasing on those times. As noted, Kholo Bridge was unusable during this period, which meant that in assessing the impact of releases on bridges, subject to the constraints of the Manual, the relevant decision facing a flood engineer in terms of downstream effects was either maintaining Burtons Bridge open at a combined flow rate with Lockyer Creek of less than 430m^3/s,[484] or increasing beyond that (with the next downstream flow limit of 1900m^3/s preventing inundation of Mt Crosby Weir Bridge). During the period 3 to 6 January 2011, there was relatively small downstream flow.

201 It is appropriate at this point to outline the defendants' objections to the "target" level approach, especially so far as SIM A is concerned.

202 Seqwater noted that the target approach is a *quantitative* use of rainfall forecasts. It submitted that there is "no evidence of any dam in the world in which releases have been selected based on [the] quantitative use of rainfall forecasts" and made the related submission that no such dam used a target approach.[485] The evidence concerning dam practices elsewhere is addressed in Chapters 5 and 9.[486] If the selection of the appropriate flood strategy based on a projected dam level that incorporates forecast rainfall is a "quantitative use," then it is clear that one dam in the world at least was obliged to make a quantitative use of forecasts, namely, Wivenhoe Dam. The Manual is unambiguously emphatic in requiring that. Further, the one practice that was universally adhered to in dam operations was (and is) the necessity to observe and not ignore the governing manual at the relevant dam. The evidence and experts relied on by Seqwater did not properly grapple with either of those two propositions.

203 SunWater noted that Dr Christensen's target level method usually required lowering to the target level being achieved within one to two days, whereas

[484] Manual at 27.
[485] Seqwater subs at [2156] to [2165].
[486] Chapter 5 at [127] to [131]; Chapter 9; section 9.1.

the Manual refers to stored floodwaters being evacuated "within seven days of the flood event peak passing through the dams" as referred to in clauses 3.1 and 3.2 of the Manual.[487] However, those parts of the Manual are not inconsistent with Dr Christensen's target level method. Clauses 3.1 and 3.2 are directed to evacuating stored floodwaters after the flood event peak has passed (ie, when in draindown). Dr Christensen's methodology is directed to flood operations on the upward limb of the hydrograph (ie, before the arrival of the peak).

204 SunWater submitted that Mr Kane's evidence was "irreconcilable with Dr Christensen's quantitative use of 4-day PME forecasts".[488] Seqwater made a similar submission.[489] The relevant part of Mr Kane's evidence on this topic is addressed in Chapter 3.[490] It follows from that analysis that there is no such lack of reconciliation.

205 SunWater further contended that, at least in SIM A, Dr Christensen departed from his stated methodology because, inter alia, he "sets a target below FSL that involves evacuating all the water both above the predicted 4-day no release level and then an additional level below FSL".[491] Dr Christensen did not do this. As explained below, the volume below FSL that Dr Christensen adopts as his target to release to in SIM A in the period 3 to 7 January 2011 is always less than the four-day inflow estimate (and by no less than 76,000ML).[492] However, on 5, 6 and 7 January 2011 Dr Christensen releases more than the target but the reservoir level never falls below an amount that could not be refilled by the estimate of four-day inflows.

206 SunWater also contended that there was a discrepancy between Dr Christensen's stated methodology and its application in the simulation, specifically an inconsistency between the timing of rainfall predicted by the forecasts and his selection of release rates based on when he asserted the

[487] Manual at 9 to 10; SunWater subs at [1149].
[488] SunWater subs at [1148].
[489] Seqwater subs at [2167].
[490] At [247] to [251].
[491] SunWater subs at [1006].
[492] See fn 498 below.

forecast rain might fall. It contended that his modelled rates afford "undue urgency to the need to evacuate water in the flood event when the weather forecasts were benign".[493] However, the example cited by SunWater to support this is Dr Christensen's modelled operations in SIM A for 2 January 2011. The modelling for this day did not involve the application of the target method but instead utilised an approach whereby he would not end flood operations unless the dam was certain not to rise above FSL based on the high end of the range of the eight-day PME forecast.[494] I have already rejected that approach but regardless, it is not relevant to any assessment of the target approach in SIM A for the period of 3 to 7 January 2011.

207 The State contended that the release rates selected by Dr Christensen in SIM A using the target approach were "arbitrary",[495] or at least "so imprecise as not to reflect any consistent logical methodology".[496] It contended that the difference between the target level reductions below FSL and the "no release" rises based on the four-day PME forecast inflows from 4 to 7 January 2011 were 6.0m, 4.5m, 4.0m and 6.75m. The State argued that these differences were always more than the four-day PME "no release" rise and are inconsistent with his stated methodology.

208 I do not accept these criticisms. The general approach adopted by Dr Christensen in those simulations that use the target approach is to create storage space in advance of forecast rainfall, including storage space below FSL, although by an amount less than the four-day inflow estimate. When that storage space is being created at 3.0m or more below FSL, then he exercises (further) caution by guarding against the possibility that less rain will fall and not refill to FSL. Hence, at midnight on 4 January 2011 when the dam is at a modelled level of EL 65.77m AHD, Dr Christensen adopts a target to release to of 3.0m below FSL. If releases are made to that level and the forecast rain reflected in his four-day PME inflow estimates eventuates, then the final level

[493] SunWater subs at [1009].
[494] T 2219.5 - .9 (Christensen).
[495] State subs at [564].
[496] Ibid at [566].

of the dam will be 229,000ML above FSL.[497] That amount of water represents a "margin" for refill to occur in case the four-day PME forecast inflow estimate did not eventuate in its entirety. There is a margin for each of the other days that varies,[498] although he plots a release rate on 5, 6 and 7 January 2011 that exceeds that target.[499]

209 The State also submitted that Dr Christensen did not explain the difference in the targets below FSL he selected for 4 and 6 January 2011 in that, even though the four-day PME forecast inflow estimates for both days suggested a "no release" rise of 4.5m, with the former Dr Christensen selected a target of 3.0m below FSL and with the latter he selected a target of 4.0m below FSL.[500] Dr Christensen was not asked to "explain" this difference in his 22 days in the witness box. However, I note that on 4 January 2011 the forecast inflow based on the eight-day average was 529,000ML, suggesting little rain after four days, whereas on 6 January 2011 it was 715,000ML (and the eight-day high was 1,056,000ML), suggesting much heavier rain after four days.[501] These differences may have prompted the selection of a lower target level below FSL on 6 January 2011 and a higher target level below FSL on 4 January 2011.

210 Otherwise, the State submitted, based on Mr Fagot's evidence, that pre-releasing based on forecasts was "flawed".[502] Mr Fagot's evidence has already been addressed. The Manual's requirement in respect of forecasts and pre-releases is addressed in Chapter 3.[503]

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497 517,000ML – 288,000ML: Response Report Vol 2, EXP.ROD.015.0261 at .0288.
498 Jan 3: 361,000ML – 245,000ML = 116,000ML; 4 Jan: 517,000ML – 288,000ML = 229,000ML; 5 Jan: 364,000ML – 288,000ML = 76,000ML; 6 Jan: 460,000ML – 370,000ML = 90,000ML; 7 Jan: 608,000ML – 409,000ML: 199,000 ML.
499 The 5 Jan inflow estimate is 364,000ML and the target below FSL is 288,000ML, but Dr Christensen releases 18,600ML more. Therefore the margin = 364,000ML v 306,600ML. (288,000ML + 18600ML) He does the same on 6 and 7 January so that margins on those days: 466,000ML v 386,027ML; and 608,000ML v 452,041ML (409,000ML + 43,041ML): Response Report Vol 2, EXP.ROD.015.0261 at .0274 to .0276.
500 State subs at [565(c)].
501 Response Report Vol 2, EXP.ROD.015.0261 at .0274 and .0276.
502 State subs at [567].
503 Chapter 3 at [176] to [192], [328] to [330].

211 SunWater contended that there is nothing in the Manual which directs the use of a four-day inflow forecast in determining a target water level.[504] Seqwater made the same submissions and added that there was “nothing” in the Manual “about rounding down [4-day inflow estimates] and reducing the volume estimates to determine release rates or [adopting] a different approach when 3.0m below FSL”.[505]

212 As explained in Chapters 3 and 9, the Manual requires the use of the “best forecast rainfall information” in the selection of strategies and releases. I have already found that, given the catchment characteristics, that the forecast period had to be longer than a day, that the four-day PME forecast was sufficiently reliable for use in operational decisions and that, on the evidence, a reasonably competent flood engineer must have utilised it. Beyond that, Seqwater and SunWater were correct to the extent that they contended that the Manual did not mandate the use of Dr Christensen’s target approach. However, as previously noted, the Manual leaves a number of matters to the professional judgment of the flood engineer. Subject to what follows, depending on its parameters the target approach represented a method that a reasonably competent flood engineer could have chosen to adopt to comply with the Manual. Whether in doing so they acted consistently with the Manual and the standard of a reasonably competent flood engineer faithfully applying the Manual requires a close examination of its application in a particular context.

213 As noted, the State submitted that the target approach leads to the adoption of “arbitrary” release rates by Dr Christensen in SIM A. I do not accept that assertion. However, I do accept that this approach leaves considerable scope for the exercise of judgment, including how far below FSL relative to the “no release” rise from the four-day PME inflow estimate the target level will be, the determination of the relevant release period and then the selection of a final release rate (after consideration of matters such as downstream effects). In this case, whether the reasonably competent flood engineer would have or

[504] SunWater subs at [1147]; see also SunWater subs at [1000] to [1005].
[505] Seqwater subs at [2156].

must have made modelled releases substantially in accordance with SIM A for the period from 3 to 7 January 2011 can be addressed by considering the sensitivity of Dr Christensen's simulated operations to reasonable variations in the four-day PME forecast inflow estimates and the extent to which the reasonably competent flood engineer could be satisfied that the modelled inflows would meet the fourth flood objective of refilling to FSL given the adopted release pattern.

Effect of Revised Estimates on Strategies and Releases

214 In Chapter 9, I rejected the use of the eight-day PME forecasts in selecting strategy.[506] I also found that Dr Christensen's forecast loss rates were reasonable, his selected rainfall depths were reasonable (although towards the high end of a reasonably narrow range[507]) and his four-day inflow volume estimates were towards the higher end of the reasonable range of estimates.[508] I found that the estimates based on Mr Giles' 'correction' for the Late December Flood Event utilised loss rates towards the lower end and rainfall depths towards the higher end of a reasonable range.[509]

215 In relation to the selection of strategies, although Dr Christensen used the eight-day PME forecast average inflow volume estimate to select strategy, each of Dr Christensen's four-day PME forecast inflow volume estimates was capable of invoking a strategy sufficient to justify the releases that were made by Dr Christensen. As noted, the release rate in SIM A did not exceed 1900m^3/s until 5.00am on 11 January 2011.[510] All the "no release" rises from 3 January 2011 that were based on Dr Christensen's four-day inflow volume estimates were sufficient to take Wivenhoe Dam well above EL 68.0m AHD and invoke at least Strategy W1D or higher up to and including 6 January 2011 and above EL 68.5m AHD, thus invoking Strategy W3 or higher, thereafter. All of those strategies would permit releases at the rates that were

506 Chapter 9 at [128].
507 Chapter 9 at [159], [208], [231] and [232].
508 Chapter 9 at [233].
509 Chapter 9 at [233].
510 Simulation Analysis, EXP.ROD.015.0461 at .0470.

modelled.[511] Given that in SIM A, Mt Crosby Weir Bridge would not be inundated until 7 January 2011, when the four-day inflow forecast supported the engagement of Strategy W3, the reasonably competent flood engineer would not treat the different strategies engaged by four-day PME forecasts as itself warranting the adoption of different releases.[512]

216 The same position applies to the revision of the four-day PME inflow estimates based on Mr Giles' analysis of the Late December Flood Event set out in Chapter 9 save for two days, 5 and 6 January 2011.[513] As at midnight on 5 January 2011, the "no release" rise using those revised estimates is EL 68.13m AHD[514] and, after accounting for the inflow error, is EL 68.07m AHD.[515] As at midnight on 6 January 2011, the "no release" rise using the revised estimates is EL 68.16m,[516] which accounting for the inflow error is EL 68.10m AHD.[517] Each of those figures is no more than 20,000ML above EL 68.0m AHD. Even though I accept that Mr Giles' own estimates for the four-day PME inflow volumes were unreasonable, his revision of Dr Christensen's figures to allow for the Late December Flood Event still utilised Dr Christensen's estimated rainfall depths from the PME forecasts which, at least for the period of 3 to 6 January 2011, were towards the higher end of the range of interpretations.[518] The end result is that I am not satisfied that the range of reasonable estimates for the four-day PME forecast inflow volumes could support the adoption of a strategy sufficient to justify a release of above $500m^3/s$ (ie, Strategy W1D or higher) on 5 January 2011 and 6 January 2011

[511] 3 Jan: 66.55m + 3.1m = EL 69.65m AHD; 4 Jan: 65.77m + 4.5m = EL 70.27m AHD; 5 Jan: 64.96m + 3.5m = EL 68.46m AHD; 6 Jan: 64.03m + 4.5m = EL 68.53m AHD; 7 Jan: 63.26m + 6m = EL 69.26m AHD; 8 Jan: 63.39m + 9.3m = EL 72.69m AHD; 9 Jan: 63.33m + 8.1m = EL 71.43m AHD; 10 Jan: 64.33m + 10.4m = EL 74.73m AHD; 11 Jan: 68.25m + 5.2m = EL 73.45m AHD: Response Report Vol 2, EXP.ROD.015.0261 at .0287 to .0299.

[512] Cf Sunwater subs at [1113] to [1132] which compares strategies chosen on eight-day forecasts to strategies selected by QPF forecasts without making mention of the four-day forecasts.

[513] 3 Jan: 66.55m (1117180) + 328,000m = EL 69.43m AHD; 4 Jan: 65.77m (1038615) + 501,000m = EL 70.17m AHD; 7 Jan: 63.26m (816008) + 547,000m = EL 68.75m AHD; 8 Jan: 63.39m (826065) + 934954m = EL 71.84m AHD; 9 Jan: 63.33m (821691) + 782,000m = EL 70.67m AHD; 10 Jan: 64.55m (924117) + 1,192,000m = EL 74.26m AHD.

[514] EL 64.96m AHD (961,203ML) + 329,585 = EL 68.13m AHD.

[515] EL 64.96m AHD (961,203ML) + 329,585 – 6,304ML = EL 68.07m AHD; see SBM.020.021.0001 at .0004.

[516] EL 64.03m AHD (879,698ML) + 414,500 = EL 68.16m AHD.

[517] EL 64.03m AHD (879,698ML) + 414,500 – 7091 = EL 68.10m AHD.

[518] See Chapter 9 at [233].

(although the latter may depend on a higher revised level if releases are lowered in SIM A on 5 January 2011).

217 A similar concern effects the calculation of a release rate for those days. As stated, for the period from 3 to 7 January 2011 (and every day thereafter) there is a reasonably large difference between Dr Christensen's four-day PME inflow estimate and the target volume below FSL,[519] although it is smaller on 5, 6 and 7 January 2011 as Dr Christensen planned releases beyond his target.[520] As is clear from the above, the selected target level below FSL was utilised by Dr Christensen to calculate the first "cut" of his proposed release rates, with the final release rate determined after having regard to that figure and other considerations. The size of the differential between the four-day PME inflow estimate and the target volume below FSL for some of the days is such that it means that the reasonable variations in the volumetric estimates of the four-day PME inflow estimates will not affect the calculation of the first cut of the proposed release rate. Thus, using the revised volumetric estimates for the four-day PME forecast inflow based on Mr Giles' analysis of the Late December Flood Event was very unlikely to effect the modelled rate of release on 3, 4 or 7 January 2011, because for those days there was still a significant differential between that volumetric estimate and the target volume below FSL.[521] However, on 5 January 2011, the differential between the revised four-day PME inflow estimates based on Mr Giles' analysis and the target volume below FSL is approximately 42,000ML[522] and on 6 January 2011 it is approximately 45,000ML[523] (which in both cases is around half a metre). It is unclear whether, if those four-day PME inflow estimates were used in modelling in SIM A, that the same target below FSL would have been selected or a target 0.5m higher would have been selected and, if it was, whether that would have a consequential effect on the calculation of at least the first cut of the proposed release rate.

[519] See footnote 498.
[520] See footnote 499
[521] 3 Jan: 328,000ML v 245,000ML; 4 Jan: 501,000ML v 288,000ML; 7 Jan: 547,000ML v 409,000ML.
[522] 5 Jan: 329,585ML v 288,000ML.
[523] 6 Jan: 414,500ML v 370,000ML.

Releases Below FSL

218 As noted, the modelling of releases below FSL in SIM A was subject to the limitation that Wivenhoe Dam must have always been able to be refilled to FSL by the four-day PME inflow estimate. In fact, as the above illustrates, the modelled releases would have taken Wivenhoe Dam well below FSL but always by an amount that was less than Dr Christensen's four-day PME inflow estimate (as well as the revised estimate using Mr Giles' analysis). However, with the exception of a short period on 6 January 2011, from 3 January 2011 to the morning of 9 January 2011 the simulated water levels in SIM A are below the amount at which they could have been refilled to FSL based on Dr Christensen's one-day QPF forecast estimate of inflows (as corrected by Mr Pokarier) and for some periods by more than a metre.[524]

219 The difference between the approach to refill to FSL in SIM A compared to SIM C is illustrated by the yellow portion of the following diagram which maps the simulated heights at Wivenhoe Dam for all of Dr Christensen's simulations:[525]

[524] One-day QPF forecast inflows set out in Table 9-8 in Chapter 9 at [286]; SIM A volumes at Wivenhoe set out in Simulation Analysis, EXP.ROD.015.0461, .0466 to .0470; 3 Jan 11:00: 66.19 (1080392) + 36,674 = 1117066ML = EL 66.54m AHD; 3 Jan 17:00: 66.00 (1060735) + 91,437 = 1152172ML = EL 66.88m AHD; 4 Jan 11:00: 65.41 (1003436) + 84,426 = 1087862ML = EL 66.26m AHD; 4 Jan 17:00: 65.20 (983761) + 59,018 = 1042779ML = EL 65.81m AHD; 5 Jan 11:00: 64.53 (922921) + 106,762 = 1029683ML = EL 65.68m AHD; 5 Jan 17:00: 64.27 (900435) + 230,752 = 1131187ML = EL 66.68m AHD; 6 Jan 11:00: 63.64 (846476) + 326,730 = 1173026ML = EL 67.07m AHD; 6 Jan 17:00: 63.45 (831077) + 301,671 = 1132748ML = EL 66.70m AHD; 7 Jan 11:00: 63.29 (818268) + 274,866 = 1093134ML = EL 66.32m AHD; 7 Jan 17:00: 63.37 (824271) + 324,839 = 1149110ML = EL 66.85m AHD; 8 Jan 11:00: 63.52 (837053) + 319,471 = 1156524ML = EL 66.92m AHD; 8 Jan 17:00: 63.49 (833935) + 307,425 = 1141360ML = EL 66.78m AHD; 9 Jan 11:00: 62.92 (788588) + 414,881 = 1203469ML = EL 67.35m AHD; 9 Jan 17:00: 63.12 (804853) + 836,748 = 1641601ML = EL 70.96m AHD.

[525] AID.500.004.0001.

Simulated Water Level - Wivenhoe Dam

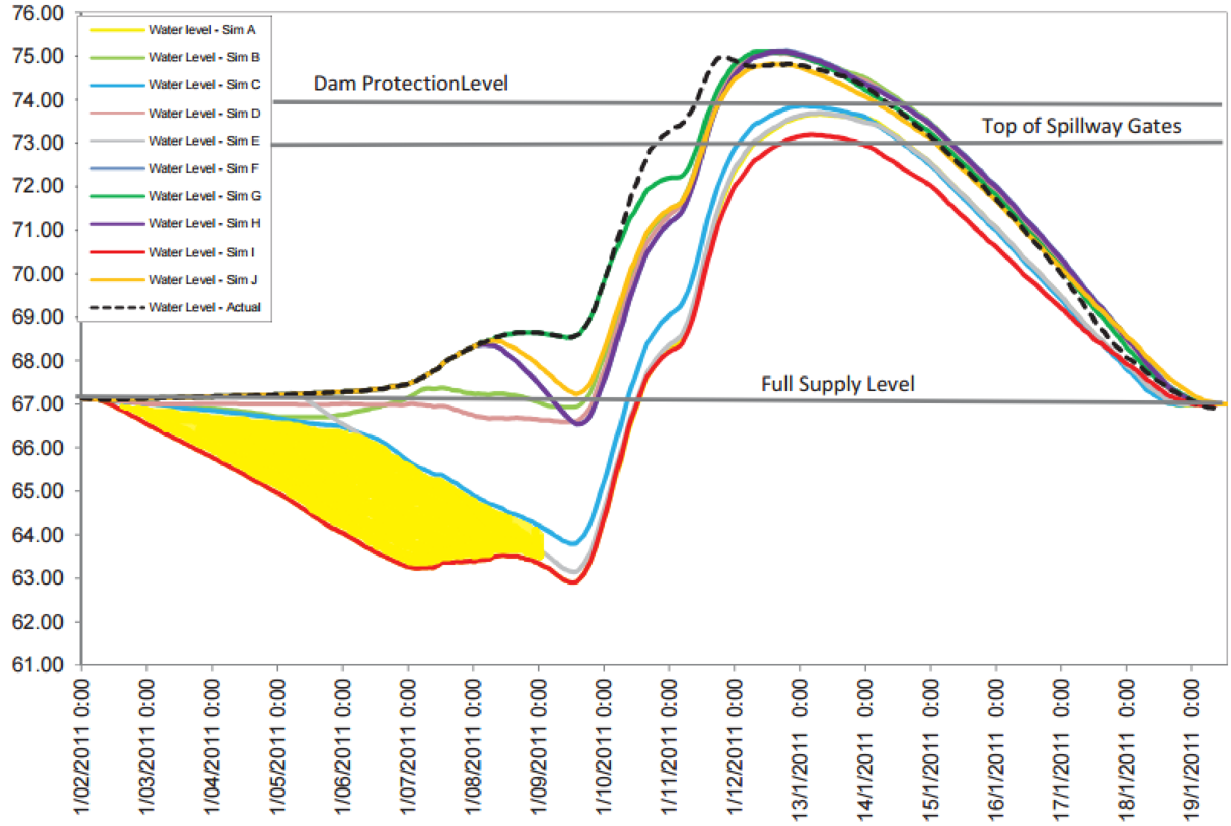

Figure 10-3: Water Level Comparisons in Dr Christensen's Simulations

220 The red line in Figure 10-3 represents the simulated water level in SIM A. The graph's key states that the red line represents the water level in SIM I, but up until 11 January 2011 SIM A and SIM I maintained identical release patterns and lake levels. The light blue line represents the simulated water level in SIM C. The yellow portion represents the volumetric difference in the extent to which both simulations make releases below FSL in the period up to 9 January 2011. On 9 January 2011, the rain on the ground inflow estimates climbed rapidly and the forecast inflows from the QPF and PME forecasts began to converge as the time for heavy rain drew nigh. In the period up to 7 January 2011 at Wivenhoe Dam, SIM C is never below FSL by more than the one-day inflow forecast at the corresponding time, and in fact, the level is always higher by a considerable amount. In contrast, and as just explained, during that period SIM A is below FSL by more than the one-day QPF inflow forecast and in some periods it is lower by much more.

221 It follows that, to find that a reasonably competent flood engineer would have made releases substantially in accordance with SIM A, it must be found that such a flood engineer would have taken Wivenhoe Dam below FSL to a point substantially beyond the level it could be refilled by an estimate based on the QPF forecast. I address the approach to refill in Chapter 5. With SIM F and SIM H, I have found that flood operations that do not draw Wivenhoe Dam below FSL unless it can be refilled by an amount above FSL in Somerset Dam meets the fourth flood objective[526] and that a reasonably competent flood engineer would (at the very least) make such releases, if necessary, to conduct flood operations. In relation to SIM C, I have found that the circumstances prevailing during the January 2011 Flood Event were such that a reasonably competent flood engineer would make releases below FSL if those releases did not take the reservoir level to a height below that which it could not be refilled by the inflow estimate based on the QPF forecast, that to do so would be consistent with the Manual and would be undertaken by a reasonably competent flood engineer if necessary to give effect to the flood objectives.[527] Those circumstances included the relative accuracy of the QPF, the seasonal weather conditions and the forecast of more rainfall beyond the QPF (as suggested by the four-day and eight-day PMEs).

222 However, with the approach in SIM A, while it might have been open to a reasonably competent flood engineer to make releases below FSL that could be refilled based on inflow estimates generated by the four-day PME forecasts, I am not satisfied they necessarily would do so. Such a flood engineer would not have the comfort of knowing that a sufficiently accurate forecast for a period beyond four days was suggesting more rain would be forthcoming. Notwithstanding the seasonal conditions, it would be open to an engineer to reasonably conclude that they would not take the dam below an amount at, or around, what the QPF forecast suggested would refill to FSL. To this point and to that extent, I do not accept Dr Christensen’s target approach.

[526] Chapter 5 at [200], see above at [28].
[527] See above at [178].

Conclusion

223 The effect of the above findings concerning SIM A is such that I am not satisfied that a reasonably competent flood engineer would have made releases substantially in accordance with SIM A for the period of 2 to 7 January 2011. In those circumstances, it is not necessary to address the balance of the simulation. Accordingly, I am not satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing as at midnight on 2 January 2011 would have made flood releases substantially in accordance with SIM A.

10.4: Simulations B and D – 2 January 2011 Start

224 Both SIM B and SIM D are described in Chapter 8.[528] As noted, SIM B was governed by an assumption that only runoff predictions using a rain on the ground estimate of inflows were to be deployed for "operational decisions". SIM D was governed by an assumption that flood releases could be made below FSL from Wivenhoe Dam to the extent that there was sufficient water above FSL in Somerset Dam to refill Wivenhoe Dam to FSL.

225 It follows from the previous chapters and the above that I do not accept that flood operations were confined by either assumption. In particular, I do not accept that a reasonably competent flood engineer would operate under the assumption governing SIM B. To do so would be completely inconsistent with the Manual. Further, in light of my acceptance of SIM C, it is not necessary to address the detail of SIM B by reference to either its governing assumptions or the findings that have been made. This is so because, save for a period on 3 and 4 January 2011 which is immaterial,[529] up to and including 8.00am on 11 January 2011, modelled releases from Wivenhoe Dam in SIM B are never greater than modelled releases in SIM C and dam levels in SIM B are never lower than in SIM C. Thereafter, releases in SIM B are always higher. Thus, so far as reducing urban inundation is concerned, SIM C represents a far

[528] Chapter 8 at [143] to [145] and [151] to [154] respectively.
[529] SIM B models releases of around 375m^3/s on those days and SIM C models releases of around 325m^3/s for a period on both of those days: Simulation Analysis, EXP.ROD.015.0461 at .0547 to .0548 and .0627 to .0628.

more favourable outcome. Otherwise, given the findings made in relation to SIM C, SIM F and SIM H, an analysis of SIM B does not assist in determining the allegations of breach compared to either of SIM C, SIM F and SIM H. The same applies with SIM D. In the period up to 11 January 2011, modelled releases in SIM D never exceed modelled releases in SIM C.

10.5: Simulation E – 5 January 2011 Start

226 The modelled releases in SIM E are described in Chapter 8.[530] The modelled water levels in SIM E are represented by the grey line in Figure 10-3. SIM E uses the same methodology as SIM A, however there are two important differences. First, as SIM E commences at midnight on 5 January 2011 with the dams well above FSL and all the forecasts pointing to significant rain, there is no scope to consider a drain down to end flood operations. Second, as already noted, Dr Christensen determined to apply the gate opening trigger of EL 67.25m AHD to flood operations in SIM E. Otherwise, SIM E uses the selection of target levels below FSL to release to on 5 to 7 January 2011 but, given the forecasts, not thereafter.

227 In light of the findings in relation to SIM A, it is necessary to address whether any reasonable variations in the estimates of four-day forecast inflows is capable of affecting the selection of strategies or release rates in SIM E and whether the refill condition applied in SIM C is capable of being met by SIM E.

Strategies and Refill

228 When the simulated heights in Wivenhoe Dam at midnight in SIM E are added to the revised four-day PME inflow estimate for Wivenhoe Dam using Mr Giles' assessment of the Late December Flood Event, then the projected height is still well above EL 68.5m AHD. In fact, the difference is so great that I am satisfied that the use of the range of reasonable estimates for four-day

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[530] Chapter 8 at [155] to [157].

PME inflow estimates would lead to the same result,[531] (and that is so even if the flood engineers' rain on the ground estimates were used).[532]

229 In relation to refill, all of Mr Pokarier's corrections of Dr Christensen's one-day inflow estimates based on the QPF forecasts yield a projected height above FSL for Wivenhoe Dam in SIM E from the time of the forecast.[533]

5 January 2011 Release Rates

230 At the time of the commencement of SIM E, Wivenhoe Dam was at EL 67.22m AHD and releasing 50m^3/s through a regulator.[534] Dr Christensen's four-day PME inflow estimate was 364,000ML, which corresponds to a "no release" rise of 3.1m (to EL 70.33m AHD). Using the target approach explained by reference to SIM A, Dr Christensen identified a target level of 2.5m below FSL at Wivenhoe Dam (and 1.5m below FSL at Somerset Dam[535]). This required a release of 269,150ML at Wivenhoe Dam and 70,906ML at Somerset Dam (which total 340,056ML).

231 In his day-by-day release rates explanation, Dr Christensen stated that, given the eight-day PME forecast, the flood engineer "would determine to lower the water level relatively quickly".[536] Dr Christensen calculated the release rate necessary to meet the target level, this being 1968m^3/s over two days and

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[531] EL 68.5m AHD = 1,334,000ML. 5 Jan: EL 67.22m AHD (1,189,150ML) + 329,585ML = 1,518,735ML (EL 70.01m AHD); 6 Jan: EL 66.55m AHD (1,116,948ML) + 414,500ML = 1,531,448ML (EL 70.11m AHD); 7 Jan: EL 65.34m AHD (997,392ML) + 547,000ML = 1,544,392ML (EL 70.21m AHD); 8 Jan: EL 64.58m AHD (927,500ML) + 934,954ML = 1,862,454ML (EL 72.56m AHD); 9 Jan: EL 63.69m AHD (850,708ML) + 782,000ML = 1,632,708ML (EL 70.89m AHD); 10 Jan: EL 64.54m AHD (923,930ML) + 1,199,500 = 2,123,430ML (EL 74.31m AHD); 11 Jan: EL 68.35m AHD (1,316,894ML) + 639,840 = 1,956,734ML (EL 73.21m AHD).

[532] Chapter 9 at [284].

[533] 5 Jan: 17:00 – EL 66.83m AHD (1,147,152ML) + 230,752ML = 1,377,904ML (EL 68.87m AHD); 6 Jan: 11:00 – EL 66.04m AHD (1,064,799ML) + 326,730ML = 1,391,529ML (EL 68.99m AHD); 17:00 – EL 65.71m AHD (1,032,651ML) + 301,671ML = 1,334,322ML (EL 68.5m AHD); 7 Jan: 11:00 - EL 64.97m AHD (962,417ML) + 274,866ML = 1,237,283ML (EL 67.65m AHD); 17:00 – EL 64.80m AHD (947,375ML) + 324,839ML = 1,272,214ML (EL 67.97m AHD); 8 Jan: 11:00 – EL 64.27m AHD (900,379ML) + 319,471ML = 1,219,850ML (EL 67.50m AHD); 17:00 – EL 64.03m AHD (879,816ML) + 307,425ML = 1,187,241ML (EL 67.20m AHD); 9 Jan: 11:00 – EL 63.16m AHD (808,146ML) + 418, 881ML = 1,227,027ML (EL 67.56m AHD); 17:00 – EL 63.35m AHD (823,116ML) + 836,748ML = 1,659,864ML (EL 71.1m AHD); 10 Jan: 11:00 – EL 66.89m AHD (1,153,995ML) + 854,498ML = 2,008,493ML (EL 73.56m AHD).

[534] Simulation Analysis, EXP.ROD.015.0461 at .0801.

[535] Response Report Vol 2, EXP.ROD.015.0261 at .0380.

[536] Id.

1574m^3/s over two and a half days.[537] Dr Christensen concluded that to lower the reservoirs while keeping Fernvale Bridge and Mt Crosby Weir Bridge open the flood engineer would have to make releases at or below 1800m^3/s.[538]

232 As noted, in SIM E Dr Christensen chose not to make releases until Wivenhoe Dam exceeded EL 67.25m AHD. To facilitate this, he modelled releasing water from Somerset Dam such that Wivenhoe Dam would have reached EL 67.25m AHD at 4.00am on 5 January 2011.[539] Releases from the crest gates at Wivenhoe Dam were modelled to commence at that time and by 11.00am it would have been releasing 1783m^3/s.[540] That release rate was continued throughout the day. By midnight on 6 January 2011, SIM E was at EL 66.55m AHD and releasing 1767m^3/s.[541]

233 In contrast, on 5 January 2011 in SIM C, Dr Christensen made releases of around 321m^3/s in Strategy W1B until the publication of the afternoon QPF, which caused Strategy W3 to be engaged. Thereafter, he increased releases to around 1363m^3/s. As noted above, on 5 January 2011 in SIM C when W3 was engaged, Dr Christensen selected a target of 2.1m below FSL which would have been achieved by releases of around 1400m^3/s in around 31.5 hours.[542] By midnight on 6 January, SIM C was modelled at EL 66.47m AHD with releases being made at 1379m^3/s.[543] The average rate of release modelled in SIM C on 5 January 2011 was 415m^3/s, whereas in SIM E it was 1198m^3/s.[544]

234 The revised four-day inflow estimate for Wivenhoe Dam using Mr Giles' assessment of the Late December Flood Event is 328,000ML, which is still greater than Dr Christensen's selected target volume to be released at Wivenhoe Dam in SIM E on 5 January 2011, which was 2.5m below FSL

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537 Id: 340,056/48 x 3.6 = 1,968; 340,056/60 x 36. = 1,574.
538 Id.
539 Simulation Analysis, EXP.ROD.015.0461 at .0785; .0793.
540 Ibid at .0785.
541 Id.
542 17:00 volume – 2.1m below FSL target volume: (1115213 – 956000)/1400/3 x 6.
543 Simulation Analysis, EXP.ROD.015.0461 at .0628.
544 Sum of hourly release rates for 5 Jan 2011 /24: Simulation Analysis, EXP.ROD.015.0461 at .0628 and .0785.

(269,150ML).[545] However, as noted, that estimate still uses Dr Christensen's interpretation of the PMEs. On the basis that Dr Christensen always selects a target volume that is less than the four-day estimate by a reasonable margin, it is conceivable that a four-day inflow estimate within the reasonable range of such estimates could lead to the adoption of a target below FSL of say 2.0m at Wivenhoe Dam, instead of 2.5m, (and a target below FSL at Somerset Dam of say 1.0m, instead of 1.5m). That would reduce the target volume by 45,000ML at Wivenhoe Dam and 18,800ML at Somerset Dam.[546] The two-day release rate calculation would then yield a rate of 1598m^3/s,[547] as opposed to the rate of 1968m^3/s calculated by Dr Christensen. The two and a half day release rate would be 1279m^3/s as opposed to the rate of 1574m^3/s calculated by Dr Christensen. Those figures would support the adoption of a release rate that is at or higher than that modelled as released in SIM C in that period when W3 was engaged (around 1350 to 1400m^3/s) but less than that modelled in SIM E (around 1800m^3/s).

6 January 2011 Release Rates

235 Dr Christensen's estimate of the inflow volume into Wivenhoe Dam based on the four-day PME available at midnight on 6 January 2011 was 460,000ML. This yielded a no release rise of 3.9m (to EL 70.45m AHD from EL 66.55m AHD). Dr Christensen selected a target level of 3.5m below FSL at each of Wivenhoe Dam and Somerset Dam, which required the release of an additional 281,948ML at Wivenhoe Dam and an additional 114,521ML at Somerset Dam. The rate required to release those volumes in one day was 4588m^3/s and in two days it was 2294m^3/s.[548] Dr Christensen determined that a release of around 2400m^3/s would be modelled which would close the remaining bridges.[549] Dr Christensen modelled increasing releases to around 2400m^3/s by 7.00am. As at midnight on 7 January 2011, the modelled level of

[545] Bearing in mind that at this point Wivenhoe Dam is above FSL.
[546] Manual at 53 and 59.
[547] (276256) / (3.6 x 48) + 1598m^3/s; (276256) / (3.6 x 60) = 1279m^3/s.
[548] Response Report Vol 2, EXP.ROD.015.0261 at .0381: 281,948 + 114521 = 396469.
[549] Ibid at .0382.

Wivenhoe Dam in SIM E was EL 65.34m AHD and the modelled releases were 2396m^3/s.[550]

236 In SIM C, releases continued from Wivenhoe Dam on 6 January 2011 at a rate of around 1372m^3/s until the time of the morning QPF when they were increased to around 2000m^3/s and then increased again to a rate similar to SIM E later that day. From 6.00am onwards, the modelled height of SIM E on 6 January 2011 was lower than the modelled height of SIM C at the corresponding time. By midnight on 7 January 2011, the modelled height of SIM C was EL 65.69m AHD, which was 35cm higher than the modelled height in SIM E (or 33,553ML).[551] The average release rate modelled in SIM C on 6 January 2011 was 1712m^3/s whereas in SIM E it was 2245m^3/s.

237 As at midnight on 6 January 2011, the revised four-day PME inflow estimate for Wivenhoe Dam using Mr Giles' assessment of the Late December Flood Event is 414,500ML, which was still higher than the volumetric difference between the target level and FSL, namely 330,000ML (being 3.5m below FSL at Wivenhoe Dam). Again, as noted, that estimate still uses Dr Christensen's selected rainfall depths from the PMEs. On the basis that Dr Christensen always adopts a target volume below FSL that is less than the estimated four-day PME inflow by a reasonable margin, it is conceivable that an inflow estimate within reasonable range of such estimates could lead to the adoption of a target of say 3.0m below FSL at Wivenhoe Dam (and say 3.0m below FSL at Somerset Dam), especially having regard to the conservatism that Dr Christensen states should be adopted once the water level is more than 3.0m below FSL.[552] That would reduce the target volume by 42,000ML at Wivenhoe Dam and 15,700ML at Somerset Dam,[553] yielding a revised amount to be released of 338,769ML.[554] A release rate calculated over two days of releasing that amount yields a rate of 1960m^3/s.[555] Given that rate and consistent with the analysis in relation to SIM C above, I cannot exclude the

[550] Simulation Analysis, EXP.ROD.015.0461 at .0786.
[551] Ibid at .0628 and .0786.
[552] T 1223.36 (Christensen).
[553] Manual at 53 and 59.
[554] 396,469ML – 42000ML – 15700ML: Response Report Vol 2, EXP.ROD.015.0261 at .0381.
[555] 338,769/(3.6 x 48).

possibility that a reasonably competent flood engineer modelling in that manner might decide to release at rates that were able to keep Mt Crosby Weir Bridge and Fernvale Bridge open for another day.

7 January 2011 Release Rates

238 Dr Christensen's estimate of the inflow volume into Wivenhoe Dam based on the four-day PME available at midnight on 7 January 2011 was 608,000ML. This yielded a "no release" rise of 5.3m (to EL 70.64m AHD from EL 65.34m AHD). Dr Christensen selected a target level of 4.5m below FSL at Wivenhoe Dam (but with Somerset Dam remaining stable at EL 97.79m AHD).[556] This required the release of an additional 241,392ML at Wivenhoe Dam. The rate required to release those volumes in one day was 2794m^3/s and in two days it was 1397m^3/s.[557] Dr Christensen stated that he determined a target level of 4.5m below FSL due to the deteriorating forecasts. He calculated that he could not have released all of that given the rate of inflows and the limits on discharge from certain water levels specified in the Manual.[558] Thus, Dr Christensen modelled making releases between 2400m^3/s and 2700m^3/s for the balance of the day. As at midnight on 8 January 2011, the modelled level of Wivenhoe Dam in SIM E was EL 64.58m AHD and the modelled releases were 2458m^3/s.[559]

239 As noted, Wivenhoe Dam in SIM C commenced 7 January 2011 35cm higher than SIM E. Dr Christensen did not select a target to release to in SIM C for that day but instead simply sought to maintain flows at Moggill below 4000m^3/s with all bridges inundated from the previous day. The modelled release rates from Wivenhoe Dam in SIM C were less than those in SIM E. The average release rate in SIM C on 7 January 2011 was 2483m^3/s, whereas in SIM E it was 2571m^3/s.

240 As at midnight on 7 January 2011, the revised four-day inflow estimate for Wivenhoe Dam using Mr Giles' assessment of the Late December Flood

556 Response Report, EXP.ROD.015.0261 at .0382.
557 Id.
558 Response Report, EXP.ROD.015.0261 at .0382 to .0383.
559 Simulation Analysis, EXP.ROD.015.0461 at .0786.

Event is 547,000ML, which is still much higher than the target volume below FSL, namely 409,000ML (being 4.5m below FSL). Again, given that this estimate still uses Dr Christensen's interpretation of the PMEs and on the basis that Dr Christensen always adopts a target volume below FSL that is less than the four-day PME inflow estimate by a reasonable margin, it is conceivable that an inflow estimate within reasonable range of such estimates could lead to the adoption of a target below FSL of say 4.0m below FSL at Wivenhoe (especially if it used the flood engineers' estimate of rain on the ground inflows).[560] That would reduce the target volume to be released at Wivenhoe Dam by 39,000ML,[561] yielding a revised amount to be released of 202,392ML.[562] A release rate for that amount calculated over a day yields a rate of 2354m^3/s.[563] This is materially less than that which was modelled, although not sufficient to warrant reopening bridges (especially given the eight-day PME forecast and the forecasts for surrounding areas).

8 to 11 January 2011

241 Unlike SIM C, strategies in SIM E were not determined by inflow estimates based on QPF forecasts. Accordingly, SIM E remained in Strategy W3 throughout 8 and 9 January 2011. Releases were not governed by a target volume or height but instead by the approach of keeping the dam as low as possible whilst obeying the relevant constraints, including maintaining combined downstream flows below 4000m^3/s.[564] However, as the modelled level of Wivenhoe Dam was between EL 64.58m AHD and EL 63.74m AHD, the maximum discharge limits on releases from certain water levels specified in the Manual curtailed releases such that the releases modelled in SIM E on the weekend of 8 and 9 January 2011 were similar to SIM C, which was in turn constrained by strategy limits from the afternoon of 8 January 2011.[565] In the end result, the average release rate on 8 January 2011 in SIM E was 2267m^3/s compared to 2251m^3/s in SIM C (and 2746m^3/s in SIM F, for the

[560] See Chapter 9 at [284].
[561] Manual at 53.
[562] 241392 – 39000.
[563] 203392/(3.6 x 24).
[564] Response Report Vol 2, EXP.ROD.015.0261 at .0373 and .0383.
[565] Manual at 53.

period from midday on 8 January to midnight on 9 January 2011).[566] On 9 January 2011, the average modelled release rate in SIM E was 1837m^3/s, in SIM C it was 1861m^3/s and in SIM F it was 2635m^3/s.

242 On 10 January 2011, modelled releases in SIM E were governed by the necessity to keep combined downstream flows below 4000m^3/s[567] and were thus similar to the outflows in SIM C and in SIM F.

243 The modelled approach in SIM E on 11 and 12 January 2011 was similar to described in SIM C. As at midnight on 11 January 2011, SIM E was at a modelled level of EL 68.35m AHD compared to EL 69.03m AHD in SIM C. As at 1.00pm on 11 January 2011, the height differential was 65cm (EL 70.98m AHD v EL 70.33m AHD). Dr Christensen's analysis of SIM E from that point is the same as explained for SIM C in Chapter 9,[568] save that, due the differences in height, he determined that each gate only had to be raised at a minimum of 0.5m for the afternoon of 11 January 2011, compared to a minimum of 1.0m for SIM C.[569] It is that difference, and the (much smaller) effect of the difference in water levels on outflow rates, that results in the difference in outflows that were modelled in the two simulations during 11 and 12 January 2011.

Conclusion

244 Seqwater and SunWater's various criticisms of SIM E reflected various submissions that have already been addressed in relation to SIM F, SIM C and SIM A.[570] They include the criticism made in relation to SIM A of unduly aggressive releases early in the simulation, the release of water well below FSL and the use of a target method.[571]

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566 All averages calculated from Simulation Analysis, EXP.ROD.015.0461.
567 Response Report Vol 2, EXP.ROD.015.0261 at .0384.
568 Chapter 9 at [302] to [304].
569 Gates open to 16 increments in SIM E (Simulation Analysis, EXP.ROD.015.0461 at .0805) v gates open to 18 increments in SIM E (Simulation Analysis, EXP.ROD.015.0461 at .0653).
570 SunWater subs at [1367] to [1416]; Seqwater subs at [2446] to [2457].
571 SunWater subs at [1367(a), (d) and (e)]; Seqwater subs at [2448] to [2456].

245 It suffices to state that the above analysis reveals that, for the period of 5 to 7 January 2011, Dr Christensen's target approach was sufficiently sensitive to variations in the estimation of four-day inflow volumes that I cannot be satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing at midnight on 5 January 2011 would, or must, have made releases substantially in accordance with that simulation during that time. That being said, the analysis also supports the conclusion that for the period of 5 to 9 January 2011, any consideration of four-day PME forecasts in determining releases would support releases being made at rates equal to, or greater than, those which were substantially in accordance with the releases modelled in SIM C.

10.6: Simulation G: 10 January 2011 Start

246 SIM G is described in Chapter 8.[572] It commences at midnight on 10 January 2011 when Wivenhoe Dam was at EL 69.80m AHD and releasing 1462m^3/s. Somerset Dam was at EL 102.38m AHD and releasing 1359m^3/s through five open sluice gates. At that time, the rate of inflows into Wivenhoe Dam was 7936m^3/s[573] and into Somerset Dam was 3283m^3/s. Dr Christensen modelled an immediate increase in releases from Wivenhoe Dam from midnight on 10 January 2011, reaching just over 3100m^3/s by 7.00am. He also modelled immediately closing all five sluice gates at Somerset Dam, reducing outflow to 290m^3/s. This would have increased over the balance of the day to 950m^3/s as uncontrolled spillage occurred above EL 100.45m AHD.[574]

247 The modelled Somerset Dam operations in SIM G are discussed in Chapter 9.[575] SIM G does not involve any releases being made from below FSL in either dam. As it starts on 10 January 2011, and given the rate of inflows into both dams on 9 January 2011, there is no suggestion that its modelled rate of outflows exceeds the past rate of inflows. As explained below, although SIM G utilised four and eight-day PME forecasts in selecting strategies and

[572] Chapter 8 at [166] to [167].
[573] Simulation Analysis, EXP.ROD.015.0461 at .0894, .0899.
[574] Ibid at .0899.
[575] Chapter 9 at [356] to [357].

release rates, the same operations would result if it was restricted to using QPFs for that purpose. Given its starting date and height, SIM G does not use Dr Christensen's target approach described above in relation to SIM A.

Circumstances at Midnight on 10 January 2011

248 The circumstances prevailing as at midnight on 10 January 2011 are addressed in section 7.4 of Chapter 7. At the risk of repetition, two particular matters should be noted.

249 The first is the effect of the 9 Jan 22:00 Forecast run.[576] This run modelled increasing gate openings to 46 increments by 10.00am on 10 January 2011 and releasing 2670m^3/s, with that release rising, through increases in water pressure but not increases in gate openings, to over 2900m^3/s the following day. The forecast maximum height of Wivenhoe Dam in that run was EL 75.11m AHD at 11.00pm on 11 January 2011. The forecast peak flow at Moggill was 5652m^3/s at 5.00pm on 10 January 2011. The 9 Jan 22:00 Forecast run did not contemplate opening the gates at Wivenhoe Dam above EL 74.0m AHD while the dam was rising. Consistent with the analysis in this forecast run, at around 12.55am on 10 January 2011 Mr Ruffini advised Mr Drury that, if combined downstream flows were kept to below 3500m^3/s, then a fuse plug would trigger.[577] As the following makes clear, the reasoning and approach behind this forecast run and Mr Ruffini's advice to Mr Drury are very much consistent with Dr Christensen's analysis of the circumstances at the commencement of SIM G, namely a recognition of a need to increase in outflows to around 3000m^3/s and an acceptance that flooding of urban areas downstream would occur, with the objective being to protect the dam and minimise urban flooding.

250 Two Appendix A "with forecast" runs reinforce this analysis. The 10 January 2011 01:00 Appendix A "with forecast" run modelled maximum releases of 2700 to 2800m^3/s from early on 11 January 2011 through to 12 January 2011, a peak height of EL 74.73m AHD and peak combined downstream flow at

[576] QLD.001.001.2825; Chapter 7 at [235].
[577] Chapter 7 at [271].

Moggill of 4477m^3/s.[578] The 10 January 2011 09:00 Appendix A "with forecast" run modelled releases of 2700m^3/s to 2800m^3/s from the evening of 10 January 2011 to 12 January 2011, a peak height of EL 74.53m AHD and a peak combined downstream flow at Moggill of 4675m^3/s.[579]

251 The second matter to note is the various estimates of natural downstream flows for 10 and 11 January 2011 based on the rain on the ground and "with forecast" runs.

252 The 9 Jan 19:00 ROG run predicted that the naturally occurring peak flow rate at Moggill was 843m^3/s and that it had already occurred, namely at 1.00pm on 7 January 2011.[580] The 9 Jan 19:00 Forecast run estimated a peak flow without releases at Moggill of 1940m^3/s at 5.00pm on 10 January 2011.[581] It was this estimate that prompted a reduction in releases in all of Dr Christensen's simulations (bar SIM G, which had not commenced at that time).[582]

253 The 9 Jan 22:00 ROG run predicted a naturally occurring peak flow at Moggill of 830m^3/s on 10 January 2011 at 6.00am.[583] The 9 Jan 22:00 Forecast run predicted a naturally occurring peak at Moggill of 2883m^3/s at 3.00pm on 10 January 2011.

254 The 10 Jan 01:00 ROG run predicted a naturally occurring peak flow at Moggill of 834m^3/s at 6.00am on 10 January 2011.[584] The 10 January 2011 1.00am Appendix A "with forecast" run predicted a naturally occurring peak flow of 2002m^3/s at 11.00pm on 10 January 2011.[585] The 10 January 2011 9.00am Appendix A "with forecast" run predicted a naturally occurring peak flow of 2092m^3/s at 7.00am on 11 January 2011.[586] Both of those Appendix A

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578 QLD.001.001.2851; SUN.002.002.2648.
579 SUN.002.002.2662.
580 QLD.001.001.2798; LAY.SUN.001.0001 at .0772.
581 Chapter 7 at [214]; QLD.001.001.2797; January FER at .0527.
582 See above at [21] and [140].
583 Chapter 7 at [233]; QLD.001.001.2826.
584 QLD.002.001.8886; LAY.SUN.001.0001 at .0772.
585 SUN.002.002.2648.
586 SUN.002.002.2662.

"with forecast" runs predicted naturally occurring flows at around those rates for a number of hours which both preceded and succeeded the peak time.

Releases in SIM G

255 The distinctive feature of SIM G is the contrast between the level of releases in that simulation on 10 January 2011 compared to all of Dr Christensen's other simulations on the same day. All of Dr Christensen's other simulations modelled releases just below 2000m^3/s on 10 January 2011 in an effort to avoid exceeding the flow threshold of 4000m^3/s at Moggill based on an assessment of downstream flows using a 24-hour QPF forecast. The reason for the difference between SIM G and the other simulations concerns the smaller flood storage space available as at midnight on 10 January 2011 in the events that happened (and SIM G) compared to that available in the other simulations.[587] All of the other simulations would have had at least an extra 208,000ML in extra storage available as at midnight on 10 January 2011.[588]

256 In his day-by-day release rates explanation, Dr Christensen described the primary objective of flood operations in SIM G at this time as protecting the safety of the dam, as required in a W4B strategy, whilst "doing what is possible to prevent or minimize flows in excess of 4,000m^3/s at Moggill".[589] Given the level of the dams and the four-day PME forecast which predicted rain falling in the next three days, he calculated a total of 2,223,181ML would need to be released from the dam over a period of five days ("3 days of forecast rain and 2 days of runoff inflow"), which corresponded to a release rate of approximately 5,146m^3/s over five days or 2,573m^3/s over ten days.[590] Based on these figures, Dr Christensen determined that releases and downstream flows could not be held below the threshold for urban damage of 4000m^3/s. Instead, he adopted a target for combined flows of 5300m^3/s. He

[587] See T 1853.8.
[588] SIM B's modelled water level was the highest of the other simulations and it would have been at EL 68.06m AHD at midnight on 10 January 2011 (Simulation Analysis, EXP.ROD.015.0461 at .0551) or EL 67.97m AHD accounting for the inflow error: SBM.020.021.0001 at .0004: 1,491,685ML – 1,283,061ML = 208,674ML.
[589] Response Report Vol 2, EXP.ROD.015.0261 at .0411.
[590] Id.

explained the rationale for this rate even if only one-day estimated inflows were considered as follows:

> "It is not possible to keep Moggill from rising above 4,000 m³/s due to dam safety concerns, gate overtopping and a potential fuse plug breach. *That fact can be shown using only the 1-day forecast, without considering the 4-day and 8-day forecasts*. At 1:00, Moggill was forecast to peak at 2,000 m³/s, leaving only 2,000 m³/s that could be spilled from Wivenhoe [to keep downstream flows below 4000 m^3/s]. *The no rain inflow to Wivenhoe and Somerset Dams is 800,000 (615,000 ML + 185,000 ML). The 1-day forecast inflow = 356,000 ML*
>
> Total = 1,156,000 ML
>
> At the current water level of 69.80 m [at midnight on 10 January 2011], the storage up to 74.0 dam protection level is 584,000 ML. That storage is insufficient to hold the 1,156,000 ML inflow in Wivenhoe Dam below 74.0 m and the average spill will be 1,156,000 – 584,000 ML = 572,000 ML. The majority of that volume is expected to enter the dam within 2-days based on hydrographs and the fact [that] the Somerset crest gates are constrained to remain open.
>
> The average 2-day spill is thus calculated to be 572,000 ML/[3.6 x 48] = 3310 m³/s[591]. Thus, *regardless of the flow at Moggill*, based on the forecasts, it is likely that the peak flow with Wivenhoe releases will exceed 5,300 m³/s (2,000 + 3,310).
>
> Further, given the 8-day forecast no release rise of 8.4 m, a W4 strategy dam protection spill is thus imminent. Even the flood engineers 1:00 case runs and gate operations showed the 1-day forecast causing a rise to nearly 75.0 m with releases (Run 23).
>
> The Moggill urban flood mitigation target therefore must not be used, but must be replaced with attempting to minimise the contribution to the peak flow at Moggill from the dam safety spills.
>
> That conclusion is buttressed by the fact that the 2,230,000 ML (1,768,000 + 462,000 ML) 8-day high range inflow exceeds the current 793,000 ML storage capacity below the 75.5 fuse plug breach prevention level (by over 1.4 million ML; and the 4-day average of 1,730,000 ML (1,288,000 + 442,000 ML) exceeds that capacity by nearly 1 million ML. A potential fuse plug breach is forecast if releases are not increased.
>
> A reasonable target to minimise the flow at Moggill while protecting Wivenhoe Dam would be the 5,300 m³/s. Releases are thus increased accordingly to just over 3,200 m³/s." (emphasis added)

257 The no rain inflows for midnight in the above extract are based on Dr Christensen's own calculations undertaken as at midnight on 10 January

[591] If there was an extra volume of 208,000ML available (the difference between SIM G and SIM B at midnight on 10 January 2011) that rate would be = 364,000/3.6 x 48 = 2106m^3/s.

2011.[592] The 356,000ML one-day forecast inflow figure is based on the difference in inflows for Wivenhoe Dam between the no rain and 24-hour case runs in the January FER referable to 1.00am on 10 January 2011.[593] It is unclear why Dr Christensen referred to “regardless of the flow of Moggill” in the above passage, as his calculation of 5300m^3/s includes an estimate of the natural flows at Moggill, namely 2000m^3/s. Leaving that aside, the effect of the above calculations is that, just based on the flood engineers’ assessment of inflows from one day of forecast rain alone, then unless around 3300m^3/s was released over two days, the combination of rain on the ground inflows and the rain that was forecast to fall by the one-day forecast would require releases from above EL 74.0m AHD from Wivenhoe Dam (most likely on the following day), and still risk a fuse plug breach. The one-day PMEs available from 6.00pm on 9 January 2011 and 6.00am on 10 January 2011 predicted substantial rain above the dams for 11 January 2011 (although less than that which fell).[594]

258 In relation to 11 January 2011, Dr Christensen modelled commencing releases on that day in SIM G in line with that “as determined for January 10 [by] targeting a maximum flow of 5,400 m^3/s at Moggill”.[595] He noted that at 8:00 am the forecast for the naturally occurring peak flow at Moggill increased to 3,000m^3/s. Dr Christensen then modelled closing gates “at the maximum rate specified in the manual” to lower releases to around 2653m^3/s at around 1.00pm.[596] The next part of his day-by-day release explanation states as follows:[597]

> “But, then at 13:00, the Moggill 1-day forecast run indicated a Moggill peak flow of 5,770 m^3/s confirming that it was impossible to keep Moggill from rising above 4,000 m^3/s. Given the W4B Strategy, the engineer’s main priority is the protection of the dam. With the rising lake levels and increasing inflows, it is necessary to continue releases from the dams. The releases are fully determined by minimum gate opening settings at Wivenhoe Dam.”

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592 MSC.010.095.0001.
593 January FER at .0526 and .0527: 1,376,000ML – 1,020,000ML.
594 SEQ.013.005.0501 and SEQ.013.005.0512.
595 Response Report Vol 2, EXP.ROD.015.0261 at .0412.
596 Simulation Analysis, EXP.ROD.015.0461 at .0905.
597 Response Report Vol 2, EXP.ROD.015.0261 at .0413.

259 Dr Christensen then calculated the minimum gate openings using the approach explained in Chapter 9[598] which, in the case of SIM G, yielded a minimum release rate of at least 2700m^3/s, which was then increased to around 2800m^3/s.[599] By around 6.00pm, SIM G exceeded EL 74.0m AHD[600] and rose to a peak of EL 75.10m AHD at 10.00am on 12 January 2011.[601] Mr Ickert produced a variation of the operations in SIM G above EL 74.0m AHD.[602]

Seqwater's Submissions

260 Seqwater was critical of the rate of releases modelled in SIM G on 10 January 2011. It contended that Dr Christensen's approach on 10 January 2011 in SIM G "contradicts his proposed management of dam safety risks on 11 January and was based on reasoning not replicated by him on 11 January 2011 in Simulation G, nor in any other simulation, nor in Dr Christensen's statement of his methodology".[603] As noted, Dr Christensen explained that the relevant difference between SIM G and the other simulations at midnight on 10 January 2011 was the (sizeable) difference in water levels as at midnight on 10 January 2011.[604] The highest level as at midnight on 10 January 2011 in his other simulations was EL 68.06 AHD in SIM B. In his day-by-day release explanation for SIM B and SIM D, Dr Christensen performed the same calculation for the four-day inflow estimate as noted above for SIM G, but due to the extra storage he concluded the combined flows were able to be held below 4000m^3/s.[605]

261 By reference to Mr Fagot's evidence, Seqwater contended that SIM G "unreasonably increases releases to damaging levels in circumstances where a significant amount of flood storage remains available and a significant amount of rainfall was actually occurring downstream (and which was

598 Chapter 9 at [302ff].
599 Simulation Analysis, EXP.ROD.015.0461 at .0894 to .0895.
600 Ibid at .0895.
601 Id.
602 EXP.SUN.009.0001 at .0314, Table 19.
603 Seqwater subs at [2466].
604 T 1853.8.
605 Response Report, EXP.ROD.015.0261 at .0324, .0365 to .0366.

predicted to continue)".[606] Mr Fagot's evidence has already been addressed. Given the rain on the ground estimates, a "significant amount of flood storage" did not remain available. Otherwise, Seqwater's contention does not grapple with the implications of the flood engineers' forecast modelling undertaken at 10.00pm on 9 January 2011 to the effect that the flood engineers were confronted with a choice between significantly increasing releases or risking a fuse plug breach.

262 By reference to what is described as Mr Pokarier's "unchallenged" evidence, Seqwater submitted that Dr Christensen's flood operations on 10 January 2011, which used a combination of his own rain on the ground inflow estimate and the flood engineers' 24-hour inflow estimate, was a methodology only adopted in SIM G. It was submitted that this was inconsistent with Dr Christensen's evidence that the 24-hour forecast does not provide sufficient foresight of the magnitude of the event.[607] The reference to Mr Pokarier's evidence being "unchallenged" does not assist in circumstances where he is simply one expert commenting on another and none of these criticisms were taken up with Dr Christensen.[608] Presumably, Dr Christensen used the flood engineers' modelling of 24-hour inflows because his modelling of the 9 January 2011 afternoon QPF was out of date by then.

263 In any event, it is not correct that Dr Christensen's approach in SIM G was inconsistent with his evidence that the QPF does not provide sufficient foresight of the magnitude of the event. As explained above, Dr Christensen's explanation of the day-by-day release rates addressed the estimated inflows from the four day PME forecast and concluded that "[i]t was not possible to keep Moggill from rising above 4,000 m^3/s due to dam safety concerns, gate overtopping and a potential fuse plug breach". Dr Christensen then illustrated the same point by using the one-day QPF forecast.[609] Using the four-day PME forecast, Dr Christensen determined that a release rate of between

[606] Seqwater subs at [2464].
[607] Ibid at [2465(a)(ii)].
[608] Dr Christensen was cross-examined on his releases in SIM G at T 1846.33 to 1853.16. It was only suggested that his releases on 10 January 2011 were inconsistent with his approach on 11 January 2001 (T 1852.31) and inconsistent with his approach in SIM C (T 1847.41; and T 1852.41).
[609] Response Report Vol 2, EXP.ROD.015.0261 at .0411.

2573m^3/s and 5146m^3/s was required depending on whether the volume above EL 74.0m AHD was released over a five-day period or a ten-day period. Using the one-day forecast, Dr Christensen determined that a release rate of 3300m^3/s was required as “[a] reasonable target to minimise the flow at Moggill while protecting Wivenhoe Dam”. That rate is consistent with his analysis of the four-day PME, although the four-day PME could potentially support the adoption of a lower rate.

264 Seqwater also contended that, as Dr Christensen was using the volume required to fill Wivenhoe Dam from the current level to EL 74m AHD as a “key input” into his calculations then, “[i]f the calculation was to demonstrate that the ‘expected’ water level would not exceed EL74, W4 could not be adopted and the target flow at Moggill would need to be less than 4,000m^3/s” and “[i]f the calculation was intended to suggest that Wivenhoe Dam would only be filled to EL74, then this is inconsistent with the approach taken in other simulations”.[610] The first point overlooks the fact that Dr Christensen used a “no release” assumption, an approach I accept as a correct. In relation to the second point, there is nothing in Dr Christensen’s reports to suggest that in SIM G Wivenhoe Dam could only be filled to EL 74.0m AHD. Instead, in that simulation and all of the other simulations, Dr Christensen identifies EL 74.0m AHD as a dam level to be avoided if possible.

265 To similar effect, Seqwater noted that the release rate of 3,300m^3/s was not maintained when the forecast peak flow at Moggill increased at 8.00am on 11 January 2011. It contended that this was “inconsistent with the reasoning used to calculate the release rate (which was to determine the rate of release required to avoid reaching EL74 at Wivenhoe Dam)”.[611] However, this mischaracterises Dr Christensen’s approach which was to make releases by reference to “a reasonable target to minimise the flow at Moggill while protecting Wivenhoe Dam”, namely 5300m^3/s (or 5400m^3/s). To a point, it is consistent with that target to (marginally) reduce outflows when a higher flow rate at Moggill was predicted. Ultimately, as explained below, when a naturally

[610] Seqwater subs at [2465(b)].
[611] Id.

occurring flow rate at Moggill is predicted that well exceeded that target (ie, at 1.00pm on 11 January 2011) a revised approach was required and was thus modelled.

266 The balance of Seqwater's submissions in relation to SIM G address the releases made on 11 January 2011. It noted Dr Christensen's evidence that one difference between the circumstances prevailing on 10 January 2011 and 11 January 2011 was that the forecasts on 10 January 2011 were predicting a further two days of rainfall, whereas the forecasts on 11 January 2011 indicated that there would be little or no rain on 12 and 13 January.[612] Seqwater also referred to Dr Christensen's explanation for the modelled position on receipt of the estimate of natural flows at Moggill of 5770m^3/s at 1.00pm on 11 January 2011. In that part of his evidence, it was suggested to Dr Christensen that he acted inconsistently across all his simulations by releasing based on forecasts up to 11 January 2011 and then holding releases despite the forecasts on 11 January 2011,[613] a proposition addressed in section 9.7 of Chapter 9. Dr Christensen denied that his approach was inconsistent. He stated that he followed the Manual and preserved storage by:

> "…making pre-releases when you know you can without doing any damage. Or not 'any damage', but according to the criteria of the manual. You know you can make releases within what the manual tells you is non-damaging flows. *So your criteria is: Don't damage anyone. Don't damage anyone. Don't exceed 4,000[m^3/s]*.
>
> Now, at 1300, I have a position where I can't pre-release any more. I can't do it. So what do I do? Well, at 1300 I've got people downstream flooding, and I'm supposed to keep pre-releasing when I've got people downstream flooding? No. A reasonably competent flood operations engineer would not do that. What he would do is he would say, 'Moggill is above 4,000. I cannot make any pre-releases any more. I have a condition where I must minimise the damage downstream.' So we've flipped into a different part of the manual. That's the key, is the manual tells you to keep it below 4,000 and then, now, you can't do that, it's impossible…"[614] (emphasis added)

[612] T 1849.45 to T 1850.22; Seqwater subs at [2473(a)].
[613] T 1700.38.
[614] T 1700.47 to T 1701.21.

267 Seqwater contended that these explanations were unreasonable because they ignored the material increase in the QPFs between 10 and 11 January 2011 and the greater risk to the safety of the dams on 11 January 2011 when Dr Christensen reduced releases "without providing any release plan to demonstrate he could safely manage the inflow volume".[615] These points are addressed in section 9.7 of Chapter 9. Dr Christensen addressed the risk to dam safety by determining the height that was necessary to pull the Wivenhoe crest gates out of the water to allow for rapid raising of gates if necessary.

268 Seqwater also submitted that Dr Christensen's approach was "inconsistent with his reasoning justifying the releases on 10 January" in SIM G. It contended that "[I]n effect, Dr Christensen claims (on 11 January) that the Manual required the engineer to keep Moggill below 4,000m^3/s and the stated criteria was 'don't damage anyone'" but adopted "operations on 10 January which are deliberately intended to exceed the Manual's required target of 4,000m^3/s, infringing his own 'stated criteria' by taking steps to proactively cause damage downstream of Wivenhoe Dam".[616]

269 The answer set out in [266] was not given in the context of any questioning of Dr Christensen about SIM G releases, much less Dr Christensen being asked to explain an alleged inconsistency between the approach modelled in SIM G on 10 January and on 11 January 2011. Dr Christensen was later asked about that alleged inconsistency.[617] Before he answered, it was noted that on 10 January 2011 the predicted peak flow downstream was around 2000m^3/s[618] but at 1.00pm on 11 January 2011 it had climbed to 5770m^3/s.[619] Dr Christensen explained that the releases on 10 January 2011 in SIM G were required because there was a forecast of two days of rain whereas on 11 January 2011 there was only a forecast of one.[620]

[615] Seqwater subs at [2474(a) and (b)].
[616] Ibid at [2474(c)].
[617] T 1847.41 to T 1848.14.
[618] T 1848.16.
[619] T 1849.26.
[620] T 1851.19.

270 In all of his other simulations, Dr Christensen maintained outflows below 2000m^3/s on 10 January 2011 in an endeavour to keep combined downstream flows below 4000m^3/s because those simulations had storage space available to take that step. Hence, as stated in the above extract from his oral evidence (at [266]), in those simulations he sought not to exceed 4000m^3/s. However, in SIM G Dr Christensen determined that, as at midnight on 10 January 2011, achieving that objective was no longer possible without causing a fuse plug breach. Mr Ruffini reached the same conclusion early in the morning of 10 January 2011 and it is overwhelmingly supported by the Appendix A "with forecast" modelling. Instead, based on the predicted downstream natural peak of 2000m^3/s, Dr Christensen determined a revised target to limit combined downstream flows to, namely 5300m^3/s. He then modelled flood releases with that figure as the limit. However, after the 11 January 2011 1.00pm forecast of a natural peak of 5770m^3/s at Moggill, that approach could no longer be sustained. Instead, Dr Christensen adopted a revised approach of minimising downstream flows while not endangering the safety of the dam. Thus, there was no "inconsistency" between the approach to releases on 10 and 11 January 2011 in SIM G. Instead, Dr Christensen simply modified the approach to releases as the circumstances changed.

SunWater's Submissions

271 SunWater was critical of so much of the modelled flood operations in SIM G that involved suspending gate openings on 11 January 2011 while the simulated level of Wivenhoe Dam was above EL 74.0m AHD and rising.[621] Dr Christensen modelled keeping the Wivenhoe Dam gates open by 44 increments from 1.00pm to 5.00pm on 11 January 2011 and by 45 increments thereafter until 7.00pm on 12 January 2011.[622] Mr Ickert's variation on those operations involved opening gates at a rate of four increments per hour from 6.00pm on 11 January 2011 to 4.00am on 12 January 2011, when the water level of Wivenhoe Dam would have

[621] SunWater subs at [1553] to [1562].
[622] Simulation Analysis, EXP.ROD.015.0461 at .0905 to .0906.

stabilised at EL 74.73m AHD. Over that period of time the inflows into Wivenhoe Dam fell, and via reverse routing would have been observed to fall, from 7563m^3/s to 4533m^3/s.[623] It follows from the finding in Chapter 9[624] that I am not satisfied that a reasonably competent flood engineer would or must have suspended gate openings during the period that Dr Christensen modelled doing so in SIM G on 11 and 12 January 2011. Instead Mr Ickert's variations on Dr Christensen's flood operations, albeit very conservative, represents an approach that a reasonably competent flood engineer could have adopted in the sense of being the most favourable to the defendants.

272 SunWater also submitted that SIM G should be rejected because it involved a significant increase in releases on 10 January 2011 despite severe downstream weather warnings.[625] It referred to the various flood warnings issued throughout 9 January 2011 and 10 January 2011 concerning the "rainband moving south," as noted in Chapter 7,[626] as well as Mr Ayre's evidence on that topic.[627] In his affidavit, Mr Ayre stated that sometime around 6.00am on 10 January 2011 he concluded he "did not want to greatly increase the rate of releases considering that downstream Brisbane may well have significant flows from rainfall in the local catchments".[628] (In Chapter 7, I rejected Mr Ayre's evidence that he held off increasing releases *during 9 January 2011* on account of a concern about a rainband moving south.[629]) SunWater also referred to Mr Fagot's evidence on this topic.[630] However, that evidence was premised upon an approach that is inconsistent with the Manual.

273 Dr Christensen's approach accepts the legitimacy of using concerns about rainfall forecasts to ameliorate releases based on downstream flows. As noted, he adopts that approach in all of his simulations for 10 January 2011 other than SIM G. In SIM G, he recognises the concerns about downstream

[623] EXP.SUN.009.001 at .0314, Table 19.
[624] Chapter 9 at [329].
[625] SunWater subs at [1563] to [1592].
[626] Chapter 7 at [205] to [209]; SunWater subs at [1563].
[627] SunWater subs at [1565] to [1574].
[628] LAY.SUN.001.0001 at [2287].
[629] Chapter 7 at [209]; cf SunWater subs at [1574].
[630] SunWater subs at [1580] to [1583].

flows based on forecasts but also recognises what was demonstrated by the 9 Jan 22:00 Forecast run, namely that the dam levels and the forecasts were such that urban flooding could not be avoided while ensuring dam safety.

274 Nevertheless, SunWater's submissions address the real issue presented by the releases modelled in SIM G on 10 January 2011, namely the dilemma facing a flood engineer commencing flood operations as at midnight on 10 January 2011. SunWater noted that such an engineer would face a choice between "hold[ing] off increasing releases, in the face of a south-moving system and downstream flooding, in an effort to prevent flows at Moggill in excess of 4,000 m^3/s" or "increas[ing] releases, in a way which would definitely result in flows at Moggill in excess of 4,000 m^3/s, but which might … ultimately result in a lesser peak flow at Moggill".[631] It contended that this was a topic "about which reasonable minds might differ",[632] a matter addressed below.

Plaintiff's Submissions

275 The plaintiff's submissions described the circumstances facing a flood engineer at midnight on 10 January 2011 as "critical".[633] It sought to respond to the various suggestions that Dr Christensen's approach to releases on 10 January 2011 was inconsistent with his approach to releases on 11 January 2011 and inconsistent with the other simulations.[634] The substance of its submissions on this topic has been considered in the above analysis.

Consideration

276 The state of the downstream forecasts prevailing during the evening of 9 January 2011 and the morning of 10 January 2011 are described above. In summary, from late in the evening of 9 January 2011 through to the morning of 10 January 2011, the rain on the ground modelling predicted natural peak

[631] SunWater subs at [1589] to [1590].
[632] Ibid at [1590].
[633] Plaintiff subs at [1969].
[634] Ibid at [1971] to [1979].

flows at Moggill of around 900m^3/s occurring during the morning of 10 January 2011 and the "with forecast" modelling predicted natural peak flows at Moggill of around 2000m^3/s to 2100m^3/s occurring sometime between late on the evening of 10 January 2011 and midday on 11 January 2011. There is no suggestion that the "with forecast" modelling of downstream flows was not sufficient to accommodate the concern over the rainband moving south on 10 January 2011.

277 The approach adopted by Dr Christensen in SIM G on 10 January 2011 is not dictated by the Manual and does not stem directly from the necessity to use forecasts or his general methodology, although it is consistent with all three. Instead, it is a matter of engineering judgment exercised in an excruciating context. The logic employed by Dr Christensen in support of his proposed releases in SIM G on 10 January 2011 is sound and consistent with his other simulations. As noted, if the same calculations and approach are applied to his other simulations as at that same time, then it is likely those simulations would have a real prospect of keeping the dam height below EL 74.0m AHD while making releases at around 2100m^3/s and thus avoiding exceeding the downstream threshold of 4000m^3/s (based on the estimate of forecast downstream flows of around 2000m^3/s).[635] Accordingly, I am satisfied that a flood engineer faced with the dire circumstances prevailing as at midnight on 10 January 2011 could reasonably have adopted the discharge rates modelled in SIM G for that day. Further, based on Dr Christensen's calculations, the 9 Jan 22:00 Forecast run and the other forecasts, I am satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing at midnight on 10 January 2011 was obliged to increase outflows beyond 2000m^3/s even though that carried with it a risk of the downstream flow at Moggill exceeding 4000m^3/s. If that step was not taken, then such an engineer would assume too large a risk, bordering on a practical certainty, that EL 74.0m AHD would be exceeded by a very large measure, which would require large uncontrolled outflows or potentially result in a fuse plug breach or even both.

[635] See footnote 591.

278 However, was such an engineer required to increase outflows to the level of around $3200m^3/s$ to $3300m^3/s$ as modelled in SIM G? A conclusion that a flood engineer, faced with a current dam level of EL 69.80m AHD, was *obliged* to increase releases to a level that had a high probability bordering on a certainty of causing downstream flows that inundate urban areas is a very difficult finding to make. I have no doubt that such a flood engineer had to raise releases, and do so well before midnight to inundate the bridges, and in doing so had to risk exceeding the threshold downstream. However, based on the rain on the ground estimates of naturally occurring flows downstream of $900m^3/s$, a decision to increase the flows to around $3300m^3/s$ carried with it an inevitability of the $4000m^3/s$ threshold being exceeded and urban areas becoming inundated. On the other hand, to increase to a level of around $2600m^3/s$, as envisaged by Messrs Ayre and Ruffini at some point on the morning of 10 January 2011, or even to the levels planned for in the 9 Jan 22:00 Forecast run, carried with it a prospect of potentially avoiding that outcome if not all of the forecast rain fell (although it would raise other and possibly larger risks for the following day).

279 A flood engineer commencing at midnight on 10 January 2011 was faced with an invidious choice. They could accept the forecasts in their entirety and raise releases to better address the relatively high likelihood of large inflows over at least the next two days or take the risk that the full amount of the forecast rain would not fall and try to avoid urban inundation that day, while hoping for an improvement in conditions on the next. Neither is satisfactory. While the former seems the better course, I am not satisfied that a reasonably competent flood engineer was obliged to take it. It follows that, while I am satisfied that such an engineer commencing work at midnight on 10 January 2011 had to increase releases, I am not satisfied they had to be increased to the levels modelled in SIM G on that day.

Conclusion

280 It follows that I am not satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing as at midnight on 10 January 2011

would have increased flood releases substantially in accordance with simulation G.

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CHAPTER 11: DUTY OF CARE, STANDARD OF CARE, VICARIOUS LIABILITY AND NUISANCE

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CHAPTER 11: DUTY OF CARE, STANDARD OF CARE, VICARIOUS LIABILITY AND NUISANCE

1 As noted in Chapter 1, every relevant aspect of these proceedings, other than the venue of the trial, took place in Queensland. It follows that all aspects of the substantive law of the proceedings are governed by the law of Queensland[1], save that there is no common law of Queensland, only a common law of Australia.[2] Thus, for the plaintiff's claims in negligence, nuisance and trespass, the applicable body of substantive law is the common law of Australia as modified by Queensland statute, especially the *Civil Liability Act 2003* (Qld) (CLA (Qld)).

2 This chapter addresses two aspects of the negligence claim, namely the existence of a duty of care and the standard of any such duty. It also addresses the plaintiff's contention that the defendants are vicariously liable for any breaches of duty by the flood engineers that they employed and the plaintiff's claims in nuisance and trespass. There a number of concepts that are common to these issues.

3 So far as negligence is concerned, the first issue to determine is the plaintiff's contention that Seqwater and SunWater owed to "Group Members" (or a class of people that included group members) a "duty to take reasonable care in the conduct of flood operations of both dams ... to avoid or minimise the risk of harm to property and the risk of interference with use and enjoyment of property".[3] The plaintiff made the same contention in respect of the flood engineers personally, although the duty was said to relate to the "operation" of both dams as opposed to the "conduct of flood operations".[4] Nothing turns on the difference.[5] Further, in respect of Seqwater and SunWater, the plaintiff pleaded and contended that they owed a non-delegable duty, that is a duty to

[1] *John Pfeiffer Pty Ltd v Rogerson* (2000) 203 CLR 503; [2000] HCA 36, [101] to [102]; "John Pfeiffer v Rogerson".
[2] *John Pfeiffer v Rogerson* at [15].
[3] 5ASOC at [144(a)] and [148(a)].
[4] Ibid at [150].
[5] Plaintiff subs at [68] and [98].

ensure that reasonable care was taken by persons engaged by or on behalf of them to conduct flood operations.[6]

4 For the reasons that follow, I accept that Seqwater and the flood engineers each owed such a duty but I do not accept that Seqwater's duty was non-delegable. I accept that SunWater owed such a duty but only in respect of the provision of "flood management services" pursuant to its agreement with Seqwater. I do not accept that SunWater's duty was non delegable. Otherwise, I accept that Seqwater, SunWater and the State are vicariously liable for any breaches of the duty of care owed by the flood engineers they each employed. The standard of care is that owed by the reasonably competent flood engineer. No issue under s 36 of the *CLA* (Qld) arises in respect of any vicarious liability the defendants incur in respect of any breaches of any duty owed by the flood engineers. Section 22 of the *CLA* (Qld) is potentially engaged in respect of the breaches alleged against the flood engineers but all the attempts to invoke it fail as a matter of fact. The plaintiff's case in nuisance and trespass fails.

11.1: Facts and Factors Affecting the Existence of a Duty of Care

5 None of the provisions of the *CLA* (Qld) are directed to the general circumstances in which one person or entity owes a duty of care to another. There is no all-embracing common law test for determining whether such a duty is owed. Instead, (at least) four propositions concerning the circumstances in which such a duty will be found to exist can be stated.

6 First, if the relationship between the parties falls within an existing category of case in which a duty of care has been recognised to exist then the inquiry is generally complete.[7]

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[6] 5ASOC at [144(b)] and [148(b)].
[7] *Caltex Refineries (Qld) v Stavar* (2009) 75 NSWLR 649; [2009] NSWCA 258 at [102] per Allsop P; "Stavar".

7 Second, the reasonable foreseeability of the relevant form of harm resulting from a failure to take reasonable care is a necessary but not sufficient condition to the finding of a duty.[8]

8 Third, in circumstances that do not involve a recognised duty of care, "the proper approach" to ascertaining the existence of a duty of care requires "a close analysis of the facts bearing on the relationship between the plaintiff and the putative tortfeasor by reference to the 'salient features' or factors affecting the appropriateness of importing a legal duty to take reasonable care to avoid harm or injury".[9] Some of those salient features were identified in *Stavar* at [103]. In addition to those listed in *Stavar*, they include the scope of any statutory duties imposed on a public authority.[10] The close analysis spoken of in *Stavar* does not involve simply addressing a checklist of factors which may be present or absent in a particular case in order to determine the existence of a duty of care. Instead it involves an evaluation by reference to the guidance provided by the High Court as to their significance in particular contexts, including any matter that is said to be inconsistent with the posited duty.

9 Fourth, where a question about the existence of a duty of care arises in a statutory context with a public or quasi-public authority then the analysis must begin with the statute.[11] This includes evaluating the various salient features by reference to the statutory scheme.[12]

10 Bearing in mind these propositions it is first necessary to address the various facts and factors that were deployed by the parties as bearing upon the existence of the alleged duties of care.

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8 *Tame v New South Wales; Annetts v Australian Stations Pty Ltd* (2011) 211 CLR 317; [2002] HCA 35 at [12]; "Tame".
9 *Stavar* at [102].
10 *Weber v Greater Hume Shire Council* [2019] NSWCA 74 at [17]; "Weber".
11 *Leichhardt Municipal Council v Montgomery* (2007) 230 CLR 22; [2007] HCA 6 at [137]; "Leichhardt Municipal Council".
12 See Leeming, *Statutory Foundations of Negligence* (The Federation Press, 2019) at 31.

Control over the Dams

11 It is necessary to identify the extent of the control exercisable, and that was exercised, by Seqwater and the flood engineers over dam operations as part of the inquiry into whether any legal obligations accompanied that control.

12 The statutory scheme governing the ownership and management of Wivenhoe and Somerset Dams is addressed in Chapter 2 and Chapter 5. In summary, the only statutory power or function pointed to by Seqwater as referable to it carrying out the task of flood mitigation was s 9(2) of the *Restructuring Act*, specifically the carrying out of "water activities" including "water supply", "flood prevention" and "flood control". However, Seqwater only had that function "to the extent that [it] was consistent with its operational and strategic plans" and no such plan was in force.[13] Thus, no statutory function was exercised.

13 Instead, Seqwater was vested with ownership of the dams[14] and was conferred with various permissions necessary to conduct flood mitigation and to ensure the supply of water. In particular, save as to the gate opening procedures which have the force of law as a condition of a development consent,[15] the legislative scheme did not impose a positive obligation on Seqwater as the dams' owner to comply with the Manual but instead provided it with a statutory protection from liability if it complied.[16] Further, as the owner of the dams, only Seqwater was authorised to hold a licence to interfere with the flow of water necessary to operate the dams (*Water Act*; s 107A). The form of licence that was granted, namely the ROL, permitted the release of water which was the subject of the Central Brisbane River and Stanley River water supply schemes, which governed water at and below FSL.[17] The ROL also excused Seqwater from any contravention of s 808 of the *Water Act* if it released water above FSL.[18] Further, Seqwater received a specific

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[13] Chapter 2 at [7] to [14].
[14] Chapter 2 at [10].
[15] Chapter 2 at [24] to [28].
[16] Chapter 2 at [34].
[17] Chapter 5 at [15] to [23].
[18] Chapter 5 at [22].

permission pursuant to clause 13 of the Moreton ROP to release water from below FSL for the purposes of flood mitigation.[19] Thus, Seqwater was not statutorily obliged to undertake flood mitigation at the dams in accordance with the Manual. However it held the exclusive legal authority to release water above and below FSL to do so. Otherwise, historically both Wivenhoe and Somerset Dams were built and operated to mitigate downstream flooding.[20] It was admitted on the pleadings that both Wivenhoe and Somerset Dams were designed for both water supply and flood mitigation.[21]

14 Accordingly, the source of Seqwater's "authority" to operate the dams was its status as the owner of both Dams and the exclusive licences that enabled it to interfere with the flow of water in the Brisbane River and make releases above and below FSL. Subject to what follows, it exercised that authority through its employed dam operators.

15 Although Seqwater was not obliged by statute to comply with the Manual (other than its gate opening sequences), Seqwater subjected itself to its terms. Accordingly, during flood events and flood operations, Seqwater ceded control of gate operations at the dams to the flood engineers in accordance with the Manual. It did so as the price for obtaining protection under s 374(2) of the *Safety and Reliability Act*. (In addition, the Manual had contractual force as between Seqwater and SunWater.)[22] Thus, section 2.1 of the Manual recorded that "Seqwater is responsible for operating and maintaining the dams in accordance with this Manual" to retain the protection from liability afforded by s 374(2).[23] The balance of the provisions of Section 2 of the Manual are described in Chapter 3. In summary, Seqwater was obliged to "ensure" that, inter alia, there was a DFOE, a SFOE and that the [r]elease of water at the dams during Flood Events is carried out under the direction of" the DFOE. These obligations reflect Seqwater's position as owner of the dams and the employer of the dam controllers. They are also the source of

[19] Chapter 5 at [73].
[20] Chapter 2, sections 2.4 and 2.5.
[21] 5ASOC at [13] and [43]; Seqwater defence: PLE.020.010.0001 at [13] and [43]; SunWater defence, PLE.030.008.0001 at [13] and [43]; State defence, PLE.040.007.0001 at [9] to [38].
[22] See [142] to [146].
[23] Manual at 5.

the de-facto authority that was conferred on, and in fact exercised by, the flood engineers to direct the release of water during flood operations (which was commenced by a decision of the DFOE to declare a flood event).

16 The plaintiff submitted that Seqwater had substantial control over the operation of Somerset Dam and Wivenhoe Dam for flood mitigation purposes.[24] It submitted that the evidence of various Seqwater senior personnel disclaiming authority to direct the activities of the flood engineers during flood operations was irrelevant because (1) as a matter of fact they did intervene; (2) those personnel accepted that they would have intervened to prevent misconduct by the flood engineers during the course of flood operations; (3) the Chairperson of Seqwater retained authority under the Manual to approve various actions and authorise departure from the Manual's procedures; and (4) the relevant issue was Seqwater's "actual capacity to lawfully control" the dams, irrespective of whether or not it was recognised or exercised.[25] Of these matters only the last is of real significance at the point at which an existence of a duty of care on the part of Seqwater is being considered. Once it is recognised that the Manual only has the legal effect noted above, then it follows that, at all times during flood operations, Seqwater retained the power to control flood operations. As stated, as the price for obtaining the protection conferred by s 374(2), it purported to comply with the Manual by ceding control to the flood engineers during flood operations as well ceding to them the ability to declare and conclude a flood event. This involved Seqwater sharing control of the Dams with the flood engineers. However the flood engineers' control was not exclusive of Seqwater's. This sharing of control meant that both were potentially subject to duties of care, although it does not necessarily mean that Seqwater was liable for the conduct of the flood engineers. Whether that is so depends on whether Seqwater's duty was non-delegable or whether it was otherwise vicariously liable for the conduct of the flood engineers.

[24] Plaintiff subs at [91].
[25] Ibid at [93(a),(b),(d) and (e)].

Mitigating or Increasing Flooding

17 In Table 7-4 in Chapter 7,[26] there is set out a table of actual inflows, outflows and gate openings for 10 to 11 January 2011. According to that table, the peak rate of inflow to the Wivenhoe Dam during the January 2011 Flood Event was 11561m^3/s at 1.00pm on 11 January 2011 and the peak rate of releases was 7464m^3/s from 7.00pm to 8.00pm on that day. The defendants sought to deploy the differential between these two figures of just over 4000m^3/s in a number of different ways and with varying degrees of success. First, Seqwater contended that this meant that actual flood operations did not create or exacerbate any risk of harm. In one part of its submissions, Seqwater contended that this was fatal to any finding as to the existence of a duty of care.[27] It otherwise contended that it weighed heavily against the imposition of such a duty.[28] Second, it was contended that this differential meant that flood operations at Wivenhoe Dam would not have fallen within the rule in *Rylands v Fletcher*,[29], which it was submitted meant that no non-delegable duty was owed.[30] Third, it was contended that this differential meant that the releases from the dam could not constitute a nuisance (or a trespass).[31]

18 One matter of relevance to this issue is the so called “hydraulic effect” of the reservoir behind Wivenhoe Dam on a comparison of peak flow rates with and without the dam’s existence. Building a dam such as Wivenhoe Dam creates a reservoir of water behind the dam wall. Given the high levels of Wivenhoe Dam on 10 and 11 January 2011, the surface area of that reservoir was correspondingly very large. Dr Christensen noted that the existence of that reservoir effects a change in the Brisbane “river[’s] hydraulics”. He explained that “before the dam [existed], runoff entering the river in the lower reaches of the river near the current dam site would flow down the river past the current dam site and would be gone far downstream long before the runoff from areas

[26] Chapter 7 at [378].
[27] Seqwater subs at [381(1)(a)]; see also Seqwater subs at [291].
[28] T 9505.22-.37.
[29] (1868) LR 3 HL 330.
[30] See [127] to [128].
[31] SunWater subs at [2602] to [2603]; see also section 11.8.

in the upper reaches of the current reservoir area could flow down the river and reach the dam site".[32] He stated that the "hydraulic effect of the current dam and reservoir is to dramatically speed up the flood runoff water from the upstream reaches" such that "[m]ost or all of the flood water from the upper reaches of the reservoir reached the dam site at about the same time as the lower reaches in a literal traffic jam of flood runoff waters at the reservoir".[33] (Another consequence of a larger reservoir is to reduce the continuing loss rate for the rain falling directly on the area of the reservoir to zero compared to rain falling on the ground.)

19 In short, before the dam was built, water flowed downhill across land into streams and then the river. After the dam was built, water flowed into the much wider area of the reservoir behind the dam compared to that previously occupied by the Brisbane River. This meant that from the time water arrived at the Wivenhoe Dam reservoir, water levels rose and pressure accumulated at Wivenhoe Dam at the speed at which hydraulic pressure propagates through a body of water, rather than at the speed that water runs downhill across land. Dr Christensen estimated that this accelerating effect caused an increase in the peak inflow rate to 11,561m^3/s from a likely peak inflow rate without the dam's existence of 8400m^3/s to 8500m^3/s.[34] Mr Malone addressed this effect in his first affidavit.[35] He appeared to accept Dr Christensen's reasoning but stated that, by reference to hydrological modelling done after the event, the relevant difference was not as great as that suggested by Dr Christensen.[36] A graph included in his affidavit set out the results of this modelling. The graph is unclear but it seems to suggest that the peak rate of inflow absent the dam would have been around 9800m^3/s (instead of 11561m^3/s with the dam) and would have occurred some hours later.

20 Senior Counsel for Seqwater objected to any reference, much less reliance, on this aspect of Dr Christensen's reports. He sought to characterise that

[32] February 2015 Report, EXP.ROD.001.0016 at [2182].
[33] Ibid at [2183].
[34] Ibid at [2185].
[35] LAY.SEQ.007.0001 at [907].
[36] Ibid at [907(d)].

reliance as a reformulation of the plaintiff's case to the effect that the "physical structure [of the dam] presents a risk of harm".[37] This misstates the plaintiff's submission. The hydraulic effect was relied on as part of the plaintiff's response to Seqwater's submission that the existence of a duty of care was to be analysed as though this case merely involved omissions and that the defendants' conduct did not add to the already present risk of harm presented by rising upstream inflow. In response, the plaintiff contended that Dr Christensen's analysis of the hydraulic effect and his determination that the presence of a dam would heighten the peak inflow of a flood event compared to the position if no dam existed only emphasised that, failing to act while operating a dam that already exists is different to the situation where a dam does not exist in the first place. In that sense, there is no mere failure to act, as you "cannot not operate a dam"[38] and thus, for example, a failure to open a gate should be treated as a positive act of storing water.[39] I have treated the plaintiff's submission in this way. In that regard I note that one of the salient factors stated by Allsop P in *Stavar* was the "nature or the degree of the hazard or danger liable to be caused by the defendant's ... activity…controlled by the defendant."[40]

21 Neither Dr Christensen nor Mr Malone was cross-examined on their evidence concerning the hydraulic effect. In those circumstances, I do not propose to resolve the difference between them as to the extent of the hydraulic effect. Instead I will proceed on the basis that, but for the dam, the peak inflow would have been somewhere between 8400m^3/s and 9600m^3/s compared to the peak releases of 7464m^3/s and otherwise this effect meant that there was the potential for either the operation of a dam or the non-operation of a dam to make peak inflow rates worse than what they might have been had the dam not existed.

[37] T 10199.42.
[38] T 10150.40 to T 10151.21.
[39] T 10151.25 (Owens).
[40] *Stavar* at [103(j)].

Control over Downstream River Flows

22 One matter of significance to the determination of the existence and scope of any duty of care is the level of control exercised by Seqwater and the flood engineers over the "source of harm" or the "risk of harm". The proper formulation of those concepts is addressed below. At this point it is convenient to assess the control exercised by Seqwater and the flood engineers over the Brisbane River flows downstream of the dams.

23 Conceptually, all of the relevant flooding from the Brisbane River overflowing downstream can be seen as sourced in flows from four different sources, namely releases from Wivenhoe Dam, outflows from Lockyer Creek, outflows from the Bremer River and outflows from smaller tributaries into the Brisbane River.[41] In Chapter 7[42] it was noted that the outflows from Wivenhoe Dam contributed somewhere between 4200m^3/s and 5300m^3/s to a peak flow at Moggill on 12 January 2011 of between 10420m^3/s and 10700m^3/s; ie, a contribution of between 39% and 50% of the peak flood rate. Depending on the distribution of rainfall, this represents a reasonable approximation of the range of contributions that releases from Wivenhoe Dam can be expected to make to flooding in the Brisbane River catchment below Moggill. In early December 2010, Mr Drury emailed James Pruss a draft of a paper on the merits of lowering FSL by 5%.[43] The paper, stated, inter alia[44]:

> "*Wivenhoe Dam and Somerset dam control only 50% of the Brisbane River catchment (Bremer River and Lockyer Creek catchments are not controlled*), therefore the Flood Mitigation benefits provided by the dam will depend on the rainfall distribution experienced during a flood event". (emphasis added)

24 This assessment is less than what might be suggested by comparing the size of the catchment areas. The combined catchment area of the Stanley River, Upper Brisbane and Middle Brisbane catchment areas is around 7000km^2 whereas the combined areas for the Lockyer Creek and Bremer River

[41] A fact conceded by the State in its defence: State defence, PLE.040.007.0001 at [36] referring to 5ASOC at [41].
[42] Chapter 7 at [404].
[43] LAY.SEQ.003.0001_2 at [73]; SEQ.016.008.9237.
[44] SEQ.016.008.9237 at .9239.

catchments is approximately 5000km^2.[45] That said, the statement in this memorandum will suffice.

25 As between the Bremer River and Lockyer Creek, the catchment size of the former is just over 2000km^2 whilst the latter is just under 3000km^2.[46] Consistent with this, the rain on the ground inflow charts generated during the January 2011 Flood Event typically showed Lockyer Creek flows as higher than the Bremer River flows, although not by significant amounts.[47] In rough terms, and always depending on the distribution of rainfall, Lockyer Creek can be treated as the source of just under 30% of the uncontrolled downstream flows below Moggill with the Bremer River being the source of just under 20%. As noted in Chapter 2 there are a number of smaller tributaries that flow into the Brisbane River downstream of Wivenhoe Dam.[48] Dr Altinakar's modelling confirmed the relatively small contribution of those tributaries to the flow rates in the Brisbane River during the January 2011 Flood Event.[49]

26 Further, the control over Wivenhoe Dam outflows exercised by someone with authority to operate Wivenhoe Dam and Somerset Dam as described in the above extract is not absolute. There is a point at which no matter what flood operations are undertaken, if sufficient rain falls, control will be lost either because of dam overtopping, fuse plug breaches or dam failure. That said, in broad terms, the level of "control" over flows in the Brisbane River downstream of Wivenhoe Dam has three aspects. The first concerns the area immediately below the dam before the conjunction with Lockyer Creek. Leaving aside the possibility of backflow up the Brisbane River from high Lockyer Creek outflows and depending on the distribution of rainfall, Seqwater and the flood engineers had the capacity to exercise a large measure of

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[45] See Chapter 2 at [40] to [44].
[46] Chapter 2 at [43] to [47]; AID.500.028.001 at .0004.
[47] See for example 11 Jan 1800 ROG run, QLD.001.001.3392; inflow chart.
[48] Chapter 2 at [46].
[49] In his "2015 Set Up" (see Chapter 13), Dr Altinakar incorporated inflow from Lake Manchester via Cabbage Tree Creek which joins the Brisbane River downstream from Lowood. The discharge hydrograph appears to show a peak discharge or around 260m^3/s on 12 January 2011 (EXP.ROD.005.0058 at .0187 and .0191). In his 2017 Set Up (see Chapter 13) Dr Altinakar incorporated discharge hydrographs provided by the BRCFS for a number of the other tributaries along the lower Brisbane River (EXP.ROD.016.0071 at .0246ff; EXP.ROD.017.0001, Appendix D at .0439). The outflows were all relatively small.

control over a very large proportion of the river's flow in this area (and a significant degree of control over flooding in the lower Lockyer Valley). The second aspect concerns the area from the conjunction of the Brisbane River with Lockyer Creek to just upstream of the conjunction of the Brisbane River with the Bremer River. Again, leaving aside the possibility of backflow up the Brisbane River from Bremer River outflows and depending on the distribution of rainfall, Seqwater and the flood engineers had the capacity to exercise a large measure of control over the bulk (but not all) of the flows in this area of the river (and again a significant degree of control over flooding of the lower Bremer River). In respect of the area downstream from that point, depending on the distribution of rainfall, then Seqwater and the flood engineers had the capacity to exercise a large measure of control over approximately one third to one half of the flows in this area of the river bearing in mind the small tributaries that join the Brisbane River downstream of Moggill. These differing levels of control over downstream flows do not warrant different findings at the existence of a duty of care.

27 For the reasons just stated, the statutory scheme and practicalities of the infrastructure were such that, leaving aside Sunwater, the level of control that Seqwater and the flood engineers possessed and exercised over Brisbane River flows downstream of Wivenhoe Dam was exclusive of any other person or entity.

Risk of Harm - Principles

28 If a relevant duty of care is found to have been owed by any of the defendants or the flood engineers, then the next inquiry is breach which involves an application of ss 9 and 10 of the *CLA (Qld)*. Those provisions are set out in Chapter 12.[50] It is self-evident that an application of those provisions requires the identification of an appropriate "risk of harm".[51] In *Roads and Traffic Authority of NSW v Dederer* (2007) 234 CLR 330; [2007] HCA 42 ("Dederer"), Gummow J observed that it is only through the correct identification of the risk

[50] Chapter 12 at [2].
[51] *Uniting Church in Australia Property Trust (NSW) v Miller; Miller v Lithgow City Council* (2015) 91 NSWLR 752; [2015] NSWCA 320 at [101] to [106]; "Miller".

of harm that one can assess what the reasonable response to that risk would be.[52] In *Dederer*, the judgment, the subject of appeal, identified the relevant risk faced by the injured person as “serious spinal injury flowing from the act of diving off [a] bridge”.[53] Gummow J rejected that characterisation of the risk, finding that “it obscured the true source of potential injury”. Instead, his Honour found that the risk “arose not from the state of the bridge itself, but rather from the risk of impact upon jumping into the potentially shallow water and shifting sands of the estuary”.[54]

29 The formulation of the correct risk of harm can be problematic.[55] In *Miller*, Leeming JA acknowledged that “there may commonly be a range of appropriate formulations of the generality of the risk of harm” and that it was “unrealistic to expect there to be a single canonically ‘right’ characterisation of the risk of harm”[56]. Nevertheless, some principles concerning the appropriate formulation have emerged. The relevant formulation can and possibly must use some degree of hindsight such that “the legal analysis be framed so as to encompass the risk which is claimed to have materialised and caused the damage of which the plaintiff complains” *(Coles Supermarkets Australia Pty Ltd v Bridge* [2018] NSWCA 183 at [22]; “Coles”)). However, the risk is not to be limited to the “precise set of circumstances which are alleged to have occurred, although it must encompass those circumstances”.[57] In *Coles*, it was stated that “[w]hat is to be avoided is an unduly narrow formulation of risk of harm which then distorts the reasoning, because, for example, it obscures the true source of potential injury … or because it too narrowly focusses on the particular hazard which caused the injury”.[58] In *Coles*, a possible risk of harm was rejected as being too widely framed because it encompassed a set of circumstances that could have caused injury, namely a customer pushing a shopping trolley being hit by car. This formulation was rejected because it was

[52] *Dederer* at [59].
[53] *Dederer* at [60].
[54] At [60].
[55] See *Perisher Blue Pty Ltd v Nair-Smith* (2015) 90 NSWLR 1; [2015] NSWCA 90 at [105] to [106].
[56] *Miller* at [119] (per Leeming JA).
[57] *Miller* at [118] (per Leeming JA).
[58] At [22].

wholly unrelated to the risk that materialised, namely a customer pushing a shopping trolley and falling over.[59]

30 The identification of an appropriate risk of harm is not, however, a matter that only arises at the point at which breach is to be determined. In a case such as this, it is also relevant to ascertaining the existence and scope of any duty of care. Hence, in *Dederer*, Gummow J observed that the "obscuring [of] the true source of potential injury" by the incorrect characterisation of the relevant risk meant that there was an "erroneous... attribut[ion] to the [defendant of] a greater control over the risk than it possessed".[60] Similarly, in *Stuart v Kirkland-Veenstra* (2009) 237 CLR 215; [2009] HCA 15 ("Stuart"), Gummow, Hayne and Heydon JJ noted that an "[e]valuation of the relationship between the holder of the power and the person or persons to whom it is said that a duty of care is owed … require[d] [an] examination of the *degree and nature of control exercised over the risk of harm that has eventuated*" and that "in a number of cases about the exercise of statutory power … it is the *factor of control* that is of critical significance".[61]

The Risk of Harm, Source of Harm and Control

31 The relevant forms of "harm" alleged to have been suffered by the plaintiff and group members include loss or damage from the inundation of real property, damage to personal property, loss of profits from business interruption and generally costs associated with the clean-up and rectification of the inundated land or damaged personal property.[62] Further, for all group members, it is pleaded that the "large volume releases" made by the flood engineers over the period 9 to 19 January 2011 would not have been necessary, or would have been less, had the flood engineers not committed one or more of their pleaded breaches[63] and that the releases caused greater flooding downstream "where such flooding would not have otherwise occurred had the

[59] *Coles* at [23].
[60] At [60].
[61] *Stuart* at [113] to [114].
[62] 5ASOC [6(a) and (b)] (group member pleading); 5ASOC [347] (Rodriguez); PLE.010.003.0001 (Keller points of claim); PLE.010.004.0001 (Harrison points of claim); and PLE.010.005.0001 (Visser points of claim).
[63] 5ASOC at [346(a)].

Flood Engineers not committed one or more of the Flood Engineers' Breaches"[64] (referred to in the 5ASOC as "greater flooding"). It is also pleaded that, had it not been for the flood engineers' breaches, the plaintiff and group members would not have suffered any loss or damage, or would have suffered lesser loss and damage.[65] At least so far as the plaintiff and at least some of the sample group members[66] are concerned, given the findings in the balance of the judgment those contentions are established.

32 Paragraph 142A of the 5ASOC pleads an overall risk of harm to the effect that: "there was a risk that a failure [to properly] conduct Flood Operations at Somerset Dam and Wivenhoe Dam would reduce the available flood storage capacity of Lake Somerset and Lake Wivenhoe during times of flood and necessitate the release of water from Wivenhoe Dam in such volumes as to cause the inundation":

> "[a] …of real and personal property located downstream of Wivenhoe Dam by water (or increase the extent of such inundation), resulting in damage to that real or personal property (or increased damage to such property) and causing consequential loss arising from such damage (including, but not limited to, loss arising from the disruption of commercial activities using that real or personal property) (**Risk of Harm to Property**); and
>
> [b] …of real property located downstream of Wivenhoe Dam (or increase the extent of such inundation), and that the inundation so caused would interfere with the use or enjoyment of that real property by persons holding an interest in that property (**Risk of Interference with Use and Enjoyment**)" (bold emphasis in original)

33 As explained in Chapter 12, for each day of the flood event the plaintiff also pleads a particular risk of harm referable to that day which is similar to this risk but which is related to the particular circumstances prevailing on that day including dam levels and rainfall forecasts.[67]

34 In its submissions the plaintiff described the relevant risk as a "risk of harm ... that insufficient flood storage capacity in the dams would necessitate greater releases from Wivenhoe Dam as the flood peaked, resulting in greater

[64] 5ASOC at [346(b)].
[65] Ibid at [346(c)].
[66] Namely Mr and Mrs Keller, Ms Visser and Ms Lynch: see Chapter 13.
[67] Eg 5ASOC at [209] and [226].

damage from combined flows in Brisbane and Ipswich".[68] As a matter of substance this risk does not differ from the pleaded risk, save that it omits the reference to a "failure to properly conduct flood operations".[69] I consider that omission to be correctly made. The discussions in the cases of the formulation of risk of harm do not appear to encompass the intrusion of a failure to take particular care as part of the formulation of the risk of harm, although it could include a failure to take a specific precaution. In *Miller* Leeming JA contemplated the possibility of a risk of harm defined by reference to an elevated risk arising from the absence of non-stick tiles around a pool.[70] In any event, the formulation of a risk of harm by reference to the alleged tortfeasors' failure to exercise reasonable care has a tendency to obscure the related but separate analysis of the capacity to control the source of harm which, as formulated by the plaintiff at 5ASOC [142A], is forced releases of water from Wivenhoe Dam occasioning or worsening downstream flooding.

35 In its amended defence, Seqwater contended that the "true source of the risk … was rain falling above and below Somerset and Wivenhoe Dams".[71] In supplementary written submissions, Seqwater (wisely) reformulated this. It identified the "*source* of the risk of harm" as the "naturally occurring flooding in the Brisbane and Stanley Rivers (both above and below Wivenhoe and Somerset Dams respectively), due to the heavy rain".[72] Seqwater deployed this characterisation of the source of the risk of harm as part of its contention, that the operation of the dam did not "add" to the flooding downstream of Wivenhoe Dam because the peak outflow from Wivenhoe Dam was always less than the peak inflow (even when adjusted for the hydraulic effect).[73] It was thus argued that the operation of the Dams "did not *cause* the flooding below the dams".[74] Seqwater's argument that the operation of the dams did not create or add to the risk of harm is addressed below but it does not add

[68] Plaintiff subs at [16].
[69] Seqwater subs at [480].
[70] At [123].
[71] Seqwater Defence, PLE.020.010.0001 at [207(b)].
[72] SBM.020.007.0001 at [486].
[73] Ibid at [488].
[74] Ibid at [489C].

anything to the analysis at this point. Otherwise, whether the operation of the dams “caused” the flooding below the dams is a conclusion that can only be made after it is determined whether a duty was owed and whether it was breached.

36 In its supplementary submissions, Seqwater characterised the *risk of harm* as the “risk of widespread inundation of properties below Wivenhoe by ‘over the floor’ flooding of the Brisbane River and its tributaries”.[75] It submitted that the plaintiff’s characterisation of the risk was unduly narrow and “confine[d] consideration to only one (possible) cause of the flooding of the river and exclude[s] from consideration other possible causes of the flooding”.[76] However, in this case, the only “other possible causes” of flooding were the flows from Lockyer Creek and the Bremer River (as well as from the smaller tributaries flowing into the Brisbane River). This was acknowledged by the plaintiff’s formulation (“greater damage from combined flows in Brisbane and Ipswich”). The pleaded premise of the plaintiff’s case which it sought to prove through Dr Altinakar was that, but for the Wivenhoe releases (or at least but for the excessive Wivenhoe releases) and allowing for other sources of flow downstream, the relevant damage to group members would not have been occasioned.

37 In essence, the difference between Seqwater and the plaintiff as to the characterisation of the *risk* of harm is that Seqwater identified the risk of harm as the risk of property damage and consequential loss occasioned by the Brisbane River overflowing by reason of flows from effectively three sources, namely flows from Lockyer Creek, the Bremer River and the rivers upstream of Wivenhoe Dam which pass through the dam (and possibly a fourth source namely smaller tributaries flowing into the Brisbane River). The plaintiff characterised the risk of harm as the risk of property damage and consequential loss, or least additional property damage and consequential loss, occasioned by one source, namely releases from Wivenhoe Dam.

[75] SBM.020.007.0001 at [489F].
[76] Ibid at [489I].

38 Subject to addressing three matters, both of those formulations falls within what Leeming JA referred to as the “range of appropriate formulations of the generality of the risk of harm”.[77] For the reasons set out below, an analysis of the balance of interrelated factors relevant to ascertaining the existence of a duty of care by reference to these differing formulations of the risk of harm does not lead to any different outcome.

39 First, in considering those formulations, it is necessary to consider that they are addressing harm occasioned to different classes of people, although one subsumes the other. In Seqwater’s case it is a wider class, namely all people who sustained damage by ‘over the floor’ flooding (i.e. flooding of buildings or homes). In the plaintiff’s case it is a narrower group within that class, namely only those persons who suffered loss, or greater loss, by the addition of the large volume of releases from Wivenhoe Dam to naturally occurring downstream flows (ie, “greater flooding”).

40 The second concerns the necessity to assess the relevant level of control over that risk. Seqwater’s written submissions were critical of the plaintiff’s submissions on control, contending that it wrongly “focuse[d] solely on Seqwater’s alleged control over the activity of flood operations”.[78] Instead, it contended that “Seqwater’s alleged control over the activity of flood operations did not amount to control over the true source of the risk of harm” namely “the rainfall”. These submissions were made prior to Seqwater reformulating the risk of harm as outlined above. After it reformulated its definition of risk it did not revisit the issue of control. As noted, one aspect of its reformulation was to describe the *source* of the risk as the “naturally occurring flooding in the Brisbane and Stanley Rivers (both above and below Wivenhoe and Somerset Dams respectively) due to the heavy rain”.[79] To the extent that it identified the source of the risk as river flows from above Wivenhoe Dam, then that differs from the plaintiff’s formulation which is directed to forced outflows from Wivenhoe Dam. However, in the end result,

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[77] *Miller* at [119].
[78] Seqwater’s subs at [423].
[79] SBM.020.007.0001 at [486].

provided that the level of control with each formulation is correctly appreciated, that is a distinction without a difference because the upstream flows only occasion downstream damage if they pass through Wivenhoe Dam. As discussed above, the control exercised by Seqwater and the flood engineers over Wivenhoe outflows is not absolute because if inflows are sufficiently high then releases must be made or a fuse plug will breach or the dam may overtop no matter how well the flood is managed. Nonetheless, it follows from the above that, adopting Seqwater's formulation of the risk of harm, control of Wivenhoe Dam confers a substantial measure of control over a significant part of the risk of over the floor flooding from combined downstream flows. In the case of the plaintiff's formulation, control of Wivenhoe Dam confers a substantial measure of control over all of the relevant downstream flows, that is that part of downstream flows that caused the additional flood damage above that caused by flows from downstream sources (i.e. greater flooding).

41 The third matter concerns the assessment of whether the risk of harm was foreseeable. An assessment of whether the risk was foreseeable is "relevant at each of the three, related, stages of the analysis of liability in negligence: the existence and scope of a duty of care, breach of the duty, and remoteness of damage".[80]As noted, at the duty stage of the inquiry, the foreseeability of harm is a necessary but not sufficient condition to the finding of a duty of care.[81] Moreover, at the duty stage the assessment of foreseeability is conducted at "a higher level of abstraction" than at the subsequent stages.[82] The analysis does not require the precise events that lead to the risk materialising to have been foreseen.[83] The requirement that the risk of harm be foreseeable at the breach stage is reinforced by the *CLA (Qld)* which also requires that the risk be foreseeable and not insignificant (ss 9(1)(a) and 9(1)(b)). The assessment of whether the competing risks of harm were foreseeable is undertaken next.

[80] *Sydney Water Corporation v Turano* (2009) 239 CLR 51; [2009] HCA 42 at [45]; "Turano".
[81] *Tame* at [12].
[82] *Turano* at [45]; *Vairy v Wyong Shire Council* (2005) 223 CLR 422 at [70] to [72]; [2005] HCA 62 per Gummow J; *Shirt v Wyong Shire Council* [1978] 1 NSWLR 631 at 639 per Glass JA.
[83] *Turano* at [46].

Foreseeability of the Risk of Harm – Duty Inquiry

42 The different level of inquiry as to the foreseeability of the risk of harm at the duty stage of the inquiry compared to the breach stage is reflected in the 5ASOC. It pleads the reasonable foreseeability of a risk of harm materialising in support of the existence of a duty of care.[84] In the context of the pleaded allegations of breach for each day of flood operations, the 5ASOC pleads a similar but more focused risk that was said to arise from the prevailing circumstances.[85] The foreseeability of the risk of harm at the breach stage of the inquiry is addressed in Chapter 12. The present discussion concerns the foreseeability at the duty stage.

43 As just noted, in its supplementary submissions Seqwater departed from its own pleading and formulated a revised risk of harm. In its defence, it contended that the risk of harm arising from rainfall was not foreseen and not foreseeable and, in the alternative, was insignificant. [86] After it reformulated the risk of harm, Seqwater did not indicate whether it maintained its pleaded contention with respect to unforeseeability. In any event, regardless of which of the competing formulations of the risk of harm noted above is adopted, both were reasonably foreseeable.

44 Four matters should be noted.

45 First, as noted in Chapter 2, the Brisbane River Basin was prone to flooding, the January 2011 Flood Event was a one in 40 to 50-year flood event and it was an order of magnitude similar to (although higher) than the 1974 flood event.[87] The 1974 Flood Event was a very significant event in the history of the construction of Wivenhoe Dam.[88]

46 Second, the foreseeability of flood events of the kind experienced in January 2011 was contemplated by the Manual. The Manual commences by

[84] 5ASOC at [143(a)] and [149(a)].
[85] See, for example 5ASOC at [209], [226].
[86] PLE.020.012.0001, [207(c) and (d)].
[87] Chapter 2 at [51] to [52].
[88] Chapter 2 at [67] to [69].

recognising the "potential significant impact on downstream populations" of the operation of both dams, thereby warranting "Wivenhoe and Somerset Dams be[ing] operated during flood events in accordance with clearly defined procedures to minimise impacts to life and property".[89] To that end, the Manual identifies the second priority as "provid[ing] optimum protection of urbanised areas from inundation" and states that the "prime purpose of incorporating flood mitigation measures into Wivenhoe Dam and Somerset Dam is to reduce flooding in the urban areas of the flood plains below Wivenhoe Dam".[90]

47 To similar effect, in an email sent in October 2009,[91] Mr Tibaldi noted that "Wivenhoe and Somerset dams have the potential to prevent billions of dollars in flood damage if operated correctly in large floods" and then added "[t]he dams also have the potential to cost similar amounts if operated incorrectly during flood events". Put bluntly, it was at least partly because significant flood events of the order of magnitude that eventuated in January 2011 were clearly foreseeable and foreseen that Wivenhoe Dam was built in the first place. This is why the Dam was designated as having a flood mitigation function and why the order of priorities were stated as they were in the Manual.

48 Third, as noted in Chapter 6,[92] there was some debate about whether the risk of rainfall of the kind experienced in the period from 9 to 11 January 2011 was not reasonably foreseeable. As submitted, that does not address the relevant risk of harm, including the risk as ultimately submitted by Seqwater. In any event, as was found in Chapter 6,[93] while the precise combination of weather events, rainfall amounts and the distribution of rainfall may not have been readily predicted in the period leading up to 11 January 2011, there was nevertheless a reasonable possibility of rainfall eventuating in, around and below the upstream catchments in amounts that approximated to the rainfall that actually fell.

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89 Manual at 1.
90 Manual at 9 to 10.
91 SEQ.206.006.8743.
92 Chapter 6, section 6.2.
93 Chapter 6 at [16].

49 Fourth, in the case of flooding or additional flooding from forced releases from Wivenhoe Dam, it was the defendants' contention that once Wivenhoe Dam levels rose above EL 74.0m AHD then releases had to increase until levels began to stabilise,[94] a contention that has been largely accepted.[95] This approach reflected the flood engineers' understanding.[96] Thus, to take the plaintiff's formulation, a combination of the known risks of large rainfall and consequential flooding meant that it was reasonably foreseeable that a failure to properly conduct flood operations at Wivenhoe and Somerset Dams would result in reservoir levels above EL 74.0m AHD and force releases that were likely to cause additional flooding.[97] The position is not relevantly different with Seqwater's formulation.

50 Otherwise as noted, the 5ASOC pleads the existence of a particular risk arising on each day of the January 2011 Flood Event which is denied by the defendants. The existence of such a risk on each day is addressed in Chapter 12. In that Chapter I find that the existence of each of those pleaded risks on those days was established, that it was foreseeable and not insignificant.

Actual Knowledge of the Risk of Harm

51 Seqwater submitted that by its pleading the plaintiff confined itself to a case that was premised on establishing that each of the flood engineers had actual knowledge of the relevant risk of harm and could not therefore contend that they ought to have known of that risk.[98] This appears to be a reference to sub-paragraphs 143(d) and 149(e) of the 5ASOC which plead, in the context of establishing the existence of a duty of care, that each of Seqwater and the Flood Engineers had "actual knowledge of the Risk of Harm to Property and the Risk of Interference with the Use and Enjoyment of Property.[99] However, this submission overlooks the balance of those paragraphs which are also directed to pleading facts and circumstances that impose a duty of care on

[94] Chapter 3 at [299].
[95] Chapter 3 at [315].
[96] Chapter 3 at [304] to [306].
[97] Cf Seqwater subs at [402] to [406].
[98] Seqwater subs at [503] to [504].
[99] See also Seqwater subs at [1227] to [1228].

each of Seqwater and the flood engineers. They include allegations that, inter alia, each of those risks were reasonably foreseeable by Seqwater and the flood engineers respectively, which is particularised by reference to the Manual (and 5ASOC at [142B] which pleads that those risks were not remote or insignificant). Each of those paragraphs was sufficient to invoke a claim based on imputed knowledge. The significance of pleading actual knowledge is that it is capable of strengthening the case for the existence of a duty of care.[100] However, it does not restrict the plaintiff to only pursuing a case predicated on the existence of actual knowledge of the relevant risk of harm.

52 Otherwise, the extent to which the flood engineers were aware of the risk of harm depends on the level of generality that the risk is formulated. At the level of abstraction necessary for the purpose of determining the existence of a duty of care, the flood engineers clearly did have actual knowledge of the risk of harm. To take Seqwater's formulation of risk being a "risk of widespread inundation of properties below Wivenhoe by 'over the floor' flooding of the Brisbane River and its tributaries", then it is inconceivable that the flood engineers were not aware of that risk in a general sense even if they did not consider that the rainfall forecasts raised that specific potentiality in early January 2011. This risk would have been apparent to anyone with knowledge of the 1974 floods, as well as to anyone who read the Manual and its references to providing protection against urban flooding. Similarly, at the level of generality pitched by the plaintiffs, the reasonable possibility that forced releases from above EL 74.0m AHD necessitated by a loss of storage space in the dam could cause additional urban damage downstream was also obvious to anyone who was familiar with the Manual (much less someone who participated in drafting it). As noted, it was the defendants' contention that once actual levels rose above EL 74.0m AHD that gate openings had to occur to arrest the rising levels and to a significant extent that contention was accepted.[101]

[100] *Stavar* at [103(k)].
[101] Chapter 3 at [315].

Vulnerability

53 A related factor affecting the existence and content of any duty of care is the degree to which members of the postulated class of persons are relevantly "vulnerable"; that is, whether they are unable to protect themselves from the consequences of a defendant's want of reasonable care, either entirely or in such a way as to cast the consequences of loss on the defendant.[102] The plaintiff contended that each of the affected downstream real property owners had no effective means of protecting themselves from such additional flooding as may be caused by the negligent conduct of flood operations. Save as to the possibility of sandbags and the like, or the construction of levees (which no one suggested), then I agree. Such control as there was over flows in the Brisbane River was exclusive to Seqwater and the flood engineers. Again, Seqwater's analysis of vulnerability in its written submissions was tied to its initial identification of the source of the risk of harm as "rainfall" and its analysis of the degree of control over that risk.[103] It did not revisit vulnerability when it reformulated its definition of the risk of harm.

54 One category of affected group members is those whose personal property was damaged by the additional flooding. It can be accepted that, depending on the nature of the personal property, such persons have some capacity to guard against an absence of reasonable care, by (possibly) moving the property to higher ground or removing it from the vicinity of flooding. This is what Mr Rodriguez attempted to do on 12 January 2011[104]. Nevertheless, I do not accept that this limited capacity to protect one's own interests affects the categorisation of such persons as relevantly vulnerable. With some levels of flooding, the owner of personal property may have been able to move it to safety depending on the nature of the property, the availability of higher ground, the means of travel and the warning time of impending flooding. However, with large scale flooding of the kind that was experienced, the owners ability to move their property was severely restricted, especially when regard is had to the thousands of others who might be taking the same course

[102] *Woolcock Street Investments Pty Ltd v CDG Pty Ltd* (2004) 216 CLR 515; [2004] HCA 16 at [23].
[103] Seqwater subs at [433(b)(i)].
[104] LAY.ROD.001.0001 at [83] to [85].

at the same time and the priority that every affected person can reasonably be accepted to afford to preserving their own physical safety and that of their families. For example, Ms Visser received short notice of the impending flooding of her home. She left with her family in a car "packed to capacity".[105] Many items were left behind.

Indeterminacy

55 Seqwater contended that the persons or class of person to whom the postulated duty of care was owed were "indeterminate" and that either negatived or weighed against any conclusion that it owed a duty of care.[106] Seqwater contended that one must be able to prospectively identify the class of persons to whom the duty is owed and that "the class must be capable of being defined and confined within reasonable limits".[107] Seqwater placed reliance on the analysis of Jagot J in *Electro-Optic Systems Pty Ltd v State of New South Wales* (2014) 10 ACTLR 1; [2014] ACTCA 45 ("Electro-Optic Systems") of a posited duty of care in relation to firefighting operations concerning a bushfire that had the potential to "damage properties in all directions radiating out … for an unknown and perhaps unknowable distance".[108] Her Honour referred to the supposedly indeterminate nature of the suggested class of property owners to whom the duty was owed as follows:[109]

> "It is not simply that the individual members of the class cannot be identified. The class itself is indeterminate. Membership may extend to property owners who are located in all directions from the Park to an unknowable extent depending on factors outside the defendant's control …. The class may change from moment to moment depending on those other uncontrollable factors. These considerations also weigh heavily against the existence of the posited duty of care."

56 The concept of indeterminacy of the persons or class of person to whom the duty is owed is not to be equated with the possibility that the number of affected persons may be large. In *Perre v Apand* (1999) 198 CLR 180; [1999]

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105 LAY.ROD.010.0001 at [32].
106 Seqwater subs at [441] to [447].
107 Ibid at [443].
108 At [352].
109 At [353].

HCA 36 ("*Perre v Apand*") Hayne J addressed the contention that the proposed duty involved the potential imposition of a liability on the alleged tortfeasor to an indeterminate class of persons stating as follows:[110]

> "It is important to understand what is meant by indeterminate liability. It means more than "extensive" or "large". The damage suffered by persons affected by the defendant's negligence may be very large; there may be many who are affected. But neither of those considerations means that the liability is indeterminate. What is meant by indeterminate in the present context is that the persons who may be affected cannot readily be identified. That formulation invites attention to when this identification is to be possible: is it to be possible at or before the time of the negligent act or omission, or is it sufficient if it is possible to identify the class of those affected after the event? I do not think it necessary to say, in this case, whether identification at the later time would suffice. If, as here, it was possible to identify those who *would* be directly affected by the conduct concerned at the time of the act or omission that is said to be negligent, and it was known to the person alleged to have been negligent that that was possible, then the liability to those persons is not indeterminate."

57 In *Perre v Apand*, Hayne J explained that it was possible to identify such affected persons before the sale of the affected seed, they being "growers of potatoes within 20 kilometres of the place where the seed was grown" and "any processor who handled potatoes from that area, and any grower who had potatoes processed with that equipment".[111]

58 In *Weber*, Basten JA, with whom Gleeson JA agreed,[112] rejected the reasoning in *Electro-Optic Systems*, holding that "it is fallacious to argue that a duty of care cannot arise if the members of the class to whom it is owed cannot be identified before the harm eventuates"[113] and that "the mere fact that it is not possible to predict in advance how far, or in what direction, a fire may spread is not the kind of indeterminacy which prevents the imposition of a duty of care".[114] To similar effect, Sackville AJA stated that "the mere fact that it is not possible in advance to identify precisely the members of the class who may suffer damage by reason of the defendant's negligence does not

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[110] At [336].
[111] At [337] to [338].
[112] At [200].
[113] *Weber* at [23].
[114] *Weber* at [24].

mean that the potential liability is indeterminate, such that no duty of care arises".[115]

59 In identifying and applying the common law of Australia, I am bound by *Weber* which enables the ascertainment of the affected class of people by reference to the flooding that occurred. However, even if I was limited to addressing it in the manner undertaken by Hayne J in *Perre v Apand*, namely by reference to "those who *would* be directly affected by the conduct concerned at the time of the act or omission that is said to be negligent", then that group of people could have been identified by reference to the location and elevation of their real and personal property in relation to the Brisbane River and areas near the confluence of Lockyer Creek and the Bremer River with the Brisbane River. There is no doubt that it would have been difficult to ascertain the identity of all such persons unless one had Dr Altinakar's modelling, but difficulty of ascertainment in that sense does not render the relevant class indeterminate.

60 Two further matters should be noted. First, in its submissions on indeterminacy, Seqwater noted that each of the claimants is only bound by the characteristic that they suffered "physical *or* economic" loss.[116] In fact, the relevant harm suffered by the class to whom the duty is owed is a form of physical harm with economic loss only consequential. More importantly, it follows from the above that the relevant common characteristic for each group members is the susceptibility of property they owned to "over the floor" flooding from the Brisbane River (or greater flooding) as determined by the proximity of their property to the river and its elevation.

61 Second, Seqwater contended that the plaintiff had not related its posited duty to the definition of group members, which is relevantly defined as all those who suffered inundation from overflows of the Brisbane River, the Bremer River or their tributaries.[117] However as noted, the 5ASOC pleads that each group member suffered "greater flooding". Moreover, it was only necessary that the plaintiff demonstrate each of the group members fell within a class of

[115] At [210].
[116] Seqwater subs at [444].
[117] 5ASOC at [6(a)(i) and (ii)]; Seqwater subs at [446].

persons to whom the duty was owed. In this case the relevant class of persons is those who owned real or personal property that, due to its proximity to the Brisbane River and elevation, were susceptible to 'over the floor' flooding or greater flooding. The combination of the group definition and 5ASOC at [346], which pleads that group members suffered greater flooding, suffices to bring them within that class.

Type of Harm

62 In *Stavar* at [103(b)], Allsop P noted that the "nature of the harm alleged" was one of the salient features bearing upon the determination of the existence of a duty of care. The two relevant forms of harm relied on this case are described above these being the Risk of Harm to Property or Risk of Interference with an owner's Use and Enjoyment (of real property and consequential loss). These types of harm form part of the analysis of the other salient features such as foreseeability, indeterminacy, vulnerability and control. These forms of harm tend in favour of the existence of a duty, at least when compared to so called "pure economic loss".[118]

11.2: Seqwater and the Flood Engineers' Duty of Care

63 The respective analyses of the plaintiff and Seqwater of whether Seqwater and the flood engineers owed a duty of care reflected a difference between them as to whether the existence of a duty should be analysed by reference to Seqwater's status as the owner and controller of an asset undertaking an activity with potentially deleterious consequences for a class of property holders downstream[119] or as a public authority effectively regulating an external source of harm under a statutory scheme.[120]

64 Seqwater's primary contention was that the statutory scheme must be analysed first. This is undoubtedly correct but such an analysis only leads to a position close to that identified by the plaintiff. In any event, whether the existence of a duty of care is analysed by reference to statute or by reference

[118] *Tame* at [6] per Gleeson CJ.
[119] Plaintiff subs at [82] to [97].
[120] Seqwater subs at [293] to [297].

to control over an asset, ultimately the crucial factors in favour of a finding of the existence of a duty of care in this case turn on the interplay between the level of control over the risk of harm and the degree of vulnerability of the postulated class to that risk. Both of these factors are analysed above by reference to their statutory and practical contexts.

65 In *Graham Barclay Oysters Pty Ltd v Ryan* (2002) 211 CLR 540; [2002] HCA 54 ("Graham Barclay Oysters"), McHugh J summarised the effect of the cases concerning whether ownership and control of land or an asset and the undertaking of an activity by a public authority give rise to a duty of care. His Honour stated:[121]

> "Where an individual has control of land or chattels or undertakes a task, courts will usually find that that individual has a duty to take reasonable care for the safety of those entering the land or affected by the use of the chattels or the execution of the task. Often enough the courts will have little difficulty in holding that a public authority that exercises its power to carry out, or an authority that undertakes to carry out, a task has a duty to take care for the safety of those affected by the task". (citations omitted).

66 The cases cited by McHugh J in support of the second proposition were *Pyrenees Shire Council v Day* (1998) 192 CLR 330; [1998] HCA 3 ("Pyrenees Shire Council"); *Crimmins v Stevedoring Industry Finance Committee* (1999) 200 CLR 1; [1999] HCA 59;[122] ("Crimmins") and *Brodie v Singleton Shire Council* (2001) 206 CLR 512; [2001] HCA 29;[123] ("Brodie"). Both *Pyrenees Shire Council* and *Crimmins* are addressed further below. At this point it suffices to state that, in *Pyrenees Shire Council* and *Crimmins*, the relevant public authority did not create or materially increase the risk of harm that eventuated, namely damage from fire (*Pyrenees Shire Council*) and disease from exposure to asbestos (*Crimmins*). Nevertheless, in those cases the interplay between the level of control exercised by the public authority over the risk of harm and the vulnerability of the affected person or class to that risk warranted the conclusion that a duty of care was owed.

[121] *Graham Barclay Oysters* at [90].
[122] At 24 to 25 [43] to [46], per Gaudron J; at 42 to 43 [104], per McHugh J; at 61 [166], per Gummow J; at 82 [227], per Kirby J; at 104 [304] to [305], per Hayne J; at 116 [357], per Callinan J.
[123] At [102], per Gaudron, McHugh and Gummow JJ.

67 Similarly, the passage cited by McHugh J from the judgment of Gaudron, McHugh and Gummow JJ in *Brodie* referred to the "powers vested by statute in a public authority … giv[ing] it such a significant and special measure of control over the safety of the person or property of citizens as to impose upon the authority a duty of care" which "oblige[s] the particular authority to exercise those powers to avert a danger to safety".[124] Their Honours added that "the factor of control is of fundamental importance".

68 In a different context, in *Stuart* Gummow, Hayne and Heydon JJ stated:[125]

> "Statutory power to act in a particular way, coupled with the fact that, if action is not taken, it is reasonably foreseeable that harm will ensue, is not sufficient to establish a duty to take that action. Rather, as was pointed out in *Graham Barclay Oysters Pty Ltd v Ryan*, the existence or otherwise of a common law duty of care owed by a statutory authority (or in this case the holder of statutory power) "turns on a close examination of the terms, scope and purpose of the relevant statutory regime". Does that regime erect or facilitate "a relationship between the authority [here the holder of statutory power] and a class of persons that, in all the circumstances, displays sufficient characteristics answering the criteria for intervention by the tort of negligence"?
>
> Evaluation of the relationship between the holder of the power and the person or persons to whom it is said that a duty of care is owed will require examination of the degree and nature of control exercised over the risk of harm that has eventuated, the degree of vulnerability of those who depend on the proper exercise of the relevant power, and the consistency or otherwise of the asserted duty of care with the terms, scope and purpose of the relevant statute. Other considerations may be relevant.
>
> In the present matter, as in a number of cases about the exercise of statutory power, it is the factor of control that is of critical significance." (citations omitted)

69 In *Stuart*, their Honours concluded that the relationship between the police officers, as persons vested with a statutory power to detain mentally ill persons, and a person against whom such a power might be exercised who was threatening suicide was not such as to give rise to a duty of care.[126]

[124] At [102].
[125] At [112] to [114]; see also *Graham Barclay Oysters* at [149] per Gummow and Hayne JJ.
[126] At [118].

70 In light of the finding in Chapter 2,[127] the relevance of the reference to statutory powers in *Stuart* falls away. However, even if the conclusion in Chapter 2 was wrong, the conferral on Seqwater of a statutory function to engage in flood mitigation generally might commence the analysis as to whether a duty of care was owed but it would still lead to the same result. In the end, the relationship created by the statutory scheme considered with the characteristics of the dam and the catchments were such as to create a relationship between those exercising control over the dams during flood operations and the affected property holders downstream as to warrant intervention by the tort of negligence. In particular, subject to considering the negativing factor adverted to in the above passage (ie, consistency with statute) and the matters raised by Seqwater considered next, the level of control over flooding (or greater flooding) caused by the Brisbane River breaking its banks that came with control over the dams, the exclusivity of that control and the consequential vulnerability of potentially affected property holders to its negligent exercise were such that a duty to exercise reasonable care in the conduct of flood operations to avoid or minimise the Risk of Harm to Property and/or the Risk of Interference with Use and Enjoyment of Property should be imposed.

Seqwater's Contentions

71 In addition to resisting the plaintiff's salient features analysis, in its written submissions Seqwater submitted that the duty of care proposed by the plaintiff in respect of it and the flood engineers should not be imposed for five reasons.[128] First, it was submitted that the common law will not impose a duty of care to confer benefits, including the benefit of preventing or further reducing harm from natural causes such as extreme rainfall. Second, it was submitted that Seqwater's statutory powers are not directed towards some individual or even an identifiable class of persons, but rather to the public at large. Third, Seqwater submitted that there are a "number of forms of incoherence" that arise with the posited duty which "tell against the existence

[127] At [14].
[128] Seqwater subs at [381].

of a duty of care". Fourth, it was submitted that Seqwater did not owe a duty of care requiring it to exercise its "statutory" powers in the period up to 6 January 2011. Fifth, Seqwater submitted that it did not owe a duty of care requiring it to consider making, and ultimately to make, releases below the Dams' respective FSLs.

Duty to Confer a Benefit?

72 As noted above, Seqwater relied heavily on the difference between the peak rate of inflow into Wivenhoe Dam during the January 2011 Flood Event and the peak rate of outflow. It characterised the plaintiff's case as being that the dams should "have been operated differently from 2 January 2011, so as to produce an even greater flood mitigation benefit".[129] Seqwater cited Lord Reed JSC in *Robinson v Chief Constable of West Yorkshire Police* [2018] 2 WLR 595 at [69], who stated that the "law of negligence ... does not generally impose duties to provide … benefits". In oral submissions[130] reliance was placed on the judgment of Brennan J in *Council of the Shire of Sutherland v Heyman* (1985) 157 CLR 424; [1985] HCA 51 at 479; ("Sutherland Shire Council"), where his Honour referred to a "distinction between a case where the repository of a statutory power does something which creates or increases the risk of foreseeable damage and that damage occurs and a case where a person is able to foresee that damage might occur but does nothing to cause it." His Honour noted that if the repository of the statutory power "takes no reasonable steps to prevent the occurrence of the damage" then in the former case it is negligent but in the latter case it is not. Seqwater also relied on a passage from the judgment of Crennan and Keifel JJ in *Stuart*,[131] to the effect that the "law draws a distinction between the creation of, or the material increase of, a risk of harm to another person and the failure to prevent something one has not brought about".

73 Seqwater's assertion that flood mitigation at Wivenhoe Dam was being carried out in exercise of a statutory power is inconsistent with the finding in Chapter

[129] Seqwater subs at [288].
[130] T 9498 to T 9499.
[131] At [127].

2.[132] Leaving that aside, I am nevertheless sceptical of the overall characterisation of Seqwater and the flood engineers' position as akin to that of a rescuer who fails to intervene to prevent harm occasioned by an external source. In the passage from the judgment of Crennan and Kiefel JJ in *Stuart* noted above, their Honours noted that the distinction between creating a risk of harm and failing to prevent harm from something the alleged tortfeasor has not brought about is reflected "in notions of misfeasance and non-feasance".[133] In this case, the premise of Seqwater's submission is that such a distinction is said to be reflected in the difference between supposedly doing nothing and allowing water to pass through the dams downstream on the one hand and undertaking active flood control on the other. Such a distinction has an air of unreality about it. As explained above, the building of the dam and the creation of a reservoir behind it irrevocably changed the characteristics of the Brisbane river system. It created the likelihood of increasing inflow rates through the hydraulic effect (and loss rates of zero over the surface area of the reservoir). The existence of the dam created the potential for catastrophic outcomes downstream arising from dam failure. Further, the configuration of the dam and the reservoir may mean in some circumstances it is not necessarily possible to allow inflow to pass through above FSL because in the case of extreme inflows the gate capacity may not allow that to occur before the build-up of water levels blows a fuse plug.

74 To paraphrase what Dr Christensen repeatedly stated, if a person has ownership of a dam with a designated flood mitigation function and possesses an exclusive licence to interfere with the river flow for that purpose, then they cannot decide not to operate the dam. Regardless of whether at any point they are actively opening or closing a gate, they are nevertheless storing or releasing an amount of water. Thus, during the period of 2 to 6 January 2011, Seqwater and the flood engineers were effectively operating the dam. The regulators were open, the gates were closed and water was accumulating above FSL. In contrast, a firefighter who does not leave their fire station is not fighting or managing a fire and their conduct is properly characterised as an

[132] Chapter 2 at [14]; Cf Seqwater subs at [295] to [297].
[133] At [127].

omission. Generally, a firefighter does not have ownership or control of an asset through which the fire must pass before it burns houses.

75 Putting to one side the dispute over Seqwater and the flood engineers' position in respect of operating or not operating the Dams, Seqwater's submissions on this topic can be addressed on the premise that they were correct to characterise the plaintiff's case as being that the Dams should have been operated differently to produce a greater flood mitigation benefit. As noted, Seqwater's written submissions appeared to contend that it followed from that characterisation that no duty of care could be found to exist.[134] However, in oral argument it was conceded that this point was not determinative.[135] This concession was correctly made. Leaving aside the judgment of Brennan J in *Sutherland Shire Council*, the judicial statements relied on by Seqwater in support of the contention were either conditioned by the phrase "generally"[136] or expressed in terms that recognised exceptions. [137] In relation to Brennan J, as noted in *Pyrenees Shire Council*, his Honour found the existence a duty of care even though the Council did not create or increase the risk of harm. Immediately after the passage from the judgment of McHugh J in *Graham Barclay Oysters* cited above, his Honour referred to the circumstance in which a public authority does not increase the risk of harm but nevertheless becomes subject to a duty of care.[138]

76 Thus, whether the public authority created or increased the risk of harm forms part of the analysis of whether such a duty exists along with the other indicia of the existence of a duty, especially the level of control over the risk of harm and the vulnerability of the affected class. In *Pyrenees Shire Council*, the Council was aware, from an inspection, of a particular danger posed by a fireplace in a dwelling. It notified the owners of the danger but failed to take action to require its rectification or advise new owners of the problem. A fire destroyed the premises when it was occupied by a tenant. The Court

[134] Seqwater subs at [381(a)].
[135] T 9504.24.
[136] *Robinson v Chief Constable of West Yorkshire Police* at [69].
[137] *Stuart* at [127] to [130].
[138] At [91].

unanimously held that a duty of care was owed by the Council to the new owners[139] and a majority, Brennan CJ, Gummow and Kirby JJ, held that it owed a duty of care to the tenants.[140] In concluding that a duty of care was owed, Gummow J reasoned:[141]

> "The Shire had statutory powers, exercisable from time to time, to pursue the prevention of fire at No 70. This statutory enablement of the Shire "facilitate[d] the existence of a common law duty of care" [citing *Sutherland Shire* v *Heyman*], but the touchstone of what I would hold to be its duty was the *Shire's measure of control of the situation including its knowledge, not shared by* [the tenants] *or by* [the owners]*, that, if the situation were not remedied, the possibility of fire was great and damage to the whole row of shops might ensue*. The Shire had a duty of care "to safeguard others from a grave danger of serious harm", in circumstances where it was "responsible for its continued existence and [was] aware of the likelihood of others coming into proximity of the danger and [had] the means of preventing it or of averting the danger or of bringing it to their knowledge"." (citations omitted unless specified; emphasis added)

77 The Council in *Pyrenees Shire Council* did not create or increase the risk of harm. It did not light the fire. Nevertheless, its "control" over the risk, measured by its statutory powers and functions and by its knowledge of the particular risk, coupled with the vulnerability of the owners and the tenants, who had no such knowledge, warranted the imposition of the duty.

78 Similarly in *Crimmins*, Gleeson CJ, Gaudron, McHugh, Kirby and Callinan JJ held that a statutory body with responsibility for the regulation and discipline of casual labour on a waterfront owed a duty to take reasonable care to protect such employees from reasonably foreseeable risks of injury arising from their employment by registered stevedores, which included the risks of handling asbestos.[142] The statutory authority did not introduce the asbestos, did not direct that it be handled and did not employ the labourers. Nevertheless, Gaudron J held:[143]

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[139] *Pyrenees Shire Council* at [28]-[29] per Brennan CJ; at [81] per Toohey J; at [115] per McHugh J; at [168]-[170] per Gummow J; at [255] per Kirby J.
[140] *Pyrenees Shire Council* at [28]-[29] per Brennan CJ; at [171] per Gummow J; at [256] per Kirby J.
[141] At [168].
[142] At [3] per Gleeson CJ; at [43]-[46] Gaudron J; at [104], [112] per McHugh J; at [236] per Kirby J; at [360] per Callinan J.
[143] At [46].

> "Given the *vulnerability* of the late Mr Crimmins, the knowledge the Authority had or should have had, and *its position to control or minimise the risks* associated with the handling of asbestos, there was, in my view, a relationship between Mr Crimmins and the Authority giving rise to a duty of care on the part of the Authority to take those steps, short of making binding orders, which, in the circumstances, a reasonable authority with its powers and resources would have taken to avoid foreseeable risk of injury as a result of exposure to asbestos" (emphasis added)

79 Even accepting Seqwater's characterisation of the plaintiff's case as the assertion of "a positive duty to confer benefits", the nature of the risk, the degree of control and the vulnerability of the affected class of persons were still such as to warrant the imposition of a duty in the form pleaded on those who had the capacity to exercise, and otherwise exercised, control over Wivenhoe Dam outflows, namely Seqwater and the flood engineers.

UCC v ESB and Ibrahimi v Commonwealth

80 Seqwater placed great reliance on the analysis of the Irish Court of Appeal in *University College Cork – National University of Ireland v Electricity Supply Board* [2018] IECA 82 ("UCC v ESB"), a case in which the defendant operated dams that generated hydroelectricity on the River Lee. During a period of severe storms releases were made but they did not exceed peak inflows.[144] The plaintiff suffered flooding to its building downstream. It was accepted that the defendants owed a duty of care in respect of two risks, namely dam failure and flooding from outflows that exceeded inflows.[145] However, beyond that, the Irish Court of Appeal found that there was no duty of care to avoid "unnecessary flooding".[146]

81 Four matters should be noted about *UCC v ESB*. First, part of their Honours' analysis included the general proposition to the effect that the "common law does not generally impose liability for pure omissions without just cause".[147] Their Honours cited Brennan J in *Sutherland Shire Council* supra.[148] However, of most significance is their Honours' analysis of cases from the

[144] At [2].
[145] At [9].
[146] At [306(iv)].
[147] At [83].
[148] At [84].

United States in relation to “single purpose dams”. Their Honours noted the effect of the US decisions which adopted the principle that “[s]ince the Dam and Reservoir *were not created for flood control*, the *Iodice*[149] rule governs; the only duty imposed on [the] Defendant is to avoid making the flooding worse than it would be under natural conditions”.[150] Thus, in *UCC v ESB*, their Honours concluded:[151]

> “The standard of not worsening nature has been adopted in other jurisdictions in respect of *single purpose dams*, but that is what this dam is also. It is not a multipurpose dam. It is a separate question whether ESB has, by its words or conduct, assumed or accepted a legal liability that can be invoked by downstream occupiers, but that is not to be confused with the legal question arising from the nature of the dam. The trial judge correctly rejected the suggestion that this was a multipurpose dam.” (emphasis added)

82 In *UCC v ESB*, the dams in question had a single statutory mandate, namely the production of hydroelectricity.[152] Hence, it was a “single purpose dam”. As noted, it was common ground in this case that Wivenhoe and Somerset Dams are dual purpose dams, with one of those purposes being flood mitigation.[153]

83 Second, in *UCC v ESB* their Honours concluded that the prioritisation of flood mitigation was inconsistent with the statutory purpose of prioritising electricity generation which precluded the existence of any duty of care in respect of the former.[154] The issue of coherence and incompatibility is addressed below but it suffices to state there is no statutory counterpart to that provision in this case. Instead the Manual prioritises dam safety and flood mitigation.

84 Third, the content of the formulated duty of care in *UCC v ESB* was said to be a duty to prevent “unnecessary flooding” which was criticised as “wholly vague, impractical and ... necessarily retrospective”[155] and not reflected in the

[149] *Iodice v State of New York*, 247 App. Div. 647
[150] At [154].
[151] At [159].
[152] At [140].
[153] Agreed Facts, AID.500.028.00019 at [52] (Somerset Dam) and at [55], [60] and [74] (Wivenhoe Dam).
[154] At [142].
[155] At [193].

relevant water control manual.[156] No equivalent criticism, or at least no such valid criticism, was made in this case.

85 Fourth, in determining whether a duty of care existed, the Court in *UCC v ESB* applied other Irish decisions, which in turn adopted the test in *Caparo Industries PLC v Dickman* [1990] 2 AC 605 ("Caparo").[157] *Caparo* does not represent the law of Australia.[158]

86 In an email sent after (the first round of) oral submissions concluded in December 2018 (and with the agreement of the other parties)[159], Seqwater drew the Court's attention to the judgment of the Court of Appeal in *Ibrahimi v Commonwealth of Australia* [2018] NSWCA 321 ("Ibrahimi"). In *Ibrahimi*, Payne JA (with whom Meagher and Simpson JJA agreed) upheld a finding of the trial judge that the Commonwealth of Australia did not owe a duty of care to, inter alia, asylum seekers aboard a boat that foundered off rocks near Christmas Island to "take reasonable care in the exercise of its powers and deployment of its resources in conducting [an] interception operation, so as to avoid foreseeable risk of physical injury, death and property damage".[160]

87 In *Ibrahimi*, Payne JA identified the relevant risk of harm as the risk of shipwreck.[161] His Honour noted that the actions of the Commonwealth did not cause or materially increase that risk,[162] that the relevant affected persons were not relevantly "vulnerable" because they were able "to protect themselves from the risk of shipwreck by not embarking on the journey"[163] and the capacity of the Commonwealth to take action to protect that class from the risk was "too remote to constitute legal or practical 'control'".[164] *Ibrahimi* is an illustration of how a consideration of the salient features approach yields a finding that a duty of care should not be imposed in what

[156] At [61].
[157] *UCC v ESB* at [54].
[158] *Sullivan v Moody* (2001) 207 CLR 562; [2001] HCA 59 at [49]; "Sullivan v Moody".
[159] Email sent by Seqwater on Friday, 4 January 2019 at 11.11am.
[160] At [157] and [259].
[161] At [233].
[162] At [207].
[163] At [232] to [233].
[164] At [237].

was in effect a "rescue case".[165] The finding that the actions of the Commonwealth did not cause or increase the risk of harm was not treated as determinative but, when considered with the absence of control and vulnerability in the relevant sense, warranted a finding that there was no duty owed. *Ibrahimi* is an instance in which a different configuration of salient features yields a different conclusion to this case.

Statutory Power Directed to an Identified Class or Individual

88 Seqwater sought to deploy the following passage from the judgment of Hayne J in *Brodie* in support of its contention that no duty was owed:[166]

> "Ordinarily, the more general the statutory duty and the wider the class of persons in the community who it may be expected will derive benefit from its performance, the less likely is it that the statute can be construed as conferring an individual right of action for damages for its non-performance. In particular, a statutory provision giving care, control and management of some piece of infrastructure basic to modern society, like *roads*, is an unpromising start for a contention that, properly understood, the statute is to be construed as providing for a private right of action." (emphasis added)

89 Seqwater contended that the various provisions of the *Restructuring Act* suggest that the performance of statutory functions "was intended to be for the benefit of the community generally" and not intended "to be performed for the benefit of a particular class or group".[167]

90 I do not accept this submission for three reasons. First, Seqwater's submissions are predicated on the assumption that the conduct of flood mitigation functions at Wivenhoe and Somerset Dams was the exercise of the function conferred by s 9(2) of the *Restructuring Act*, a proposition rejected in Chapter 2.[168] Second, even if such a function was conferred, this would form at most only part of the necessary analysis, which would also need to embrace the statutory vesting of ownership and control in the particular dams in question, namely Wivenhoe and Somerset Dams. Thus, the combination of conferring a function of flood mitigation and ownership of a particular dam

[165] At [237].
[166] At [326].
[167] Seqwater subs at [302].
[168] Chapter 2 at [14].

would be for the benefit of a class of people, namely persons who owned physical or personal property that, due to its proximity to the Brisbane River and elevation, were susceptible to inundation by "over the floor" flooding (or greater flooding). In contrast, even though they are part of the public at large, the property owners and residents of Surfers Paradise, Townsville or Gladstone derive no particular benefit from the conduct of flood operations at Wivenhoe and Somerset Dams and were not susceptible to such flooding even if flood operations were conducted negligently. Third, it is material that Hayne J was in dissent in *Brodie*. Consistent with the passage cited above at [65] from *Graham Barclay Oysters*, the vesting of control over infrastructure was in fact treated by the majority in *Brodie* as a promising start to the imposition of a duty.[169]

Coherence and Inconsistency

91 Where a suggested duty of care, if imposed, would give rise to obligations inconsistent with a statute, that will "ordinarily be a reason for denying that the duty exists".[170] One aspect of the concept of coherence is that "[a] duty of the kind alleged should not be found if that duty would not be incompatible with other duties which the respondents owed."[171] Where there is no such inconsistency but nevertheless a tension between the statutory scheme and the posited duty, then that tells against the existence of such a duty, although all the salient features must be considered.[172]

92 In its submissions, Seqwater identified three forms of inconsistency or incoherence said to deny, or at least weigh heavily against, a finding that the posited duty existed.

[169] *Brodie* at [102] to [103] and [150] per Gaudron, McHugh and Gummow JJ; at [243] and [249] per Kirby J in agreement.
[170] *Sullivan v Moody* at [60].
[171] *Sullivan v Moody* at [55].
[172] *Dansar Pty Ltd v Byron Shire Council* (2014) 89 NSWLR 1; [2014] NSWCA 364 at [161] to [164] per Meagher JA, with whom Leeming JA agreed at [191] to [192]; "Dansar"; Leeming, supra at 30 to 31.

93 The first was that the posited duty was supposedly "[i]nconsisten[t] with a statutory obligation to prioritise the safety of the dams".[173] This statutory obligation was said to derive from the dam safety conditions imposed under s 355 and s 356 of the *Safety and Reliability Act*, which made the gate operating conditions in the Manual part of the conditions attaching to the development permit.[174] While it may be that the objective of those conditions extends beyond preserving the safe operation of the dam and into preserving the structural safety of the dam,[175] those provisions do not create any statutory duty to prioritise "the safety of the dams" such that the suggested inconsistency between the posited duty and the statute does not arise. Instead, the gate safety conditions simply represent an operating constraint within which any such duty had to be discharged. Seqwater conceded that, if the constraints only related to the manner in which gates were opened, then no inconsistency arose.[176] However, even if there was such a statutory command reflecting the Manual's priorities, that would still not give rise to any inconsistency or even any tension. To the contrary, the prioritisation of dam safety is completely consistent with and reinforces the posited duty. The Manual states that the "structural failure of Wivenhoe Dam would have catastrophic consequences" and a failure of Somerset Dam "could" have such consequences.[177] Thus, avoiding a failure of either dam is the ultimate form of flood mitigation. Conducting flood operations to avoid that outcome is the first aspect of complying with the posited duty, although it does not exhaust it.

94 The second form of inconsistency or incoherence pointed to by Seqwater was that the posited duty was said to create a real risk of Seqwater's statutory functions being distorted or impaired.[178] The written submissions in support of this ground did not specify the statutory function or provision that was said to be compromised by the posited duty.[179] Presumably it was the flood mitigation function Seqwater contended was conferred by s 9(2) of the *Restructuring*

[173] Seqwater subs at [314(a)] and [315] to [324].
[174] Chapter 2 at [24] to [29].
[175] See T 9560.43 to T 9561.41.
[176] T 9567.32.
[177] Manual at 9.
[178] Seqwater subs at [314(b)] and [325] to [334].
[179] Ibid at [325] to [334].

Act. As noted, I have already found that function was not conferred but, even if it was, a duty to exercise reasonable care in the conduct of flood operations at a particular dam to avoid the Risk of Harm to Property and the Risk of Interference with the Use and Enjoyment of property is neither incompatible or even in tension with a statutory provision that does no more than provide a bare conferral of the function in the first place. To the contrary, "the well-settled principle [is that] when statutory powers are conferred, they must be exercised with reasonable care".[180]

95 The third form of inconsistency and incoherence said to arise from the imposition of the posited duty was between duties owed to different members of the community or affected class.[181] Both SunWater[182] and the State[183] made similar submissions. Seqwater contended that, as the posited duty extends to a very large group of people, they would have "competing and conflicting interests in how the duty is discharged".[184] As the argument was developed, the form of inconsistency identified was a locational inconsistency, that is a conflict between the "interests" of different persons at different locations downstream of Wivenhoe dam.[185] Hence the example given was a flood engineer determining to release an amount of water immediately that would flood residents at one location in an endeavour to avoid forecast rain forcing much larger releases at a later time that would flood residents at other locations.[186] SunWater made the same point and also referred to the interests of persons and businesses that might be flooded by flow rates below 4000m^3/s, as referred to in the damages curve spreadsheet sent to Mr Ayre by the Brisbane City Council early on the morning of 11 January 2011.[187] This

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[180] *Caledonian Collieries Ltd v Speirs* (1957) 97 CLR 202; [1957] HCA 14 at 220; "Caledonian Collieries".
[181] Seqwater subs at [314(c)].
[182] SunWater subs at [2519] to [2549].
[183] State subs at [616].
[184] Seqwater subs at [335].
[185] T 9566.31.
[186] T 9566.21.
[187] SEQ.004.045.0662; SunWater subs at [2531] to [2532].

spreadsheet reflected the outcome of the 2007 study on levels of flood damage in Brisbane City, as set out in Figure 4-3 of Chapter 4.[188]

96 The plaintiff contended that this submission was misconceived for two related reasons. First, it submitted that an inconsistency or incoherence could only arise from a comparison of the posited duty to another existing or accepted legal duty, whereas Seqwater's argument was said to raise the possibility of competing interests as a basis for rejecting the existence of *any* legal duty on Seqwater.[189] Second, it was submitted that the form of inconsistency identified by Seqwater and SunWater is no more than an issue that is to be taken into account at the breach stage, rather than as a basis for concluding that no duty exists. Thus in *Wyong Shire Council v Shirt* (1980) 146 CLR 40; [1980] HCA 12 at 47-48, Mason J described the approach in determining whether there was a breach of duty as an inquiry into what "a reasonable man would do by way of response to the risk" which "calls for a consideration of the magnitude of the risk and the degree of the probability of its occurrence, along with the expense, difficulty and inconvenience of taking alleviating action and *any other conflicting responsibilities which the defendant may have*."

97 Subject to addressing the cases noted below, the various instances of inconsistency and incoherence identified in the case law supports the plaintiff's contention in that they concern a comparison between the posited duty and an existing or accepted legal duty.[190] However, the starting point in the analysis is to correctly identify the posited duty before turning to address whether it is either internally incoherent or inconsistent with an existing legal obligation in the relevant sense. The contention made by Seqwater may not evince an inconsistency or demonstrate incoherence in the sense discussed in *Sullivan v Moody* and the other authorities, but it may nevertheless reveal that the duty is formulated incorrectly. However, in this case, the defendants' contentions proceed on an incorrect premise about the nature and content of

[188] At [117].
[189] Citing *Sullivan v Moody* at [60]; Plaintiff subs at [110].
[190] *Sullivan v Moody* (inconsistent with the statutory duties of medical practitioners and social workers); *Hunter and New England Local Health District v McKenna* (2014) 253 CLR 270; [2014] HCA 44 (inconsistent with statutory responsibility imposed on hospitals and doctors); see also [102] to [108].

the posited duty. In explaining the supposedly inconsistent obligations that might be imposed on a flood engineer, Senior Counsel for Seqwater contended that "they [the flood engineers] would be under an obligation to operate the dam in a way which *protects people at each location* where the duty is owed".[191] Similarly, both SunWater and the State asserted that a discharge of the duty to some persons might be a breach of the duty owed to someone else.[192] However, even though the posited duty must be owed to each member of the relevant class,[193] the posited duty that is owed to each class member is not a duty to "protect [them] at each location", such that a discharge of the duty at one location is breach of the duty somewhere else. Instead, it is a single duty owed to all of them to exercise reasonable care in the conduct of (flood) operations at the dam to avoid or minimise the Risk of Harm to Property and the Risk of Interference with Use and Enjoyment of property.

98 As both of the passages from *Wyong Shire Council v Shirt* and *Sullivan v Moody*[194] relied on recognise, a person who owes a tortious duty to another person can be subject to competing duties or responsibilities. Even if a tortious duty is imposed, there remains the possibility that, in discharge of the duty, action might be taken by the person who owes the duty that has an adverse outcome for a person to whom the duty is owed (or one or more members of the class to whom it is owed). The "interest" or "entitlement" of the latter is only that reasonable care be taken in the conduct of the relevant activity to avoid or minimise the risk of harm eventuating. The duty is not strict in that it is not a guarantee that harm will not eventuate and it is not a fiduciary duty in that, unlike a fiduciary duty, competing obligations can and in some circumstances must be considered.[195]

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[191] T 9566.3.
[192] SunWater subs at [2549]; State subs at [616].
[193] *Agar v Hyde* (2000) 201 CLR 552; [2000] HCA 41 at [66] to [67].
[194] At [60].
[195] See *Wyong Shire Council v Shirt* supra and *Breen v Williams* (1996) 186 CLR 71 at 93; [1996] HCA 57 per Dawson and Toohey JJ; at 110 per Gaudron and McHugh JJ.

99 Thus, to use an example deployed by the plaintiff,[196] it is indisputable that a driver of a motor vehicle owes a duty of care to other road users, pedestrians and owners of property adjacent to the road to avoid or minimise the risk of physical injury and damage to property. If a child runs onto the road a driver might be faced with a choice of swerving left to damage a fence on one side of the road or swerving right to damage a car parked on the other side of the road. At no point would the driver cease to owe either property owner (or anyone else) a duty of care, although the conclusion may be that the driver did not breach that duty to the owner of the fence if they swerved left or the owner of the parked car if they swerved right. The duty owed to the fence owner and the duty owed to the owner of the parked car is the same single duty of care and no question of distinct competing duties (or possible duties) arises. In its submissions, SunWater contended that this example does not assist because the duty of care owed by a road user falls into an established category of duty, whereas the present case concerns a novel duty.[197] However, that is not a relevant point of distinction given that the entire approach to this area of the law involves incremental development "by analogy with established categories".[198] A different type of incoherence would emerge if different standards applied to novel duties as compared to established categories.

100 In this case, each of the persons to whom the duty was owed did not have the "benefit" of any obligation imposed on Seqwater or the flood engineers to "protect [their property] at [their] location".[199] Instead, they had the "benefit" of an obligation imposed on Seqwater and the flood engineers to exercise reasonable care in the conduct of (flood) operations at the dam to avoid or minimise the Risk of Harm to Property and the Risk of Interference with Use and Enjoyment of property. If that duty was discharged then the fact that a particular property owner was not "protect[ed] … at [their] location" was immaterial. Otherwise, to the extent that there was a conflict between considering types of damage and degree of inconvenience downstream, that

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[196] Plaintiff subs at [114].
[197] SunWater subs at [2506].
[198] *Sutherland Shire Council v Heyman* at 481.
[199] T 9566.3; see at [97].

was able to be resolved at breach stage by reference to the Manual, especially its priorities and the other evidence.[200] It is to be addressed in a context where the determinant of what location is flooded, if any, is largely a function of the combined flow rate at a particular location and time. Thus, for example, while acknowledging that the Manual nominates 4000m^3/s as the "upper limit of non-damaging floods downstream", SunWater contended that the "Manual does not say for example that [in] operating in W3 the interests of persons flooded at 4000m^3/s are to be preferred to those flooded at 2000m^3/s".[201] To the contrary, the Manual says exactly that. It prioritises the avoidance of urban flooding over inundation of downstream bridges and designates a downstream flow rate of 4000m^3/s as the point where the former commences.

101 Otherwise, three decisions relied on by the defendants should be noted.

102 First, there is *UCC v ESB*. As already noted, one part of the reasoning for the finding of no duty in that case was that the posited duty was inconsistent with the statutory prioritisation of electricity production.[202]

103 Second, Seqwater placed great reliance on *Southern Properties (WA) Pty Ltd v Executive Director of the Department of Conservation and Land Management* (2012) 42 WAR 287 ("Southern Properties"). In *Southern Properties*, the plaintiffs complained about a prescribed burn undertaken pursuant to various provisions of the *Conservation and Land Management Act 1984* (WA) statute in advance of the fire season. The burn was said to have been undertaken carelessly in a manner that caused smoke damage to the plaintiffs' grape crop. The posited duty of care was said to be owed to neighbouring land owners and concerned the escape of "fire, smoke or ash" from the prescribed burn.[203] The "primary purpose" of the burn was "to materially reduce the destructive impact of wildfires".[204] It was "clear from the

[200] Cf Seqwater subs at [328].
[201] SunWater subs at [2529].
[202] See [83] above.
[203] At [77].
[204] At [100].

statutory language and its scope and purpose that the objective of minimising the risk of smoke from a prescribed burn …[was]… subsidiary to the primary objects of the power" (ie, reducing the impact of wildfires).[205] It was conceded that a duty of care was owed in respect of the escape of fire during such a burn.[206]

104 A majority (McClure P and Buss JA agreeing; Pullin JA dissenting) held that no duty was owed. McClure P rejected the posited duty on the basis that, inter alia, it was incompatible with the "primary objects of the power".[207] Her Honour added:[208]

> "Further, it is of particular significance that the Department exercises its powers in relation to prescribed burning for the benefit of the south-west community as a whole. Different classes of interested parties and even individuals within classes will have interests which are in conflict. For example, *minimising the risk of <u>smoke</u> over the appellants' vineyards increased the risk of <u>fire</u>* escaping over the western boundary of DPHB8 where there are residential dwellings." (*emphasis added*)

105 McClure P then addressed an alternative formulation of the duty set out by Pullin JA namely, "a duty … to take reasonable care to avoid the reasonably foreseeable risk of smoke damage to the grape growers' grapes".[209] In relation to that formulation, her Honour stated:[210]

> "The question is whether the Department owes a duty to grape growers in the Donnelly District to take reasonable care to avoid the reasonably foreseeable risk of smoke damage to the grape growers' grapes. The answer is no for a number of reasons. First, grape growers as a class form a subset of a much wider class, or group of classes, *all of which are potentially affected by the Department's exercise of its statutory functions in connection with a single prescribed burn*, many of which will have different and often conflicting interests to grape growers. Indeed, a single prescribed burn may also generate conflicts of interest within the class of grape growers. The best interests of a vigneron whose grapes are not at risk of <u>smoke</u> taint from a particular prescribed burn may be in reducing the risk of destruction of its income producing assets from an *uncontrollable <u>wildfire</u>*<u>.</u>

[205] At [102].
[206] At [94].
[207] At [102].
[208] At [103].
[209] At [106].
[210] At [106] to [107].

> Secondly, the duty is to avoid the risk of smoke damage to grapes. The only way the risk can be avoided is to not carry out a prescribed burn anywhere in the Warren region when there is a not insignificant risk of smoke damage to the grapes on one or more of the 60 vineyards in the region. *That outcome is incompatible with the primary purposes of the Department's powers and duties* and with its duty to perform its statutory functions in the best interests of the community as a whole." (*emphasis added*)

106 Seqwater relied on these passages as rebutting the plaintiff's contentions that an inconsistency or incoherence only arises where it is suggested that the posited duty is inconsistent with an existing legal duty. Instead it was suggested that these passages suggested that conflicting interests between different sub-groups within an identified class are sufficient to rebut the duty "even though there was not an existing duty to others".[211] I reject that contention. In the passage extracted in [104] above, the relevant inconsistency that McClure P identified was between a duty to minimise the risk of smoke generally and the conceded duty of care in respect of uncontrollable wildfire. In the passage extracted in [105] above, the relevant inconsistency that her Honour identified was between the statutory obligation to prioritise fire reduction and the posited duty reformulated by reference to smoke damage to grape growers' grapes. Her Honour explained that the refinement of the duty and the class of persons to whom it was owed did not remove the inconsistency between the posited duty and the statutory scheme even in respect of the narrower class of people who benefitted from the protection of the refined duty.

107 Thus, *Southern Properties* was a case where the statutory scheme and factual circumstances differentiated between the treatment of the risks presented by smoke and fire. The statutory scheme prioritised managing fire over smoke. From that, it followed that there were statutory and common law duties in respect of fire and those duties excluded any common law duty in respect of smoke, however formulated. *Southern Properties* is not authority for the proposition asserted by Seqwater.[212]

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[211] Seqwater subs at [338(a) and (b)].
[212] The same applies to *Regent Holdings Pty Ltd v State of Victoria* [2013] VSC 601; cf Seqwater subs at [338(a)].

108 Third, in contending that the "diverse and irreconcilable interests of the various property owners" gave rise to the circumstance that no duty of care was owed,[213] SunWater relied on the following passage from *Electro-Optic Systems*:[214]

> "This is because an exercise of reasonable care on the part of an incident controller *exercising powers* under the Rural Fires Act to deal with a fire might involve sacrificing one property to a fire to preserve others. It might involve destroying a property by burning it out to save others. It might involve directing a person to stop trying to save their property in order to save the person from a risk of harm. It might involve commandeering one property's water supply for some other purpose seen to be more important at the time which, if available to that property, might have saved it from fire. If a person in the position of incident controller fighting a fire owed a duty of care to individual property owners to protect their property from damage, *then there would be a real risk of the functions of the incident controller under the Rural Fires Act being distorted and impaired*. There would be a real risk that the incident controller may favour the protection of private property over public property, or favour the protection of property over the safety of persons, or favour the protection of one property over another based not on an overall assessment of how best to control or suppress a fire but on the likelihood of a property owner suing or the value of one property compared to another. The effect of such a duty of care to individual property owners is potentially invidious. These are strong indications against the existence of any such duty of care." (emphasis added)

109 This passage is not authority for the proposition that due to the (potentially) disparate interests of different property owners at different locations no legal duty is owed to any of them. Instead, it is an example of an attempt to impose a duty of care that was either inconsistent with, or had the tendency to distort and impair the exercise of, statutory powers and responsibilities conferred by the *Rural Fires Act 1997* (NSW).

110 For the reasons stated above I reject the contention that the posited duty is inconsistent or incoherent with any existing obligation or cannot be sustained because it creates inconsistent obligations as between the persons to whom the duty is owed.

[213] SunWater subs at [2504].
[214] At [340] per Jagot J; SunWater subs at [2503].

Duty to Exercise Statutory Power in the Period Prior to 6 January 2011

111 One part of Seqwater's submissions on duty addressed the period from 2 to 6 January 2011 when flood operations ceased.[215] Seqwater contended that the plaintiff's complaint about that period was "properly characterised as a complaint about a failure to exercise a discretionary statutory power".[216] Seqwater contended that this meant it was encompassed within the "general rule" stated by Mason J in *Sutherland Shire Council* that "[g]enerally speaking, a public authority which is under no statutory obligation to exercise a power comes under no common law duty of care to do so".[217]

112 I reject these submissions for three reasons. First, it is notable that they do not identify the "discretionary statutory power" that was said not to be invoked. The only possible statutory provision that these submissions could be referable to was s 9(2) of the *Restructuring Act*, which I have found was not applicable but, even if it was, that is not a "discretionary statutory power".

113 Second, for the reasons already stated, it is not accurate to characterise the plaintiff's pleaded case as a failure to exercise any such power or function. It is true, as Seqwater submits,[218] that the 5ASOC pleads that flood operations were discontinued on 2 January 2011,[219] the FOC was mobilised on 6 January 2011,[220] releases resumed again on 7 January 2011[221] and that in the meantime the flood engineers failed to take various steps.[222] However, the 5ASOC also pleads that flood operations were conducted up to 2 January 2011[223] and, in breach of the Manual and the various duties of care, that they ceased on 2 January 2011 when the dams were above FSL.[224] It also pleads that the water continued to accumulate above FSL during that period while

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[215] Seqwater subs at [342] to [364].
[216] Ibid at [358].
[217] At 459 to 460.
[218] Seqwater subs at [358].
[219] 5ASOC at [206].
[220] Ibid at [239].
[221] Ibid at [257].
[222] Chapter 12, sections 12.5 to 12.8.
[223] 5ASOC at [184] to [191] and [196] to [206].
[224] Ibid at [207] and [211].

releases were only made through the regulators with gates closed[225] and that the Manual commanded that flood operations resume.[226]

114 For the reasons already stated this is not properly characterised as an "omission".[227] Instead, it was a form of management, albeit inadequate, of the flood. In *Pyrenees Shire Council*, Gummow J referred to *Caledonian Collieries* and continued:[228]

> "A public authority which enters upon the exercise of statutory powers with respect to a particular subject matter may place itself in a relationship to others which imports a common law duty to take care which is to be discharged by the continuation or additional exercise of those powers. *An absence of further exercise of the interconnected statutory powers may be difficult to separate from the exercise which has already occurred and that exercise may then be said to have been performed negligently*. These present cases are of that kind. They illustrate the broader proposition that, whatever its further scope, Lord Atkin's formulation in *Donoghue v Stevenson* includes 'an omission in the course of positive conduct ... which results in the overall course of conduct being the cause of injury or damage'." (emphasis added, citations omitted)

115 This passage is apposite to the operation of the dams in January 2011. Although I have not accepted that s 9(2) of the *Restructuring Act* conferred on Seqwater a statutory function, the operation of the dams, including flood operations, nevertheless involved the exercise of at least the statutory permission granted by the ROL and the conferral of a form of authority to control the dam on the flood engineers by the Manual. This combination of authority and permission might not answer the description of "interconnected statutory powers" but it is similar. Putting that aside, the conduct of flood operations up to 2 January 2011 and then the operation of the dam for a four-day period thereafter in a manner which allowed inflowing flood waters to accumulate in the dams above FSL is either an instance of, at least analogous to, an "an omission in the course of positive conduct ... which results in the overall course of conduct being the cause of injury or damage."

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[225] 5ASOC at [218] to [222].
[226] Ibid at [223] and [226].
[227] See [73] to [74] above.
[228] At [177].

116 Third, one of the exceptions noted to the principle stated by Mason J in *Sutherland Shire Council v Heyman* noted above was where an "authority's occupation of premises … or its ownership or control of a structure in a highway or of a public place … attracts to it a duty of care".[229] This exception corresponds to the statement of McHugh J in *Graham Barclay Oysters* noted above (at [65]) and is itself reflective of the proposition that control of such infrastructure in these circumstances undermines any attempt to characterise a failure to properly operate the asset as a mere "omission".

Making Releases Below FSL

117 Seqwater submitted that it did not have a duty to consider making, much less to actually make, releases below FSL for the purposes of flood mitigation.[230] Seqwater advanced three reasons in support of that contention. First it contended that such releases were prohibited,[231] a proposition rejected in Chapter 5.[232]

118 Second, Seqwater submitted it "cannot be subjected to a duty of care in tort in respect of core policy making or quasi-legislative activities".[233] Seqwater embraced the plaintiff's submission that the question of whether to make releases below FSL was a matter of policy.[234] Accordingly, Seqwater submitted:[235]

> "Whether to release water below the FSLs of the dams and, if so, when and to what extent, are core policy making or quasi-legislative activities. They impinge upon the FSLs set by statutory instrument. And they involve setting (or re-setting) the balance between water supply security and flood mitigation.
>
> These are not matters that can be the subject of a duty of care in tort. They are matters to be addressed by the parliament or the executive, not engineers working in real time in managing a flood event."

[229] At 460.
[230] Seqwater subs at [365].
[231] Ibid at [366].
[232] At [197].
[233] Citing *Sutherland Shire Council* at 442 and *Crimmins* at [93] per McHugh J Seqwater subs at [367] to [375].
[234] Eg plaintiff subs at [52].
[235] Seqwater subs at [374] to [375].

119 I agree that the threshold question of whether or not releases below FSL can be made for flood mitigation purposes is a matter for the Executive Government and not for the flood engineers. It follows from the findings in Chapter 5 that the relevant policy decision was that such releases could be made. This policy decision finds expression in the approval granted under section 13 of the Moreton ROP[236] and the approval of the Manual[237], the combined effect of which made the objective of retaining water at FSL at the conclusion of the flood event subordinate to flood mitigation objectives.[238] Both of those decisions were made by the Executive Government and not by the flood engineers.

120 Third, Seqwater contended that a duty of care which required "substantial releases below the dams' FSLs from 2 January … would be difficult to reconcile with Seqwater's contractual obligation under the Grid Contract to use its best endeavours to minimise 'release losses'" and that a breach of that obligation would also constitute a breach of the Market Rules.[239] These provisions are addressed in Chapter 5. As noted,[240] the obligations in the Grid Contract are all subject to clause 24.1 which would enable releases below FSL if that was necessary for the purpose of flood mitigation. Otherwise, to characterise the duty as "requiring substantial releases below the dams FSL's" confuses the formulation of the duty with what may be required for its discharge in a particular circumstance. Consistent with the passage from *Wyong Shire Council v Shirt* set out above and s 9(1)(c) of the *CLA* (Qld), the necessity to address the potential impact of releasing water on the water supply is a competing obligation that arises at the breach stage and not at the point of determining whether a duty is owed.[241] The analysis in Chapter 10 and Chapter 12 proceeds on that basis.

[236] Chapter 5 at [24] to [73].
[237] Chapter 4 at [157].
[238] Chapter 5 at [200].
[239] Seqwater subs at [379] to [380].
[240] Chapter 5 at [79].
[241] Cf State subs at [617].

The Flood Engineers

121 Seqwater contended that, even if it was held that Seqwater owed a duty of care, the same conclusion would not follow in relation to Messrs Tibaldi and Malone because they were subject to personal constraints, "such as their obligation to their employer to comply with the Manual, which in turn entailed an obligation to follow the general strategy determined by the SFOE and to give priority to dam safety over protection against urban inundation".[242] This was said to raise the "spectre of yet further inconsistent obligations", with the example being "if the SFOE set a general strategy which would sacrifice one sub-group within the class, Messrs Tibaldi and Malone would be under a duty to their employer to follow that strategy even if it was inconsistent with a duty owed personally by Messrs Tibaldi and Malone *to members of that sub-group to protect the sub-group from flooding*".[243] This was said to emphasise the lack of control of the flood engineers over the interests of group members and a consequential lack of vulnerability of the latter to the negligent performance of their duties by the former.[244]

122 Again, these submissions proceed on the same misconstruction of the posited duty as noted above, namely that it was a duty to protect a sub-group from flooding. Instead the posited duty was to exercise reasonable care in the conduct of dam and flood operations in circumstances where the content of that duty involved compliance with the Manual.[245] The manner in which the Manual delineated between the SFOE and the DFOE has been addressed in Chapters 3, 6 and 7 and there is nothing to suggest any potential or actual conflict between Messrs Tibaldi and Malone's position as employees of Seqwater and their roles as flood engineers. As noted, Seqwater subjected itself to the Manual. During and in anticipation of flood events they ceded control of gate operations at the Dams to the flood engineers in accordance with the Manual as the price for obtaining protection under s 374(2) of the *Safety and Reliability Act*. Consistent with the Manual, the flood engineers

[242] Seqwater subs at [471(a)].
[243] Ibid at [471(b)].
[244] Ibid at [471(c)].
[245] See Chapter 3 at [2]; fn 2 and Chapter 12, section 12.1.

acquired and exercised the capacity to control the dams, specifically the capacity to end a flood event, to declare a flood event and to direct gate openings and closings as part of flood operations.[246] Otherwise, there is nothing unusual about an employed professional owing a duty of care in their own right. To the extent each flood engineer acquired from time to time the capacity to individually or jointly end a flood event, declare a flood event and conduct flood operations, they were subject to the posited duty.

Conclusion

123 I accept the plaintiff's contention that each of Seqwater and the flood engineers owed a duty to take reasonable care in the conduct of flood operations at both dams to avoid or minimise the Risk of Harm to Property and the Risk of Interference with Use and Enjoyment of property. So far as the scope of that duty is concerned, in the case of the flood engineers, it relates to those periods they could exercise control over dam releases under the Manual including the capacity to declare a flood event, to end a flood event and conduct flood operations.

11.3: Seqwater's (Alleged) Non-Delegable Duty of Care

124 The plaintiff submitted that Seqwater not only owed a duty to take reasonable care in the conduct of flood operations at both dams to avoid or minimise the Risk of Harm to Property and the Risk of Interference with Use and Enjoyment of property, it also pleaded and submitted that the duty was "non-delegable"; ie, a duty to ensure that reasonable care was taken including by any flood engineer conducting flood operations.[247] This non-delegable duty was said to arise either from its status as the owner and occupier of the dams or from the fact that it was the recipient of a licence entitling it to interfere with the flow of the Brisbane River to conduct flood operations at the dams. The practical significance to this case of a finding that Seqwater owed a non-delegable duty of care as opposed to an "ordinary" duty of care is that, in the case of the former, it would not be able to avoid liability for any failure of any flood

[246] Manual at 5 (clause 2.2) and 6 (clause 2.4).
[247] 5ASOC at [144(b)] and [145]; Plaintiff subs at [68] to [100].

engineer to take reasonable care in respect of whom it was not vicariously liable.[248] Neither Mr Ayre nor Mr Ruffini were employees of Seqwater.

Non-Delegable Duty – Occupier of Land

125 In relation to the first basis relied on to found a non-delegable duty of care, in *Burnie Port Authority v General Jones Pty Ltd* (1994) 197 CLR 520; [1994] HCA 13 ("Burnie Port Authority"), the owner of a building was found to owe a non-delegable duty of care to a licensee of part of the building in respect of welding activities carried out a by a contractor near cartons containing a highly combustible chemical. The plurality found that, save for any possible liability in nuisance, the rule in *Fletcher v Rylands* (1866) LR 1 Exch 265 (and confirmed in *Rylands v Fletcher* (1868) LR 3 HL 330) concerning liability for the escape of "anything likely to do mischief" had been absorbed into the law of negligence.[249] Instead, their Honours found that a non-delegable duty arose out of the control exercised by a person who introduced or retained a dangerous substance on their land and the dependence or vulnerability of the prospective plaintiff to harm from the substances escape.[250] Their Honours held that the critical question is "whether the Authority *took advantage of its occupation and control of the premises to allow its independent contractor to introduce or retain a dangerous substance or to engage in a dangerous activity on the premises*".[251] Their Honours explained that what is "dangerous" is not limited to an activity that is inherently dangerous, but extends to activities or substances where the "combined effect of the magnitude of the foreseeable risk of an accident happening and the magnitude of the foreseeable potential injury or damage if an accident does occur is such that an ordinary person acting reasonably would consider it necessary to exercise special care to take special precautions in relation to it".[252]

126 As an illustration of these principles, in *AD & SM McLean Pty Ltd v Meach* [2005] VSCA 305; 13 VR 241("AD & SM McLean"), the Victorian Court of

[248] *Leichhardt Municipal Council* at [10].
[249] At 556, per Mason CJ, Deane, Dawson, Toohey and Gaudron JJ.
[250] At 551.
[251] At 557 to 558.
[252] At 558 to 559.

Appeal held that the agisting of horses on land abutting a major highway was sufficiently likely to create a danger for persons using the highway so as to create a non-delegable duty in relation to the horses' confinement.[253] Nettle JA (as his Honour then was) noted that this finding would likely not have been the outcome of the application of the "rule" in *Rylands v Fletcher*.[254]

127 In his submissions, Senior Counsel for Seqwater referred to the passage in *Rylands v Fletcher* in which Lord Cairns stated that "if, in ... the natural use of...land there ha[s] been any accumulation of water, either on the surface or underground, and, if, by the operation of the laws of nature, that accumulation of water had passed off into the close occupied by the plaintiff, [then] the plaintiff could not have complained that that result had taken place".[255] By reference to that passage and various decisions that applied *Rylands v Fletcher*,[256] it was submitted that the rule in *Rylands v Fletcher* did not concern the situation where a "dam is in the river and there is a natural flow of water…into the dam" which is simply released downstream because that "is not a situation where a dam owner has introduced on to his property that which, in its natural condition, was not there".[257]

128 It may be the case that, as the peak amount of water released from Wivenhoe Dam throughout the January 2011 Flood Event did not exceed the peak inflow, then if it had survived, the rule in *Rylands v Fletcher* may not have been engaged. However, the rule did not survive *Burnie Port Authority* and instead it was subsumed into the law of negligence. One of the many differences between the two is that a consideration of whether a non-delegable duty of care arose from the conduct of some activity on a potential tortfeasor's land is a prospective inquiry, whereas the form of "strict liability" encompassed by *Rylands v Fletcher* only requires a consideration of what happened, specifically whether the damage was occasioned by an escape of

[253] At [23] and [33] per Nettle JA, with whom Chernov JA and Hollingworth AJA agreed.
[254] At [22].
[255] At 338 to 339.
[256] Including *Hazelwood v Webber* (1934) 52 CLR 268; [1934] HCA 62.
[257] T 9491.3; Seqwater subs at [387(e)].

a dangerous substance as a result of a “non-natural use” of the land, irrespective of whether negligence was involved.[258] Cases concerning liability under *Rylands v Fletcher* developed their own jurisprudence concerning non-natural uses of the land. The outcome in *AD & SM McLean* is an instance in which a non-delegable duty will be found to have been imposed on an occupier of land in circumstances which would not necessarily have given rise to liability under the rule in *Rylands v Fletcher*.

129 The plaintiff’s submissions contended that the relevant activity engaged in by Seqwater was dangerous because the magnitude of the risk and the magnitude of the harm of the foreseeable potential injury were “extremely large”.[259] The plaintiff instanced a document prepared by Seqwater in December 2009 which referred to the (potential) population at risk from flooding as 244,000[260], as well as Mr Tibaldi’s email which stated that “Wivenhoe and Somerset dams have the potential to prevent billions of dollars in flood damage if operated correctly in large floods” but the “potential to cost similar amounts if operated incorrectly during flood events”.[261]

130 In addition to the point noted at [127], Seqwater submitted that it could not be said that it took advantage of its ownership and occupation of the dam to “engage in a dangerous activity” when in substance it was “performing and exercising its statutory function and powers for public objects”.[262] It otherwise contended that the relevant characterisation of the activity being engaged in was “flood management”, which could not be characterised as a “dangerous activity for the purposes of imposing a duty of care”.[263]

131 Seqwater also pointed[264] to the statement in *Aircraft Technicians of Australia Pty Ltd v St Clair* [2011] QCA 188 at [68] (“Aircraft Technicians”), to the effect that “[r]ecent decisions of the High Court suggest that the imposition of [a]

[258] *Burnie Port Authority* at 588 per McHugh J, citing Lord Cairns LC in *Rylands v Fletcher* at 340.
[259] Plaintiff subs at [72].
[260] SEQ.016.066.0555 at .0586.
[261] SEQ.206.006.8743.
[262] Seqwater subs at [385(a)].
[263] Ibid at [388(b)].
[264] Ibid at [456].

non-delegable duty … is exceptional", such that the "categories of case in which it applies should not therefore be expanded without some compelling reason" and that "[s]ave, perhaps, for cases which are very closely analogous to existing categories the expansion of categories should not be undertaken by an intermediate appellate court." It also relied on the observation of Campbell JA in *Transfield Services (Australia) Pty Ltd v Hall* (2008) 75 NSWLR 12 at [90], that "I do not regard [the statements in *Burnie Port Authority*] as intending to suggest that there could be a non-delegable duty concerning such dangerous things or activities outside the context with which *Burnie Port Authority* was concerned, of activities formerly covered by the ancient law concerning spread of fire and *Rylands v Fletcher*". The general caution in the High Court cases spoken of in *Aircraft Technicians* can be accepted[265], although the observations in that case appear to be directed more to a reluctance in imposing non-delegable duties on parties to relationships that have not previously had such duties imposed, rather than the circumstance of an owner or occupier undertaking an activity on their land. Otherwise, with respect to the obiter of Campbell JA in *Transfield Services*, there is nothing in *Burnie Port Authority* which suggests that the concept of "dangerous activity" is confined to escaping fire or storing water. Such a contention is flatly inconsistent with *AD & SM McLean.*

132 It can be accepted that the collection of a large volume of water for the supply of water and the conduct of flood operations carries with it risks of causing catastrophic flood damage either from dam failure, the hydraulic effect or even simply the making of large releases that coincide with downstream flows to cause the Brisbane River to breach its banks. However, leaving aside whether Seqwater was carrying out a statutory function when it was undertaking flood operations, the existence of those possible outcomes does not alter the characterisation of the generally positive character of the activity of flood mitigation that was being undertaken primarily for the benefit of downstream residents and property owners. To characterise the undertaking of that activity as "dangerous" in the sense discussed in *Burnie Port Authority* and ultimately

[265] Eg *Leichhardt Municipal Council* at [23] to [24] per Gleeson CJ; at [153] per Hayne J and at [188] per Callinan J.

impose a non-delegable duty would constitute a significant extension of the circumstances in which such duties are imposed in a number of respects.

133 First, it would involve an extension of the class of persons to whom a non-delegable duty is owed from property owners and others in the immediate vicinity of Seqwater's property and activities to owners of real and personal property many hundreds of kilometres away.

134 Second, it would involve an extension to the circumstance that the supposedly dangerous activity was not being undertaken for the private benefit of the alleged tortfeasor but was being undertaken for the benefit of the affected persons; that is to protect them against the risk of flooding. In that sense, it is difficult to see how that activity could be characterised as Seqwater "tak[ing] advantage" of the land to undertake an activity that is dangerous to downstream residents and property owners, rather than undertaking a task designed to protect downstream residents and property owners even though it had concomitant risks if not undertaken properly.

135 While the first matter might not represent a significant obstacle to the imposition of a non-delegable duty for activities that are inherently dangerous to people over a vast area, such as the operation of a nuclear power plant, the second matter is insurmountable. In this respect, I accept Seqwater's contention that the imposition of a non-delegable duty in these circumstances would be a step too far for a judge at first instance.

Non-Delegable Duty – Sole Licensee

136 The other basis upon which the plaintiff submitted that Seqwater was subject to a non-delegable duty is said to arise from the statutory scheme applicable to flood mitigation. It sought to invoke the following passage from the judgment of Gleeson CJ in *Leichhardt Municipal Council*:[266]

> "Non-delegability … would arise where there was nothing to prevent the engagement of a third party to perform the function, but it appeared from the

[266] At [10].

> terms of the statute that the legislature intended the repository of the power or duty to have responsibility for ensuring the exercise of reasonable care even if a third party were engaged to perform the function. That would involve a question of statutory construction."

137 In relation to the position of Seqwater, the plaintiff submitted that it was "apparent from the provisions of the *Water Supply Act* and the *Water Act* that the Legislature intended that the owner of a dam would be principally responsible for ensuring the operation of that dam, including its operation in accordance with any approved flood mitigation manual". The plaintiff also noted that it was only the owner of a dam (or its subsidiary) that was capable of holding a resource operations licence in respect of Wivenhoe Dam and Somerset Dam under s 107A(3) of the *Water Act*.[267]

138 The statutory scheme governing the designation of Wivenhoe and Somerset Dams as having a flood mitigation function as well as the ownership, management and control of the dams is summarised above.[268] In summary, Seqwater was not statutorily obliged to undertake flood mitigation in accordance with the Manual, but it was the exclusive holder of statutory permissions entitling it to do so.

139 In *Leichhardt Municipal Council*, s 71 of the *Roads Act* empowered a roads authority to carry out road work on any public road that was within its area of responsibility. Gleeson CJ noted that this was a form of discretionary power and that nothing in the *Roads Act* "makes a case of … strict non-delegability".[269] His Honour added that "[h]aving regard to the well-known practice of the engagement by public authorities of independent contractors it would have been surprising to find in the *Roads Act* any express or implied statutory requirement that roads authorities undertake road construction and maintenance only through their own employees".[270] There is not much that can be said about the "well-known practice[s]" of entities such as Seqwater. However given the degree of specialised knowledge required of flood

[267] Plaintiff subs at [100].
[268] See also Chapter 2, section 2.1 and Chapter 5, section 5.1.
[269] *Leichhardt Municipal Council* at [12].
[270] At [12].

engineers,[271] it would also seem surprising to construe the statutory provisions discussed in Chapters 2 and 5 as though the only persons that Seqwater could cede control of its dams to for the purposes of flood mitigation and interference with the flow of the Brisbane River were its own employees. In any event, there is nothing in the *Water Act*, the *Restructuring Act* or any other provision which appears to support the form of "strict non-delegability" discussed by Gleeson CJ in *Leichhardt Municipal Council*.

140 Accordingly, I reject the plaintiff's contention that Seqwater owed a non-delegable duty of care to a class of persons that included the plaintiff or any group members. This conclusion means that, in the end result, the finding that Seqwater owed a duty of care adds nothing to the plaintiff's case as the particulars of breach are all directed to the conduct of the flood engineers (see Chapter 12). Any vicarious liability on the part of Seqwater for their conduct is addressed below.

11.4: SunWater's Duty of Care

141 As noted, the plaintiff pleaded that SunWater owed a duty to take reasonable care in the conduct of Flood Operations at Wivenhoe Dam and Somerset Dam and that the duty was non-delegable, that is, a duty to ensure that "reasonable care was taken".[272] Before addressing those contentions, it is necessary to describe SunWater's contractual obligations.

SunWater's Contract with Seqwater

142 SunWater was engaged by Seqwater under a "Service Level Agreement – Flood Management Services" dated 13 October 2009[273] (the "SLA"). Clause 3.1 of the SLA obliged SunWater to provide the "Service" to Seqwater on the terms of the agreement. Clause 3.2 obliged SunWater to "[p]rovide the Service in accordance with the Service Schedule",[274] to "provide the Service

[271] Chapter 3 at [11].
[272] 5ASOC at [148(b)].
[273] SEQ.001.022.8933 at .8933 and. 8936.
[274] SLA at .8941.

to Seqwater using appropriately qualified and experienced personnel"[275] and to "act in accordance with reasonable directions from Seqwater in respect of SunWater's performance of the Service".[276] Clause 3.3 required the performance of the Service in a "diligent manner" and to a minimum standard which is the higher of either the standard it was performed at over the previous 24 months or the "standard of skill and care expected of a contractor experienced in the provision of the Service".[277]

143 Clause 3.4 obliged SunWater to, inter alia, "co-operate with Seqwater and its Personnel" in the performance of the Service and "observe and comply with all lawful requests, directions and instructions which are made by Seqwater's relevant Personnel",[278] where "Personnel" is defined as including Seqwater's employees and "contractors".[279] Sub-clause 3.6(a) precluded SunWater from "subcontract[ing] the performance of, or otherwise arrang[ing] for another entity (other than its own employees) to perform the Service" without Seqwater's prior written consent. Sub-clause 3.6(b) provided that, if SunWater subcontracted the performance of the Service, then it assumed responsibility for the subcontractor's act and omissions.[280]

144 The "Service" provided under the SLA is defined as meaning the service "as described in the Service Schedule".[281] The "Service Schedule" is 16 pages in length. Clause 1 defines the "scope of work" and "SunWater's Organisation" as follows:[282]

> "**Scope of Work**
>
> SunWater shall provide *flood management services* for Wivenhoe, Somerset and North Pine Dams *in accordance with the provisions of* the Service Schedule, the Emergency Action Plans, Standards Operating Procedures, the *Flood Operations Manuals*.
>
> **SunWater's Organisation**

[275] SLA at .8941.
[276] Id.
[277] Id.
[278] Ibid at .8941, Cl.3.4(a) and 3.4(c).
[279] Ibid at .8939.
[280] Ibid at .8942.
[281] Ibid at .8939.
[282] Ibid at .8955 to .8970.

SunWater will provide the following information in relation to the provision of services:

- Organisation Chart
- Name, curriculum vitae and contact details for nominated Duty Flood Engineers.
- Name and contact details for nominated flood duty staff.
- Name and contact details for any sub-contractors together with details of functions to be carried out by the sub-contractor.

Should SunWater have a requirement to change organisation arrangements, it shall immediately submit details of and reasons for such changes to Seqwater." (italicised emphasis added)

145 Clause 1.1 of the SLA defines the "Flood Operations Manual" as meaning the "Manual for Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam" (ie, the Manual).[283] The Service Schedule refers to Seqwater as beings responsible for "obtaining any necessary approval [for the manual] under the *Water Supply (Safety and Reliability) Act 2008* (Qld)".[284] This is clearly a reference to s 37 of the *Safety and Reliability Act*.[285]

146 Section 5 of the Service Schedule provides:[286]

"**General**

SunWater shall be prepared to competently deal with the flood events *in accordance with the requirements of the* [Standard Operating Procedures], the [Emergency Action Plans] and *the Flood Operations Manuals*.

SunWater shall establish a dedicated Flood Control Centre. SunWater shall maintain the Centre in good operating order at all times throughout the [term of the SLA]". (italicised emphasis added)

147 The balance of section 5 address the minimum requirements of the Flood Control Centre, data collection, use of the RTFM and "flood preparedness". None of those provisions are at variance with the Manual and none of them purport to confer on SunWater any authority to direct the opening and closing of gates at the dams. One part of the Schedule provides that access to the

283 Ibid at .8937.
284 Ibid at .8958.
285 See Chapter 2 at [32].
286 SLA at .8964.

control centre is restricted to members of SunWater's project team and other persons authorised by Seqwater and notified in advance to SunWater.

148 Section 6 of the Service Schedule is entitled "Flood Operations and Reporting". It provides:[287]

> "SunWater *shall perform flood operations* during flood events *in accordance with the* relevant provisions of EAPs and SOPs, which refer to *the Flood Operations Manual.*
>
> …
>
> SunWater, *in conjunction with Seqwater*, shall mobilise flood response teams to attend each relevant dam and the Flood Control Centre when:
>
> - for Wivenhoe Dam indications are received of an imminent flood which may require flood releases.
> - for Somerset Dam indications are received of a significant inflow which may require flood releases.
> - for North Pine Dam heavy rain is experienced in the dam's catchment area.
>
> …
>
> Unless otherwise approved by Seqwater, flood response teams per shift shall comprise a Senior Flood Operations Engineer and/or Flood Operation Engineer and sufficient hydrographers/modellers and data checkers to manage operational requirements.
>
> …
>
> Unless otherwise approved by Seqwater, the flood response team are to remain on duty until the reservoir levels have returned to full supply level and flood operations have ceased.
>
> Payment for SunWater's personnel involved in the flood operations at the dams, the Flood Control Centre or elsewhere shall be made at the applicable hourly rates contained in clause 7 of this Schedule for the actual hours involved in the flood event." (emphasis added)

149 In Chapter 14, I address a cross-claim brought by Seqwater against SunWater seeking to recover damages for alleged breaches of the SLA said to have caused any liability it may incur to the plaintiff and group members. At this point I note that there is nothing inconsistent between any obligation imposed on SunWater by the SLA on the one hand and any of the posited duty of care, the Manual (as construed in Chapter 3) or any other finding in

[287] Ibid at .8968.

this judgment as to what was required of a reasonably competent flood engineer during the January 2011 Flood Event. To the contrary, the SLA requires that all aspects of the Service provided by SunWater be undertaken "in accordance with" the requirements of the Manual. SunWater contended that an inconsistency arose between the terms of the SLA and the plaintiff's posited duty so far as operations below FSL were concerned.[288] However, that submission was premised on the acceptance of SunWater's submissions concerning flood operations below FSL,[289] something that has already been rejected.[290]

SunWater's Responsibility for Messrs Tibaldi, Malone and Ruffini

150 It is necessary to ascertain the scope of SunWater's responsibilities under the SLA so far as Messrs Tibaldi, Malone and Ruffini are concerned. The phrase "SunWater personnel" as used in the Service Schedule is not defined but appears to contemplate a narrower class of personnel than all those who constituted the flood response teams. It was common ground that SunWater employed Mr Ayre, that Seqwater employed Messrs Tibaldi and Malone and that the State employed Mr Ruffini. In his first affidavit, Mr Ayre stated that, during the January 2011 Flood Event, SunWater provided personnel in the form of himself and five technical assistants and that he was unsure of any arrangements between SunWater and Seqwater in relation to Mr Malone and Mr Tibaldi acting as flood engineers.[291] No other witness addressed that issue either. Thus, there is no evidence that SunWater paid any amount to Messrs Tibaldi or Malone for acting as flood engineers or that Seqwater paid any amount to SunWater for their services (or vice versa).

151 Further, there is no evidence that SunWater ever subcontracted to any of Messrs Malone or Tibaldi or otherwise arranged for them to perform the Service in accordance with clause 3.6(b) of the SLA. There is nothing in the SLA that suggests that if any person acts as a flood engineer but is not an

[288] SunWater subs at [2557].
[289] Ibid at [2557] and [597].
[290] Chapter 5 at [197].
[291] LAY.SUN.001.0001 at [54] to [55].

employee of SunWater then somehow their conduct of flood operations amounts to the provision of "flood management services" by SunWater to Seqwater under the SLA or the "perform[ance] [of] flood operations during flood events" by SunWater such that it assumes contractual responsibility for their conduct. The SLA does not provide that SunWater is the exclusive supplier of flood management services or that it assumes responsibility for all who purport to provide such services (as opposed to those with whom it subcontracts). It follows that, at most, Messrs Malone and Tibaldi were Seqwater "personnel" with whom SunWater was obliged to co-operate with under clause 3.4(a) of the SLA. Clearly, they formed part of the flood response team but that was only formed "in conjunction with Seqwater", which included its staff.

152 There is some evidence concerning the engagement of Mr Ruffini. Tendered in evidence was a memorandum of understanding between the predecessor to SunWater and the State dated February 2001 (the "MOU").[292] The MOU recounts that it "was prepared to outline the services to be provided to SunWater by DNR [the Department of Natural Resources] and for the provision of key DNR personnel to undertake the duties required for the management of flood operations as required under SunWater's contract with the SEQWC [South East Queensland Water Corporation]".[293] The MOU recites that the "DNR are to provide key personnel to perform the State's obligations in accordance with the duty statements and terms and conditions of the Agreement between SunWater and SEQWC". The "Key Personnel" are identified as "Flood Operations Engineers" and "Data Collectors". Duty statements for those two categories of employee are included in Schedule 1 to the MOU and the other personnel to be provided are identified in Schedule 2, including Mr Ruffini.[294] The MOU notes that Mr Ruffini was then the SFOE. Provision is made in the MOU for the DNR to invoice SunWater for the work undertaken by the key personnel.[295]

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[292] SUN.006.004.2382.
[293] Ibid at .2383.
[294] Ibid at .2388.
[295] Ibid at .2384.

153 Clause 1 of Schedule 1 to the MOU (ie, the "Duty Statement") provides:[296]

> "Flood Operations Engineers are to direct flood operations at Somerset Dam, Wivenhoe Dam and North Pine Dam in accordance with the following documents, on behalf of SunWater:
>
> • Contract documents for SEQWB Contract T5-95/96
>
> • Manual of Operational Procedures for Flood Mitigation for Wivenhoe and Somerset Dam, Revision No 2, 13 November 1997
>
> • Manual of Operational Procedures for Flood Releases from North Pine Dam, Revision No 2, 13 November 1997."

154 The balance of the Duty Statement concerns the arrangements for maintaining flood engineers on call and for mobilisation of the FOC.

155 As noted, the MOU was between SunWater's predecessor and the State. The term of the MOU was stated as only continuing until 30 June 2001 with provision for an extension. Despite this, in their submissions both SunWater and the State treated the MOU as operative as at the time of the January 2011 Flood Event and referable to the discharge of SunWater's obligations under the SLA to Seqwater.[297] Consistent with the MOU, on 30 June 2011 the State invoiced SunWater for the time spent by Mr Ruffini on duty during flood operations since October 2010 and for assisting in the drafting of the January FER.[298] I infer that the MOU did govern the circumstances in which Mr Ruffini acted as a flood engineer during the January 2011 Flood Event and that he did so as part of the discharge of SunWater's obligations to Seqwater. It follows that, while this does not amount to SunWater subcontracting the performance of the Service to Mr Ruffini,[299] it either subcontracted to the State or "arrang[ed] for another entity (other than its own employees) to perform the Service" within the meaning of sub-clause 3.6(a) of the SLA

[296] Ibid at .2386.
[297] State subs at [73] to [74] and SunWater subs at [2922] to [2926].
[298] SUN.006.019.4375.
[299] See SunWater subs at [2931(a)].

which, on the assumption it was approved by Seqwater, *may have* engaged sub-clause 3.6(b).[300]

156 Accordingly, to the extent that each of Messrs Tibaldi and Malone acted as flood engineers during the January 2011 Flood Event it has not been demonstrated that they did so as part of SunWater discharging its contractual obligations to Seqwater, although I accept that was the case so far as Mr Ruffini was concerned.

SunWater's "Control" over the Dams

157 In determining whether SunWater owed a duty of care, it is also necessary to identify the degree of "control" over flood operations that was conferred on it by the SLA or that it was otherwise capable of exercising. The plaintiff contended that there was "no question that SunWater relevantly had control of the dams" from both the "terms of the ... SLA and by reason of Mr Ayre's position as Senior Flood Engineer".[301] In its submissions on duty, SunWater did not reject that assertion.[302] However, when addressing whether it was vicariously liable for any breaches of duty by Mr Ruffini, SunWater contended that, as SFOE, Mr Ayre was not authorised to direct the flood engineers in relation to gate operations,[303] that such authority that Mr Ayre had to direct flood operations as SFOE was derived from his approval as such by Seqwater under the Manual and was not derived from SunWater and that SunWater did not have any "authority to direct the Flood Engineers as to how to go about their tasks".[304]

158 I accept SunWater's contentions. Unlike Seqwater, which retained ownership of the dams and as such the ultimate right of control, SunWater's only authority in respect of the dams was derived from the SLA and its employment of Mr Ayre. It follows from the above that it has not been

[300] There is scope for debate about the operation of clause 3.6(b) which was not the subject of submissions and it is not necessary to resolve.
[301] Plaintiff subs at [104(b)].
[302] SunWater subs at [2486] to [2496].
[303] Ibid at [2916].
[304] Ibid at [2949].

established that SunWater had any direct rights under the SLA to control the conduct of Messrs Tibaldi or Malone. As SFOE, Mr Ayre had some capacity to exercise control over their conduct as flood engineers but the findings in Chapters 3, 6 and 7[305] reveal the limits of Mr Ayre's authority as SFOE and the extent of the DFOE's authority. Moreover, as submitted by SunWater, Mr Ayre's control over the dams and other engineers as SFOE or DFOE was not something that SunWater could exercise. Every aspect of the obligations imposed, and the rights conferred, on SunWater by the SLA is conditioned by the requirement to act "in accordance with" the Manual. Clauses 2.2, 2.3 and 2.4 of the Manual vest control over the dams, including the power to declare flood operations and to release or store water during flood operations, in the SFOE and DFOE who are suitably qualified and approved by the Chief Executive of Seqwater (under clause 2.5). SunWater was contractually bound to Seqwater to respect that vesting even though it was "perform[ing] flood operations" under the SLA.[306] Thus, while its employee, Mr Ayre, was conferred with at least a de facto authority to control the dams during flood operations as DFOE and whilst he did possess some authority over the other DFOE's as SFOE, SunWater was not conferred with that authority and under the SLA it could not direct Mr Ayre as to the manner of exercise of that authority. SunWater's level of control over Mr Ruffini was no greater than its control over Mr Ayre.

SunWater's Duty of Care

159 The plaintiff contended that SunWater owed a duty of care by reference to the "same recognised category of duty in relation to the operation of potentially hazardous equipment".[307] The contention that Seqwater owed a non-delegable duty of care has been rejected. As it does not owe such a duty, then neither does SunWater, especially given the findings that have just been made regarding its control over the dams.

[305] Chapter 3 at [319] to [327]; Chapter 6 at [66] to [67], [144] to [148], [260] to [263]; Chapter 7 at [125] to [132] and [250] to [253].
[306] SLA at .8968 (s 6 of the Service Schedule).
[307] Plaintiff subs at [101].

160 The plaintiff further submitted that as SunWater was "contracted to *provide* professional engineering services to Seqwater, the scope and content of that duty in this case is informed by the duty which all professionals *performing* professional services owe to third parties who might reasonably foreseeably suffer physical damage to person or property as a result of any failure to take reasonable [care] in the performance of those services".[308] The plaintiff cited the following passage from the judgment of McLure JA (with whom Le Miere and Kenneth Martin JJ relevantly agreed) in *Drexel London (a firm) v Gove (Blackman)*:[309]

> "An *engineer* owes a duty to exercise reasonable care and skill in the provision of professional services. The duty is owed not only to the client but to other classes of persons who might foreseeably suffer injury as a result of the failure to exercise reasonable care." (emphasis added)

161 The plaintiff's submissions elide the difference between "provid[ing] professional engineering services" and acting as an engineer. SunWater is not an "engineer" and it did not so much promise to act as an engineer as promised to provide professional engineers and other support to enable the performance of flood management services "in accordance with the Manual".

162 It follows from the above findings that a salient features analysis, especially in relation to control and vulnerability, is different for SunWater on the one hand as compared to Seqwater and the flood engineers on the other. The latter had direct control over Wivenhoe Dam outflows and gate operations whereas SunWater did not. SunWater's authority to exercise control over the dam was solely derived from the SLA. As explained above, SunWater was contractually obliged to provide flood management services including "perform[ing] flood operations" and to do so to a reasonable standard. However, all of its obligations was subject to the Manual, which vested control over operation of the dams and gate operations in the flood engineers. SunWater did not acquire any direct right of control over dam operations or even over Mr Ayre's conduct of dam or flood operations given that it was required to observe the Manual.

[308] Plaintiff subs at [101] to [102].
[309] [2009] WASCA 181 at [121].

163 It follows that SunWater's "control" over the risk of harm, however formulated, was only indirect in the sense that, without SunWater's provision of flood management services, including the staffing of the flood response team and the provision of other support services that constituted the "Service", the proper management of inflows and outflows from Wivenhoe Dam and Somerset Dam could not be undertaken or at least would be impaired. The members of the affected class were only correspondingly vulnerable in that respect.

Conclusion

164 In some circumstances "the existence of a contract will provide the occasion for, and constitute a factor favouring the existence of, a [finding of] liability in negligence between one or other of the parties to the contract and a third party" (*Hill v Van Erp* (1997) 188 CLR 159 at 234; [1997] HCA 9, per Gummow J). Given the form of control conferred on SunWater and the corresponding degree of vulnerability of downstream property owners to the proper performance of its duties under the SLA this is such a case.

165 It follows from the above that SunWater owed the group members the posited duty of care but only in and about the provision of "flood management services" under the SLA. As noted, that obligation was subject to and conditioned by the Manual. I do not accept that any relevant part of the duty was non-delegable, namely a duty to ensure that all the personnel it supplied pursuant to the SLA exercised reasonable care. As with Seqwater, this means that, in the end result, the finding that Seqwater owed a duty of care to group members adds nothing to the plaintiff's case, as the particulars of breach are all directed to the conduct of the flood engineers and SunWater admitted that it was vicariously liable for the conduct of Mr Ayre.[310] The contention that it might be vicariously liable for the negligence of the other flood engineers is addressed below (and rejected).

[310] PLE.030.008.0001 at [372(a)].

11.5: The State

166 It was not pleaded that the State owed any duty of care. Instead, it was only pleaded that the flood engineers, including Mr Ruffini, did[311] and that the State was vicariously liable for his breaches.[312] This contention is addressed next.

11.6: Vicarious Liability

167 In light of the findings concerning duty of care and the submissions addressed below concerning the applicable standard of care and breach, it is necessary at this point to address whether the defendants are vicariously liable for any breaches of the duty of care owed by the flood engineers. Other than the State, none of the parties submitted that the flood engineers' work was not undertaken in the course or scope of their employment,[313] although they debated who the relevant employer was.

The Pleadings

168 The 5ASOC pleads that Seqwater is vicariously liable for any of Mr Malone and Mr Tibaldi's breaches of any duty of care they owed (as well as for any trespass or nuisance they committed), that SunWater is vicariously liable for Mr Ayre's breaches and the State is vicariously liable for Mr Ruffini's breaches.[314] The 5ASOC also pleads that Mr Ruffini's services were provided by the State to SunWater[315] and that, in the alternative to the State being vicariously liable for his conduct, SunWater was.[316] SunWater admitted that it was vicariously liable for Mr Ayre's conduct but denied any liability for Mr Ruffini's conduct.[317] Seqwater denied that it was vicariously liable for Mr Malone and Mr Tibaldi's breaches,[318] averred that flood operations were conducted by SunWater under the SLA and that each of Messrs Tibaldi and

[311] 5ASOC at [150].
[312] Ibid at [374].
[313] *Prince Alfred College Incorporated v ADC* (2016) 258 CLR 134; [2016] HCA 37 at [40].
[314] 5ASOC at [363] to [376].
[315] Ibid at [93].
[316] Ibid at [377].
[317] PLE.030.008.0001 at [372(a)] and [376] to [377].
[318] PLE.020.010.0001 at [468(d)] and [469(d)].

Malone performed the function of Flood Operations Engineer for and on behalf of SunWater and under the control and direction of SunWater.[319]

169 In response to the pleaded allegation that it was vicariously liable for the conduct of Mr Ruffini, the State pleaded as follows:[320]

> "As to paragraphs 373 to 376 inclusive of the Statement of Claim, the State:
>
> (a) denies that Mr Ruffini committed any of the breaches alleged in paragraph 373 of the Statement of Claim;
>
> (b) denies that Mr Ruffini caused any alleged nuisance or trespass;
>
> (c) repeats and relies on the matters pleaded in response to paragraphs 91, 92 and 93 of the Statement of Claim;
>
> (d) <u>says that in performing the services of Flood Engineer, Mr Ruffini acted under the direction of SunWater and became the employee *pro hac vice* of SunWater</u>;
>
> (e) <u>further, or in the alternative, says</u> <u>that the State could not direct the manner in which Mr Ruffini was to perform his duties and functions as a Flood Engineer</u>;
>
> (f) <u>says that the State was not vicariously liable for the acts or omissions of Mr Ruffini while he was acting as Flood Engineer</u>;
>
> (g) in the premises, denies each of the allegations in paragraphs 373 to 376 inclusive of the Statement of Claim." (underlined and italicised emphasis in original)

Employee "Pro Hac Vice"

170 Consistent with their respective pleadings, both Seqwater and the state submitted that Messrs Malone, Tibaldi and Ruffini were employees "pro hac vice" of SunWater.[321] SunWater submitted to the contrary[322] while the Plaintiff's submissions were neutral on the issue.[323]

[319] PLE.020.010.0001 at [468(b), (c)] and [469(b), (c)].
[320] PLE.040.007.0001 at [315].
[321] Seqwater subs at [2566] and State subs at [73] to [88].
[322] SunWater subs at [2908] to [2949].
[323] Plaintiff subs at [60].

171 Under the common law of Australia only one person can be vicariously liable for the negligent acts of an employee.[324] Seqwater accepted that the prima facie position is that the employer is vicariously liable but nevertheless submitted that, in some circumstances, "vicarious liability can be transferred to another who, on a particular occasion (ie, *pro hac vice)*, is using the services of the employee under an agreement or other arrangement with the employer."[325]

172 All the parties referred to the analysis of Ashley J in *Deutz Australia Pty Ltd v Skilled Engineering Ltd*[326] ("Deutz") of the circumstances in which such a transfer occurs.[327] Three related matters should be noted about his Honour's analysis in *Deutz*.

173 First, Ashley J noted that "a general employer which seeks to shift vicarious responsibility for the negligence of its servant onto another bears a heavy onus, which can only be discharged in quite exceptional circumstances".[328]

174 Second, in *Deutz* Ashley J noted that such a transfer will less readily be inferred where the general employer provides a skilled worker.[329]

175 Third, in *Deutz* Ashley J isolated a number of judicial statements concerning the high level of control that the temporary employer must exercise before the onus is discharged.[330] Thus, Ashley J referred to "[w]here the hirer can direct not only what the workman is to do, but how he is to do it",[331] "[w]here the hirer is entitled to tell the employee the way in which he is to do the work"[332] or "[w]here, by an agreement the employer vests in the third party complete,

[324] *Kelly v Bluestone Global Ltd (In liq)* [2016] WASCA 90 at [62]-[63] and [110]; *Day v Ocean Beach Hotel Shellharbour Pty Ltd* (2013) 85 NSWLR 335; [2013] NSWCA 250 at 344-346, per Leeming JA.
[325] Seqwater subs at [2566].
[326] [2001] VSC 194; (2001) 162 FLR 173 at 189 to 190, [113].
[327] Seqwater subs at [2566]; State subs at [77]; SunWater subs at [2936].
[328] *Deutz* at 189, citing *Mersey Docks & Harbour Board v Coggins & Griffith (Liverpool) Ltd* [1947] AC 1 at 10, per Lord Simon ("Mersey Docks"); see also *Oceanic Crest Shipping Co v Pilbara Harbour Services Pty Ltd* (1986) 160 CLR 626 at 646; [1986] HCA 34 per Wilson J ("Oceanic Crest").
[329] *Deutz* at 189 citing *Savory v Holland and Hannen & Cubitts (Southern) Ltd* [1964] 3 All ER 18 at 20 per Denning MR; *Denham v Midland Employers Mutual Assurance Ltd* [1955] 2 QB 437 at 444 per Denning MR.
[330] *Deutz* at 189 to 190.
[331] Citing *Mersey Docks* at 18, per Lord Simonds.
[332] Citing *Mersey Docks* at 17 per Lord Porter.

or substantially complete, control of the employee, so that he is not only entitled to direct the employee what he is to do, but how he is to do it".[333]

176 In its submissions, Seqwater referred to both the provisions of the SLA and the Manual as the basis for contending that the level of control that was exercised or capable of being exercised by SunWater over Messrs Malone and Tibaldi was sufficient to satisfy the various tests identified by Ashley J in *Deutz*.[334] The State also referred to those documents and the MOU so far as Mr Ruffini was concerned.[335]

177 In relation to Messrs Malone and Tibaldi, it has already been found that their performance of the duties of a flood engineer did not constitute or involve the provision of "flood management services" by SunWater to Seqwater under the SLA. In relation to Mr Ruffini, the findings made above concerning the SLA mean that SunWater was not conferred with any authority to "tell [a DFOE] the way in which he is to do the work". Further the suggestion that the Manual conferred sufficient control on the SFOE over the DFOE to satisfy those tests is inconsistent with the findings made in Chapters 3, 6 and 7 concerning the interaction of clauses 2.2, 2.3 and 2.4 of the Manual and their application during the January 2011 Flood Event.[336] Again, those provisions do not support the contention that Mr Ayre was entitled to "tell [a DFOE] the way in which he is to do the work" in the sense discussed in the authorities collected by Ashley J in *Deutz*.

178 SunWater further contended that "[a]ny authority of the Senior Flood Operations Engineers was a function of the Manual" and that it "follow[ed] that the authority of Mr Ayre as a Senior Flood Operations Engineer was not the authority of SunWater generally, and, accordingly, the exercise of that authority by Mr Ayre could not operate to transfer to SunWater the liability of

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[333] Citing *McDonald v Commonwealth* (1945) 46 SR (NSW) 129 at 132 per Jordan CJ.
[334] Seqwater subs at [2555] to [2569].
[335] State subs at [84] to [88].
[336] Chapter 3 at [319] to [327]; Chapter 6 at [66] to [67], [144] to [148], [260] to [263], Chapter 7 at [125] and [250].

acts or omissions of Mr Ruffini" (or Messrs Malone or Tibaldi).[337] That submission is consistent with the above analysis.[338]

179 Accordingly, I reject the contention that any of Messrs Ruffini, Tibaldi and Malone were employees *pro hac vice* of SunWater.

Independent Legal Duty

180 In both its opening submissions[339] and its final written and oral submissions,[340] the State contended that it was not vicariously liable for Mr Ruffini's actions on the basis that he exercised an independent legal duty. It relied on the following passage from the judgment of Dixon J in *Little v Commonwealth* (1947) 75 CLR 94 at 114; [1947] HCA 24 ("Little"):

> "…any public officer whom the law charges with a discretion and responsibility in the execution of an *independent legal duty* is alone responsible for tortious acts which he may commit in the course of his office and that for such acts the government or body which he serves or that appointed him incurs no vicarious liability." (emphasis added)

181 The plaintiff contended that this point was not pleaded and should have been.[341] The State contended that it was sufficiently raised by its denial of vicarious liability for Mr Ruffini's conduct in [315(e)] and [315(f)] of its amended defence set out above,[342] that it was otherwise made clear in its opening and was specifically referred to in an email between the parties dated 20 April 2018.[343]

182 There is considerable force in the plaintiff's objection to this point being raised by the State. Uniform Civil Procedure Rule 14.14(2) requires a party to specifically plead in their defence any matter "(a) that, if not pleaded specifically, may take the opposite party by surprise" or any matter that the "(b) party alleges makes any claim …. of the opposite party *not maintainable*".

[337] SunWater subs at [2948].
[338] See above at [158].
[339] T 780.28.
[340] State subs at [95] to [110]; T 10040.8 to T 10043.21.
[341] Plaintiff subs at [172] to [174].
[342] See above at [169].
[343] State subs at [94] to [95].

A contention that Mr Ruffini fell within the scope of the independent legal duty principle appears to be capable of taking a party by surprise. Further, in *Oceanic Crest* at 635, Gibbs CJ described the successful invocation of the independent legal duty doctrine in *Fowles v Eastern and Australian Steamship Co Ltd* [1916] 2 AC 556 ("Fowles") as rendering a claim "not maintainable".

183 The plaintiff submitted that it was prejudiced by the State raising the independent legal duty point at the time it was. The plaintiff contended that it, if it had been put on notice of this contention earlier then it would, or at least could, have applied to join Mr Ruffini personally. Instead it contended that, when it was raised, it was too late to join him as any claim was by then statute-barred.[344] Apparently there are indemnity arrangements in place for public servants such as Mr Ruffini.[345] The State contended that no prejudice could be occasioned by the manner in which it was raised because the "plaintiff never applied to join Mr Ruffini after being on express notice of the submission".[346] However, that does not undermine the plaintiff's point. Instead it reinforces it. The earliest communication in which the State alleges it expressly notified the plaintiff that the point was being taken is an email of 20 April 2018. Prima facie, the six-year limitation period in s 10(1)(a) of the *Limitation of Actions Act 1974* (Qld) expired sometime in January 2017. Any application to join Mr Ruffini thereafter would have faced considerable if not insurmountable difficulties.

184 It is not necessary to finally determine whether it was open on the pleading to take this point because I do not accept that it is made out. For the reasons set out below, at its highest the independent legal duty doctrine is only applicable in respect of a personal legal duty or a power which is either imposed by statute or conferred by the "common law" on the holder of an "office". Neither of these circumstances are applicable to a flood engineer.

185 The above statement from *Little* is expressed in terms of a "public officer" exercising an "independent legal duty". The meaning of "public office" and a

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[344] Plaintiff subs at [174].
[345] T 10042.47.
[346] State subs at [96].

"public officer" are context specific,[347] but in broad terms they connote a public position that exists independently of the occupant and to which certain duties are attached.[348] The plaintiff pointed to cases in which the source of the independent legal duty is statute.[349] However, the State correctly submitted that this doctrine is not confined to statutory duties and can include a duty "imposed by common law",[350] citing the position of a police officer as discussed in *Attorney-General (NSW) v Perpetual Trustee Co Ltd* (1952) 85 CLR 237 at 303 to 304; [1952] HCA 2, per Kitto J ("Perpetual Trustee"). However, the concept of a duty imposed by the common law has a different meaning to that suggested by the State. In *Perpetual Trustee*, Kitto J observed that "in the execution of his duties a constable has powers and discretions which he derives not by delegation from the Crown, but from the nature of his office and which he exercises on his own independent responsibility" such that "a member of the police force is under an obligation to perform duties of which some are statutory, some derive from common law, and all are of a public character".[351] Thus, a police officer is a species of "public officer" to which duties are attached by, inter alia, the common law,[352] however it is not the common law of contract or tort that imposes the relevant independent duty.

186 The State also relied on a passage from the judgment of Gibbs CJ in *Oceanic Crest* as supportive of the contention that, as persons supposedly subject to common law duties, flood engineers fall within the proposition stated in *Little*.[353] In *Oceanic Crest,* the relevant position was that of a ship's pilot employed by a company that had statutory authority conferred on it for the "entire control of all port services".[354] The pilot was appointed by the Governor under statute and then provided to the shipping company by the employing

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[347] *Obeid v R* (2015) 91 NSWLR 226; [2015] NSWCA 309 at [86] ("Obeid"); *Sykes v Cleary* (1992) 176 CLR 77 at 96-97; [1992] HCA 60.
[348] *R v Boston* (1923) 33 CLR 386 at 402; [1923] HCA 59; *Williams v Commonwealth of Australia* (2012) 248 CLR 156 at [444]; [2012] HCA 23 per Heydon J; *Obeid* at [115].
[349] Eg, *Cubillo v The Commonwealth (No 2)* (2000) 103 FCR 1 at [1089] to [1121]; Plaintiff subs at [175] to [182].
[350] State subs at [98].
[351] At 303.
[352] See *State of NSW v Briggs* [2016] NSWCA 344 at [51], per Leeming JA.
[353] State subs at [92] to [93].
[354] At 633.

company. The employing company was held not to be vicariously liable for the pilot's navigation of a ship. After referring to the decision in *Fowles* and the judgment of Dixon J in *Little*, Gibbs CJ continued:[355]

> "The principle is not limited to cases in which the duty which is being carried out is imposed by statute - the question is whether the person who committed the tort was acting in the performance (or supposed performance) *of a duty imposed by law (either by statute or by common law)* or whether his authority to act was derived from his employment. Further, although many of the decisions in which the principle has been applied were cases in which the Crown was sought to be made liable for the tort of a public officer, the principle is not confined to such cases. *Stanbury v Exeter Corporation* was a case in which a local authority was held not to be liable for the negligence of an inspector whom it had appointed, where the inspector was negligent in carrying out a duty imposed by statute upon him and not on the local authority … The fact that in the decisions of this Court to which reference has been made *Fowles v. Eastern and Australian Steamship Co. Ltd.* is regarded as falling within the principle plainly shows that this Court was of the view that the doctrine is not confined to the Crown." (emphasis added)

187 The second part of the above passage from *Oceanic Crest* focuses on the source of the power rather than either the identity of the employer or the public or private nature of the position per se. To similar effect, in *Oceanic Crest*, Wilson J noted that "it is the statutory authority possessed by the servant that renders the employer immune to vicarious responsibility" and that it was "immaterial whether the employer be the Crown, as in *Fowles*, a statutory corporation, as in *Stanbury v Exeter Corporation* ... or a private company, as in this case".[356] Even so, a pilot is simply another species of "officer" or "office" holder, albeit in *Oceanic Crest* the pilot was not employed by the Crown but by a company. For many years a duly qualified pilot had been recognised as "a public officer …. occupy[ing] an independent position, very much as a notary-public or messenger-at-arms does" and that the "public constitute his master, and he is the servant of the public, like these and other public functionaries".[357]

188 Thus, the critical issue for the invocation of the doctrine is to identify the nature and source of the independent legal duty being exercised. If the duty or

[355] *Oceanic Crest* at 637 to 638.
[356] At 650.
[357] *Holman v Irvine Harbour Trustees* (1877) 4 Sess Cas. (4th series) 406 cited in *Oceanic Crest* at 636, per Gibbs CJ.

power is sourced in statute then it does not matter whether the donee is an "officer", public or otherwise.[358] If it is not, then the relevant legal duty must be sourced to the common law and often, perhaps invariably, that will require that the person be either a "public officer", or at least an "office" holder, because it is only to such positions that the common law will attach independent legal duties. Ship pilots and constables are examples of such positions. However, merely being a skilled professional performing a role to which a contractual scheme confers a great deal of autonomy will not suffice.[359]

189 In its submissions in support of the contention that a flood engineer fell within the scope of the statement in *Little*, the State referred to various provisions of the Moreton ROP which conferred authority *on Seqwater* to make release from the dams, including the interim approval under clause 13 as discussed in Chapter 5.[360] Those provisions take the matter nowhere as they do not confer any personal legal authority, power or duty on the *flood engineers* as opposed to Seqwater. The State also referred to s 22 of the *CLA* (Qld) which is set out below. The State submitted that, by virtue of s 22, as an engineer, Mr Ruffini was "free to act within the scope of peer professional opinion in their field, *a further source of discretion*" and the "common law … is a further source then of the obligation, and one which is to be exercised independently, namely, within the scope of peer professional opinion".[361] These submissions elide the difference between the common law providing a source of power to act, which is the case with some "offices" and "officers" such as constables and ship pilots, and the principles of negligence which are part of the common law (and supplemented by s 22 of the *CLA* (Qld)). As explained above, it is only the former that is of significance to the independent legal duty principle and it has no relevance to the flood engineers. No independent statutory powers were conferred on flood engineers. The common law neither created nor recognises an "office" of a flood engineer and nor does it confer or impose legal powers, privileges or duties on such a position. In light of this conclusion it is not necessary to address the plaintiff's contention that the independent

[358] *Stanbury v Exeter* (1905) 2 KB 838 at 841.
[359] See *Zuijs v Wirth Brothers Pty Ltd* (1955) 93 CLR 561 at 570 to 571; [1955] HCA 73.
[360] State subs at [102].
[361] Ibid at [103].

legal duty doctrine could never apply to Mr Ruffini as he was not licensed as an engineer under s 115 of the *Professional Engineers Act 2002* (Qld)[362] and not eligible to be appointed a flood engineer.[363]

Conclusion

190 Seqwater is vicariously liable for any breaches of duty committed by Messrs Malone or Tibaldi. The State is vicariously liable for any breaches of duty committed by Mr Ruffini.

11.7: Standard of Care

191 In addressing the statutory provisions affecting the standard of care it is necessary to identify, in light of the pleaded case and the findings to this point, who owed the relevant duty and who (allegedly) committed the relevant breach. The above findings are to the effect that each of the flood engineers owed a duty of care in the conduct of flood operations, as did Seqwater and also SunWater at least in respect of its provision of flood management services under the SLA. However, the duties owed by Seqwater and SunWater were not found to be non-delegable. As discussed in Chapter 12, all of the allegations of breach concern the conduct of the flood engineers. It follows that the only form of liability in negligence that may be imposed on Seqwater, SunWater or the State is a "true vicarious liability", that is "the master is liable not for a breach of a duty resting on [it] and broken by [it] but for a breach of duty resting on another and broken by another."[364]

192 Subject to considering the effect of three sets of provisions of the *CLA* (Qld), the relevant standard of care for a professional person such as an engineer is that of the "ordinary skilled person exercising and professing to have that special skill".[365] In an engineering case, Glass JA described the standard

[362] As conceded by the State: T 10045.41 to T 10046.16.
[363] Plaintiff subs at [59]; see *Oceanic Crest* at 636; Manual at 6 to 7 (Section 2.5).
[364] *Darling Island Stevedoring & Lighterage Co Ltd v Long* (1957) 97 CLR 36 at 57; [1957] HCA 26, per Fullagar J; *Parker v Commonwealth* (1965) 112 CLR 295 at 300-301; [1965] HCA 12, per Windeyer J; and *Hollis v Vabu Pty Ltd* (2001) 207 CLR 21 at [34], per Gleeson CJ, Gaudron, Gummow, Kirby and Hayne JJ.
[365] *Rogers v Whitaker* (1992) 175 CLR 479 at 483; [1992] HCA 58.

expected of a consulting engineer as that which "would be shown by a reasonably competent qualified engineer retained for the purpose at hand".[366] This judgment and the parties' submissions used the phrase the "reasonably competent flood engineer" as reflective of this standard.[367]

193 The standard expected of such an engineer is addressed further in Chapter 12.[368] At this point it should be noted that each of the defendants made submissions to the effect that, in considering whether there are a number of ways in which the duty can be discharged, the standard expected of such an engineer is not one that is free from making mistakes or errors.[369] This is clearly correct. They also made submissions directed to the proposition that there may be a range of interpretations of (say) the Manual and that just adopting one that is erroneous did not necessarily mean the flood engineers were negligent.[370] This issue is addressed in Chapter 3 in relation to the Manual[371] and Chapter 5 in relation to the conduct of flood operations below FSL.[372]

194 The first set of statutory provisions relevant to the standard of care are ss 9 and 10 of the *CLA* (Qld). They are set out and addressed in Chapter 12 which concerns the particulars of breach. The second and third relevant statutory provisions are ss 36 and 22 of the *CLA* (Qld) respectively. They will be addressed in turn.

Section 36

195 Each of the defendants pleaded reliance on s 36 of the *CLA* (Qld).[373]

366 *Brickhill v Cooke* [1984] 3 NSWLR 396 at 399.
367 Eg Plaintiff's subs at [773]; Seqwater subs at [515(a)]; SunWater subs at [3], [2569] to [2981]; and State subs at [35].
368 Chapter 12, section 12.1.
369 Eg Seqwater subs at [592]; SunWater subs at [2579].
370 Seqwater subs at [595] to [605]; SunWater subs at [2576] to [2578]; [2580] to [2581].
371 Chapter 3 at [124] to [129].
372 Chapter 5 at section 5.4, especially at [167] to [171].
373 Eg, Seqwater Defence, PLE.020.012.0001, [299(c)], [318(c)]; SunWater Defence, PLE.030.008.0001, [148(e), (f)], [150(e)]; State Defence, PLE.040.007.0001, [117(d)(ii)].

196 Section 36 is found within Part 3 of the *CLA* (Qld) which is entitled "Liability of public and other authorities and volunteers". Part 3 has three operative provisions. Section 35 sets out certain principles applicable to a "proceeding in deciding whether a public or other authority has a duty or has breached a duty", including that "(b) the general allocation of financial or other resources by the authority is not open to challenge". It is not relevantly different to s 42 of the *CLA* (NSW). Section 37 addresses the position of road authorities and provides that "[a] public or other authority *is not liable* in any legal proceeding for any failure by the authority in relation to any function it has as a road authority" to repair or inspect the road.

197 The balance of the relevant provisions of Part 3 provide:

> "**34 Definitions for div 1**
>
> In this division—
>
> ***function*** includes power.
>
> ***public or other*** authority means—
>
> (a) the Crown (within the meaning of the *Crown Proceedings Act 1980*); or
> (b) a local government; or
> (c) any public authority constituted under an Act.
>
> …
>
> **36 Proceedings against public or other authorities based on breach of statutory duty**
>
> (1) This section applies to a proceeding that is based on an alleged wrongful exercise of or failure to exercise a function of a public or other authority.
>
> (2) For the purposes of the proceeding, <u>*an act or omission* of the authority</u> does not constitute a wrongful exercise or failure unless the act or omission was in the circumstances so unreasonable that no public or other authority having the functions of the authority in question could properly consider the act or omission to be a reasonable exercise of its functions." (underlined emphasis added; bold and italicised emphasis in original)

198 There is no direct counterpart to s 36 of the *CLA* (Qld) in the *CLA* (NSW). Section 43 of the *CLA* (NSW) is similar but in express terms only applies to a

"*liability* based on a breach of a statutory duty" and therefore does not concern a liability arising from a breach of a duty of care.[374] Section 43A of the *CLA* (NSW) is also similar, but its operation is confined by s 43A(1) to proceedings where the "*liability* is based on a public or other authority's exercise of, or failure to exercise a special statutory power" (as defined). Sub-section 43A(3) provides that "any act or omission involving an exercise of, or failure to exercise, a special statutory power does not give rise to civil *liability*" unless something akin to the *Wednesbury*[375] test is established.

199 Relying on the judgment of Dalton J in *Hamcor Pty Ltd v Queensland* [2014] QSC 224 ("Hamcor") the plaintiff contended that s 36 is, like s 43 of the *CLA* (NSW), confined to cases where the alleged liability is for a breach of a statutory duty. In *Hamcor*, Dalton J held that the heading to s 36 and a reading of the whole section warranted a conclusion that the provision was so limited.[376] Seqwater and the State contended that *Hamcor* was wrongly decided.[377]

200 In *Hamcor*, Dalton J noted that both ss 35 and 37 were wide enough to include a tortious duty and stated:[378]

> "Section 36 is the only section of the three which speaks in terms of 'breach of statutory duty' and it is hard to conclude that this was not deliberate. After using that phrase in the heading, the section does not use the words 'duty' or 'breach of duty' again. Again this seems a deliberate choice not to use the words which are defined to include tortious duties."

201 In *Hamcor*, Dalton J described s 36 as a provision which "drastically reduces the rights of persons to a remedy by very significantly lowering the standard of care owed by public or other authorities".[379] Her Honour found that this attracted a rule of construction stated by Kitto J in *Board of Fire Commissioners (NSW) v Ardouin* (1961) 109 CLR 105 at 116; [1961] HCA 71, to the effect that "a presumption … arises that the Legislature, in enacting it,

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[374] *Dansar* at [92].
[375] *Associated Provincial Picture Houses Ltd v Wednesbury Corporation* [1948] 1 KB 223.
[376] At [193] to [196].
[377] Seqwater subs at [553]; State subs at [598] to [614].
[378] At [195].
[379] At [196].

has chosen its words with complete precision, not intending that such an immunity, granted in the general interest but at the cost of individuals, should be carried further than a jealous interpretation will allow”.

202 The finding of Dalton J in *Hamcor* concerning s 36 derives its strongest force from the heading to the provision. Section 14(2)(a) of the *Acts Interpretation Act 1954* (Qld) provides that the heading to a provision of legislation enacted after 30 June 1991 is part of the Act. This is in contrast to the position in New South Wales[380] and the common law.[381] Seqwater contended that Dalton J wrongly treated the heading as referring to “an independent cause of action for breach of statutory duty” as opposed to any cause of action in tort to which a breach of statutory duty might be an aspect.[382] However, her Honour’s reading of the *heading* to the section is identical to the interpretation of the effectively identical phrase in s 43(1) of the *CLA* (NSW).[383]

203 Nevertheless, with respect to her Honour I do not accept that the substantive words of s 36 can be exclusively confined to causes of action for breaches of statutory duty. I respectfully consider that her Honour was plainly wrong to so find. Such a conclusion is inconsistent with the text of s 36(1) which, even allowing for its difficulties, is directed to a wider class of proceedings rather than just proceedings for the breach of a statutory duty. The provision requires that the nature of the proceedings or claim be first characterised to ascertain what the proceeding is “based on”. Such a process of characterisation requires that “primary attention … be given to the allegations made by the plaintiff”, although they are not determinative.[384] Such a process of characterisation may lead to the conclusion that a proceeding in negligence is “based on” a wrongful exercise or failure to exercise a “function” of a public or other authority. In that regard, the definition of “function” in s 34 is not confined to a “duty”.

[380] *Interpretation Act 1987* (NSW), s 35(2)(a).
[381] *Silk Bros Pty Ltd v State Electricity Corporation of Victoria* (1943) 67 CLR 1 at 16; [1943] HCA 2.
[382] Seqwater subs at [555].
[383] *Dansar* supra.
[384] *Bankstown City Council v Zraika; Roads and Maritime Services v Zraika* [2016] NSWCA 51 at [90] to [91], per Leeming JA.

204 This conclusion is reinforced when regard is had to the operative provision of s 36, namely s 36(2). Section 36(2) is directed to regulating the circumstance in which an “act or omission of” the relevant public authority is found to be “wrongful” for the “purposes of the proceeding”. Like s 36(1), an issue as to whether the act or omission of a public or other authority was “wrongful” may arise in a claim of negligence as well as a claim for breach of statutory duty. Insofar as s 36(2) addresses that question “for the purposes of the proceeding”, it applies to both types of proceedings.

205 Nevertheless, when regard is had to how, in light of the Court’s findings to this point, the case against the defendants is “based”, then it follows that the section is not engaged. Section 36(2) stands in contrast to some of the other provisions of the *CLA* (Qld)[385] that provide that, in various circumstances, a person or entity is not “liable”, such as s 37. Similarly s 16(1) of the *CLA* (Qld) provides that a “person is *not liable* in negligence for harm suffered” as a result of the materialisation of an inherent risk. Unlike those provisions, s36(2) does not address the “liability” of the public authority. Instead, it is directed to a narrower topic namely, whether the public authority’s acts or omissions were “wrongful”. Thus in a case of “true vicarious liability” such as the present, where the (alleged) public authority is being attributed with the “liability” of an employed flood engineer, s 36(2) has no application.[386] On any view of the definitions in s 34, none of the flood engineers was a “public or other authority”. As s 36(2) only deals with the wrongful acts of such authorities, it has no relevance to any assessment of whether any of the *flood engineers*’ acts or omissions were “wrongful”, that is a breach of any duty owed by them. If their acts or omissions are found to be wrongful, then any “liability” of the flood engineer is attributed to SunWater, Seqwater and the State as the case may be, independent of s 36 and irrespective of whether any of them constituted a “public authority” or not. The circumstance that an act or omission of a flood engineer who owes a duty of care in their own right might also be an act or omission of a public authority through principles of agency is irrelevant because, even if by operation of s 36(2) that act or omission qua the

[385] And the *CLA* (NSW).
[386] As submitted by the plaintiff: T 9428.84 to T 9429.23.

public authority was not "wrongful", the vicarious "liability" of the flood engineer would still be attributed to their employer.

206 In oral submissions, Senior Counsel for Seqwater submitted that this outcome raises a "serious coherence problem" because of the potential for differing standards of care being imposed on flood engineers as opposed to their employers who might be public authorities.[387] Senior Counsel for SunWater made a similar submission.[388] I disagree. If that is the outcome then that is the result of the various compromises represented by the statute and the conferring of control over the dams on the flood engineers as the price of gaining protection under s 374 of the *Safety and Reliability Act*. It is clear that s 22 of the *CLA* (Qld) applies to flood engineers in circumstances where neither Seqwater nor SunWater are a "professional" and could not deploy s 22 in their own right.[389] If s 22 was to personally excuse a flood engineer for a breach of duty, then no vicarious liability could be attributed to Seqwater (or SunWater).[390] It was not suggested that such an outcome presented a "serious coherence problem". It was also submitted that this approach to s 36 would deny the section of any real application in that all public authorities act through servants and agents.[391] However, this circumstance has only arisen because the flood engineers have been found to owe a duty in their own right. This obstacle to s 36 being engaged would not arise in the more straightforward example where the only basis of liability is an alleged breach of the public authority's own duty that was committed by an employee who did not owe a duty in their own right.

207 For completeness, I will address some of the remaining issues concerning whether the defendants could invoke s 36. Three matters should be noted.

208 First, there was a substantial dispute as to whether Seqwater was a "public or other authority" and, in particular, whether it was a "public authority

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[387] T 9663.7.
[388] T 9957.9 to T 9958.22.
[389] None of the defendants submitted that they were "professionals" in their own right.
[390] See *South West Sydney Local Health District v Gould* [2018] NSWCA 69 at [33].
[391] T 9664 to T 9665.

constituted under an Act", what its "function[s]" are and whether the proceedings were based on a wrongful exercise or failure to exercise those functions.[392]

209 The phrase "public authority constituted under an Act" in (c) of the definition of "public or other authority" is not further defined in the *CLA* (Qld). However, discussions of the same phrase in other statutory contexts are relevant.[393] In *Re Anti-Cancer Council (Vict); Ex parte State Public Services Federation* (1992) 175 CLR 442; [1992] HCA 53 ("Re Anti-Cancer Council"), an issue arose as to whether the Anti-Cancer Council of Victoria was a "public authority" for the purpose of a union eligibility rule that included employees of such an entity. Mason CJ, Brennan and Gaudron JJ stated:[394]

> "… it is convenient to have regard to some aspects of the cases concerned with public authorities, the expression 'public authorities' also being one that has much the same meaning in popular usage as in a legal context.
>
> The question whether a body is a public authority is one of fact and degree which often requires a balancing of the various features of the body concerned. In that process, it may be decisive that private individuals have a financial interest in its profits or assets, or that its public functions are merely incidental to its private pursuits. Or it may be important that its powers derive from a private or non-statutory source, although that consideration is not necessarily decisive.
>
> In *Renmark Hotel Inc. v Federal Commissioner of Taxation* [(1949) 79 CLR 10 at 18; [1949] HCA 7 ("Renmark")], Rich J, at first instance, *said that for a body to be a public authority 'it should carry on some undertaking of a public nature for the benefit of the community or of some section or geographical division of the community and that it should have some governmental authority to do so'. His Honour's decision was upheld on appeal, emphasis being given to the need for 'public functions', 'duties to be exercised for public objects' or 'power ... to act on behalf of the public or the State*'. However, this last feature would seem to indicate a body of the kind that is usually identified as a State or public instrumentality." (emphasis added, citations omitted)

210 As noted in this passage, on appeal in *Renmark* Latham CJ identified the defining characteristic of a "*public authority*" for purposes of the *Income Tax Assessment Act 1936* (Cth) as being that the entity performs "*statutory duties*"

[392] Plaintiff subs at [158] to [164]; Seqwater subs at [518] to [586]; SunWater: SBM.030.004.0001; State subs at [597] to [601].
[393] *Re NSW Grains Board* [2002] NSWSC 913 at [37] per Barrett J.
[394] At 450 to 451.

or exercises "*public functions*".[395] Similarly, McTiernan J[396] said that to be a "*public authority*", a body must be "*constituted under statute and…given by statute powers or duties to be exercised for public objects*."

211 This discussion of the meaning of a public authority and their various duties and functions confirms that the "function" referred to in s 36(1) of the *CLA* (Qld) is related to the status of the body as a "public or other authority". While "function" may include "power", that does not mean that every grant of statutory permission or licence to a public body to undertake some activity amounts to the conferral of a "function" on that body. The exercise of a "function" usually involves the "discharging [of] public duties or [the exercise of] authorities or powers of a public nature".[397] On the other hand, where a statutory body is given statutory responsibility to regulate some activity, then the grant of an individual power to take action in a particular context may itself amount to a "function". In that context, a complaint of negligence about the wrongful exercise or failure to exercise that power by the authority may fall within s 36(1) and be regulated by s 36(2).

212 The main statutory provisions concerning Seqwater are set out in Chapter 2. There is no doubt that Seqwater "is constituted under an Act". To the discussion in Chapter 2 it should be added that: the *Restructuring Act* made provision for Ministerial oversight and direction in that the board, chairperson and any deputy chairperson were appointed by the "responsible Ministers" (ss 16(1), 17(1) and 18(1)); they could be removed for any reason or no reason (s 19(4)); the Chief Executive Officer is to be appointed only with the prior written approval of the responsible Ministers (s 27(2)); and there were various other reporting and accountability measures (ss 36-39) including in relation to the strategic and operation plans (s 46(3)-(4); s 49). Seqwater was required to pay an annual return to the State (s 53(1)). Section 6(3) specified that, as a "new water entity", Seqwater did not "represent the State", although s 64 provides that, as a new water entity, Seqwater expires at the end of

[395] At 23.
[396] At 23.
[397] *Puntoriero v Water Administration Ministerial Corporation* (1999) 199 CLR 575; [1999] HCA 45 at [15], citing *Little* at 108.

99 years after it is established and the State is the successor in law of any new water entity that has expired.

213 These provisions suggest that Seqwater has a public or quasi-public character. The plaintiff noted that s 11(2) of the *Restructuring Act* required Seqwater, as a new water entity, to "carry out its functions as a commercial enterprise". However, public functions can still be carried out in a commercial manner. It is the functions, not the manner of their performance, that is critical. That said, so far as Seqwater and s 36 are concerned, the plaintiff's contention only begs the related questions as to what are the powers, duties and functions that render it a "public authority" and what is the relevant "function" that engages s 36(1)? Seqwater's written submissions referred to the functions of a new water entity listed in s 9(2) of the *Restructuring Act*[398] and the various permissions granted to it under the *Water Act* as well as the vesting of ownership of the dams.[399] However in light of the finding in Chapter 2[400] concerning s 9(2) of the *Restructuring Act*, its statutory functions do not include flood mitigation and the conferral of permission to interfere with the flow of water and operate the dams cannot therefore be ancillary to any such function. Moreover, for the reasons just explained, the mere granting of those permissions did not of itself amount to the conferral of a "function" on Seqwater by statute.

214 It is not necessary to determine whether, in light of the other statutes that address Seqwater's activities, Seqwater is a "public authority" per se. Instead, it suffices to state that, in light of the finding that s 9(2) of the *Restructuring Act* was not engaged, then it follows that however the plaintiff's case against Seqwater is characterised, it is not "based on" an alleged "wrongful exercise of or failure to exercise a function of a public or other authority".

215 Second, it follows that SunWater has a weaker case for calling on s 36 than Seqwater. At all relevant times SunWater was a government owned corporation within the meaning of s 5 of the *Government Owned Corporations*

[398] Seqwater subs at [519] to [522].
[399] Ibid at [523] to [530].
[400] Chapter 2 at [14].

Act 1993 (Qld) (the "GOC Act"). Section 75 of the *GOC Act* requires that a Government Owned Corporation ("GOC") be a "public company" and "a company limited by shares, under the *Corporations Act 2001* (Cth)". On about 1 July 2008, SunWater was declared a GOC and registered under the *Corporations Act*. Upon registration, a company constitution dated 1 July 2008 took effect.[401] SunWater's shares remained vested in the Minister for Trade and Energy and the Ministers for Water Supply.[402] Under its constitution, SunWater's objects included the performance and provision of engineering consultancy services, operations and maintenance services, and performing any other function or exercising any other powers conferred on it under any Act or Regulation.[403] A number of provisions of the *GOC Act* emphasise that GOCs are to provide services on a commercial basis in a competitive market (*GOC Act*; s 13(a); 17(1)).

216 These provisions cast significant doubt on whether SunWater is an "authority constituted under an Act". Leaving that aside, SunWater is not conferred with any statutory objects, functions, duties or powers. Its only claim to being a "public authority" and to exercising a function for the purposes of s 36(1) is its engagement under the SLA.[404] However, having regard to *Re Anti-Cancer Council* and *Renmark*, neither a private or public body acquires status as a "public authority", much less a "function", by entering into an agreement. Again, it follows that, however the plaintiff's case against SunWater is characterised, it is not "based on" an alleged "wrongful exercise of or failure to exercise a *function* of a public or other authority". Otherwise, SunWater sought to claim some "derivative" application of s 36 flowing to it from Seqwater. Even if Seqwater could rely on s 36, there is no possible justification for giving s 36 any wider scope than its words can reasonably bear, including any suggested derivative application.

217 Third, it was not disputed that the State fell within the definition of a "public or other authority". However, for s 36 to be engaged, the proceeding must be

[401] MSC.030.043.0001.
[402] SBM.030.004.0001 at [3(b)]; GOC Act; s 6.
[403] MSC.030.043.0001; cl 2.1.
[404] SBM.030.004.0001 at [12(e)].

"based on" an alleged wrongful exercise or failure to exercise one of *its* functions.[405] The only means by which the State suggested that this arose was because "[i]f the State is vicariously liable for Mr Ruffini, it must follow that the State (by Mr Ruffini) is undertaking a function of the kind to which s 36 can apply".[406] However, for the reasons already explained, just because the State made one of its employees available to act as a flood engineer at Wivenhoe Dam and Somerset Dam does not render the conduct of flood mitigation a "function" of the State.

218 Hence, for these additional reasons, the defendants' reliance on s 36 of the *CLA* (Qld) fails.

Section 22

219 As noted in Chapter 9,[407] each of the defendants pleaded reliance on s 22 of the *CLA* (Qld). It relevantly provides:

> "**20 Definition for div 5**
>
> In this division—
> …
> a professional means a person practising a profession
>
> **22 Standard of care for professionals**
>
> (1) A professional does not breach a duty arising from the provision of a professional service *if it is established that* the professional *acted* in a way that (at the time the service was provided) was widely accepted by peer professional opinion by a significant number of respected practitioners in the field *as competent professional practice*.
>
> (2) However, peer professional opinion can not be relied on for the purposes of this section if the court considers that the opinion is irrational or contrary to a written law.
>
> (3) The fact that there are differing peer professional opinions widely accepted by a significant number of respected practitioners in the field concerning a matter does not prevent any 1 or more (or all) of the opinions being relied on for the purposes of this section.

405 S 36(1).
406 State subs at [615].
407 Chapter 9 at [48].

(4) Peer professional opinion does not have to be universally accepted to be considered widely accepted.

(5) This section does not apply to liability arising in connection with the giving of (or the failure to give) a warning, advice or other information, in relation to the risk of harm to a person, that is associated with the provision by a professional of a professional service." (emphasis added)

220 The equivalent provision in the *CLA* (NSW) is s 5O. One substantive difference[408] between the two provisions is that ss 5O(1) and (3) specify that the relevant "widely accepted practice" is a practice "in Australia" whereas s 22 is silent on the geographical area in which the practice must be accepted.[409] Thus, one issue debated between the parties concerned the geographical scope of s 22. The plaintiff contended that it was confined to practices in Queensland,[410] whereas the defendants contended that it was unrestricted and therefore included overseas practices.[411] The findings of fact in Chapter 9 concerning practices at other dams reflect that debate.[412] However, as explained below, in light of the findings in Chapter 5 and Chapter 9, it is not necessary to resolve this issue.

221 Two related issues have arisen in the New South Wales Court of Appeal concerning so much of s 5O of the *CLA* (NSW) that is not relevantly different to s 22 of the *CLA* (Qld).

222 The first is whether the section affords a "defence". This raises related issues as to whether the section places an onus of proof on any party, whether any relevant practice forms part of the assessment of whether there has been a breach of duty and whether it should be addressed before or after the application of ss 9 and 10 of the *CLA* (Qld).[413]

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408 Section 22(1) also appears to require that the "peer professional opinion" be held by a "significant number of respected practitioners" whereas s 50 does not expressly state that. None of the parties suggested that this was of any significance to this matter.
409 Although section 5O does not contain any equivalent to s 22(5), s 5P is to the same effect.
410 Plaintiff subs at [226] to [239].
411 Seqwater subs at [611] to [621]; Sunwater subs at [714] to [723]; State subs at [630] to [632].
412 Chapter 9 at [48] to [50].
413 *Sparks v Hobson; Gray v Hobson* [2018] NSWCA 29 ("Sparks"); *Dobler v Halverson* (2007) 70 NSWLR 151; [2007] NSWCA 355; *Sydney South West Area Health Service v MD* [2009] NSWCA 343; *Mules v Ferguson* [2015] QCA 5.

223 The various authorities on this point were considered and reconciled by Leeming JA (with whom Basten and Meagher JJA agreed) in *South Western Sydney Local Health District v Gould* [2018] NSWCA 69 ("Gould"). Leeming JA described as "uncontroversial ... [the proposition] that the defendant bears the onus of establishing the elements of s 5O(1), namely that he or she was a "professional" and acted in a manner which, at the time, was widely accepted in Australia by peer professional opinion as competent professional practice.[414] His Honour noted that the description of the section as a "defence" in some of the cases was capable of being "ambiguous"[415] because "if the preconditions are established, then the standard of care against which the defendant's conduct is assessed is that which was widely accepted by peer professional opinion as competent professional practice, unless the court considers that opinion is irrational".[416] Leeming JA confirmed that a contention that s 5O of the *CLA* (NSW) is engaged should be considered first[417] because, if it is established, "it will fix the relevant standard"[418] to the exclusion of ss 9 and 10.[419]

224 The second issue is whether it is necessary to identify some practice prevailing at the time the relevant professional acted or whether it is simply sufficient to demonstrate that the particular manner in which the relevant professional acted in the given case was widely accepted by peer professional opinion. In *McKenna v Hunter & New England Local Health District; Simon v Hunter & New England Local Health District* [2013] NSWCA 476 ("McKenna"), Macfarlan JA held that the former was correct, stating:[420]

> "To establish a defence under s 5O a medical practitioner needs to demonstrate, first, that what he or she did conformed with a *practice* that was in existence at the time the medical service was provided and, secondly, to establish that that *practice* was widely, although not necessarily universally, accepted by peer professional opinion as competent professional *practice*." (emphasis in original)

[414] At [30].
[415] *Gould* at [120].
[416] *Gould* at [123].
[417] Citing Simpson JA in *Sparks* at [329].
[418] Citing *Sparks* at [24], per Basten JA.
[419] *Gould* at [125] to [126].
[420] At [160].

225 In *McKenna*, Beazley P agreed with Macfarlan JA.[421] Garling J dissented but did not address s 5O. On appeal, the High Court reversed the result in *McKenna* on the basis that no duty of care was owed but did not address this issue.[422] In *Sparks*, Macfarlan JA reiterated the approach stated by his Honour in *McKenna*.[423] Simpson JA expressed doubts about that approach but followed it.[424] Basten JA in *Sparks* observed that the approach in *McKenna* "may well sufficiently describe many circumstances in which s 5O is invoked" but added that he "would not understand it as a general proposition as to the constraints imposed by s 5O(1)" and, if it was necessary to go further, "would not follow *McKenna*".[425] His Honour appeared to identify his preferred view as to how s 5O operates as follows:[426]

> "To speak of "a practice" adopted by a group of professional persons suggests a regular course of conduct adopted in particular circumstances. By contrast, the phrase "competent professional practice" is apt to cover the whole gamut of professional services provided by the practitioner, whether or not the particular circumstances have arisen sufficiently often to result in an established practice."

226 In *Mules v Ferguson*,[427] Boddice J (with whom McMurdo P agreed) referred to the defence in s 22 as "requir[ing] an identification of the particular conduct and the group of peer opinion supporting that conduct as being widely accepted practice". In support of that contention, his Honour stated "[s]ee generally, *Hunter and New England Local Health District v McKenna*." In *Gould*, Leeming JA did not suggest that this aspect of *McKenna* was wrong. It follows that the approach stated by Macfarlan JA in *McKenna* is binding on this Court at first instance.

Practices Generally

227 In considering the application of s 22, it is important to note the finding in Chapter 3 that it was common ground amongst the experts across a variety of

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[421] At [1].
[422] *Hunter and New England Local Health District v McKenna; Hunter and New England Local Health District v Simon* (2014) 253 CLR 270; [2014] HCA 44 at [12].
[423] *Sparks* at [209] to [210].
[424] At [332].
[425] *Sparks* at [34] to [35], [40].
[426] *Sparks* at [31].
[427] At [191].

disciplines that a flood engineer should follow the water control manual for a dam during flood operations, with its obvious corollary that a flood engineer cannot refuse to apply the approach stated in such a manual because they disagree with it.[428] Otherwise, the analysis in Chapter 3,[429] Chapter 5[430] and Chapter 9[431] confirms the futility of a search for underlying practices beyond what is reflected in the relevant water control manual. As submitted by the plaintiff, "[t]he primacy of the relevant manual to each dam's operation is explained by the circumstance that every dam is different"[432] and that each dam "typically has its own manual dealing with the circumstances relating to that particular dam".[433] Consistent with the findings in Chapter 9,[434] the manner of operation of each particular dam is reflected in its water control manual which is itself a product of a multi-factorial assessment of each dams particular circumstances,[435] including the size of the reservoir,[436] the proximity to downstream populations, the upstream flood travel times,[437] and weather patterns, including whether the dam's inflows are principally the result of snowmelt or rainfall.[438]

SunWater's Reliance on Section 22

228 SunWater accepted that s 22 "operates as a defence" upon which it bears the onus.[439] Although SunWater pleaded reliance on s 22, it did not plead the particular practice relied on[440] as would appear to be required by *McKenna*.[441] However, as noted in Chapter 5,[442] in its submissions SunWater identified the relevant practice it relied on as a practice "in multi-purpose dams with a *constant* FSL, [of] … not drawing dams below FSL for the purposes of flood

[428] Chapter 3 at [2].
[429] At [331] to [376].
[430] At [105] to [131].
[431] Section 9.1.
[432] Plaintiff subs at [151] citing (Fagot 1, EXP.QLD.001.0232_3, [4]; T 4152.5 (Dreverman); T 7366.3 (Swain); T 9007.36 (Fagot).
[433] T 2799.4-16 (Christensen); T 4152.8-19 (Dreverman); T 9007.36 (Fagot).
[434] Section 9.1; esp at [4], [50] and [51] to [60].
[435] T 7383.42, T 7397.2 (Swain); T 9008.22 (Fagot).
[436] T 7375.25 to T 7376.16 (Swain).
[437] T 7383.1.18, T 7409.24 (Swain).
[438] T 7383.25, T 7383.47 to T 7384.4 (Swain).
[439] SunWater subs at [705].
[440] SunWater defence, PLE.030.008.0001, [213(e)], [229(e)], [246(e)], [268(e)], [289(e)], [340(e)].
[441] See Plaintiff subs at [211] to [212].
[442] At [194] to [196].

mitigation".[443] As stated in Chapter 5,[444] it was not established that the flood engineers acted "in a way" that was in accordance with that practice. Instead, at most, it was only established that they did not release water below FSL in circumstances where there was not a "constant" FSL.[445]

The State's Reliance on Section 22

229 The State also pleaded reliance on s 22,[446] but also did not purport to identify the particular practice relied on. Instead, it particularised the USACE Report noted in Chapter 7[447] and stated that it "would rely upon the reports and opinions of the dam operations experts from whom it is intended to adduce expert evidence at trial".[448] Further, despite embracing *McKenna* in its submissions,[449] the State did not in those submissions identify any pre-existing practice that the flood engineers acted in accordance with. Instead it only submitted that they acted in accordance with "general practice".[450] Accordingly, it follows from *McKenna* that the State's reliance on s 22 must fail. For the sake of completeness, I will address its submissions on the basis that the approach of Basten JA in *Sparks* represents the law.

230 Consistent with its pleading, the State's submissions sought to rely on "a great deal of evidence supporting a finding that a significant number of respected practitioners would have acted in the way the Flood Operations Engineers did".[451] It also relied on the favourable conclusion of the USACE in their review of flood operations during the January 2011 Flood Event, as noted in Chapter 7.[452]

231 Even adopting the approach of Basten JA in *Sparks*, the level of generality that the State pitched its submission, namely by reference to "a great deal of

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443 SunWater subs at [705].
444 At [195].
445 See Chapter 5 at [195].
446 State defence, PLE.040.007.0001, [254(h)], [277(d)], [308(a)].
447 Chapter 7 at [478].
448 State defence, PLE.040.007.0001 at [308(a)(ii)].
449 State subs at [628(b)].
450 State subs at [625]; In State subs at [628(b)] the State submits that "it was widely accepted as a basis of a practice of dam operation" without specifying what "it" was.
451 State subs at [628(a)].
452 ROD.901.001.8997 at .9020; Chapter 7 at [478] to [480]; State subs at [634].

evidence", makes it difficult to be persuaded that it has discharged its onus. To the extent that it can be ascertained which opinions of the experts as to the approach adopted by the flood engineers are being relied on by the State, those opinions were all subject to the acceptance by their author of the necessity for a flood engineer to act in accordance with the relevant water control manual (or at least a reasonable interpretation of the Manual).[453] In circumstances where the flood engineers acted contrary to the relevant water control manual (and any reasonable interpretation of it), then I do not accept that those opinions mean that s 22(1) has been satisfied. In particular, I do not accept that the evidence adduced by any of the experts called by any of the defendants established that a flood engineer who acted contrary to the relevant water control manual (or any reasonable interpretation of it) nevertheless acted "in a way that … was widely accepted by peer professional opinion by a significant number of respected practitioners in the field as competent professional practice." Further, if that was the true effect of any opinion provided by any expert then I am satisfied that any such opinion would be "irrational" even according to the (stringent) test for irrationality stated in *Gould*,[454] namely:

> "…..it is a seriously pejorative and exceptional thing to find that a professional person has expressed an opinion that is "irrational", and even more exceptional if the opinion be widely held. To consider a body of opinion to be "irrational" is a stronger conclusion than merely disagreeing with it, or preferring a competing body of peer professional opinion"

232 This test would be met because an opinion to the effect that a flood engineer who acted contrary to the relevant water control manual (and any reasonable interpretation of it) nevertheless acted "in a way that … was widely accepted … *as competent professional practice*", would be internally inconsistent and inconsistent with the overwhelming body of evidence that the fundamental requirement of a flood engineer was to follow the relevant water control manual.[455] The State's reliance on the USACE conclusion suffers from these very deficiencies. Moreover, the limitations imposed on the USACE review

[453] Chapter 3 at [2].
[454] At [96] per Leeming JA.
[455] Chapter 3 at [2].

noted in Chapter 7[456] are such that I do not regard it as any persuasive evidence capable of satisfying s 22(1) of the *CLA* (Qld), even on the approach stated by Basten JA in *Sparks*.

Seqwater's Reliance on Section 22

233 Seqwater framed its principal submission by reference to the approach in *McKenna*[457] but, in the alternative, submitted that the approach of Basten JA in *Sparks* was to be preferred.[458] In relation to the former, all of the practices that were either pleaded or the subject of submissions by Seqwater were addressed in Chapter 9.[459] None were established. In relation to the latter, the analysis of the State's reliance on Basten JA's approach in *Sparks* to this aspect of s 22 just undertaken applies equally to Seqwater's alternative submission.

Conclusion

234 None of the defendants have satisfied the onus placed on them by s 22(1) of the *CLA* (Qld). It follows that the standard of care is that of the reasonably competent flood engineer and the allegations of breach of duty are to be determined by reference to ss 9 and 10 of the *CLA* (Qld).

11.8: Nuisance and Trespass

235 The plaintiff pleaded a case in (private) nuisance and trespass against each of the defendants,[460] although it was accepted by all the parties, including the plaintiff, that it was properly analysed as a case in nuisance.[461] In relation to trespass, Seqwater referred to *Southport Corporation v Esso Petroleum Co Ltd* (1954) 2 QB 182 at 195 to 196 ("Southport") as support for the proposition that it "[i]t is not a trespass for A to discharge water which, through natural forces such as the flow of a river or tides, at some later time ends up on B's

[456] Chapter 7 at [480].
[457] Seqwater subs at [631].
[458] Ibid at [632].
[459] At [48] to [60].
[460] 5ASOC at [354] to [362].
[461] Plaintiff subs at [283]; Seqwater subs at [2544]; SunWater subs at [2676].

property".[462] *Southport* is authority for that proposition. Although the force of *Southport* as an authority may be diminished by its reversal in the House of Lords in relation to nuisance,[463] in the House, Lord Tucker nevertheless, agreed with this aspect of Denning LJ's analysis of trespass.[464] It appears to reflect the accepted position that for an invasion of land by an object to constitute a trespass it must be the immediate or direct result of the defendant's actions and not merely some consequence of those actions.[465] In this case, there were many kilometres between the Wivenhoe Dam gates and the plaintiff's store which appears sufficient to rob the act of releasing water of the necessary directness to constitute a trespass to the plaintiff's leasehold.

236 The plaintiff's case in nuisance was confined to only those Group Members "who held an interest in land located downstream of Wivenhoe Dam … and whose use or enjoyment of that interest was interfered with by reason of the inundation by water in the period 9 January 2011 to 24 January 2011" (the "sub-group members").[466] This excluded those group members who held such an interest in land but only suffered loss or damage from inundation but not an interference with the use and enjoyment of their interest[467] and Group Members who only suffered damage to their personal property.[468]

237 As against Seqwater, it was pleaded that the act of nuisance was the release of water by the flood engineers in the period 9 January 2011 to 19 January 2011, which was said to have caused "greater flooding", that is more flooding than would have occurred had the flood engineers not committed one or more of their breaches.[469] Seqwater was pleaded to be liable in nuisance by reason of its ownership and control of land from which the nuisance was created (ie, the dams)[470] as well as its various licences and permissions to conduct flood

[462] Seqwater subs at [2544(b)].
[463] *Esso Petroleum v Southport Corporation* [1956] AC 218.
[464] At 244.
[465] See Balkin and Davis, *The Law of Torts* (5th edition, 2013, Lexisnexis Butterworths) at [5.2] and *Reynolds v Clarke* (1725) 2 Ld Raym 1399; *Reynolds v Clerk* (1725) 88 ER 193.
[466] 5ASOC at [354].
[467] Ibid at [6(a)(i) and (ii)].
[468] Ibid at [6(b)].
[469] Ibid at [346].
[470] Ibid at [360(a)].

operations,[471] the actual conduct of flood operations that carried with it a risk of nuisance[472] and various other factors.[473] However, in its submissions, the plaintiff stated that its case in nuisance was (confined to) “a claim against Seqwater as the owner and occupier of the land from which the nuisance emanated for failing to take reasonable steps to prevent the nuisance”.[474] Each of Seqwater, Sunwater and the State was also pleaded to be vicariously liable for the nuisance or trespass caused by the flood engineers they respectively employed.[475] In its submissions, the plaintiff stated that this was also referable to releases made in the period between 9 January 2011 to 19 January 2011.[476]

238 The plaintiff noted (correctly) that a “private nuisance is an unreasonable interference with the use and enjoyment of land”, citing *Melaleuca Estate Pty Limited v Port Stephens Council* (2006) 143 LGERA 319; [2006] NSWCA 31 at [22] (“Melaleuca”)[477] and that flooding is a commonly accepted example of a nuisance.[478] While it is not necessary to establish negligence on the part of the alleged wrongdoer, “fault of some kind is always necessary”.[479] However, the plaintiff contended that it was only necessary to prove foreseeability and material damage to property with the fault element being the obligation on Seqwater to prove that its interference with the plaintiff’s use and enjoyment of the property was reasonable.[480] Subject to what follows, that contention should be accepted.[481]

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[471] Ibid at [360(b) and (c)].
[472] Ibid at [360(d)].
[473] Ibid at [360(e) to (f)].
[474] Plaintiff subs at [258].
[475] 5ASOC at [368], [372] and [376].
[476] Plaintiff subs at [258]; 5ASOC at [356] to [359].
[477] Ibid at [261].
[478] See for example *Gales Holdings Pty Ltd v Tweed Shire Council* (2013) 85 NSWLR 514; [2011] NSWSC 1128 at [133] (“Gales”).
[479] *Elston v Dore* (1982) 149 CLR 480 at 488; [1982] HCA 71; “Elston v Dore”.
[480] Plaintiff subs at [260(a)]; see *Quick v Alpine Nurseries Sales Pty Ltd* [2010] NSWSC 1248 at [141], per Ward J.
[481] *Kraemers v A-G (Tas)* [1966] Tas SR 113 at 122 to 123, per Burbury CJ.

Unreasonable Interferences and Watercourses

239 Leaving aside which party bore the onus of demonstrating that any interference with the sub-group member's interest in law was unreasonable, difficult questions arise in determining that issue when considering the respective rights and obligations of competing land owners in respect of interferences with watercourses. Seqwater and SunWater contended that, as the peak outflow from Wivenhoe Dam never exceeded peak inflow into the Wivenhoe reservoir, that meant there was in effect no interference with the natural flow of the watercourse by flood operations during the January 2011 Flood Event. In turn this meant, so it was said, that any flooding of the plaintiff's store from the natural flow of the watercourse did not amount to an *unreasonable* interference with the plaintiff's use and enjoyment of its leasehold interest.[482]

240 Seqwater developed its contention by reference to *Gartner v Kidman* (1962) 108 CLR 12; [1962] HCA 27 ("Gartner"),[483] in which the owner of lower land erected sandbanks around a sandpit. This blocked a drainage ditch across his (lower) land which carried excess surface water from the higher land. The High Court rejected a contention that the owner of the lower land is always obliged to receive runoff surface water from the owner of the higher land.[484] Windeyer J, stated various propositions concerning the rights of higher and lower land owners in respect of surface runoff, including that, in respect of the "[t]he higher proprietor", he or she:[485]

> "… is not liable merely because surface water flows naturally from his land on to lower land. He may be liable if such water is caused to flow in a more concentrated form than it naturally would. It flows in a more concentrated form than it naturally would if, by the discernible work of man, the levels or conformations of land have been altered, and as a result the flow of surface water is increased at any particular point."

241 On its face, if this principle was applicable to the circumstances of the January 2011 Flood Event, then the proprietor of the higher land, namely Seqwater,

[482] Seqwater; SBM.020.007.0001 at [2538A]; SunWater subs at [2615] to [2618].
[483] SBM.020.007.0001 at [2538B].
[484] At 49.
[485] At 48 to 49.

would not be liable in nuisance in the absence of proof that the dams caused a "more concentrated flow than it naturally would". However, in *Gartner* this principle was expressly stated to be only applicable to "surface waters" which "…do not include the waters of a stream or river which when periodically swollen in time of flood flows in a wider channel than ordinarily, the super-abundant waters following the general course of the stream but flowing on lands outside its ordinary bed" and that such "'flood channels' are to be regarded as if they were part of the alveus [riverbed] of the stream".[486] In such cases, "[t]he law of natural watercourses applies, not that of surface waters" and the "riparian owner may not impede the flow or *throw the flood waters upon the lands of his neighbour on the opposite bank*".[487] This statement is also strongly suggestive of there (only) being a legal obligation on the higher land owner not to make flooding worse for those downstream.

242 In *Gales*, Emmett JA addressed the law of watercourses stating:[488]

> "*A riparian owner, being the proprietor of land on the banks of a natural stream of running water, is entitled to enjoy, and is obliged to accept, the flow of water past the land*. The law of natural watercourses, not surface waters, applies even to waters of a river flowing in a wider channel than usual, when the river is swollen in time of flood, even though they flow on land outside the riverbed while still following the river's general course. Such flood channels are treated as part of the alveus, or riverbed.
>
> A riparian owner can neither deprive those lower down the river of its flow, nor pen it back upon the lands of a neighbour higher up. Riparian rights and obligations are proprietary, being natural incidents of the ownership or lawful possession of the land abutting on the stream or river. They turn on who owns the riverbank, not the riverbed, [citing *Gartner* at 23]" (emphasis added)

243 Most of the incidents or riparian rights, including the power to take water from a watercourse, have either been removed, or are at least governed by, statute including the *Water Act*.[489] That said, this passage is difficult to reconcile with any suggestion that a land owner such as Seqwater creates a nuisance for downstream land owners by failing to lessen the effects of a flood unless it was shown that the presence of the dam or the conduct of flood operations

[486] At 47 to 48.
[487] At 48.
[488] At [133] to [134].
[489] See Chapter 5, section 5.1.

lead to a greater concentration of flow than would otherwise have been, such as through the hydraulic effect, or by altering the direction of flow of flood water, both of which were not shown. The acts constituting a nuisance in *Gales* channelled water onto the affected land "in greater quantities and volumes than the natural flow".[490]

244 The closest that any decision concerning watercourses came to the present case was *Thomas & Evans Ltd v Mid-Rhondda Co-operative Society Ltd* (1941) 1 KB 381 ("Thomas & Evans"), in which a land owner erected a wall to protect his land from the naturally occurring flow of water from a river but then later removed the wall, causing water to pass onto his land and then onto his neighbours' land. In circumstances where the neighbour had no legal right to compel the preservation of the wall, no action in nuisance was held to be maintainable.[491] In *UCC v ESB*, a claim in nuisance was rejected on the basis that a "lower riparian proprietor such as UCC" was "obliged to accept the natural flow of the river".[492] Their Honours stated:[493]

> "Riparian rights and duties are indicia of land ownership. The law of private nuisance as between landowners, by reasons of history and the evolution of societal norms over time is informed by and reflects the key principles of riparian law.
>
> Absent the establishment of a positive obligation on ESB to hold water back there can be no cause of action in negligence, the measured duty or nuisance because riparian law permits discharge of the flow of the river."

245 I have already rejected the application of the reasoning in this passage concerning "negligence" to these proceedings but the balance of it concerning nuisance appears to be consistent with *Thomas & Evans*. The only "positive obligation" on Seqwater to conduct flood operations is that imposed by the law of negligence and I do not accept that this is the relevant obligation being adverted to (and even if it was, it would mean that this aspect of the case rises no higher than a negligence claim).

490 *Gales* at [174].
491 At 392 to 393.
492 At [79].
493 At [80] to [81].

246 *Thomas & Evans* was referred to with approval in *Elston v Dore* at 489 to 490, but its effect was significantly qualified by Gibbs CJ, Wilson and Brennan JJ who stated that "[w]here a person, by doing something on his own land, causes actual and material damage to another's land, the act of the first mentioned person, although otherwise lawful, may be actionable if it was unreasonable having regard to all the circumstances, including the effect it was likely to have on the other land".[494] This qualification appears to leave considerable scope for an assessment of what is "unreasonable" on the part of the higher landowner (and is another reason why *UCC v ESB* cannot be directly translated into an Australian context for either negligence or nuisance). Nevertheless, it is difficult to envisage how a duty of a landowner vis-a-vis another landowner extends to taking action to mitigate flooding as opposed to not making it worse, such that it is difficult to conclude that it was "unreasonable" to fail to do so in the sense discussed in *Elston v Dore*.

247 In circumstances where it has not been shown that Seqwater, in its capacity as the owner and occupier of the land upon which the dams were built, increased the flow of flood waters affecting downstream properties or otherwise materially increased the level of flooding downstream compared to the circumstance which would pertain if no dam was built on its land, then I am not satisfied that it has committed a nuisance. The same reasoning applies to the flood engineers (and through them, SunWater and the State).

248 In addition, SunWater also submitted that the releases from Wivenhoe Dam that flooded Mr Rodriguez's premises during the morning of 12 January 2011 could only have been occasioned by releases made during the period that Messrs Malone and Tibaldi were on duty during 11 January 2011.[495] In light of the finding I have just made, it is not necessary to address that contention.

Defences

249 In view of the manner in which the common questions are posed it is necessary to consider the "defences" to the nuisance claim.

[494] At 490.
[495] SunWater subs at [2628].

250 First, all of the defendants contended that the claim in nuisance failed because Seqwater exercised its statutory authority and powers with all reasonable regard and care for the interests of other persons.[496]

251 In *Bankstown City Council v Alamdo Holdings Pty Ltd* (2005) 223 CLR 660; [2005] HCA 46 at [16], Gleeson CJ, Gummow, Hayne and Callinan JJ noted a "line of authority marshalled" by the English Court of Appeal in *Marcic v Thames Water Utilities Ltd* ([2002] QB 929 at 988) ("Marcic") to the effect that "a body such as [a] Council is not, without negligence on its part, liable for a nuisance attributable to the exercise of, or failure to exercise, its statutory powers". In *Marcic* at [60], Lord Phillips noted that in *Department of Transport v North West Water Authority* [1984] 1 AC 336 at 344 the House of Lords approved four principles stated by the trial judge (Webster J), namely:

> "1. In the absence of *negligence*, a body is not liable for a nuisance which is attributable to the exercise by it of a duty imposed upon it by statute…
>
> 2. It is not liable in those circumstances even if by statute it is expressly made liable, or not exempted from liability, for nuisance…
>
> 3. In the absence of *negligence*, a body is not liable for a nuisance which is attributable to the exercise by it of a power conferred by statute if, by statute, it is not expressly either made liable, or not exempted from liability, for nuisance…
>
> 4. A body is liable for a nuisance by it attributable to the exercise of a power conferred by statute, even without *negligence*, if by statute it is expressly either made liable, or not exempted from liability, for nuisance…". (emphasis added)

252 In *Melaleuca*, Giles JA explained that the reference to "negligence" in this context is not the same as "negligence" in the sense of failure to exercise reasonable care and diligence in the discharge of a duty of care.[497] Instead, it has a "special sense of meaning [namely] that there would be negligence if the nuisance could have been prevented by reasonable exercise of the powers given by the statute and if there was a failure to prevent it by

[496] Seqwater subs at [2543]; SunWater subs at [2631] to [2665]; State subs at [669].
[497] At [50].

neglecting to make such reasonable use of the powers".[498] Thus, Giles JA stated that an "[a]bsence of negligence in this sense is a reflection of inevitability", in that "[i]f the exercise of the statutory power means that the interests of other persons are harmed despite all reasonable regard and care for those interests, there is no right of action".[499] Further, the onus lay on the defence to demonstrate that "its statutory authority could not be carried out without creating that nuisance".[500]

253 It follows that the defendants cannot bring themselves within any of the principles stated by Webster J above and approved in *Marcic*. In the absence of an operational or strategic plan enlivening s 9(2) of the *Restructuring Act*, no statutory function of flood mitigation, much less any power, could be said to have been exercised in the conduct of flood operations.[501] Further, in light of the findings in previous chapters and the following chapter, the defendants have comprehensively failed to demonstrate that they took "all reasonable regard and care" in the exercise of any such powers.

254 Second, both SunWater and Seqwater claim that any nuisance arising from releases on or after 9 January 2011 could be justified as a matter of "necessity".[502] They both relied on the following observations of Devlin LJ (at first instance) in *Esso Petroleum Co Ltd v Southport Corporation* [1956] AC 218 at 228:

> "The safety of human lives belongs to a different scale of values from the safety of property. The two are beyond comparison and the necessity for saving life has at all times been considered a proper ground for inflicting such damage as may be necessary upon another's property."

In the House of Lords, Earl Jowitt endorsed this principle ([1956] AC 218 at 235).

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[498] *Provender Millers (Winchester) Ltd v Southampton County Council* (1940) Ch 131 at 137, per Holland J as quoted by Giles JA in *Melaleuca* at [50].
[499] *Melaleuca* at [49].
[500] *Benning v Wong* (1969) 122 CLR 249 at 325; [1969] HCA 58, per Owen J.
[501] See Chapter 2 at [14].
[502] Seqwater at [2540] to [2542]; SunWater subs at [2669] to [2675].

255 Both Seqwater and SunWater pointed to the necessity to make large releases, at least on 11 January 2011, when the safety of the dam was potentially at risk and with consequential risks for human life.[503] The plaintiff contended that none of the defendants or flood engineers could rely on this defence "when it was the conduct of the Flood Engineers in the days leading up to 11 January that created the state of affairs requiring the large releases on 11 January 2011".[504] Both Seqwater and SunWater denied any negligence on their or the flood engineers' part in the period prior to 9 January 2011 (or thereafter). Seqwater contended that this meant that "[i]f the claim in negligence fails, so too will the claim in nuisance and trespass".[505] SunWater made a similar submission.[506] Again, in light of the findings in previous chapters and the following chapter, it follows that the defendants and the flood engineers were responsible for the state of affairs that necessitated such large releases on 11 January 2011. Moreover, SunWater and Seqwater's submissions are premised on a similar misconception as to the meaning of negligence in this context that was dispelled by Giles JA in *Melaleuca*. In this context, no question arises about whether a duty of care was owed or whether any counterfactual dam operations should be accepted. The defendants bear the onus of demonstrating they took the necessary steps and they failed to discharge it.

256 Third, each of Seqwater and SunWater relied on s 374 of the *Safety and Reliability Act* as a defence to the claim in nuisance.[507] The text of s 374 is set out in Chapter 2.[508] The extended definition of an "owner of a dam" would appear apt to include SunWater and the flood engineers. To invoke s 374, it must be shown that there was an observance of the operational procedures in the Manual, and that the relevant acts or omissions were made honestly and "without negligence in observing the procedures". It was not shown that the Manual was observed, much less that it was done without negligence.

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[503] Seqwater subs at [2540]; SunWater subs at [2672] to [2673].
[504] Plaintiff subs at [279].
[505] Seqwater subs at [2541].
[506] SunWater subs at [2675].
[507] Seqwater subs at [2545]; SunWater subs at [2666] to [2668].
[508] Chapter 2 at [32].

Conclusion about Nuisance and Trespass

257 The plaintiff's claim in trespass fails. The plaintiff's claim in nuisance against all defendants fails as it was not demonstrated that there was an unreasonable interference with its use and enjoyment of its interest in land. Had the plaintiff demonstrated an unreasonable interference with its interest in land then all the defences would have failed.

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CHAPTER 12: BREACH OF DUTY

CHAPTER 12: BREACH OF DUTY

1 Having found that each flood engineer owed a duty of care in their own right, it is necessary to address the pleaded allegations of breach of that duty. In summary, for the reasons stated in the balance of this Chapter:

(1) I do not accept that the plaintiff's case on breach is tied to establishing that on each and every day of the January 2011 Flood Event the relevant flood engineer failed to act in accordance with one or more of Dr Christensen's simulations. Instead, the allegations of breach are to be addressed in a manner consistent with the findings concerning the Manual and so much of Dr Christensen's simulations and methodology that I have accepted were required of a reasonably competent flood engineer, which is itself reflected in the acceptance of SIM C, SIM F and SIM H;

(2) I am satisfied that each of the defendants and the flood engineers had a proper opportunity to meet the case on breach that was pleaded by the plaintiff and the subject of submissions;

(3) I am satisfied that Mr Malone committed breaches of duty during the period he was DFOE from 2 to 5 January 2011, that thereafter each of the flood engineers committed breaches of duty while they were on shift during the period 6 to 10 January 2011 and Mr Ayre committed a breach of duty when he was not on duty on the evening of 7 January 2011 but was supervising flood operations as the Senior Flood Operations Engineer.

12.1: The Manual and Breach of Duty

2 In Chapter 11 it was concluded that allegations of breach of duty are to be determined by reference to ss 9 and 10 of the *CLA* (Qld).[1] They provide:

"**9 Duty of Care**

[1] Chapter 11 at [234].

(1) A person does not breach a duty to take precautions against a risk of harm unless—

(a) the risk was foreseeable (that is, it is a risk of which the person knew or ought to have known); and

(b) the risk was not insignificant; and

(c) in the circumstances, a reasonable person in the position of the person would have taken the precautions.

(2) In deciding whether a reasonable person would have taken precautions against a risk of harm, the court is to consider the following (amongst other relevant things)—

(a) the probability that the harm would occur if care were not taken;

(b) the likely seriousness of the harm;

(c) the burden of taking precautions to avoid the risk of harm;

(d) the social utility of the activity that creates the risk of harm.

10 Other Principles

In a proceeding relating to liability for breach of duty happening on or after 2 December 2002 –

(a) the burden of taking precautions to avoid a risk of harm includes the burden of taking precautions to avoid similar risks of harm for which the person may be responsible; and

(b) the fact that a risk of harm could have been avoided by doing something in a different way does not of itself give rise to or affect liability for the way in which the thing was done; and

(c) the subsequent taking of action that would (had the action been taken earlier) have avoided a risk of harm does not of itself give rise to or affect liability in relation to the risk and does not of itself constitute an admission of liability in connection with the risk."

3 The Dictionary in Schedule 2 of the Act defines "duty" as meaning:

"(a) a duty of care in tort; or

(b) a duty of care under contract that is concurrent and co-extensive with a duty of care in tort; and

(c) another duty under statute or otherwise that is concurrent with a duty of care mentioned in paragraph (a) or (b)."

4 The relevant “risk of harm” was discussed in Chapter 11, namely either the risk of inundation or damage to property from flooding from the Brisbane River breaking its banks or the risk of inundation or damage to property from the loss of flood storage space at Wivenhoe Dam forcing releases which would combine with downstream flows to cause flooding (or greater flooding) from the Brisbane River breaking its banks. As stated in Chapter 11, so far as breach is concerned, ultimately there is no material difference between the two.

5 Further, as explained below, the 5ASOC identifies a risk of harm for each day of flood operations which is expressed in similar, although more precise, terms. On 9 and 10 January 2011 it incorporates aspects of Somerset Dam operations. The existence of the relevant risks is addressed for each day along with the substance of the provisions of ss 9 and 10. At this point I note six points concerning the relevance of the provision of the Manual to an application of s 9 and s 10.

6 The first has already been adverted to in Chapter 3,[2] namely the significance of the Manual to an assessment of the appropriate response “in the circumstances” of a “reasonable person”. Translated to this case, that is the appropriate response of the reasonably competent flood engineer. As noted in Chapter 3,[3] the one matter that all the relevant experts agreed upon was that a reasonably competent flood engineer would conduct flood operations in accordance with the Manual irrespective of their own preferences and views about how flood operations should be conducted. For the reasons stated in Chapter 3,[4] and Chapter 5,[5] the possibility that this approach extends to reasonable interpretations of the Manual does not arise on the findings that have been made.[6]

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[2] Chapter 3 at [124ff].
[3] Chapter 3 at [2].
[4] Chapter 3 at [124] to [129].
[5] Section 5.4.
[6] Cf SunWater subs at [2576] to [2581], citing *Heydon v NRMA Ltd* (2000) 51 NSWLR 1 at [251]; Seqwater subs at [595] to [605].

7 Second, the Manual itself provides guidance to the reasonably competent flood engineer as to the type of risks that are, or at least may be, both "foreseeable" and "not insignificant" such that at the very least they ought to have been aware of them. The Manual also provides guidance as to the interrelated assessment of the "probability that the harm would occur if care were not taken" and the "likely seriousness of the harm". As noted in Chapter 3, the Manual directs an order of prioritising risk in its operations and discusses the potential for harm associated with those risks materialising. Thus, the first priority is ensuring the structural safety of each of the Dams. Consistent with this, the Manual states that a structural failure of Wivenhoe Dam "would have catastrophic consequences" and that a structural failure of Somerset Dam "could have catastrophic consequences".[7] The Manual then provides that the next priority is "providing protection of urbanised areas from inundation" and that the "prime purpose of incorporating flood mitigation measures into Wivenhoe Dam is to reduce flooding in the urban areas of the flood plains below Wivenhoe Dam". As noted in Chapter 2, the City of Brisbane has a population exceeding 1.9 million. This case is an example of a circumstance in which the levels of harm that could ensue if "care [was] not taken" are so high that even, if they had a relatively low probability of materialising then, subject to other considerations, the relevant precaution should nevertheless be taken.

8 Third, the Manual provides guidance to the reasonably competent flood engineer as to the assessment of the burden of taking precautions against the risk of harm. This is reflected in the third, fourth and fifth flood mitigation objectives in the Manual. Thus, in relation to the third objective, the Manual specifies that the inundation of dams, bridges and lower river terraces downstream should not be prolonged "unnecessarily". The impact of bridge closures is addressed in Chapter 2.[8]

9 Fourth, the question arises as to the consideration that is to be given to potential impacts beyond bridge inundation with downstream flow rates below

[7] Manual at 9.
[8] Chapter 2, section 2.7.

4000m^3/s at Moggill. As noted in Chapter 4, in preparing the Manual consideration was given to a 2007 study prepared by the Brisbane City Council on the topic of Flood Damage Minimisation.[9] The study identified a total of $1.11million in damage to 29 residential properties and 4 non-residential properties at flow rates of 3000m^3/s and $5.97million at 4000m^3/s[10] with an exponential increase in the monetary value of the damage at flow rates above that level. As noted in Chapter 2, in his statement Mr Ayre identified various properties and businesses that were potentially affected by flow rates less than 4000m^3/s.[11] Nevertheless, the Manual specified 4000m^3/s at Moggill as the threshold for “non-damaging” flows downstream.[12] Consistent with the analysis in previous chapters, the reasonably competent flood engineer would respect that specification in considering the “burden” of taking precautions to avoid the risk of harm, specifically when increasing releases (as Mr Ayre recognised).[13] The reasonably competent flood engineer could not be expected to undertake a survey of recent development in the (vast) downstream areas to gauge the impact of flows below what the relevant water control manual unambiguously specifies as the threshold for damage downstream.

10 Fifth, SunWater submitted that the content of “SunWater’s duty” is “heavily informed by its contractual relationship with Seqwater”.[14] As found in Chapter 11,[15] the relevant duty of care for these purposes was owed by Mr Ayre and not SunWater. Further, in light of the findings in the balance of that chapter there is no inconsistency between SunWater’s contractual duty and Mr Ayre’s duty of care. Similarly, in relation to breach, no part of Mr Ayre’s duty to his employer conditioned or affected the discharge of his duty of care.[16]

[9] LAY.SUN.001.0001_OBJ, [273]; SUN.900.011.5068.
[10] Chapter 4 at [118]; Figure 4-3.
[11] Chapter 2 at [93].
[12] Manual at 29.
[13] See Chapter 7 at [104].
[14] SunWater’s subs at [2582] to [2585].
[15] Section 9.2 and 11.4
[16] Chapter 11 at [139] to [149] and [121] to [122].

11 Sixth, SunWater made a number of points about the position of a reasonably competent flood engineer in relation to breach, namely: the inherent difficulties in managing a dam and dealing with the volatility of rainfall and rainfall forecasts ("at the mercy of the elements"),[17] the fact that acting as a flood engineer was not a full time undertaking but instead a diversion from the work that a civil or hydraulic engineer usually undertakes on a daily basis,[18] and that flood operations during the January 2011 Flood Event were undertaken under great stress and involved long hours.[19] These are all points of substance and I have considered them, although, as noted earlier, the allegations of breach generally involve systemic failures on the part of the flood engineers to apply the very Manual that they drafted.

12.2: The Relationship Between the Allegations of Breach and Dr Christensen's Simulations

12 There was a substantial debate between the parties about the scope of the plaintiff's pleading on breach as addressed in its closing submissions and its relationship to Dr Christensen's evidence and his simulations.

Submissions

13 The plaintiff's closing submissions did not expressly allege that the negligence of the flood engineers arose simply from their failure to conduct flood operations substantially in accordance with one or more of Dr Christensen's simulations. Instead, the submissions referred to the simulations as the basis for some aspects of the allegation of breach. For example, the submissions in respect of 3 to 4 January 2011 refer to the level of releases in SIM A on those days,[20] the submissions concerning 5 January 2011 refer to the level of releases made in SIM E which commenced on that day,[21] the submissions for 8 January 2011 refer to SIM F which was modelled to commence on that day[22] and the submissions for 10 January 2011 refer to SIM G which was

[17] SunWater subs at [2571] to [2572] and [2575].
[18] Ibid at [2573].
[19] Ibid at [2573] to [2574].
[20] Plaintiff subs at [1054] and [1070].
[21] Ibid at [1091].
[22] Ibid at [1326].

modelled to commence on that day.[23] Beyond that, allowing for the differences in governing assumptions and simulated levels, the plaintiff's submissions on breach reflected the approach that underlies those simulations, namely the selection of strategies by reference to projected heights determined by forecasts, the creation of storage space by making releases in advance of forecast rain when downstream conditions permitted it and the adoption of Dr Christensen's approach to operations at Somerset Dam.

14 Seqwater contended that the plaintiff's case on breach was tied to establishing an obligation on the part of the flood engineers to conduct flood operations substantially in accordance with one of Dr Christensen's simulations on each day.[24] It submitted that most, if not all of the plaintiff's submissions, were entirely outside the pleaded case because it had in effect abandoned Dr Christensen's simulations as the basis for alleging breach of duty by the flood engineers.[25] SunWater noted that the submissions on breach did not invoke Dr Christensen's simulations, but it did not, at least expressly, contend that the submissions were outside the pleaded case.[26]

15 In supplementary submissions, the plaintiff denied that it had abandoned a case of breach based on Dr Christensen's simulations.[27] Instead, it contended that its "case as to how the actual conduct of the Flood Engineers' conduct fell short of the standard of reasonableness is not limited to [a] failure to conduct operations in accordance with Dr Christensen's simulations" but extended to "general criticisms of their operations contained in [Dr] Christensen's evidence, and the pleaded failures to comply with the Manual, including by [not] adopting appropriate strategies and, in particular, by [not] creating more storage capacity".[28] The plaintiff submitted that its submissions in respect of breach, which made reference to (but were not limited to) reliance on Dr

[23] Ibid at [1467].
[24] T 9674.3 to T 9675.33.
[25] Seqwater subs at [975] to [1021], especially at [994] which is then repeated for each day of the flood (eg Seqwater subs at [1209]).
[26] Eg SunWater subs at [1874], [1892] and [1931].
[27] SBM.010.008.0001 at [12].
[28] Ibid at [14] and [8].

Christensen's evidence, demonstrated "that the actions of the Flood Engineers were unreasonable in the circumstances" and are "also relevant to the question of causation" in that they demonstrate that the "actual operation of the dams was *not* an operation that could have been undertaken consistently with the applicable standard of care". The plaintiff submitted that once that is found, the (causation) question becomes "whether a reasonable flood engineer 'would' have achieved a better outcome" and accepted that[29] its case in this respect was based on Dr Christensen's description of the Manual and his simulations.[30] Hence, in oral submissions Senior Counsel for the plaintiff accepted that the plaintiff had to demonstrate that a reasonably competent flood engineer *would have* conducted flood operations substantially in accordance with at least one or more of Dr Christensen's simulations.[31] Nevertheless, the plaintiff noted, that, save for Mr Ickert's variations on operations above EL 74.0m AHD,[32] the defendants did not seek to identify some other method of operating the dam beyond that actually undertaken by the flood engineers in the January 2011 Flood Event.[33]

16 The plaintiff submitted that its primary position is that the "reasonable response to the risk of harm was to create more storage by making releases substantially in accordance with Simulation I" but if "the Court finds that one or more of the fundamental aspects of Dr Christensen's operations in Simulation I … were either prohibited or not reasonable, then the alternative simulations prepared by Dr Christensen are evidence of what a reasonable flood engineer *would have done* on the parameters assumed for each simulation".[34] In that manner it seeks to invoke the Court's findings in relation to Dr Christensen's simulation both in relation to breach and causation.

[29] Subject to the point noted in *Rodriguez (No 9)* at [30].
[30] SBM.010.008.0001 at [11] and [19].
[31] T 9419.20.
[32] SBM.010.008.0001 at [18].
[33] Ibid at [11].
[34] Ibid at [15].

Significance of Debate

17 Before addressing this dispute, it is necessary to note that, if the plaintiff was tied to a case on breach that was based solely on a failure to make releases in accordance with one or more of Dr Christensen's simulations over the course of the flood event, that would be problematic to say the least. The 5ASOC pleads particulars of negligence by reference to each calendar day throughout the January 2011 Flood Event. The plaintiff's submissions address those particulars by reference to each day and then, after flood operations commenced, each relevant shift. As the flood event progressed, the deviation between the modelled water levels in a particular simulation that commenced at a previous time and the actual water levels confronting a particular flood engineer on a particular shift widens. This has two consequences. First it means that, even if one adopts Dr Christensen's approach to flood operations generally, the response of the flood engineer to the prevailing circumstances at a time after the start date for a particular simulation may, and sometimes will, differ from his simulations because the actual levels in the dam are higher. Second, as there is a growing divergence between the modelled levels and actual levels as time progresses, it means that at some point it may be no longer reasonable (or even possible) for the flood engineers to make releases that bring the actual levels into alignment with the simulated levels. [35]

18 Thus, for example, at 7.00am on 8 January 2011 the simulated level of SIM A was EL 63.47m AHD whereas the actual level of the dam was EL 68.48m AHD. In SIM A on that day until 9 January 2011, Dr Christensen simulated releases sufficient to keep Fernvale Bridge open.[36] However, adopting Dr Christensen's approach, a reasonably competent flood engineer commencing a shift at around that time then would make releases just below the threshold for urban inundation downstream and above the inundation level for Fernvale Bridge as he simulated in SIM F which commenced at midnight on 8 January 2011.[37] Further, in terms of dam levels, such a flood engineer could never

[35] Although for example it is likely that commencing gate operations on 3 January 2011 could have converged with operations in SIM C.
[36] See Chapter 10 at [197] to [199].
[37] See Chapter 10 at [11], [15] to [16].

make releases to “catch up” to the modelled levels in SIM A (or SIM C) and probably not to the modelled levels in SIM F because of the constraints imposed by the Manual on downstream conditions.[38] In such circumstances, it would not make any sense to allege a breach of duty on 9 January 2011 by the flood engineers in failing to operate substantially in accordance with SIM A because the releases would be higher, as would the water levels. The position would not be much different if the alleged breach was failure to conduct flood operations substantially in accordance with SIM F because the releases would be similar but the actual levels would still be higher. However, the reasoning and findings in relation to Dr Christensen’s simulations (especially SIM C, SIM F and SIM H) would clearly be of relevance to an assessment of the pleaded breaches for particular shifts on 8 and 9 January 2011, even though the prevailing circumstances did not precisely correspond to those modelled in any simulations.

Rodriguez (No 1)

19 Before setting out the text of the relevant parts of the 5ASOC, it is necessary to revisit the point made in Chapter 6 about the pleading of breach.[39] The structure of the 5ASOC is a consequence of two particular aspects of the judgment of Garling J in *Rodriguez (No 1)* (*Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority t/as Seqwater* [2014] NSWSC 1565). The first concerns the pleading of breach. At the time *Rodriguez (No 1)* was decided, the 5ASOC pleaded two categories of breach. His Honour described the “first [as] a category which relates to the integers to which reference may have been had by the flood engineers for the purpose of forming various opinions or which formed the basis upon which judgments were made, and the second category being allegations of the failure to take identified action or else omissions to act reasonably”.[40] In relation to the first category of breach, His Honour found that “it is not correct to regard mental processes, in the circumstances of the pleading in this case, as being capable

[38] Chapter 10 at [10] to [11].
[39] Chapter 6 at [2].
[40] At [14].

of constituting a breach of duty".[41] His Honour ordered that the pleading be struck out and an amended pleading be filed. His Honour noted that "the plaintiff will need to address its allegations of breach of duty by deleting those allegations which deal with states of mind, and limiting its claim for breach of duty to allegations of acting inappropriately or failing to act appropriately".[42] As noted in Chapter 6,[43] this meant that many of the overarching criticisms of the flood engineers levelled by the plaintiff were not pleaded (and not permitted to be pleaded) as particulars of negligence.[44]

20 The second aspect of *Rodriguez (No 1)* concerns causation. During argument before Garling J, SunWater had complained that it was "impossible to identify what breach or combination of breaches is said to have been causative of the plaintiff's and group members' loss".[45] His Honour upheld that complaint finding that "to the extent that the pleading does not include a paragraph, referrable to each of the selected nine time periods, which alleges that by the relevant point during the time period, the conduct of the defendants was negligent, because the level of the dam was no higher than a specified, and identified level, the pleading is defective".[46] This is reflected in the amendments to the 5ASOC that added paragraphs such as [211B] (set out below) and which is the foundation in the 5ASOC for the causation submission noted above (at [15] to [16]).

The Pleading

21 To resolve this issue, it is necessary to return to the precise wording of those parts of the 5ASOC that allege breach, starting with the alleged breaches on 2 January 2011. Paragraph [211] of the 5ASOC is set out in Chapter 10 but it is necessary to repeat it. It pleads as follows:

[41] At [63].
[42] At [87].
[43] Chapter 6 at [2].
[44] See for example Plaintiff subs at [5].
[45] At [65].
[46] At [67].

“Further, by reason of the matters pleaded at paragraphs 192-204 and 209, a reasonably prudent flood engineer responsible for Flood Operations at Somerset Dam and Wivenhoe Dam on 2 January 2011:

a) would have complied with the Flood Mitigation Manual;

b) would have recommenced or continued Flood Operations and releases at Somerset Dam and Wivenhoe Dam on 2 January 2011;

c) would have *implemented* Strategy W3 at Wivenhoe Dam;

d) would have *implemented* Strategy S2 at Somerset Dam;

e) would have caused Somerset Dam and Wivenhoe Dam to release water at rates substantially exceeding the rate of inflow;

…

h) would have continued Flood Operations until Lake Somerset and Lake Wivenhoe were no longer likely to exceed their respective Temporary Full Supply Levels, or alternatively, Full Supply Levels; and

i) would have selected and input losses and continuing loss rates equal, or approximate, to those specified in the table below[47] into the Real Time Flood Model to forecast future inflows into Lake Somerset and Lake Wivenhoe to take account of the increased runoff that would be generated from continuing rainfall by reason of the increasingly saturated catchments” (emphasis added)

22 As explained below, with the possible exception of [211(i)] it can be seen that each of the particulars amounts to some form of action as opposed to a “state of mind”, including the implementation of strategies.

23 The “particulars” to [211] are as follows:

“PARTICULARS

A. A reasonably prudent flood engineer would have complied with the Flood Mitigation Manual by taking the actions pleaded in paragraphs 211(b)-(h).

B. Flood Mitigation Manual, sections 1.1, 3.1, 8.4, 8.5, 9.3, 9.4.

C. ~~Christensen Report, Chapter VIII, [771]-[797]~~. Christensen Reply Report, Volume 1, pp 73-74, [253].

D. ~~Christensen Report, Chapter X, [1194]-[1214]~~. The plaintiff’s primary case is that in operating the dams in accordance with the Flood Mitigation Manual a reasonably prudent flood engineer would have

[47] The table sets out initial and continuing loss rates for no rain modelling and 4 to 8 day modelling.

adopted release rates and gate operations on and from 2 January 2011 substantially in accordance with Simulation I in the Christensen Response Report.

E. In the alternative, the plaintiff contends that operations substantially in accordance with Simulations A, B, C, and D in the Christensen Response Report would have constituted reasonably prudent Flood Operations on assumptions reflecting different findings that the Court may make concerning which of the matters pleaded in paragraph 211 were required for reasonably prudent Flood Operations on 2 January 2011."

24 Those parts of the Manual referred to in Particular B are outlined in Chapter 3. They consist of the provisions specifying the flood objectives, the selection of strategies, including by reference to forecasts, and the statement that within any strategy consideration is given to the flood objectives in their order of priority in setting release patterns. Particular C is that part of Dr Christensen's report that concerns loss rates. The balance of the particulars is addressed below.

25 Paragraph 211A is not used. Paragraph 211B states:

"Further, by reason of the matters pleaded in paragraphs 192-201, by the end of 2 January 2011, a reasonably prudent flood engineer:

a) [Not used]

b) having first commenced reasonably prudent Flood Operations on 2 January 2011 (by taking the actions pleaded in paragraph 211 above), would have reduced the water level in Lake Somerset to no higher than approximately EL 99.00 m AHD, and would have reduced the water level in Lake Wivenhoe to no higher than approximately EL 67.02 m AHD; or, alternatively,

c) would have reduced the water levels in Lake Somerset and Lake Wivenhoe to their respective Temporary Full Supply Levels; or, alternatively,

d) would have reduced the water levels in Lake Somerset and Lake Wivenhoe to their respective Full Supply Levels.

PARTICULARS

A. The term "reasonably prudent Flood Operations" is used to refer to operations conducted in accordance with the Flood Mitigation Manual. The *requirements of the Flood Mitigation Manual are described* in the methodology used by Dr Christensen in his reports (and summarised in Chapter VI of Volume 1 of the Christensen Reply Report at [201] to [238]).

B. The actions required of the Flood Engineers to commence "reasonably prudent Flood Operations" on 2 January 2011 are pleaded in paragraph 211.

C. The plaintiff's primary case is that "reasonably prudent Flood Operations" required release rates and gate operations substantively in accordance with Simulation I in Dr Christensen's Response Report.

D. In the alternative, the plaintiff contends that operations substantially in accordance with Simulations A, B, C and D in the Christensen Response Report would have constituted "reasonably prudent Flood Operations" on the assumptions relevant to each simulation.

E. [Not used]

F. Flood Mitigation Manual, sections 1.1, 3.1, 8.4, 8.5, 9.3, 9.4" (emphasis added)

26 The interrelationship between the phrase "the assumptions relevant to each simulation" in Particular D to [211B] and [211] is addressed in Chapter 10.[48] Paragraph 211B was inserted following the decision in *Rodriguez (No 1)* and addresses the second aspect of that judgment noted above at [20] (ie, the issue of causation). Thus, this part of the pleading identifies the causal consequence of conducting the plaintiff's counterfactual flood operations (ie, "reasonably prudent flood operations") according to Dr Christensen's various simulations.

27 The next paragraph of the 5ASOC that corresponds to [211B] is [228B], which concerns the period 3 to 5 January 2011. It refers to operations in SIM I, A, B, C and D as constituting reasonably prudent flood operations on 2 January 2011 and SIM E for such operations commencing on 5 January 2011. This approach is repeated in the 5ASOC for the following days. The corresponding paragraphs for 8 January 2011 onwards include references to SIM F, H, J as constituting reasonably prudent flood operations commencing on that day.[49] The corresponding paragraph for 10 January 2011 includes a reference to SIM G as constituting reasonably prudent flood operations commencing on that day.[50]

28 Paragraphs 212 and 213 of the 5ASOC state:

[48] At [64ff].
[49] 5ASOC at [288B], [307B] and [339B].
[50] Ibid at [339B].

"212 In the circumstances pleaded at paragraphs 205-211B, the Flood Engineers (or one or more of them):

a) failed *to do* ***one or more*** *of the things pleaded in paragraph 211* on 2 January 2011; *and, or alternatively*,

b) failed, by the end of 2 January 2011, to reduce the water levels in Lake Somerset and Lake Wivenhoe to levels no higher than the respective water levels pleaded in paragraph 211B.

213 By reason of the matters pleaded in the preceding paragraph, the Flood Engineers, or one or more of them, breached their duty of care to the plaintiff and other Group Members on 2 January 2011 (the 2 January Breaches)." (bold and italicised emphasis added)

29 The pleading for each corresponding day or period of days in the January 2011 Flood Event thereafter is in the same form as these two paragraphs.[51]

30 In addressing Seqwater's contention (noted above at [14]), the first matter to note is that [212] of the 5ASOC makes it clear that the allegations of breach of duty are to be found at [211] or by the failure to act in accordance with [211B] (or both). Further, the structure of [211] and the text of [212(a)] make it clear that *each of* [211(b)] to [211(h)] is a separate, although potentially related, allegation of negligence. That is inconsistent with the proposition that Particulars D and E of [211] exhaustively define the scope of the individual allegations in [211] as contended for by Seqwater.

31 Further Particular A to [211] in the 5ASOC specifies that sub-paragraph [211(a)] requires the taking of the action pleaded in [211(b)] to [211(h)] but it does not limit [211(a)] to taking that action alone, especially when read with Particulars D and E. Particular D identifies the plaintiff's primary case as to what operating the dams "*in accordance with the Manual*" required, namely operating "substantially in accordance with Simulation I". Paragraph E posits, as an alternative, operating "substantially in accordance" with the other simulations commencing on 2 January 2011.

32 Contrary to Seqwater's submissions,[52] neither Particular D nor Particular E expressly or implicitly purport to confine sub-paragraphs [211(b)] to [211(h)]

[51] See, eg, 5ASOC at [229] to [230], [246] to [247], [268] to [269], [289] to [290].

and they do not purport to stand alone from [211]. Instead, they identify the counterfactual operation required of a reasonably competent flood engineer operating in accordance with the Manual (thus constituting "reasonably prudent Flood Operations"). They are particulars of the breach pleaded in [211(a)] but they do not exhaust its content as it also includes [211(b)] to [211(h)]. No doubt there is potential for overlap between those reasonably prudent flood operations with each of [211(b)] to [211(h)] but it is not necessarily the case that they are co-extensive, especially bearing in mind the observations at [17] above.

33 Thus, on the proper construction of the 5ASOC, the plaintiff's allegations of breach of duty are not confined to simply asserting that the flood engineers failed to act in accordance with Dr Christensen's simulations. While it was open to the plaintiff to confine its case in that way if it wanted to, albeit that would have been problematic, it was also open to the plaintiff to take the approach that it did in its submissions, namely relying on aspects of the simulations as exemplifying what was required on particular days and otherwise deploying the reasoning behind aspects of Dr Christensen's simulations as supporting its submissions on the allegations of breach in the sub-paragraphs of [211] and its equivalents. In that regard, the findings that were made in Chapter 10, especially concerning SIM C, F and H[53] for the period from 2 January 2011 to 10 January 2011 inform the analysis.

34 I have noted the effect of Seqwater's submission above. Seqwater made five points in support of its submission that the plaintiff's case on breach was tied to acting in accordance with one of Dr Christensen's simulations which, for completeness, I will address. First, it contended that Particulars D and E to [211] noted above are not "separate and distinct from" the pleaded breaches in [211].[54] The second was related to the first, namely that those particulars are not "stand-alone" allegations separate from [211].[55] Third, it was submitted that Particulars D and E to [211] are not "separate to and distinct

52 T 9674.11 to T 9675.24.
53 Chapter 10 at [56] and [188].
54 Seqwater subs at [979].
55 Ibid at [980].

from" Particulars A, B and C but instead build on each other.[56] Fourth, it was submitted that treating Particulars D and E as "separate to and distinct" from the allegations in the subparagraphs to [211] would leave the latter devoid of detail.[57] Fifth, it was submitted that for the plaintiff not to be tied to a case on breach that was solely tied to Dr Christensen's simulations would be contrary to what was found in *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 9)* [2017] NSWSC 1116 ("Rodriguez (No 9)") at [48] when various amendments to the 5ASOC which incorporated Dr Christensen's simulations were allowed.[58]

35 The phrase "separate to and distinct from" in describing Particulars D and E to [211] was emphasised and repeated in Seqwater's elaboration of these five points. However, the question is not whether Particulars D and E are "separate to and distinct from" the pleaded allegations of breach, but instead whether, as Seqwater contended, they exhaustively describe the allegations of breach. Based on a consideration of the plain words of 5ASOC [211] and [212(a)] the short answer is that they do not. Thus, with the first and second points, I accept that Particulars D and E are not assertions that stand alone from [211] but I do not accept that they exhaust the content of those pleaded breaches either. Similarly, with the third point, Particulars D and E may or may not be entirely "separate and distinct" from Particulars A, B and C but they do not exhaust their content either. As for the fourth point, I will address each day in turn but it suffices to state that, considered in context, most of the particular allegations are sufficiently clear and reflected the overarching propositions that the plaintiff contended for, namely the necessity to select strategies by reference to projected heights determined by forecasts and the necessity to create storage space by making releases in advance of forecast rain while downstream conditions permit. In the end result, all of Dr Christensen's simulations modelled releases and water levels consistently with that approach albeit by reference to different assumptions.

[56] Seqwater subs at [981].
[57] Ibid at [985].
[58] Ibid at [990].

36 As for Seqwater's fifth point, the passage relied on from *Rodriguez (No 9)* was as follows (at [48]):

> "The amendments to particulars C and D to paragraph 211[59] and the Response Report, especially the simulations in Volume 2, appear to be of great if not fundamental importance to the plaintiff's case. It is proposed to plead that Simulation I is the "primary case". *As I understand it, Dr Christensen's report is crucial to the plaintiff's case and effectively constitutes its case on liability*. The presentation of that case would appear to be crippled if the plaintiff was forced to run its case by reference to simulations and loss rates that its expert now disavows and was somehow prevented from correcting. To refuse this leave now would probably lead to an application to adjourn the hearing later." (emphasis added)

37 This passage needs to be read with the description of the significance of Dr Christensen's evidence to the overall case in *Rodriguez (No 9)* at [7] to [9]:

> "7. First, as far as the Court is aware, the plaintiff's case on liability and causation turns almost exclusively on the evidence of two experts, Dr Christensen and Dr Altinakar. In broad terms, Dr Christensen addresses what the plaintiff contends was the negligent operation of Wivenhoe and Somerset Dams by the defendants during the period December 2010 to January 2011.
>
> …
>
> 9. Thus, Dr Christensen addresses liability and one aspect of the causation inquiry, namely, the volume of water that the plaintiff contends should have been released from the two dams during the relevant period. Dr Altinakar addresses another aspect of the causation inquiry namely what, according to the plaintiff, would have been the level of flooding had the dams been operated properly."

38 This analysis is entirely consistent with the plaintiff's focus on Dr Christensen's simulations as the basis for proving causation. Insofar as *Rodriguez (No 9)* described the plaintiff's case on liability "turn[ing] almost exclusively" on Dr Christensen's "report", that observation concerned what the Court knew then about the scope of Dr Christensen's explanation of the Manual and critique of the flood engineers' conduct, rather than just his simulations. The simulations are also discussed in terms of causation because they identify "the volume of water that the plaintiff contends should have been released from the two dams during the relevant period". Further, in *Rodriguez (No 9)* (at [29]), I contemplated a scenario in which some but not

[59] This should be to a reference to Particulars D and E.

all of the particulars of negligence are established. It is difficult to envisage how that circumstance could arise if the particulars of negligence were tied exclusively to one of Dr Christensen's simulations as contended for by the defendants.

39 In the end result, I am satisfied that the plaintiff's case on breach is not tied to establishing that on each and every day of the January 2011 Flood Event the relevant flood engineer failed to act in accordance with one or more of Dr Christensen's simulations. That is not required by the text of the pleading and is otherwise an impossibility as time marched on and as the modelled levels in the simulations and those confronted by each relevant flood engineer diverged. Instead, it was open to the plaintiff to submit by reference to the pleaded sub-paragraphs of the 5ASOC what was required by each flood engineer at each relevant point during the January 2011 Flood Event, ie, what must have been done in those circumstances (see *Dovuro Pty Ltd v Wilkins* (2003) 215 CLR 317; [2003] HCA 51 at [38] per McHugh J). It was also open on the pleading for the plaintiff to submit, as it did, that the approach of Dr Christensen informs the analysis of what would have been done by a flood engineer from time to time during the flood event, especially in circumstances where I have made a finding of what was required of a reasonably competent flood engineer commencing on 2 January 2011 (ie, SIM C) and 8 January 2011 (ie, SIM F and SIM H). Leaving aside the appropriate forecast period that should be used to select strategy, the methodology of each of SIM F and SIM H is not relevantly different to SIM C. The only substantive difference is the start date. Provided that the findings on breach are consistent with the finding in relation to those simulations, which they are, the latter can then be used as the basis for the causation inquiry conducted in the next Chapter.[60]

12.3: Pleading States of Mind – Implementing Strategies

40 Relying on *Rodriguez (No 1)*, Seqwater contended that it was not open to "advance a breach case based on a condition of mind".[61] It referred to a

[60] See Chapter 13, section 13.5.
[61] Seqwater subs at [996]; see Chapter 6 at [2].

statement in the opening part of the plaintiff's submissions that highlighted the flood engineers' failing to follow the Manual insofar as they failed "to consciously select strategies".[62] Four matters should be noted about this.

41 First, to the extent that the plaintiff's submissions point out errors of approach on the part of the flood engineers which do not amount to positive action or inaction, such as their flawed modelling, then, as noted previously, they did not have to be and in fact could not be pleaded.

42 Second, the 5ASOC includes an allegation that for each day from 2 to 10 January 2011 there was a failure to "implement" a particular strategy, as opposed to a failure to "think about" or "consciously select" a particular strategy. In that respect, the pleading conformed with *Rodriguez (No 1)* in that it amounts to an "allegation" of "acting inappropriately or failing to act appropriately". It is true that in some circumstances the implementation or adoption of a higher strategy by a flood engineer does not necessarily lead to any immediate practical difference in the conduct of flood operations. The most obvious example is when Strategy W4 is engaged by a forecast maximum height above EL 74.0m AHD (and not an actual level) but the flood engineer is currently making releases at a level of say 2500m^3/s (as permitted by Strategy W3) and the circumstances do not warrant making higher releases. In such a circumstance there may be scope for the defendants to assert that a pleaded allegation concerning a failure to "implement" a strategy only concerns a "state of mind" or is otherwise devoid of practical content.

43 However, considered in context for all of the days the subject of the plaintiff's submissions on breach, save for 10 January 2011, the implementation of the correct Wivenhoe Dam strategy based on the projected height necessarily required the making of higher releases than those made by the flood engineers, even if it did not require releases up to the maximum level permitted by the strategy. Thus, for example, at midnight on 9 January 2011 the dam levels and forecasts were such that Strategy W4 was engaged as opposed to the W1 strategy that the flood engineers were actually operating

[62] Seqwater subs at [996]; Plaintiff subs at [5].

in. At the very least, that required an increase in releases to around the maximum level below that which, when considered with forecast flows downstream, would exceed the downstream thresholds for urban flooding (as in SIM F[63]). That level of outflows would be less than 4000m^3/s which is the maximum permissible in Strategy W3. However, in circumstances where the flood engineers are operating in W1, their conduct is nevertheless a failure to "implement strategy W4" as pleaded by the combination of 5ASOC [307(b)] and [308(c)], bearing in mind that while actual levels are below EL 74.0m AHD, Strategy W4 requires a consideration of lower level objectives.

44 Third, in one instance the plaintiff's submissions on a particular breach referred only to the flood engineers' state of mind, rather than concrete action.[64]

45 Fourth, on each of the days of the flood event the plaintiff pleaded a failure in the form of 5ASOC at [211(i)] on the part of the flood engineers to "select… and input [into the RTFM] losses and continuing loss rates" in accordance with a specified table which reflected the loss rates used by Dr Christensen in his modelling. This particular of negligence was not addressed by the plaintiff in its submissions. Leaving aside whether this aspect of the pleading was consistent with *Rodriguez (No 1)*, this particular adds nothing to the balance of the particulars as the use of loss rates in undertaking modelling on the RTFM does not, of itself, result in any practical difference to flood operations.

12.4: Browne v Dunn

46 In support of a submission that the Court should find that the plaintiff has not established its pleaded case for each of the days of the January 2011 Flood Event, Seqwater submitted that it was not put to Mr Malone or Mr Tibaldi in cross-examination that they should have been operating in the pleaded

[63] Chapter 10 at [19], [23].
[64] See [147] to [148].

Wivenhoe Dam strategy or otherwise should have operated substantially in accordance with Dr Christensen's simulations or utilised his methodology.[65]

47 This aspect of Seqwater's submission seeks to invoke the so-called rule in *Browne v Dunn*.[66] *Browne v Dunn* has already been addressed in the context of the acceptance or rejection of the flood engineers' evidence as to what occurred during the January 2011 Flood Event and aspects of the various experts' evidence which were said to be "unchallenged".[67] At this point it is sought to be invoked as a basis for rejecting the pleaded allegations of breach. Although extensive submissions were made in support of this contention,[68] it suffices to note that, at least in this context, in considering the application of the "rule" and the consequences of any transgression "the real issue is the fairness of the trial, as between the parties".[69] This requires a consideration of the entire circumstances of the trial to ascertain whether the parties, and in some cases witnesses, were put on notice of the allegations against them and given the opportunity to address them.[70]

48 In this case it can be accepted that Messrs Malone, Tibaldi and Ayre were more than just third-party witnesses, in that they were the witnesses whose alleged negligent conduct was said to warrant liability being imposed on Seqwater and SunWater. Fairness dictates that they had to be afforded the opportunity to address why it is they were said to be negligent. Equally, if from a consideration of the totality of the trial process it is clear they were afforded that opportunity, it is not necessary for the cross-examiner to engage in a ritualistic process of putting matters to witnesses so that they can repeat their

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[65] Seqwater subs at [1210] (2 Jan), at [1249] (3 to 5 Jan), at [1319] (6 Jan), at [1386] (7 Jan), at [1494] (8 Jan) and at [1558] (9 Jan).
[66] (1893) 6 R 67 (HL).
[67] Chapter 6 at [31]; Chapter 7 at [427]; Chapter 3; section 3.4.
[68] Seqwater subs at [1208] to [1223], [1242] to [1251], [1317] to [1336], [1383] to [1393], [1490] to [1502], [1554] to [1566], [1612] to [1624].
[69] *State Rail Authority of New South Wales v Brown* (2006) 66 NSWLR 540 at [53] (Basten JA); *R v Birks* (1990) 19 NSWLR 677 at 689G.
[70] See *West v Mead* [2003] NSWSC 161 at [98]; *Masterton Homes Pty Ltd v Palm Assets Pty Ltd* [2009] NSWCA 234 at [105]; *NU v NSW Secretary of Family and Community Services* (2017) 95 NSWLR 577; [2017] NSWCA 221 at [58] (Beazley P).

denials or explanations[71] and nor was any cross-examination required to address the various alternative permutations in which a party puts it case.[72]

49 In this case, the relevant opportunity was afforded and taken up in large measure. Six matters should be noted. First, there is the pleading itself which specifies the alleged breaches. Second, from an early stage, the plaintiff's case and Dr Christensen's approach were documented in detail. The battle lines between the plaintiff's suggested approach and the flood engineers' actual approach concerning the interpretation of the Manual (especially the use of forecasts and releases below FSL) had been known for years.[73] Third, in large part, many of the alleged breaches flow from the plaintiff's interpretation of the Manual, especially its references to forecasts. In both their affidavits[74] and under cross-examination, each of the flood engineers addressed the Manual, including the suggested use of forecasts and matters such as "no release" rises. Fourth, in their affidavits Messrs Malone and Tibaldi addressed each of the pleaded allegations against them in detail, including the suggestion that they should have implemented particular strategies.[75] In his first affidavit, Mr Ayre addressed each day of flood operations and, like Messrs Malone and Tibaldi, had the opportunity to respond to the pleaded allegations.[76] Fifth, regardless of the relationship between Dr Christensen's simulations, the pleaded breaches and the plaintiff's case on causation, each of the flood engineers who gave evidence addressed Dr Christensen's methodology and simulations in detail.[77] Sixth, without being exhaustive, it suffices to state that the cross-examination of each of the flood engineers addressed each day of the flood event and addressed the central themes of the plaintiff's case, namely the selection of

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[71] See *Raben Footwear Pty Ltd v Polygram Records Inc* (1997) 75 FCR 88 at 102C.
[72] *Vines v ASIC* (2007) 73 NSWLR 451 at [409].
[73] See *Rodriguez (No 9)* [2017] NSWSC 1116 at [27].
[74] Malone 1, LAY.SEQ.007.0001 at [167] to [261]; Ayre 1, LAY.SUN.001.0001 at [207] to [440]; Tibaldi 1, LAY.SEQ.004.0002 at [204] to [335].
[75] Malone 1, LAY.SEQ.007.0001 at [495] to [901]; Tibaldi 1, LAY.SEQ.004.0001 at [628] to [759]; Tibaldi 2, LAY.SEQ.014.0001 at [6] to [83].
[76] Ayre 1, LAY.SUN.001.0001 at .0167 to .0628.
[77] Malone 3, LAY.SEQ.013.0001; Malone 5, LAY.SEQ.016.0001; Ayre 2, LAY.SUN.006.0001; Tibaldi 1, LAY.SEQ.004.0001 at [762] to [808]; Tibaldi 2, LAY.SEQ.014.0001 at [84] to [229].

strategies by reference to forecasts and the release of water in advance of forecast rain falling.

50 By way of example, Seqwater contended that it was not put to Mr Malone that he should have been operating in Strategy W3 on 6 January 2011 and should have increased releases substantially above the rate of inflows on that day, both of which are pleaded allegations of negligence.[78] However, the approach of determining strategies and making releases based on forecasts was raised with him. He agreed with the former but said that he selected strategies based on actual, not predicted, levels.[79] He disagreed with the latter.[80] He also agreed that the projected height on 6 January 2011 based on forecasts would have exceeded EL 68.5m AHD[81] but stated that he used actual levels to determine strategies. As noted, in his affidavits he specifically addressed the pleaded allegations against him, as well as Dr Christensen's interpretation of the Manual, his methodology and his simulations.[82] This included responding to the suggestion that Strategy W3 should have been implemented on 6 January 2011[83] and releases should have been substantially increased above actual inflows on that day.[84] Mr Malone specifically addressed the use of a "no release" rise to set strategies in his affidavit[85] and oral evidence.[86]

12.5: 2 January 2011 Breaches

51 Mr Malone was on duty from around 6.45am on 2 January 2011 until flood operations ceased at around 9.00am on 2 January 2011. Thereafter he was the DFOE.[87]

52 The pleaded allegations of breach in respect of this period are set out above. Paragraph 211 of the 5ASOC refers to paragraphs 192 to 204 of the 5ASOC.

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[78] 5ASOC [245(c)] and [245(e)]; Seqwater subs at [1319] and [1330].
[79] T 5323.1.
[80] Chapter 6 at [186] to [187] and [257].
[81] Chapter 6 at [194].
[82] Malone 1, LAY.SEQ.007.0001 at [495] to [901]; Malone 3, LAY.SEQ.013.0001 at [27] to [123]; Malone 5, LAY.SEQ.016.0001.
[83] Malone 1, LAY.SEQ.007.0001 at [592].
[84] Ibid at [598].
[85] Ibid at [115(k)].
[86] T 4959.45 to 4961.21 and T 5375.32 to T 5381.14.
[87] Chapter 6 at [56] to [57].

Those paragraphs plead the effect of the various rainfall forecasts available as at 2 January 2011, the fact that rain had fallen in the 24 hours to 9.00am in the dam catchments[88] and the generally saturated state of the catchment such that further rain was likely to generate additional runoff.[89]

Existence of Risk

53 In substance, paragraphs 195 and 199 of the 5ASOC allege that the effect of the forecasts, rainfall that had already fallen and predicted inflows was such that there was either "a significant risk"[90] or at least an "increased" risk[91] that "absent ongoing releases from Somerset Dam and Wivenhoe Dam, there would be insufficient flood storage capacity in Lake Somerset and Lake Wivenhoe to prevent urban flooding downstream of Wivenhoe Dam should further rainfall occur *in accordance with, or in excess of*" the BoM forecasts. Paragraph 209 pleads that the cessation of "releases and Flood Operations on 2 January 2011 created a significant risk" of "insufficient flood storage capacity" to store inflows "should further rainfall occur *in accordance with, or in excess of, that forecast*" by the BoM and that without such capacity "subsequent releases would be necessary in volumes that would cause urban flooding downstream of Wivenhoe Dam".

54 Seqwater contended that, having regard to the prevailing weather forecasts, the plaintiff had not demonstrated an actual knowledge on the part of Mr Malone of the pleaded risk of harm.[92] The (lack of any) necessity to demonstrate actual knowledge is addressed in Chapter 11.[93] The circumstances, including the forecasts, prevailing as at midnight on 2 January 2011 are addressed in section 6.7 of Chapter 6. The level of Wivenhoe Dam was EL 67.15m AHD. Rain on the ground modelling and further rainfall in the Somerset Dam catchment overnight on 1 January 2011 meant that, even with releases through the regulators and assuming no further rain, the water level

[88] 5ASOC at [197].
[89] Ibid at [202].
[90] Ibid at [195].
[91] Ibid at [199].
[92] Seqwater subs at [1227] to [1235].
[93] Chapter 11 at [51ff].

would remain above FSL for many days.[94] The highest forecast was the eight-day PME of 15 to 25mm, although Mr Ayre's 6.00am situation report referred to a "chance of storms" on 5 and 6 January 2011.[95] Allowing for those matters and bearing in mind the various assessments of the amount of rainfall necessary to fill Wivenhoe Dam to EL 74.0m AHD,[96] I do not accept that if rainfall occurred "in accordance with" the forecasts then the risk pleaded in 5ASOC at [209] arose.

55 Seqwater took this further and contended that there is nothing to suggest that at this point "if and when the forecast rainfall occurred, it *would* be beyond the flood storage capacity of the dams" to be able to address it without making releases from above EL 74.0m AHD in W4. However, in oral submissions Senior Counsel for the plaintiff pointed to the La Niña seasonal conditions, the fact that the humid summer season was far from over, the widespread flooding that had already been experienced elsewhere in Queensland and the immediate past experience as pointing to the realistic possibility of higher rainfall of the necessary order falling on a saturated catchment.[97] He submitted that the prevailing forecasts may have been benign but the other circumstances were not.[98] He characterised the taking of precautions at this time as akin to preparation for a bushfire in a "bad fire season" during the summer.[99]

56 To an extent, the Manual supports the plaintiff's identification of the relevant risk and the necessary precaution of at least evacuating stored flood waters to address it. Thus, section 3.2, which addresses the risk of overtopping from extreme floods and closely spaced large floods, notes that "[h]istorical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane River system within a short time of each other" and specified that the "the aim during a Flood Event should be to empty stored floodwaters within seven days after the flood peak has passed through

[94] Chapter 6 at [74].
[95] SEQ.001.018.4207.
[96] See Chapter 6 at [139]; Chapter 10 at [103] to [104], [149].
[97] T 10117.35.
[98] T 10116.36.
[99] T 10118.43.

the dams". This statement setting a seven-day water evacuation timeframe is repeated elsewhere throughout the Manual.[100] As noted in Chapter 10, that peak was 4.00pm on 27 December 2010[101] and seven days from that time expired at 4.00pm on 3 January 2011. Section 3.2 notes that the seven-day time period might not "be achievable because of downstream flood conditions" and otherwise "may result in submergence of some bridges." As at 2 January 2011, downstream conditions did not hinder the achievement of the seven-day draindown. To the contrary, together with the seasonal outlook, they supported it being shortened.

57 Seqwater's submission poses the relevant risk in the wrong terms, namely by reference to the limit of the current forecast (ie, the forecast as at 2 January 2011) and by asking whether if that rain falls it "would be" beyond the flood storage capacity of the dams. The Manual, the seasonal conditions and what was known about forecast uncertainty pointed to the not insignificant possibility of much higher rainfall occurring far above the forecasts. The Manual pointed to the desirability of not compromising flood storage capacity beyond the seven day drain period. Given the Manual, the seasonal outlook and catchment conditions, I accept that there was a risk of the kind pleaded, that it was foreseeable and not insubstantial.

Precautions

58 The plaintiff submitted as follows in relation to the allegations of breach on 2 January 2011 and the relevant precautions to adopt:[102]

> "In the above circumstances, the Manual clearly required that the Flood Event continue on the morning of 2 January 2011 by continuing the drain down until such time as Mr Malone no longer expected either dam to exceed its FSL. By failing to adhere to the Manual in this regard, Mr Malone breached the Manual, thereby acting unreasonably in a manner which increased the risk of harm to urban areas and thus breached his duty of care to the plaintiff and group members (see 5ASOC, PLE.010.001.0001, [211(a), (b)] and [h]). A reasonable flood engineer would have continued draining the dam by making releases at rates substantially exceeding the rate of inflow (draining down from W3 and S2 operations) until the dams were no longer likely to exceed

[100] Manual at 1 and 9.
[101] ROD.650.003.6506 at .6606.
[102] Plaintiff subs at [1037].

their respective FSLs (see 5ASOC, PLE.010.001.0001, [211(a), (c), (d), (e), (h]).”

59 Consistent with the above analysis, these allegations of breach are only directed to the allegations of breach pleaded in [212(a)] of the 5ASOC. They are not necessarily tied to the plaintiff establishing that a flood engineer was obliged to act in accordance with one or more of Dr Christensen’s simulations, although the connection between them and the reasoning underlying his simulations that commence on 2 January 2011 is direct and obvious. Save for SIM D, all of Dr Christensen’s simulations that commenced on 2 January 2011 involved simulated operations in draindown with the object of draining below FSL to allow refill to FSL by inflows, although the level of inflows was determined by reference to different operating assumptions.[103] SIM D’s governing assumptions precluded it from draining below FSL on that day.[104]

60 The breach alleged by sub-paragraphs [211(c)] and [211(d)] concerning the necessity to implement Strategy W3 and Strategy S2 can be dealt with at the outset. On any view of the circumstances prevailing on 2 January 2011 and the requirements of the Manual, flood operations on that day should have involved a draindown. They did not involve the implementation of any Wivenhoe or Somerset strategy relating to the upwards limb of the hydrograph. Although the plaintiff no doubt meant to plead a reference to a draindown <u>from</u> W3 and S2, that is not how the particulars are framed. It follows that I reject [211(c)] and [211(d)]. The allegation in paragraph 5ASOC [211(i)] is addressed at [45].

61 In relation to [211(a)], [211(b)], [211(e)] and [211(h)], in oral submissions Senior Counsel for the plaintiff characterised these sub-paragraphs as embodying a precaution that the dam be taken below FSL “taking into account inflows”.[105] In addressing this aspect of the case against it, Seqwater pointed to Mr Malone’s evidence that it was his expectation on 2 January 2011 that

[103] See Response Report Vol 2, EXP.ROD.015.0261 at .0272 (SIM A), .0304 (SIM B), .0328 (SIM C) and .0418 (SIM I which is identical to SIM A until 9 January 2011); Chapter 10 at [75] and [192].
[104] See Response Report Vol 2, EXP.ROD.015.0261 at .0349; Chapter 10 at [224].
[105] T 10118.25.

the dam would drain down to FSL,[106] evidence that I have already found had no reasonable basis.[107] It submitted that the flood engineers did not cease draining down at 9.00am on 2 January 2011 but continued to make releases through the regulator and submitted that there was no "sensible reason why this course was not reasonably open".[108] In Chapter 6, I rejected that contention as I found there was no prospect that releases through the regulator would return Wivenhoe Dam to FSL[109] and certainly not within seven days of the peak inflow passing during the Late December Flood Event.

62 Seqwater submitted that the plaintiff's case does not address the logistics of planning "fish recovery"[110] upon gate closure and queried why that should have been halted just "to reduce the dam level by 8 – 10cm (or to 95% of FSL)".[111] As noted, the essence of the precaution identified by the plaintiff on 2 January 2011 is a draindown until such time as there is no longer an expectation that either dam is expected to exceed FSL. In the case of SIM C, the difference between the actual levels as at midnight on 3 January 2011 and SIM C at the same time is 15,401ML[112] or around 14cm.[113] The draindown operation modelled in SIM C on 2 January 2011 was designed to reduce it to EL 66.5m AHD, which represented another 53,000ML of releases below FSL, sufficient to accommodate the forecast one-day inflows before the flood event could be concluded.[114] Those differences are potentially material to creating sufficient storage space to address the contingency of a second flood as contemplated by the Manual. Otherwise, the necessity to undertake fish recovery after final gate closure does not arise until gate operations take dam levels to the point that there is no reasonable expectation of rising above FSL.

63 Finally, Seqwater contended that Mr Malone "complied with the requirement in the Manual to direct the operations during his shift in accordance with the

[106] Seqwater subs at [1214] to [1216].
[107] Chapter 6 at [74].
[108] Seqwater subs at [1224].
[109] Chapter 6 at [73] to [74].
[110] Seqwater subs at [1225].
[111] Ibid at [1239].
[112] 1,179,651ML – 1,164,250ML: see Chapter 10 at [71] and Simulation Analysis, EXP.ROD.015.0461 at .0627.
[113] EL 67.13m AHD – EL 66.99m AHD.
[114] Chapter 10 at [75ff].

general strategy determined by Mr Ayre" and that he considered making a flood release below FSL to be a breach of the Manual. I have already rejected those propositions.[115]

64 I have already found that proper compliance with the Manual required the flood event continue on 2 January 2011,[116] that the flood event could not end unless the reasonably competent flood engineer no longer expected FSL to be exceeded[117] and that releases were required to continue to bring the water level below FSL such that it was less than the one-day "no release" rise.[118] It follows from the analysis in Chapter 10 that gate operations should have continued at a rate of release that was at least that which was modelled in SIM C (which exceeded inflows).[119] Even though on this day the identified risk is only just "not insignificant", the "reasonable person" in the flood engineer's position would have taken those precautions to ensure that flood storage was evacuated before flood operations ended and another flood might have commenced (*CLA*, s 9(1)(c)). Although the probability that harm would occur if care in the form of those precautions was not taken was not high (s 9(2)(a)), as the amount of flood storage space freed up on 2 January 2011 by continuing releases might have only been modest and made up on following days, the Manual contemplates that over the course of a flood event a failure to make such releases when downstream conditions permit can accumulate to compromise flood operations as an event worsens.[120] The failure of the flood engineers to make any releases before the afternoon of 7 January 2011 bears that out. A difference in water levels of between say 15,000ML and 53,000ML can, depending on the timing of upstream and downstream flows, assume significance at elevation levels that climb well above EL 74.0m AHD. The likely seriousness of harm if the risk materialises is very significant[121] and increases exponentially as water climbs above EL

[115] Chapter 6 at [66] and Chapter 5 at [135] to [141].
[116] Chapter 6 at [81]; Chapter 10 at [78].
[117] Chapter 3 at [140].
[118] Chapter 10 at [80].
[119] Chapter 10 at [93].
[120] Manual at 10; section 3.3.
[121] See [7].

74.0m AHD (s 9(2)(b)). It is partly for that reason why the Manual itself declares that its procedures must be complied with.[122]

65 The burden of taking precautions, specifically the effect on downstream bridges, namely Burtons Bridge and the lower level bridges, and compromising the water supply, is addressed in Chapter 10 in relation to SIM C,[123] noting that the effect of any such inundation on the bridges is discussed in Chapter 2 (s 9(2)(c)). Given the bridges were already inundated at midnight on 2 January 2011, then I do not accept the burden of keeping them closed was so significant, especially having regard to recent experience and the seasonal outlook. Otherwise, the potential inconvenience to volunteers and others from not pursuing fish recovery on the morning of 2 January 2011, as opposed to later, does not weigh much in the balance.

Mr Ayre

66 Although it was open on the pleadings, the plaintiff's written submissions did not expressly allege any breach by Mr Ayre on 2 January 2011, although they made reference to him permitting Mr Malone's conduct,[124] a submission I have accepted.[125] SunWater pointed this out in its submissions.[126] Neither in oral submissions nor in its supplementary written submissions responding to complaints about the alleged disparity between the pleaded allegations of breach and its submissions[127] did the plaintiff expressly allege a breach by Mr Ayre on 2 January 2011. Accordingly, I make no finding to that effect.

Conclusion

67 I am satisfied that on 2 January 2011 Mr Malone breached his duty of care in ending flood operations contrary to the Manual (5ASOC [211(a)]), ceasing gate operations (5ASOC [211(b)]), not making releases at rates substantially in excess of inflows (5ASOC [211(e)]) and not making releases until dam

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[122] Manual at 4.
[123] Chapter 10 at [79] to [80].
[124] Plaintiff subs at [1468].
[125] Chapter 6 at [67].
[126] SunWater subs at [1872].
[127] SBM.010.008.0001.

levels were not likely to exceed their respective FSLs by the one-day inflow estimate (5ASOC [211(h)]). The balance of the allegations of breach on that day are rejected.

12.6: 3 January 2011 Breaches

68 The relevant part of the 5ASOC pleads breaches "in the period 3 January to 5 January 2011", although the plaintiff's submissions identified the breaches by reference to each day in that period.[128] I will address each day accordingly.

69 Paragraphs 214 to 222 of the 5ASOC plead the storage levels and weather forecasts available during the period 3 to 5 January 2011. Paragraph 223 pleads that the Manual required releases to continue or recommence at Wivenhoe Dam by 6 January 2011 "at the latest". Paragraph 224 of the 5ASOC pleads that the DFOE did not mobilise the FOC and paragraph 225 pleads that the failure of the flood engineers, in this case Mr Malone, to continue or commence flood operations and releases in the period 3 January 2011 to 5 January 2011 contravened the Manual. All of those assertions are consistent with the findings in Chapters 6 and 7.

Existence of Risk

70 Paragraph 226 of the 5ASOC pleads that in the period from 3 January 2011 to 5 January 2011, there was a significant risk:

> "(a) that, unless releases were immediately commenced at Somerset Dam and Wivenhoe Dam, there would be insufficient flood storage capacity in Lake Somerset and Lake Wivenhoe to store incoming flows should further rainfall occur in accordance with, or in excess of, that forecast by the Bureau of Meteorology; and
>
> (b) that, without such capacity, subsequent releases would be necessary in volumes that would cause urban flooding downstream of Wivenhoe Dam."

71 Throughout 3 January 2011, the water level of Wivenhoe Dam rose from EL 67.13m AHD to EL 67.18m AHD and Somerset Dam rose from EL 99.17m

[128] Plaintiff subs at [1039] to [1091].

AHD to EL 99.24m AHD.[129] There were still inflows from previous rainfall yet to arrive but in effect there had not been any rainfall to 9.00am in the morning. There was little rain, if any, during the day and a small amount of rain overnight into 4 January 2011.

72 The effect of the rainfall forecasts available from midnight on 3 January 2011 is addressed in Table 6-1 in Chapter 6.[130] There was a substantial increase in the four-day and eight-day PME forecasts and this was reflected in the modelling of the four-day inflows.[131] Very little rain was predicted for that day and the following two days but substantial rain was predicted for 6 January 2011 (62mm) and over the eight-day period (either 50mm or 75mm to 150mm). As noted in Chapter 6,[132] using Mr Malone's estimate of the catchment performance during the Late December Flood Event, around 200mm of rain would generate enough runoff to fill Wivenhoe Dam to EL 74.0m AHD without releases.

73 As discussed in Chapter 6[133] and in terms of 5ASOC [226], if the reference to "flood storage capacity" is meant to be storage up to EL 74.0m AHD, being the point when forced outflows would commence, then the predicted rainfall over the four-day period was of itself not able to necessitate a level of releases in volume that *would* cause urban flooding downstream of Wivenhoe Dam. However, it was not far off and either a deterioration in that forecast, or the falling of significant rain beyond the four-day forecast, could cause that to occur.

74 For the reasons addressed in Chapter 6[134] these conclusions are not undermined by the capacity to make releases before the rain falls as, amongst other matters, it presupposes that downstream flows will not impede that occurring and overlooks the fact that the forecasts suggested there was a better opportunity to respond immediately rather than later. This is borne out

[129] Simulation Analysis, EXP.ROD.015.0461 at .0466 to .0467 and .0476 to .0477.
[130] Chapter 6 at [3] and [82]; See also Chapter 9 at [138] and [161].
[131] See Appendix F to this judgment.
[132] Chapter 6 at [139].
[133] Chapter 6 at [139].
[134] Chapter 6 at [137].

by the fact that gate releases from Wivenhoe Dam did not actually commence until after 3.00pm on 7 January 2011 when the dam was already around 114,000ML above FSL,[135] with the most recent operational spreadsheet predicting rain on the ground inflows from 3.00pm of around 137,000ML[136] using the flood engineers' loss rates.

75 Given the terms of the Manual, the seasonal outlook, the catchment conditions and forecasts, I accept that there was a risk of the kind pleaded, that it was foreseeable and not insignificant (*CLA*; s 9(1)(a) and (b)).

76 Seqwater submitted that it was not established that Mr Malone had knowledge of that risk,[137] a matter I have already found did not have to be shown. Further, as submitted by the plaintiff, with little rain predicted in the following two days but substantial rain predicted thereafter, it was the ideal period to make releases; ie immediate releases were warranted as the capacity to make larger releases later could be compromised by later rainfall.

Precautions

77 In relation to the precautions required, paragraph 228 pleads as follows:

> "228 Further, by reason of the matters pleaded at paragraphs 214-223 and 226, a reasonably prudent flood engineer responsible for Flood Operations at Somerset Dam and Wivenhoe Dam in the period 3 January to 5 January 2011:
>
> a) would have complied with the Flood Mitigation Manual;
>
> b) would have:
>
> (i) continued Flood Operations and releases at Somerset Dam and Wivenhoe Dam throughout the period 3-5 January 2011; or, alternatively,
>
> ii) recommenced Flood Operations and releases at Somerset Dam and Wivenhoe Dam in the period 3-5 January 2011;

[135] Simulation Analysis, EXP.ROD.015.0461 at .0786; Manual at 53: 1,279,457ML – 1,165,000ML = 114,457ML.
[136] 7 Jan 1200 ROG run (QLD.001.001.2357); Input data tab, Wivenhoe = SUM [H134; H488] *3.6 = 108,780ML; Somerset = SUM [L134:L488] *3.6 = 27847ML: 108,780 + 27,847 = 136,627ML.
[137] Seqwater subs at [1302] to [1305].

c) would have implemented and maintained Strategy W3 at Wivenhoe Dam throughout the period 3-5 January 2011;

d) would have implemented and maintained Strategy S2 at Somerset Dam throughout the period 3-5 January 2011;

e) would have caused Somerset Dam and Wivenhoe Dam to release water at rates substantially exceeding the rate of inflow;

…..

h) would have continued Flood Operations until Lake Somerset and Lake Wivenhoe were no longer likely to exceed their respective Temporary Full Supply Levels, or alternatively, their Full Supply Levels; and

i) would have selected and input losses and continuing loss rates equal, or approximate, to those specified in the table..."

78 As with [211(i)], the losses referred to in the table mentioned in sub-paragraph (i) are Dr Christensen's forecast and rain on the ground loss rates. This aspect of the pleading has already been addressed (at [45]). The particulars and paragraphs that follow 5ASOC [228] are similar to 5ASOC [211] to [213] set out above.

79 The plaintiff's submissions note that, as at 3 January 2011, both Mr Malone and Mr Ayre knew that the dams were above FSL and rising and were not predicted to return to FSL at any time soon,[138] a proposition that I have already accepted. They then submit:[139]

"1053 In those circumstances, if not before, Mr Malone and Mr Ayre ought reasonably to have realised that the Flood Event had been ended prematurely and in breach of the Manual on 2 January and that the Manual required that the Flood Event be continued or recommenced. By failing to do so on 3 January, Mr Malone breached section 2.2 of the Manual. Further, by failing to ensure Mr Malone declared a Flood Event on 3 January, Mr Ayre breached section 2.3 of the Manual, which made Mr Ayre responsible for the "*overall strategy for management of the Flood* Event" as Senior Flood Operations Engineer (Manual, section 2.3, 5). Mr Malone's evidence was that decisions to mobilise were normally made in consultation with the Senior Flood Operations Engineer (Malone 1, LAY.SEQ.007.0001_OBJ, [41)). In failing to take those actions, Mr

[138] Plaintiff subs at [1052].
[139] Ibid at [1053] to [1054].

Malone and Mr Ayre increased the risk of flood damage in urban areas and thus breached their duty of care to the plaintiff and group members (see 5ASOC, PLE.010.001.0001, [228(a), (b)]).

1054 Furthermore, as Dr Christensen's analysis shows, the projected inflows from the rainfall forecast on 3 January were such that a reasonable engineer would have caused Somerset and Wivenhoe Dams to make releases at rates substantially above the rate of inflow. Strategy W3 was required at Wivenhoe and strategy S2 was required at Somerset. That is demonstrated in Dr Christensen's Simulation A where, even with a lower starting reservoir level on 3 January than existed in fact, Dr Christensen determines that W3 and S2 should have been engaged that day (Christensen 4.2, EXP.ROD.015.0261, 0273). Those operations should have continued until, at least, the reservoirs were no longer likely to exceed their respective FSLs (see 5ASOC, PLE.010.001.0001, [228(a), (c), (d), (e) and (h)])."

Mr Ayre

80 These submissions presuppose that in the period of 3 to 5 January 2011 Mr Ayre could have either directed Mr Malone to continue the flood event from 2 January 2011 or declared a flood event in his own right, a proposition I addressed and rejected in Chapter 6.[140] Accordingly, I reject the allegations of breach against Mr Ayre in respect of 3 January 2011.

Mr Malone

81 The first part of the submissions is directed to Mr Malone's failure to either continue or re-commence the flood event. The balance of the submissions are directed towards the necessity to make releases that exceed rates of inflow and seek to deploy the approach adopted in SIM A as informing what was required. I have not accepted that the reasonably competent flood engineer would have acted in accordance with SIM A.[141] However, I have accepted that a reasonably competent flood engineer would have, at a minimum, made releases from Wivenhoe Dam throughout 3 to 5 January 2011 substantially in accordance with the rates nominated by Simulation C.[142] At this point, reliance on SIM A is sufficient to invoke reliance on SIM C.

[140] Chapter 6 at [148].
[141] Chapter 10 at [223].
[142] Chapter 10 at [108].

82 Seqwater submitted that these contentions should not be entertained as it submitted that the pleaded case is confined to Dr Christensen's simulations that either commence on 2 January 2011[143] or 5 January 2011[144] but not 3 January 2011 or 4 January 2011.[145] This is a proposition I have already rejected.[146]

83 Seqwater further submitted that, insofar as the above passage refers to failing to declare a flood event, it is outside the pleaded case because even though [228(a)] refers to complying with the Manual and the particulars to [228] refer to various parts of the Manual, these particulars do not refer to section 2.2 which imposes the obligation on the DFOE to declare a flood event.[147]

84 However, the above passage only refers to whether Mr Ayre should have required Mr Malone to declare a flood event, presumably on the basis that, as a practical matter, where the flood engineers had purported to end flood operations on 2 January 2011, a declaration and mobilisation was necessary to undertake the flood operations as pleaded in 5ASOC [228(b)]. I have already found that with Wivenhoe Dam above FSL the flood event should not have ended and it was not necessary for the gate trigger level of EL 67.25m AHD to be exceeded before releases could occur. Otherwise, the balance of Seqwater's submissions in relation to the necessity to declare a flood event and commence releases[148] are addressed in Chapter 6.[149] While Mr Malone was obliged to declare a flood event, this only arose in a circumstance where neither the previous flood event (nor flood releases undertaken in connection with that event) should have ended.

85 Seqwater further submitted that the contention that release rates substantially exceeding the rate of inflow should have been made under Strategies W3 and S2 was effectively devoid of content as there was "no embrace of Dr

143 Ie, SIM A, SIM B, SIM C, SIM D and SIM I.
144 Ie, SIM E.
145 Seqwater subs at [1244] to [1251].
146 See above at [39].
147 See Chapter 3 at [16] to [17]; Seqwater subs at [1254].
148 Ie, Seqwater subs at [1253] to [1295].
149 Chapter 6 at [116] to [143].

Christensen" to identify the level of releases required.[150] However, consistent with the above analysis, the plaintiff's submission seeks to deploy Dr Christensen's approach in SIM A, although it cannot be exactly adopted because the actual levels in the dams were by this time different from those modelled in SIM A. On my findings, the releases in SIM C set the minimum bound on what was required on these days. Further, on the assumption that s 36 of the *CLA* (Qld) was applicable, Seqwater rhetorically questioned why a reasonably competent flood engineer would declare a flood event or make releases when firstly the dams were below trigger level, secondly releases would have taken dam levels below FSL, thus requiring the gates to be closed and thirdly peak outflow would have exceeded peak inflow to date?[151] However, these contentions overlook the fact that these days should have represented a continuation of the Late December Flood Event and are otherwise predicated on an interpretation of the Manual, and to an extent the operation of the Moreton ROP, that I reject (along with the application of s 36 of the *CLA* (Qld) to the flood engineers).

86 Given the identified risk, I am satisfied that the "reasonable person" in the flood engineers' position would have acted in accordance with the Manual, including its order of priorities, that being the relevant water control manual. In terms of the precautions that were warranted, the analysis in Chapter 6 demonstrates that a proper application of the Manual required the continuation of flood operations, or failing that, the declaration of a new flood event, and the immediate resumption of flood operations (*CLA*; s 9(1)(c)).[152] In terms of the adoption of strategies and the level of releases, the analysis in Chapter 10 in relation to SIM C informs an analysis of strategy selection and the minimum level of releases required. This is because the modelled dam levels in SIM C on 3 January 2011 are below those that in fact prevailed during the January 2011 Flood Event. In that regard, the probability of harm that would occur if "care" in the form of those precautions were not taken was appreciable. Flood storage space might be able to be recovered at a later

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[150] Seqwater subs at [1296] to [1301].
[151] Ibid at [1310(d)] and [1311] to [1313].
[152] Chapter 6 at [130].

time but if forecast rain fell then the ability to create such space before EL 74.0m AHD was exceeded may have been compromised by the limiting effect of downstream flows (*CLA*; s 9(2)(a)). As noted, the likely seriousness of the harm if the risk materialised was very large (*CLA*; s 9(2)(b)). The burden of taking precautions, specifically the effect on downstream bridges and the imperilment of the water supply, is addressed in Chapter 10 in relation to SIM C. The effect of the (continued) inundation on Burtons Bridge and bridges with lower inundation levels is described in Chapter 2. It did not warrant avoiding making releases (*CLA*; s 9(2)(c)).

87 It follows that on 3 January 2011 in respect of Mr Malone I accept that the breaches pleaded in [228(a) and (b)] are established. In SIM C, Dr Christensen selected Strategies W1 and S2 but that is only by reason of his adoption of the assumption that strategies are to be selected based on predictions of maximum heights using one-day inflows. I have found that four-day PMEs should have been used and this would have led to the adoption of Strategy W3.[153] In relation to releases, it follows from Chapter 10 that, at the very least, releases sufficient to inundate Burtons Bridge should have been made on this day as per SIM C.[154] Accordingly, I find that [228(c)] and [(e)], insofar as Wivenhoe Dam is concerned, are made out. I reject the allegation in [228(h)] which appears to be predicated on an assumption that flood operations should have been in draindown.

88 In relation to Somerset Dam, in the events that happened, Strategy S2 was clearly engaged on 3 January 2011 as Wivenhoe Dam was above EL 67.0m AHD and Somerset Dam was about EL 99.0m AHD.[155] However, as Wivenhoe Dam was rising and Somerset Dam's level was below EL 100.45m AHD, the Manual provided that the crest gates were not to be raised and the low level regulators and sluice gates were generally to be kept closed.[156] Although flood operations had not commenced at that time, the Somerset Dam gates were raised and the sluice gates were closed with one regulator

[153] Appendix F to this judgment.
[154] Chapter 10 at [93].
[155] Manual at 40.
[156] Ibid; first row of Action box.

open releasing around $34m^3/s$.[157] This was no different in substance from Somerset Dam operations in SIM C on that day, save that one sluice gate was open for part of the day, which was consistent with the Manual as Wivenhoe Dam levels in SIM C were falling at that time.[158] In most (but not all) respects, Dr Christensen's Somerset Dam operations in SIM C were consequential on his Wivenhoe Dam operations, which has the consequence that a number of the allegations of breach in relation to Somerset Dam do not truly arise as stand-alone breaches of duty. Instead, they are only requirements to be undertaken on a counterfactual analysis of what would follow from adopting Dr Christensen's approach to Wivenhoe Dam operations. Thus in relation to 3 January 2011, I do not accept that a breach in relation to a failure to implement S2 is made out.

Conclusion

89 I am satisfied that on 3 January 2011 Mr Malone breached his duty of care in failing to continue or commence flood operations contrary to the Manual (5ASOC [228(a)] and [228(b)]), failing to adopt Strategy W3 and not making releases of rates from Wivenhoe Dam which substantially exceeded the rate of inflows on that day (5ASOC [228(c) and (e)]). The balance of the allegations of breach are rejected.

12.7: 4 January 2011 Breaches

90 The pleaded allegations concerning the existence of the relevant risk of harm, required precautions and breach referable to 4 January 2011 are set out above (at [77]).

Existence of Risk

91 The analysis of the existence of the pleaded risk of harm in the circumstances prevailing as at 4 January 2011 and Seqwater's submissions on the same topic[159] are not relevantly different from that addressed in relation to

[157] Simulation Analysis, EXP.ROD.015.0469 at .0635.
[158] Manual at 40.
[159] Seqwater subs at [1253] to [1295], especially at [1272] to [1274].

3 January 2011. The prevailing circumstances on 4 January 2011 are set out in section 6.9 of Chapter 6. Throughout 4 January 2011, the level of Wivenhoe Dam rose from EL 67.18m AHD to EL 67.22m AHD and the level of Somerset Dam rose from EL 99.24m AHD to EL 99.27m AHD.[160] There was rainfall in the 24 hours to 9.00am on the morning of 4 January 2011 but it would not rain again until the following day.[161] The PME rainfall forecasts available from midnight on 4 January 2011 are described in Table 6-1.[162] On any view, the four-day PME forecast had increased from the previous day. It is apparent from Appendix F that both Dr Christensen's four-day "no release" rise and Mr Giles' adjustment of that figure takes SIM C above EL 71.0m AHD in circumstances where the modelled level of SIM C at midnight on 4 January 2011 is around 33cm less than the actual levels were at that time.[163] As noted in Chapter 6,[164] using Mr Malone's analysis of the Late December Flood Event, around 199mm of rain would generate enough runoff to fill Wivenhoe Dam to EL 74.0m AHD. This is above the upper bound of the four-day PME forecast but only by 50mm. The differential is only 28mm if Dr Christensen's assessment of the catchment response during the Late December Flood Event is used instead.[165]

92 Given the terms of the Manual, the seasonal outlook, the catchment conditions and the prevailing forecasts, I accept that there was a risk of the kind pleaded, that it was foreseeable and not insignificant (*CLA*; s 9(1)(a) and (b)).

Precautions

93 In relation to breach, both the plaintiff's submission[166] and Seqwater's response were not relevantly different from those submissions applicable to 3 January 2011.[167] The findings made above in relation to 3 January 2011 are

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[160] Simulation Analysis, EXP.ROD.015.0461 at .0467 and .0477.
[161] Chapter 6 at [3].
[162] Chapter 6 at [3] and [92]; See also Chapter 9 at [138] and [161].
[163] Simulation Analysis, EXP.ROD.015.0461 at .0628.
[164] Chapter 6 at [139].
[165] Chapter 6 at [139].
[166] Plaintiff's subs at [1069] to [1070].
[167] Seqwater subs at [1242] to [1313] were addressed to the period of 3 to 5 January 2011.

equally applicable to 4 January 2011, including those concerning Somerset Dam.

Conclusion

94 I am satisfied that on 4 January 2011 Mr Malone breached his duty of care in failing to continue or commence flood operations contrary to the Manual (5ASOC [228(a)] and [228(b)]), failing to adopt Strategy W3 and not making releases at rates from Wivenhoe Dam which substantially exceeded the rate of inflows on that day (5ASOC [228(c) and (e)]). The balance of the allegations of breach are rejected.

12.8: 5 January 2011 Breaches

95 Again, the pleaded allegations concerning the existence of the relevant risk of harm, the required precautions and breach referable to 5 January 2011 are set out above (at [77]).

Existence of Risk

96 The analysis of the existence of the pleaded risk of harm in the circumstances prevailing as at 5 January 2011 and Seqwater's submissions on the same topic[168] are similar to that addressed in relation to 3 January 2011. The prevailing circumstances on 5 January 2011 are set out in section 6.10 of Chapter 6. Throughout 5 January 2011, the level of Wivenhoe Dam rose from EL 67.22m AHD to EL 67.29m AHD and Somerset Dam rose from EL 99.27m AHD to EL 99.32m AHD.[169] There was substantial rainfall on 5 January 2011,[170] so much so that Dr Christensen's rain on the ground inflow estimate at midnight on 6 January 2011 was 79,000ML.[171] The PME rainfall forecasts available from midnight on 5 January 2011 are described in Table 6-1 in Chapter 6.[172]

[168] Seqwater subs at [1244] to [1295], especially at [1272] to [1274].
[169] Simulation Analysis, EXP.ROD.015.0461 at .0467 to .0468 and .0477 to .0478.
[170] Chapter 6 at [3].
[171] Chapter 9 at [235].
[172] Chapter 6 at [3] and [103]; See also Chapter 9 at [138] and [161].

97 As is apparent from Appendix F, there was a reduction in the four-day PME volumetric estimates at midnight on 5 January 2011. Nevertheless, the range of reasonable estimates of the "no release" rise based on the four-day PME would take Wivenhoe Dam to at least at or around EL 70.0m AHD.[173] However, as noted in Chapter 6,[174] the sum of the 1200UTC PME figures available from 6.00am on 5 January 2011 for the five days ending on 9 January 2011 predicted rainfall between 110mm and 330mm. Using Mr Malone's estimate of the catchment response during the Late December Flood Event of a 77% of rain to runoff conversion ratio, around 198mm of rain could have filled Wivenhoe Dam to EL 74.0m AHD.[175] Rainfall of that amount was more than realistic given those rainfall figures and the eight-day PME forecast available from midnight on 5 January 2011.[176] Again, given the terms of the Manual, the seasonal outlook, the catchment conditions and the prevailing forecasts, I accept that there was a risk of the kind pleaded, that it was foreseeable and not insubstantial (*CLA*; s 9(1)(a) and (b)).

98 The plaintiff's submissions again contended that Mr Malone breached his duty of care by not declaring a flood event or mobilising for flood operations.[177] They also contended that Mr Ayre breached his duty of care by not intervening and directing that outcome,[178] a contention that I have already rejected. The plaintiff further submitted:[179]

> "As Dr Christensen's Simulation E analysis demonstrates, had a Flood Event been commenced (or recommenced) on 5 January, a reasonable engineer, acting in accordance with the Manual, would have implemented W3 at Wivenhoe and S2 at Somerset and made releases at rates substantially exceeding the rate of inflow (Christensen 4.2, EXP.ROD.015.0261, 0369, 0380-0381). Those operations would have continued until the dams were, at least, no longer likely to exceed their respective FSLs (see 5ASOC, PLE.010.001.0001, [228(a), (c), (d), (e) and (h)])."

[173] EL 67.22m AHD + 330,000ML = EL 70.02m AHD.
[174] Chapter 6 at [105] to [106].
[175] Chapter 6 at [136].
[176] See Chapter 9 at [161] and Chapter 10 at [103] to [104].
[177] Plaintiff subs at [1088].
[178] Ibid at [1089].
[179] Ibid at [1091].

99 Otherwise, the plaintiff's submissions and Seqwater's response were not relevantly different from those submissions applicable to 3 and 4 January 2011.[180]

100 Thus, the plaintiff deployed SIM E in relation to its allegations of breach on 5 January 2011, presumably on the basis that SIM E modelled flood operations commencing on that day. In Chapter 10, I found that I was not satisfied that a reasonably competent flood engineer who inherited the circumstances prevailing at midnight on 5 January 2011 would or must have made releases substantially in accordance with that simulation,[181] with this conclusion extending to the modelled rate of releases on 5 January 2011.[182] However, I made the opposite finding in relation to SIM C. In SIM C, the modelled releases on 5 January 2011 are less than those in SIM E[183] and the modelled water levels are less than those that actually prevailed. It follows that I regard the modelled releases in SIM C on 5 January 2011 as, at the very least, the minimum level required of a reasonably competent flood engineer who commenced or inherited flood operations on that day.

101 Otherwise, the findings made above in relation to 3 and 4 January 2011 are equally applicable to 5 January 2011 including as to Somerset Dam.

Conclusion

102 I am satisfied that on 5 January 2011, Mr Malone breached his duty of care in failing to continue or commence flood operations contrary to the Manual (5ASOC [228(a)] and [228(b)]), failing to adopt Strategy W3 and not making releases at rates from Wivenhoe Dam which substantially exceeded the rate of inflows on that day (5ASOC [228(c) and (e)]). The balance of the allegations of breach of duty for 5 January 2011 are not made out.

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[180] Seqwater subs at [1242] to [1313] were addressed to the period of 3 to 5 January 2011.
[181] Chapter 10 at [245].
[182] Chapter 10 at [234].
[183] Chapter 10 at [233].

12.9: 6 January 2011 Breaches

103 The introductory parts of the 5ASOC for 6 January 2011 refer to the rising water levels, the widespread rainfall and runoff, the deteriorating forecasts and note that Mr Malone and then Mr Ayre were on duty during that day.[184] It pleads that the circumstances required the commencement or continuation of releases from the dams during that day but that this did not occur.[185] Those contentions are consistent with earlier findings.

Existence of Risk

104 The 5ASOC again pleads the existence of a "significant risk" on 6 January 2011,[186] this being that:

> "(a) unless releases were immediately commenced at Somerset Dam there would be insufficient flood storage capacity in Lake Somerset and Lake Wivenhoe to store incoming flows should further rainfall occur in accordance with, or in excess of, that forecast by the Bureau of Meteorology; and
>
> (b) without such capacity, subsequent releases would be necessary in volumes that would cause urban flooding downstream of Wivenhoe Dam."

105 The prevailing circumstances on 6 January 2011 are set out in section 6.11 of Chapter 6. Throughout 6 January 2011, the level of Wivenhoe Dam rose from EL 67.29m AHD to EL 67.46m AHD and Somerset Dam rose from EL 99.32m AHD to EL 99.52m AHD.[187] As noted above, there was substantial rainfall on 5 January 2011,[188] so much so that Dr Christensen's rain on the ground inflow estimate at midnight of 6 January 2011 was 79,000ML.[189] The rainfall continued throughout 6 January 2011[190] and by midnight on 7 January 2011, Dr Christensen's estimate of rain on the ground inflows was 155,000ML.[191]

[184] 5ASOC at [231] to [240].
[185] Ibid at [241] to [242].
[186] Ibid at [243].
[187] Simulation Analysis, EXP.ROD.015.0461 at .0549 and .0559.
[188] Chapter 6 at [3].
[189] Chapter 9 at [235].
[190] Chapter 6 at [3].
[191] Chapter 9 at [235].

106 The PME rainfall forecasts available from midnight on 6 January 2011 are described in Table 6-1 of Chapter 6.[192] Both the four-day and eight-day PMEs increased from the previous day, suggesting more rain and over a longer period.[193] As is apparent from Appendix F, there was an increase in the four-day PME volumetric estimates at midnight on 6 January 2011. All inflow amounts within the range of reasonable estimates of the "no release" rise based on the four-day PME would take Wivenhoe Dam from its height of EL 67.29m AHD at midnight on 6 January 2011 to above EL 70.5m AHD.[194] Dr Christensen's eight-day PME high estimate of inflow volumes would have taken those levels well above EL 74.0m.[195]

107 Further, as noted in Chapter 6,[196] the 1200UTC PME figures available from 6.00am on 6 January 2011 suggested an eight-day total for the region of up to 400mm, which could have applied to the area upstream of the dams. Also, as noted in Chapter 6,[197] taking into account rain on the ground and modelling a catchment response similar to the Late December Flood Event, further rainfall of between 165mm and 185mm was sufficient to generate enough runoff to fill Wivenhoe Dam to EL 74.0m AHD. The former figure is the preferable figure given that on any reasonable view by 6 January 2011 initial losses should have been satisfied by previous rainfall.[198]

108 Seqwater's submissions on the existence of this risk emphasised Mr Malone's calculations which have already been addressed.[199] They also contended that it was not shown that he had personal knowledge of the existence of the risk,[200] a matter that has also been addressed.

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[192] Chapter 6 at [3] and [149]; See also Chapter 9 at [138] and [161].
[193] Chapter 9 at [138] and [161].
[194] EL 67.29m AHD + 414,500ML = EL 70.73m AHD.
[195] EL 67.29m AHD + 1,056,000ML = 2,253,480ML = EL 75.13m AHD.
[196] At [155] to [157].
[197] Chapter 6 at [208].
[198] Chapter 9 at [200].
[199] Seqwater subs at [1337] to [1346]; see also Seqwater subs at [1353] to [1356].
[200] Ibid at [1349] to [1352].

109 Given the terms of the Manual, the seasonal outlook, the catchment conditions and the forecasts, I accept that there was a risk of the kind pleaded, that it was foreseeable and not insignificant (*CLA*; s 9(1)(a) and (b)).

Precautions

110 In relation to the relevant precautions that should have been adopted by each of Mr Malone and Mr Ayre, the 5ASOC pleads as follows:

> "245. Further, by reason of the matters pleaded at paragraphs 231-238 and 243, a reasonably prudent flood engineer on 6 January 2011:
>
> a) would have complied with the Flood Mitigation Manual;
>
> b) would have commenced or continued Flood Operations and releases on 6 January 2011;
>
> c) would have implemented and maintained Strategy W3 at Wivenhoe Dam;
>
> d) would have implemented and maintained Strategy S2 at Somerset Dam;
>
> e) would have caused Somerset Dam and Wivenhoe Dam to release water at rates substantially exceeding the rate of inflow;
>
> …
>
> h) would have continued Flood Operations until Lake Somerset and Lake Wivenhoe were no longer likely to exceed their respective Temporary Full Supply Levels, or alternatively, Full Supply Levels; and
>
> i) would have selected and input losses and continuing loss rates equal, or approximate, to those specified in the table below ….."

111 In relation to these precautions, the plaintiff submitted as follows:[201]

> "1165. As the foregoing analysis demonstrates, had Mr Malone and Mr Ayre modelled even the one day forecasts on 6 January, the results would have indicated that the Manual required the application of W3 at Wivenhoe Dam (5ASOC, PLE.010.001.0001, [245(c)]). As both dams were above FSL, S2 was required to be implemented at Somerset Dam (5ASOC, PLE.010.001.0001, [245(d)]). Mr Malone and Mr Ayre admit that they did not implement W3 on 6 January and it is clear that

[201] Plaintiff subs at [1165] to [1167].

S2 was not implemented by the Flood Engineers until 11:30 on 8 January 2011.[202] The correct selection of strategy would also have indicated to a reasonable flood engineer that releases could not be further delayed on 6 January. Such releases should have been commenced immediately (5ASOC, PLE.010.001.0001, [245(a), (b)]), and releases should have been made at rates substantially exceeding rates of inflow to create storage in anticipation of forecast rainfall (5ASOC, PLE.010.001.0001, [245(e)]). A reasonable engineer would then have complied with the Manual by continuing releases until the dams were no longer likely to exceed their respective FSLs (5ASOC, PLE.010.001.0001, [245(h)]).

1166. By failing to take these steps on 6 January 2011, both Mr Malone and Mr Ayre breached their duty of care to the plaintiff and group members.

1167. It is anticipated that the defendants will contend that the forecasts on 5 and 6 January did not justify making any releases from Wivenhoe at flow rates greater than 50 m^3/s, let alone at flow rates of 1,200 or 1,400 m^3/s. However, as the chronology above demonstrates and as the admissions referred to above by Messrs Malone and Ayre establish, the forecasts on 5 and 6 January plainly justified making releases to reduce the water levels in both Wivenhoe and Somerset. In particular, the chronology and the admissions establish that the forecasts required making releases from Wivenhoe because of the real possibility that the window to make non-damaging releases was closing as forecasts indicated that higher releases from Wivenhoe later in the event were likely to combine with downstream natural flows and cause damaging urban flooding."

112 Seqwater's responses to these contentions echo points that have already been addressed. First, it contended that the basis for these contentions was not pleaded because they do not involve an allegation that Mr Malone failed to make releases in accordance with a particular simulation.[203] Second, it was submitted that these submissions were divorced from Dr Christensen's simulations and it followed that no expert witness supported the adoption of this approach.[204] Third, it was submitted that it was not put to Mr Malone that he should have been operating in Strategy W3 or making higher releases (or operating as per Dr Christensen's simulations).[205]

113 The suggestion that the allegations are limited to the failure to implement each aspect of Dr Christensen's simulations has been addressed and rejected

[202] Somerset Directive 3, (8 Jan 2011), SEQ.004.024.0029.
[203] Seqwater subs at [1318], [1327] and [1335].
[204] Ibid at [1328] and [1334].
[205] Ibid at [1319], [1330].

above. At one level they do correspond with Dr Christensen's approach, in that they assume that strategies are selected by reference to forecast levels and that releases are made in advance of rainfall based on forecasts. As already explained, a direct correlation with one of Dr Christensen's simulations is not possible given the divergence in actual and simulated water levels over time, although I derive support from the findings I have made in relation to SIM C. The *Browne v Dunn* complaint in relation to Mr Malone has been addressed above.

114 Seqwater also contended that any failure to make releases on 6 January 2011 was immaterial given that Mr Ayre commenced his shift at 6.00pm and would have taken a different approach.[206] However, in the end result, it is the cumulative effect of Mr Malone's breaches that have to be considered. The balance of Seqwater's submissions were addressed in Chapter 6[207] or are predicated on a construction of the Manual[208] or approach to releasing below FSL that has already been rejected.[209]

115 SunWater's submissions in relation to 6 January 2011 and Mr Ayre have been addressed in Chapter 6.[210] SunWater's submissions were principally directed to the selection of strategies by reference to actual lake levels and Mr Ayre's supposed use of a "buffer" in determining release rates.[211] I have rejected both of these claims.[212] Otherwise, SunWater pointed to the absence of a particularised breach that referred to Dr Christensen's simulations, specifically a lack of reference to SIM E, which was modelled to commence the previous day and simulated releases of above 2000m^3/s on 6 January 2011.[213]

116 Leaving aside the reference to Strategy S2, the necessity to take all the steps referred to in [1165] of the plaintiff's submissions flows from the findings that

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[206] Seqwater subs at [1336].
[207] Ibid at [1329]: see Chapter 6 at [157]; Seqwater subs at [1332]: see Chapter 6 at [197]; Seqwater subs at [1333], [1356] and [1357]: see Chapter 6 at [197]; Seqwater subs at [1361] to [1379] (Mr Malone's approach to releases and forecasts): see Chapter 6 at [184] to [197].
[208] Seqwater subs at [1359] regarding actual lake levels.
[209] Ibid at [1358].
[210] Especially at [198] to [203].
[211] SunWater subs at [1996] to [1998].
[212] Chapter 3, section 3.3.4; Chapter 6 at [201] and Chapter 7 at [36].
[213] SunWater subs at [1999] to [2001].

have already been made to date. To the extent that the flood engineers operated by reference to any strategy on 6 January 2011, it was not W3 and it was certainly not determined by forecasts,[214] yet that was what was required, whether strategy was selected either by reference to four-day PME forecasts or one-day QPF forecasts[215] (although I have found it should have been the former). The flood engineers did not make any releases much less determine releases, by reference to forecasts. If they had done this and operated in Strategy W3, they would have commenced releases immediately,[216] and at significant rates.

117 Paragraph 1167 of the plaintiff's submissions anticipates a submission from the defendants responding to a suggested release rate of $1200m^3/s$ or $1400m^3/s$. This appears to be a reference to the level of outflows necessary to keep Mt Crosby Weir Bridge and Fernvale Bridge open and is referable to a submission made by the plaintiff that the flood engineers' modelling of rain on the ground indicated that natural downstream flows would at some point inundate Burtons Bridge and Kholo Bridge.[217] In SIM A (and SIM I), the modelled rate of outflow in SIM A (and SIM I) on 6 January 2011 was around $1200m^3/s$. In SIM C, the modelled rate of outflows on 6 January 2011 after 11.00am was sufficient to inundate those bridges.[218] In Chapter 10, although I accepted that the reasonably competent flood engineer would release at a rate of around $1400m^3/s$, I did not accept that a reasonably competent flood engineer must have released at higher rates to inundate those bridges in the circumstances prevailing in SIM C.[219] That finding is consistent with my acceptance of the above aspect of the plaintiff's submissions.

118 Given the identified risk, I am satisfied that the "reasonable person" in the flood engineers' position would have taken these precautions (*CLA*; s 9(1)(c)). In that regard the probability of harm that would occur if "care" in the form of

[214] Chapter 6 at [187], [198] and [209] to [212].
[215] Chapter 6 at [194]; see also Appendix F to this judgment; taking just Mr Giles' one-day inflow estimates at 11.00am on 6 January 2011 (206,900ML) and adding them to the water level at that time (EL 67.34m AHD) yields a projected height of EL 69.13m AHD.
[216] Chapter 6 at [190], [195] and [199].
[217] Plaintiff subs at [1123].
[218] Simulation Analysis, EXP.ROD.015.0461 at .0629.
[219] Chapter 10 at [152] to [154].

those precautions were not taken was appreciable (*CLA*; s 9(2)(a)). The effect of the forecasts was that the period of time in which to make releases without the potential to cause damage when combined with downstream flows was shortening.[220] As noted, the likely seriousness of the harm if the risk materialised was very large (*CLA*; s 9(2)(b)). The burden of taking precautions, specifically the effect on downstream bridges and compromising the water supply, is addressed in Chapter 10 in relation to SIM C, namely the continued inundation of Burtons Bridge and the bridges with inundation levels below that bridge (*CLA*; s 9(2)(c)). Given the water levels in the dams at this time, the level of rain on the ground inflows and the prevailing forecasts, there was no possibility of compromising the objective of retention of the water level at FSL by commencing releases. The effect of the inundation of Burtons Bridge and the other bridges below that inundation level is described in Chapter 2. It did not justify failing to take the specified precautions (*CLA*; s 9(2)(c)).

119 The January FER records that Strategy S2 was engaged on 6 January 2011.[221] It also states that as Wivenhoe Dam was rising (above FSL) and Somerset Dam was below EL 100.45m AHD, sluice gates were kept closed and releases through the regulator continued as part of the drain down from the Late December Flood Event.[222] Although, for the reasons stated in Chapter 7,[223] I am sceptical of the strategy descriptions in the January FER, there is no basis for stating that there was a per se failure to implement Strategy S2 as the allegation of breach at [245(d)] of the 5ASOC appears to contemplate. If Strategy W3 had been implemented and substantial releases were made from Wivenhoe Dam then this would have necessitated higher releases from Somerset Dam in Strategy S2 (as modelled in SIM C). However, consistent with what has already been stated, this does not mean that there was a standalone failure to implement and maintain Strategy S2

[220] Chapter 6 at [171] to [172]; see the daily PMEs published at 6.00am on 6 January 2011: EXP.SEQ.014.0355 (for 8 Jan); EXP.SEQ.014.0356 (for 9 Jan) and EXP.SEQ.014.0357 (for 10 Jan); daily PMEs published at 6.00pm on 6 January 2011: EXP.SEQ.014.0362 (8 Jan); EXP.SEQ.014.0363 (9 Jan); EXP.SEQ.014.0364 (10 Jan); EXP.SEQ.014.0365 (11 Jan).
[221] January FER at .0492.
[222] Id.
[223] Chapter 7, section 7.13.

given the interrelationship between flood operations at Wivenhoe Dam and Somerset Dam.

Conclusion

120 I am satisfied that, on their respective shifts on 6 January 2011, each of Mr Malone and Mr Ayre breached his duty of care in failing to continue or commence flood operations and make releases (5ASOC [245(a) and [245(b)]), failing to implement and maintain Strategy W3 (5ASOC [245(c)]) and failing to make releases on 6 January 2011 at rates which substantially exceeded the rate of inflows on that day (5ASOC [245(e)]), specifically a rate that was at least above that necessary to inundate Kholo Bridge and in the order of 1200m^3/s to 1400m^3/s. The finding at [87] applies with equal force to 5ASOC [245(h)]. The balance of the allegations of breach for 6 January 2011 are rejected.

12.10: 7 January 2011 Breaches

121 The events of 7 January 2011, including the prevailing forecasts, are described in section 6.12 of Chapter 6. Mr Malone relieved Mr Ayre at around 6.45am and he was later relieved by Mr Ruffini at around 6.45pm. Flood releases from Wivenhoe Dam did not commence until around 3.00pm.[224] The relevant parts of the 5ASOC referable to 7 January 2011 plead that the flood engineers either operated under Strategy W1 or at rates consistent with Strategy W1.[225] I have found that, to the extent the flood engineers operated in any strategy on 7 January 2011, it was Strategy W1 and that they did not operate in Strategy W3.[226] The position on 7 January 2011 so far as Somerset strategies are concerned is no different from that stated above for 6 January 2011 (save that a sluice gate was opened at 7.00pm when Somerset Dam was below EL 100.45m AHD).

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[224] Chapter 6 at [232].
[225] 5ASOC at [258] to [259].
[226] Chapter 6 at [258].

Existence of Risk

122 Paragraph 265 of the 5ASOC pleads the existence of a "substantial risk" that:

> "(a) …. unless releases were commenced at Somerset Dam and Wivenhoe Dam:
>
> i) in accordance with Strategy S2 and Strategy W3 respectively; and, or alternatively,
>
> ii) at rates substantially in excess of the rate of inflow;
>
> there would be insufficient flood storage capacity in Lake Somerset and Lake Wivenhoe to store incoming flows should further rainfall occur in accordance with, or in excess of, that forecast by the Bureau of Meteorology; and
>
> b) that, without such capacity, subsequent releases would be necessary in volumes that would cause urban flooding downstream of Wivenhoe Dam."

123 On 7 January 2011, there were no releases being made until 3.00pm and only a modest level of releases being made by midnight, namely $509m^3/s$, when inflows over the course of the day ranged between $798m^3/s$ and $2225m^3/s$.[227] An analysis of the forecasts and the available storage space throughout 7 January 2011 is set out in Chapter 6.[228] By 6.00pm in the evening, the range of reasonable estimates of four-day inflow volumes exceeded the remaining storage capacity of Wivenhoe Dam to EL 74.0m AHD and large daily forecast totals were predicted for Sunday, 9 January 2011 and Monday, 10 January 2011.[229] Any rational consideration of forecasts demanded immediate and substantial releases.[230] Given the terms of the Manual, the seasonal outlook, the catchment conditions and forecasts, I accept that throughout 7 January 2011 there subsisted a risk of the kind pleaded and, in particular, that it was foreseeable and not insignificant (*CLA*; s 9(1)(a) and (b)).

[227] Simulation Analysis, EXP.ROD.015.0461 at .0629.
[228] Chapter 6 at [213] to [215], [219] to [231] and [265] to [266].
[229] Id; See Appendix E to this judgment; EXP.SEQ.014.0356; EXP.SEQ.014.0357; EXP.SEQ.014.0363; EXP.SEQ.014.0364; EXP.SEQ.014.0365.
[230] See also Chapter 10 at [118] to [125].

Pleaded Breaches

124 The equivalent to 5ASOC [211] referable to 7 January 2011 is 5ASOC [267], which relevantly pleads that:

> "….a reasonably prudent flood engineer responsible for Flood Operations at Somerset Dam and Wivenhoe Dam on 7 January 2011:
>
> a) would have complied with the Flood Mitigation Manual;
>
> b) would have commenced releases at Somerset Dam and Wivenhoe Dam as soon as possible, and in any event, earlier than 3:00 pm;
>
> c) would have implemented and maintained Strategy W3 at Wivenhoe Dam;
>
> d) would have implemented Strategy S2 at Somerset Dam until approximately 7:00 pm and then adopted Strategy S3;
>
> e) would have caused Somerset Dam to release water at rates approximating the rate of inflow;
>
> f) would have caused Wivenhoe Dam to release water at rates exceeding the rate of inflow;
>
> …
>
> i) would have selected and input losses and continuing loss rates equal, or approximate, to those specified in the table below ……"

125 The plaintiff's submissions in support of these allegations of breach did not press for any finding concerning [267(d), (e) and (i)]. [231] They can be put aside. So far as Somerset Dam operations are concerned, the plaintiff's submissions appear to treat them at this point as dependent on the required approach to adopt for Wivenhoe Dam. In relation to [267(i)], as already stated, the use of loss rates is simply an aspect of modelling inflows for the purpose of selecting strategies and release rates (see [45]).

Balance of Mr Ayre's Shift

126 The plaintiff submitted the balance of Mr Ayre's shift on 7 January 2011 involved the same breaches as those pleaded for 6 January 2011 given that it was a continuation of the approach adopted on that day of waiting for the

[231] Plaintiff subs at [1240] to [1244].

Lockyer Creek peak to pass before commencing flood releases.[232] Although the plaintiff's submissions did not identify the specific sub-paragraphs of 5ASOC [267] that it relied on, so far as Mr Ayre is concerned they are not relevantly different from the pleaded breaches on 6 January 2011, namely failing to commence releases,[233] failing to implement Strategy W3[234] and failing to cause the dams to release water at rates that either substantially exceeded or did exceed the rates of inflow.[235] Subject to considering two matters, findings of breach in respect of those matters follow from the findings in relation to 6 January 2011.

127 The first is that the rates of inflow on 7 January 2011 increased substantially from 6 January 2011. Dr Christensen's reverse routed figures determined that rates of inflow varied between 798m^3/s and 2225m^3/s on that day.[236] Rates of outflow that exceeded rates of inflow on that day would invariably have inundated all bridges other than Mt Crosby Weir Bridge and Fernvale Bridge and most likely would have inundated those bridges as well. Nevertheless, it follows from the findings in Chapter 10 concerning SIM C that reasonable flood operations required the inundation of the remaining bridges on that day.[237] The probability of harm in the form of downstream flooding caused or contributed by releases from above EL 74.0m AHD if releases at that level were not made was appreciable (*CLA*; s 9(2)(a)) and likely to be serious and widespread (*CLA*; s 9(2)(b)). One burden of taking those precautions was the inundation of the remaining bridges, which was a serious step to take,[238] but the likelihood of making releases above EL 74.0m AHD in light of the prevailing forecasts was so high that it was now required (*CLA*; s 9(2)(c)). Given the water levels in the dams at this time and the state of rain on the ground inflows, there was little prospect of compromising the retention of FSL at the conclusion of the event (*CLA*; s 9(2)(c)).

[232] Plaintiff subs at [1174] to [1176].
[233] 5ASOC [245(a) and (b)] v 5ASOC at [267(a) and (b)].
[234] Ibid at [245(c)] v at [267(c)].
[235] Ibid at [245(e)] v at [267(f)].
[236] Simulation Analysis, EXP.ROD.015.0461 at .0468, .0469.
[237] From midnight: Chapter 10 at [154].
[238] See Chapter 2 at [90] to [91].

128 The second is that, in its written submissions, SunWater noted that the actual lake levels of Wivenhoe Dam only warranted the adoption of a W1 strategy and otherwise the predicted level of Wivenhoe Dam based on the 6 Jan 21:00 ROG run was only EL 68.24m AHD.[239] It also submitted that, even if W3 was engaged, it required the minimisation of outflows prior to the naturally occurring (rain on the ground) peak at Moggill[240] and disputed the approach of releasing water in advance of large forecasts. All of these propositions are inconsistent with the Manual. As explained in Chapter 3, W1 strategies are determined by predicted levels,[241] predictions are made by reference to forecasts,[242] the minimisation of flows prior to the naturally occurring peak in W3 is directed to the circumstance that combined flows are above 4000m^3/s[243] and, in some circumstances, the Manual requires the making of pre-releases based on forecasts.[244]

Mr Malone's Shift

129 In relation to Mr Malone's shift, the plaintiff submitted that Mr Malone should have but failed to implement Strategy W3 on the morning of 7 January 2011 and he "should have been focusing on urban flood protection, which would have meant commencing releases as soon as possible and not waiting for the Lockyer peak". The plaintiff submitted that "[b]y failing to adopt W3 and, in any event, failing to commence releases as soon as possible, Mr Malone breached the Manual and his duty of care to the plaintiff and group members [267(a), (b), (c)])".[245] It further submitted that, given the forecasts, he was obliged to "make releases from Wivenhoe Dam at rates exceeding the rate of inflow to create storage ([267(f)])". It contended that the position was "even clearer" in the afternoon when rain on the ground modelling predicted a water level above EL 68.50m AHD.[246] The submissions again point to his failure to implement Strategy W3 and his failure to make releases in compliance with

[239] SunWater subs at [2019(c) to (d)].
[240] Ibid at [2019(g)].
[241] Chapter 3 at [171].
[242] Chapter 3 at [176].
[243] Chapter 3 at [293].
[244] Chapter 3 at [329].
[245] Plaintiff subs at [1240].
[246] See Chapter 6 at [237].

the Manual and at rates exceeding the rate of inflow as establishing the reaches alleged in 5ASOC [267(a), (c), (f)].[247]

130 Seqwater's submissions in respect of this period have already been addressed either above or in Chapter 6, namely the contention that these complaints are outside the pleaded case,[248] the necessity to establish Mr Malone's knowledge of the risk of harm,[249] the alleged absence of any reason for Mr Malone to implement Strategy W3, the assertion that it should not be considered without it specifically being put to him in cross-examination,[250] the contention that transitioning to Strategy W3 or implementing Strategy W3 would not have addressed the risk of harm without specification of the releases required[251] and the contention that Mr Malone was obliged to act in conformity with Mr Ayre's "general strategy".[252]

131 Again, the necessity to take the specified precautions follows from the findings that have already been made. To the extent that the flood engineers operated in any strategy on 7 January 2011, it was not W3 and it was certainly not determined by forecasts.[253] Regardless of whether strategy was selected by reference to four-day PME forecasts or one-day QPF forecasts, a selection of Strategy W3 was required.[254] This is only reinforced by Appendix F to this judgment in that even Mr Giles' estimates of four-day PME inflows using the flood engineers' loss rates (which I regard as unreasonable) takes the projected height of Wivenhoe Dam well above EL 68.5m AHD,[255] as does his one-day QPF estimate of inflows at 11.00am.[256] As for the release rates, the implementation of Strategy W3 and the recognition of its priority of avoiding urban inundation required a substantial increase in releases. The findings in Chapter 10 concerning SIM C recognise that by midnight on 7 January 2011 at its modelled dam level, releases sufficient to inundate the remaining

[247] Plaintiff subs at [1241].
[248] Seqwater subs at [1389] to [1393].
[249] Ibid at [1394] to [1407].
[250] Ibid at [1408] to [1424]; see Chapter 6 at [257].
[251] Ibid at [1425]; see [37] above.
[252] Ibid at [1426]; see Chapter 6 at [260] to [262].
[253] Chapter 6 at [255] to [256].
[254] Chapter 6 at [257].
[255] 1,215,416ML + 203,000ML = 1,418,416ML = EL 69.21m AHD.
[256] 1,254,506ML + 219,000ML = 1,473,506ML = EL 69.66m AHD.

bridges were required to be made.[257] That finding would apply with even greater force to the events that transpired given the actual levels of the dam exceeded the modelled level of SIM C on 7 January 2011 by approximately 2m or more.[258] SIM C's modelled releases created storage space (ie, they exceeded the rate of inflow).

132 Given the risk presented by storage levels and forecasts on 7 January 2011, I am satisfied that the "reasonable person" in the flood engineers' position would have taken the precautions identified by the plaintiff in relation to Mr Malone (*CLA*; s 9(1)(c)). In that regard, the probability that harm would occur if "care" in the form of those precautions were not taken was appreciable (*CLA*; s 9(2)(a)). The effect of the forecasts was the window of time in which to make releases without the potential to cause damage was narrowing rapidly. The likely seriousness of the harm if the risk materialised was very large (*CLA*; s 9(2)(b)). The burden of taking precautions, specifically the effect on downstream bridges and compromising the water supply, is addressed in Chapter 10 in relation to SIM C and Chapter 2. The inundation for the first time of Mt Crosby Weir Bridge and Fernvale Bridge was a substantial step but the likelihood of forced releases above EL 74.0m AHD and downstream flows above $4000m^3/s$ was by this time very real and far outweighed the inconvenience arising from their closure (*CLA*; s 9(2)(c)). Given the water levels in the dams at this time and the state of rain on the ground inflows there was no possibility of compromising the retention of the dam at FSL by commencing releases (*CLA*; s 9(2)(c)).

Mr Ruffini

133 The plaintiff submitted that "Mr Ruffini simply continued Mr Malone's strategy on the night of 7 January" and made the same breaches as Mr Malone for the period after releases commenced (ie, 5ASOC, [267(a), (c), (f)]).[259] It contended that, although the 7 Jan 22:00 ROG run was "demonstrably flawed and yielded unreasonable and unreliable results", it still revealed that

[257] Chapter 10 at [152] to [154].
[258] Simulation Analysis, EXP.ROD.015.0461 at .0629.
[259] Plaintiff subs at [1242].

"Wivenhoe Dam was likely to exceed 68.5 m so that W3 was required to be implemented" and as such Mr Ruffini should have altered the release plan to cause Wivenhoe to make releases at rates exceeding the rate of inflow to create storage in Wivenhoe Dam.[260]

134 In its submissions, the State contended that the pleaded allegation against Mr Ruffini was not a "viable cause of action" because there was no relevant connection between the alleged breaches pleaded in 5ASOC [267] and the causation pleading in [267B], in that "Mr Ruffini … could not have reduced the water level in Lake Wivenhoe to any of the levels referred to in" 5ASOC [267B].[261] The State contended that, unless the alleged breaches in respect of the period from 7 to 8 January 2011 were linked to simulations F, H or J, then it could not be established that these breaches had any causative consequences.[262] I address the approach to causation (or materiality of breach) that is the premise of the submission in Chapter 13 (and reject it).[263] Otherwise, the findings I have made in relation to SIM C, SIM F and SIM H are relevant to an assessment of what was required of Mr Ruffini in that, despite modelling water levels below the actual levels, all three simulations involve releases on 8 January 2011 at levels that inundated the remaining bridges but which are less than the threshold for urban damage when they combined with downstream flows. Otherwise, the relationship between Dr Christensen's simulation and the allegation of breach is addressed above.

135 The events of Mr Ruffini's shift on the evening of 7 January 2011 are set out at Chapter 6.[264] For the reasons stated in Chapter 6, I do not accept that a reasonably competent flood engineer in his position could derive any support for the continuation of the existing approach to releases from the 7 Jan 22:00 72-hour run.[265] At the time Mr Ruffini commenced his shift, the daily PMEs for the following days had been available since 6.00pm. The effect of those one-day PMEs and the time in which they predicted rain to fall is also set out

[260] Plaintiff subs at [1244].
[261] State subs at [229].
[262] Ibid at [230].
[263] Chapter 13, section 13.5.
[264] Chapter 6 at [240] to [254].
[265] Chapter 6 at [327].

in Chapter 6[266] and can be gauged from Appendix E to this judgment. Leaving aside Mr Giles' estimate using the flood engineers' loss rates, which I regard as unreasonably low, the reasonable range of such estimates pushed the projected height to above EL 74.0m AHD.[267] The effect of the inflow estimates stemming from the afternoon QPF pushed the projected height above EL 70.0m AHD. Whether those projected heights required the selection of Strategy W3 or W4 did not relevantly matter as they definitely required a transition out of W1 and the only reasonable course of action open to a flood engineer was to increase releases to a level that inundated the remaining bridges without exceeding the threshold for causing urban damage downstream.[268]

Mr Ayre's Supervision

136 The plaintiff contended that on 7 January 2011, Mr Ayre was obliged, but failed, to intervene as Senior Flood Operations Engineer to direct the implementation of Strategy W3 and higher releases and that this failure was a breach of his duty of care to the plaintiff and the other group members.[269]

137 In Chapter 6,[270] I accepted that Mr Ayre had the authority to intervene and the capacity to do so. In his affidavit, Mr Ayre affirmed that he was monitoring the information available to the Flood Engineers on duty and their activities in the Flood Operations Centre during this time, although he could not recall speaking to any of the flood engineers during this period.[271] In addition to disputing his authority to intervene, SunWater noted that even though Mr Ayre was monitoring situation reports and gate directives, he was not in a position to monitor the flood modelling to enable him to conclude that Strategy W3 had to be adopted.[272] However, I have already found that he should have implemented Strategy W3 on his overnight shift. Given the continued rainfall throughout the day, the fact there were no releases until 3.00pm, the fact that

[266] Chapter 6 at [242].
[267] Which is consistent with the analysis in Chapter 6 at [265] to [266].
[268] Chapter 10 at [152] to [154].
[269] 5ASOC at [267(a), (c), (f)]: Plaintiff subs at [1243].
[270] Chapter 6 at [263].
[271] LAY.SUN.001.0001_OBJ at [1913]; T 7899.4.
[272] SunWater subs at [2068].

there were only minimal releases after then and the prevailing forecasts (including those issued just before he finished his shift),[273] it should have been obvious to him that forecast rainfall would take Wivenhoe Dam well above EL 68.5m AHD. Given that he was in fact monitoring flood operations, even if not reviewing the RTFM runs, I am satisfied he was obliged to exercise his authority and direct the flood engineers on duty to implement Strategy W3 and increase releases before the arrival of the peak flow from Lockyer Creek.

Conclusion

138 I am satisfied that during his shift on 7 January 2011, Mr Malone breached his duty of care in failing to implement and maintain (at least) Strategy W3 (5ASOC [267(a) and (c)]), failing to commence releases prior to 3.00pm (5ASOC [267(b)]) and failing to cause Wivenhoe Dam to release water at rates exceeding the rate of inflow (5ASOC [245(f)]).

139 Similarly with Mr Ruffini, I am satisfied that during his shift on 7 January 2011 he breached his duty of care in failing to implement and maintain (at least) Strategy W3 (5ASOC [267(a) and (c)]) and failing to cause Wivenhoe Dam to release water at rates exceeding the rate of inflow (5ASOC [245(f)]).

140 I am satisfied that, during the balance of his shift on 7 January 2011, Mr Ayre breached his duty of care in failing to commence releases (5ASOC [267(b)]), failing to implement Strategy W3 (5ASOC [267(a) and (c)]) and failing to cause the dams to release water at rates that substantially exceeded the rates of inflow (5ASOC [267(f)]). I am further satisfied that, for the remainder of 7 January 2011 when he was monitoring flood operations, Mr Ayre breached his duty of care by failing to intervene as Senior Flood Operations Engineer to direct the implementation of Strategy W3 and the making of higher releases at a rate that exceeded the rate of inflow (5ASOC [267(a), (c), (f)]). The balance of the allegations of breach are rejected.

[273] Chapter 6 at [219].

12.11: 8 January 2011 Breaches

141 The events of 8 January 2011, including the prevailing forecasts, are described in section 7.1 of Chapter 7. Mr Ayre relieved Mr Ruffini at around 6.30am. Mr Tibaldi relieved Mr Ayre at around 7.00pm.[274] The relevant parts of the 5ASOC referable to 8 January 2011 plead that Mr Ruffini and Mr Ayre either operated under Strategy W1, or released water at rates consistent with Strategy W1, and did not implement Strategy W3.[275] I have already made findings to that effect, including for the period of Mr Tibaldi's shift and that was so notwithstanding the actual levels of the dams exceeding EL 68.5m AHD.[276]

Existence of Risk

142 Paragraph 285 of the 5ASOC pleads the existence of a "substantial risk" on 8 January 2011:

> "a) that, unless releases were commenced at Somerset Dam and Wivenhoe Dam:
>
> i) in accordance with Strategy S2 and Strategy W4 respectively; and, or alternatively;
>
> ii) at rates substantially in excess of the rate of inflow;
>
> there would be insufficient flood storage capacity in Lake Somerset and Lake Wivenhoe to store incoming flows should further rainfall occur in accordance with, or in excess of, that forecast by the Bureau of Meteorology; and
>
> b) that, without such capacity, subsequent releases would be necessary in volumes that would cause urban flooding downstream of Wivenhoe Dam."

143 On 8 January 2011, the rates of inflow into Wivenhoe Dam as determined by reverse routing were between $818m^3/s$ and $2144m^3/s$, which included outflows from Somerset Dam of either around $206m^3/s$ or $413m^3/s$ depending on whether one or two sluice gates were open.[277] Releases from Wivenhoe Dam varied between $509m^3/s$ and $1241m^3/s$. The level of Somerset Dam rose

[274] Chapter 7 at [75].
[275] 5ASOC at [280] to [281].
[276] Chapter 6 at [258].
[277] Simulation Analysis, EXP.ROD.015.0461 at .0931 and .0938.

slightly, whereas Wivenhoe Dam rose from EL 68.32m AHD to EL 68.65m AHD.[278]

144 The position as at midnight on 8 January 2011 can be gauged from the second row of Appendix E to this judgment as simulations F and H commence at that time at the same height as the actual levels of Wivenhoe Dam. Both Dr Christensen's estimate of the four-day PME inflow estimate and Mr Giles' adjustment of his estimate to account for what the State asserted was the correct volume of inflows during the Late December Flood Event took the projected height of Wivenhoe Dam well above EL 75.0m AHD. Mr Giles' own estimate took the projected height to EL 71.99m AHD, although I have already rejected that assessment as unreasonably low. As at midnight on 8 January 2011, Wivenhoe Dam was at EL 68.32m AHD with a further 763,138ML required to fill Wivenhoe Dam to EL 74.0m AHD. Dr Christensen's rain on the ground inflow estimate was 168,000ML, which was only slightly higher than the figure provided by Mr Giles.[279] The balance of 595,138ML equates to 105mm of runoff from further rainfall.[280] The range of estimates of the four-day PME forecasts was between 151mm and 200mm of rain.[281] Taking the lowest end of that range, 150mm of rainfall would produce 105mm of runoff using a conversation rate of rainfall to runoff of 70%. This is well below all of the conversion rates calibrated to the Late December Flood Event that were offered in the proceedings. The one-day PMEs available from 6.00pm on 7 January 2011 suggested little rain above the dams and light rain below the dams on 8 January 2011, substantial rain above and very heavy rain below on 9 January 2011 and substantial rain everywhere on 10 and 11 January 2011.[282] As with 7 January 2011, any rational consideration of forecasts demanded immediate and large releases.[283] In these circumstances, and leaving aside any debate about the reference to Strategy W4 in 5ASOC [285], I accept that throughout 8 January 2011 there

[278] Simulation Analysis, EXP.ROD.015.0461 at .0469.
[279] Chapter 9 at [235].
[280] 1mm of rainfall is a measurement of 1L of liquid over a $1m^2$ area. 1,000,000L = 1ML and $1,000,000m^2 = 1km^2$. Ie, 595,138ML / $5673km^2$ = the amount of runoff in mm needed to generate the requisite volume of inflow = 105mm.
[281] Chapter 9 at [138].
[282] EXP.SEQ.014.0377, EXP.SEQ.014.0378 and EXP.SEQ.014.0379.
[283] See also Chapter 10 at [152] to [154].

subsisted a risk of the kind pleaded and, in particular, that it was foreseeable and not insignificant (*CLA*; s 9(1)(a) and (b)).

Pleaded Breaches

145 Paragraph 288 of the 5ASOC pleads:

> "Further, by reason of the matters pleaded at paragraphs 270-278 and 285-286, a reasonably prudent flood engineer on 8 January 2011:
>
> a) would have complied with the Flood Mitigation Manual;
>
> b) would have implemented and maintained Strategy W4 at Wivenhoe Dam;
>
> c) would have implemented and maintained Strategy S3 at Somerset Dam;
>
> d) would have caused Wivenhoe Dam to release water at rates exceeding the rate of inflow;
>
> e) would not have substantially increased the rate of outflow from Somerset Dam without implementing a corresponding increase in the rate of outflow from Wivenhoe Dam;
>
> …
>
> h) would have selected and input losses and continuing loss rates equal, or approximate, to those specified in the table below ..."

146 The particulars to this paragraph are similar to the particulars of [211] except that Particular E refers to SIM F, H and J which were modelled to commence on 8 January 2011. Paragraphs 288B and 289 are the equivalents to [211B] and [212].

Balance of Mr Ruffini's Shift

147 The plaintiff submitted that "the only available inference" is that on the morning of 8 January 2011 Mr Ruffini ignored the requirements of the Manual by, for example, not making "*predictions* of the kind required by section 8.4 of the Manual" and "not *consider*[ing] whether Wivenhoe Dam was likely to exceed 68.5 m [therefore] requiring the implementation of W3 or W4" but instead "remain[ing] focused only on W1 procedures in keeping bridges open". It submitted that Mr Ruffini "did not *turn his mind* to [the] optimum

protection of urban areas in the context of the forecasts recorded in his situation report, the seasonal conditions and the saturated catchments" and that "as a consequence, Mr Ruffini breached his duty of care to the plaintiff and group members on 8 January 2011", citing 5ASOC at [288(a) and (b)].[284]

148 These submissions attempt to equate breaches of duty with states of mind and in that respect are contrary to *Rodriguez (No 1)* ("ignored", "did not turn his mind" etc). The relevant pleaded breach in 5ASOC [288(b)] is a failure to *implement* Strategy W4 and not a failure on the part of Mr Ruffini to "turn his mind" to something. In its submissions, the State observed that the plaintiff's submissions did not expressly contend that Mr Ruffini should have implemented Strategy W4 as asserted in 5ASOC [288(b)].[285] It follows from the findings in Chapters 6, 9 and 10 as well as the above findings that a flood engineer in Mr Ruffini's position was obliged to "implement" Strategy W4 in the sense of determining a projected height above EL 74.0m AHD, although the implementation of that strategy at that point would not necessarily differ from implementing Strategy W3 in that they would both necessitate an increase in releases but only up to a level that did not appreciably risk causing downstream flows to exceed 4000m^3/s.[286] However, in the absence of an express submission that properly reflects 5ASOC [288(a)] and [288(b)], I will not make a finding of a breach in that respect.

149 However, this is ultimately immaterial as the substance of the complaints are taken up by [288(d)] of the 5ASOC. The plaintiff's submissions contended that given the forecasts, there existed "an opportunity to make releases ahead of 9 and 10 January, when the largest rainfall was forecast" such that a "reasonably competent flood engineer in the circumstances would have made releases from Wivenhoe Dam at rates exceeding the rate of inflow to drain the dam in the circumstances".[287] The plaintiff submitted that in "failing to do so, Mr Ruffini breached his duty of care to the plaintiff and group members" citing

[284] Plaintiff subs at [1251].
[285] State subs at [233] to [234].
[286] See Chapter 3 at [318]; Chapter 7 at [108] and [124]; Chapter 10 at [18].
[287] Plaintiff subs at [1252].

5ASOC [288(d)].[288] SunWater submitted that the plaintiff did not identify with sufficient clarity what that level of releases was and did not seek to tie it to one of Dr Christensen's simulations.[289] However, during the period of Mr Ruffini's shift on the morning of 8 January 2011 the releases made from Wivenhoe Dam were at much lower rates than the rate of inflows. The latter reached 1624m^3/s at 2.00am and 2144m^3/s at 7.00am.[290] If releases above that level were made it would have inundated the remaining bridges. As just noted, whichever of Strategy W3 or W4 were implemented they required an increase in releases but only up to the level that did not appreciably risk causing downstream flows to exceed 4000m^3/s.

150 SunWater's submissions sought to resist the contention that higher releases were required.[291] It contended that the releases of 825m^3/s made at 6.00am on 8 January 2011 were "significant",[292] despite being around 1000m^3/s less than the rate of inflows.[293] Otherwise, its analysis of the prevailing circumstances, including its assertion of "ample remaining storage in the Dams",[294] does not address the effect of the forecasts, instead dismissing the PMEs as "non-catchment specific".[295]

151 The analysis and findings made in Chapter 10 in relation to SIM F (and SIM H) confirm that releases at a rate that would inundate the remaining bridges without causing downstream flows to exceed 4000m^3/s were required to be made as soon as possible on 8 January 2011.[296] By this stage, the probability that harm in the form of downstream flooding or an exacerbation in such flooding would occur if releases were not increased was appreciable (*CLA*; s 9(2)(a)). The forecasts suggested that the window in which to make substantial releases was about to close and this was reiterated by the daily

288 Id.
289 SunWater subs at [2090].
290 See Simulation Analysis, EXP.ROD.015.0461 at .0786.
291 SunWater subs at [2073] to [2091], especially [2086] to [2089].
292 Ibid at [2089].
293 Simulation Analysis, EXP.ROD.015.0461 at .0786.
294 SunWater subs at [2086].
295 SunWater subs at [2084(d)(2)].
296 Chapter 10 at [18].

PMEs published just before 6.00am that morning.[297] As noted, the likely seriousness of the harm if the risk materialised was very large (*CLA*; s 9(2)(b)). The burden of taking precautions, specifically the effect on downstream bridges and compromising the water supply, is addressed in Chapter 10 in relation to SIM F and in Chapter 2 so far as bridges are concerned. In short, there was no potential to compromise the objective of retaining water at FSL at the conclusion of the flood event.[298] The effect of the inundation of Fernvale and Mt Crosby Weir Bridges is described in Chapter 2[299] and I repeat the observation made at [127] above. I am satisfied that the breach of duty pleaded in 5ASOC [288(d)] was established in relation to the balance of Mr Ruffini's shift on 8 January 2011.

Mr Ayre's and Mr Tibaldi's Shifts

152 The plaintiff submitted that "it is clear that a reasonable engineer would have expected Wivenhoe Dam to rise above EL 74.0m AHD on 8 January 2011, requiring the application of W4" citing SIM F.[300] The plaintiff contended that, in failing to implement W4, each of Mr Ayre and Mr Tibaldi breached the Manual.[301] It also submitted that "had Mr Ayre and Mr Tibaldi had proper regard to forecast rainfall on 8 January, they would have made releases from Wivenhoe Dam at rates exceeding the rate of inflow so as to create storage in anticipation of further rainfall" and that their failure to do so was a breach of "their duty of care" as pleaded in 5ASOC at [288(d)]).[302]

153 SunWater contended that there was no explanation for how the flood engineers were in breach for failing to operate in Strategy W4 as opposed to Strategy W3 and that the release rates of between 509m^3/s and 1242m^3/s on 8 January 2011 were not negligent.[303] It noted that by the end of 8 January 2011 releases were starting to exceed inflows and there was no explanation

[297] EXP.SEQ.014.0385; EXP.SEQ.014.0386; EXP.SEQ.014.0387; EXP.SEQ.014.0388.
[298] Chapter 10 at [28].
[299] Chapter 2 at [90] to [92].
[300] See Response report Vol 2, EXP.ROD.015.0261, .0389, .0398.
[301] 5ASOC at [288(a), (b)].
[302] Plaintiff subs at [1326] and [1327].
[303] SunWater subs at [2179(a) to (c)].

of why releases in the order of magnitude of 2700m^3/s as per SIM F were required.[304]

154 Seqwater's submissions in respect of the breaches alleged on 8 January 2011 were in part addressed in Chapter 7, including its contention that Mr Tibaldi was just following the strategy set by Mr Ayre as SFOE.[305] Otherwise, it also repeated the points addressed above concerning the alleged disparity between the pleaded case and the submitted case and the contention that it was necessary to demonstrate actual knowledge of the relevant risk of harm.[306] It also submitted that Mr Tibaldi in fact conducted flood operations in Strategy W3,[307] a proposition I rejected in Chapter 7.[308] It also contended that the substantive content of a requirement to implement a strategy is unknown and devoid of content. Otherwise, Seqwater queried "when should have W3 or W4 operations have commenced during Mr Tibaldi's shift?"[309] The answer is "immediately".

155 The necessity to "implement" Strategy W4 follows from previous findings concerning the projected height of Wivenhoe Dam based on forecasts.[310] In a sense SunWater is correct in so far as it asserted that the implementation of Strategy W4 on 8 January 2011 would yield no practical difference when compared to the *proper application* of Strategy W3, but that is only because both required the making of releases that at least required the remaining bridges to be inundated but which did not cause combined flows to exceed 4000m^3/s; ie releases at around the level modelled in SIM F.[311] However, the flood engineers did not implement Strategy W3 on 8 January 2011. They instead maintained Strategy W1. In that context, a pleaded failure to implement Strategy W4[312] does have practical content. In relation to releases on 8 January 2011, the flood engineers allowed Wivenhoe Dam levels to rise

[304] SunWater subs at [2179(d) to (e)].
[305] Seqwater subs at [1107] to [1117]; Chapter 7 at [125] to [132].
[306] Seqwater subs at [1490] to [1512].
[307] Ibid at [1498].
[308] Chapter 7 at [105].
[309] Seqwater subs at [1499].
[310] Chapter 7 at [124], [132]; Chapter 10 at [10] to [18] and at [149] (and Chapter 3).
[311] See Chapter 7 at [124]; Chapter 10 at [10] to [18].
[312] 5ASOC [288(b)] and [289(a)].

rather than creating storage space in anticipation of forecast rain falling. Again, the making of releases above the rate of inflows would have inundated the remaining bridges, but the level of forecast rainfall predicted warranted as much space as possible being created without creating an unacceptable risk of exceeding 4000m^3/s downstream, in line with the approach in SIM F. Otherwise, the analysis of s 9 of the *CLA* (Qld) that is set out above in relation to Mr Ruffini applies equally to both Mr Ayre and Mr Tibaldi on 8 January 2011.

Conclusion

156 I am satisfied that, during the balance of his shift on 8 January 2011, Mr Ruffini breached his duty of care in failing to cause Wivenhoe Dam to release water at rates exceeding the rate of inflow (5ASOC [288(d)]).

157 I am satisfied that in failing to implement Strategy W4 on 8 January 2011, and failing to make releases from Wivenhoe Dam that exceeded the rate of inflow, each of Mr Ayre and Mr Tibaldi breached their duty of care (5ASOC [288(a), (b) and (d)]). The balance of the allegations of breach for 8 January 2011 are rejected.

12.12: 9 January 2011 Breaches

158 The events of 9 January 2011 are described in sections 7.2 and 7.3 of Chapter 7. Mr Malone relieved Mr Tibaldi at around 6.30am.[313] Mr Ruffini commenced in the FOC at 7.00pm and Mr Ayre commenced at around 7.30pm, with Mr Malone remaining in the FOC until 9.30pm.[314] The relevant parts of the 5ASOC referable to 9 January 2011 plead that until 3.30pm “at the earliest” Mr Malone operated in Strategy “W1 or W2” and not W3, that otherwise the flood engineers “did not implement Strategy W3 at Wivenhoe Dam, or a release strategy consistent with Strategy W3, until the afternoon of 9 January 2011 at the earliest”.[315] In Chapter 7, I found that the conduct of flood operations throughout 9 January 2011 was only consistent with their

313 Chapter 7 at [149].
314 Chapter 7 at [211].
315 5ASOC at [302] to [303].

acting in Strategy W1 until rising natural flows downstream inundated the remaining bridges.[316]

Existence of Risk

159 Paragraph 304 of the 5ASOC pleads the existence of a "substantial risk" on "the morning of 9 January 2011" in identical terms to that pleaded in respect of 8 January 2011.[317] Save for one matter, the findings made at [144] apply with even stronger force to that risk for the entirety of 9 January 2011. The Wivenhoe Dam levels throughout 9 January 2011 were higher than at midnight on 8 January 2011 and the forecasts were either for the same or higher amounts of rain in a shorter period.[318] The only one matter of exception is that the reference to releases being made at rates substantially in excess of the rate of inflow does not apply to the period after 2.00pm, as rates of inflow to Wivenhoe Dam had increased to $3448m^3/s$ by that time and would rise to $7936m^3/s$ by midnight.[319] Making releases in excess of those rates was not suggested by anyone. Nevertheless, as found in Chapter 7[320] and Chapter 10,[321] releases in accordance with Strategy W3 or W4, being those modelled in SIM F and SIM H, were required.

Pleaded Breaches

160 Paragraph 307 of the 5ASOC pleads as follows:

> "Further, … a reasonably prudent flood engineer responsible for Flood Operations at Somerset Dam and Wivenhoe Dam on the morning of 9 January 2011:
>
> a) would have complied with the Flood Mitigation Manual;
>
> b) would have immediately implemented and maintained Strategy ~~W3~~ W4 at Wivenhoe Dam;

[316] Chapter 7 at [210] and [254] to [255].
[317] 5ASOC at [285] (the only difference in the text is that [285] pleads a failure to release in accordance with Strategy S2 whereas [304] refers to Strategy S3.
[318] Chapter 7 at [77] to [78] and [137] to [138].
[319] Simulation Analysis, EXP.ROD.015.0461 at .0470.
[320] Chapter 7 at [259] and [260].
[321] Chapter 10 at [19] to [23].

c) would have implemented and maintained Strategy S3 at Somerset Dam and Strategy ~~W3~~ W4 at Wivenhoe Dam;

d) would not have implemented Strategy S2 at Somerset Dam, or substantially increased releases from Somerset Dam into Lake Wivenhoe, without also implementing Strategy W3 at Wivenhoe Dam or otherwise ensuring that the rate of outflow from Wivenhoe Dam substantially exceeded the rate of outflow from Somerset Dam;

e) would have commenced storing inflows in Lake Somerset by ensuring that releases from Lake Somerset were substantially less than the rate of inflow (to the extent possible);

and

…

h) would have selected and input losses and continuing loss rates equal, or approximate, to those specified in the table below …"

161 The particulars to this paragraph are similar to the particulars to [211] except that Particular D refers to a simulation with a start date of 9 January 2011 that was contained in part of a report prepared by Dr Christensen that was rejected.[322] Paragraphs 307B and 308 are the equivalents to [211B] and [212].

162 There is an ambiguity in the temporal aspects of the pleaded breaches. Paragraph 307 of the 5ASOC refers to "the morning of 9 January 2011", however [308] refers to a failure of the flood engineers to "do one or more of the things pleaded in paragraph 307 *on 9 January 2011*" which appears to relate to the entire day. The plaintiff's submissions contended that there were breaches of duty throughout all shifts on that day.[323] Neither Seqwater nor SunWater's submissions contended that the plaintiff was confined to alleging breaches only during the morning of 9 January 2011 in light of 5ASOC [307]. The State submitted that there was no pleaded case of a breach which is "specifically referable to the second period [that Mr Ruffini] was on duty in the FOC".[324] However, at least so far as 9 January 2011 is concerned, the

[322] *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 10)* [2018] NSWSC 149.
[323] Plaintiff subs at [1350] to [1351] and [1432] to [1433].
[324] State subs at [281].

5ASOC pleaded he was on duty from 7.00pm on 9 January 2011[325] and pleaded a failure of the "Flood Engineers" to do one or more things pleaded in 5ASOC [307] "on 9 January 2011". That is sufficient to embrace the period until midnight on 10 January 2011.

Balance of Mr Tibaldi's Shift

163 The events concerning the balance of Mr Tibaldi's shift on the morning of 9 January 2011 are addressed in Chapter 7.[326]

164 The plaintiff's submissions in respect of the balance of Mr Tibaldi's shift on the morning of 9 January 2011 alleged breaches by reference to 5ASOC [288] (which concerns 8 January 2011) and not 5ASOC [307] set out at [160] above (which concerns 9 January 2011). Hence, it submitted that "Mr Tibaldi's continued operation of the dams in W1 on the morning of 9 January 2011 was a clear breach of the Manual"; that, as the analysis in relation to SIM F demonstrates, a proper application of section 8.4 of the Manual yielded a projected height of EL 74.0m AHD; and that in failing to implement Strategy W4, Mr Tibaldi "breached the Manual and his duty of care to the plaintiff and group members (5ASOC [288(a), (b)])".[327] It further submitted that "on the morning of 9 January", Mr Tibaldi was obliged to make "releases from Wivenhoe Dam at rates exceeding the rate of inflow so as to create storage in anticipation of further rainfall" and that in failing to do so he also breached his duty of care to the plaintiff and group members (5ASOC, [288(d)]).[328] (The plaintiff also advanced submissions in respect of the "flood engineers" on 9 January 2011,[329] but I understand that to refer to the conduct of Messrs Malone, Ayre and Ruffini over the balance of the day.)[330]

165 I have already found that Mr Tibaldi conducted flood operations as though he was in Strategy W1, and that he was obliged to implement Strategy W4. I

[325] 5ASOC at [299].
[326] Chapter 7 at [136] to [163].
[327] Plaintiff subs at [1350].
[328] Ibid at [1351].
[329] Ibid at [1431] to [1433].
[330] Cf Seqwater subs at [1556].

have also found that the implementation of Strategy W4 at that time would have been in substance no different from a proper implementation of Strategy W3 but nonetheless required a substantial increase in releases sufficient to inundate the remaining bridges,[331] although not to a level that was likely to cause downstream flows to exceed the downstream threshold for urban flooding. The findings in Chapter 10 concerning SIM F and SIM H are consistent with this. There is no difference between 5ASOC [288(a) and (b)] on the one hand and 5ASOC [307(a) and (b)] on the other. I will address the latter as it is directed to the morning of 9 January 2011.

166 Save for the contentions that an allegation of the necessity to implement Strategy W4 was devoid of content and that Mr Tibaldi in fact released water at rates that exceeded the rate of inflow,[332] Seqwater's submissions in respect of the alleged breach by Mr Tibaldi in failing to implement Strategy W4 on 9 January 2011[333] are addressed by the findings in Chapters 3, 7 and 10 and by the analysis above at [155]. The same applies in respect of SunWater's submissions concerning this period.[334]

167 A pleading that it was necessary to implement Strategy W4 on the morning of 9 January 2011 is not devoid of content.[335] In this context, it could only have meant increasing flows to inundate the remaining bridges. By this time, the probability of harm in the form of downstream flooding or more likely an exacerbation in such flooding would occur if releases were not increased was very likely (*CLA*; s 9(2)(a)). The forecasts suggested that very heavy rain was imminent and higher releases had to be made immediately. As noted, the likely seriousness of the harm if the risk materialised was very large (*CLA*; s 9(2)(b)). The burden of taking precautions, specifically the effect on downstream bridges, was addressed in Chapter 2 but, as with the previous day, it was bordering on inevitable that they would be closed in any event. There was no possibility of making releases that compromised the objective of

[331] Chapter 7 at [105], [119], [124], [132], and [157].
[332] Seqwater subs at [1561] and [1563].
[333] Ibid at [1551] to [1601].
[334] SunWater subs at [2182] to [2210].
[335] Cf Seqwater subs at [1563] and SunWater subs at [2179(a)].

retaining water at FSL at the conclusion of the flood event. I am satisfied that Mr Tibaldi breached his duty of care in the manner pleaded in 5ASOC [307(a)] and 5ASOC [307(b)].

168 As noted, the plaintiff's submission at [164] above contended that Mr Tibaldi was obliged to make releases at rates exceeding the rate of inflow. However, unlike 5ASOC [288(a)], 5ASOC [307] does not allege any failure to make releases from Wivenhoe Dam at a rate that exceeded inflows. However, even if it did contain an equivalent to 5ASOC [288(d)], then as Seqwater submitted,[336] such an allegation would not be made out because during his shift on the morning of 9 January 2011, Mr Tibaldi made releases that were in excess of inflows. During Mr Tibaldi's shift on the morning of 9 January 2011, releases from Wivenhoe Dam increased from 1241m^3/s to 1336m^3/s whereas inflows varied between 802m^3/s and 1189m^3/s (before increasing rapidly later that day).[337]

169 Otherwise, as I have accepted that it was not established that Mr Ayre was physically capable of monitoring Mr Tibaldi during the early morning of 9 January 2011,[338] it follows that I do not accept that he breached any duty of care in failing to intervene and failing to direct the making of higher releases even if that had been alleged.[339]

Balance of 9 January 2011 and Wivenhoe Dam Operations

170 The course of flood operations during the balance of 9 January 2011 are set out in sections 7.2 and 7.3 of Chapter 7. I found that Messrs Malone, Ayre and Ruffini conducted flood operations as though they were in Strategy W1.[340] In particular, I accepted the plaintiff's submissions that "[n]otwithstanding very significant rainfall that day, and very large forecasts, the Flood Engineers' focus remained solely on keeping Mt Crosby Weir

[336] Seqwater subs at [1561].
[337] Simulation Analysis, EXP.ROD.015.0461 at .0469 to .0470.
[338] Chapter 7 at [163].
[339] See SunWater subs at [2205(c) and (d)].
[340] Chapter 7 at [210], [254] to [255] and [258] to [259].

Bridge and Fernvale Bridge open for as long as possible and until closed by increasing natural downstream flows”.[341]

171 The plaintiff submitted that the flood engineers’ conduct was “unreasonable and not in accordance with the Manual”. It contended that, given the prevailing lake levels and forecasts, the Manual required the implementation of W4 and that the failure of the flood engineers to do so was a breach of their duty of care (5ASOC [307(a), (b), (c)]).

172 Again, the bulk of the submissions of Seqwater and SunWater in respect of this period, are addressed by the findings in Chapters 3, 7 and 10 and the above findings. SunWater attributed to the plaintiff in respect of this period of 9 January 2011 a contention that releases from Wivenhoe Dam should have been increased so that they exceeded the rate of inflows.[342] Save for the period concerning Mr Tibaldi, the plaintiff did not plead or submit that. Instead it pleaded and contended that the rates of outflow from Wivenhoe Dam should have been made at rates of outflow substantially in excess of Somerset Dam outflows, a matter addressed below. The State submitted that because of an alleged division of labour between Mr Ayre and Mr Ruffini, with the former controlling Wivenhoe Dam and the latter controlling North Pine Dam, it was not established that Mr Ruffini had any responsibility for operational decisions at the former while on duty from 7.00pm on 9 January 2011.[343] I found to the contrary in Chapter 7.[344]

173 It follows from the findings in Chapter 7 and Chapter 10 that on 9 January 2011 Messrs Malone, Ayre and Ruffini were obliged to “implement” Strategy W4 and, considered in context, this meant an immediate increase in releases to a level above that necessary to inundate the remaining bridges.[345] Until around 7.00pm, those releases would at least be those modelled in SIM F, which did not risk combined downstream flows exceeding 4000m^3/s

[341] Plaintiff subs at [1431]; Chapter 7 at [210], [254] to [255] and [258] to [259].
[342] SunWater subs at [2348(b)] citing Plaintiff subs at [1433].
[343] State subs at [241] and [338].
[344] Chapter 7 at [253].
[345] Chapter 7 at [242] and [259] to [260]; Chapter 10 at [19] to [23]; and [276] to [278].

having regard to inflows that were predicted over the ensuing 24 hours.[346] However, from 7.00pm, releases in SIM F were reduced on account of an increase in the 24-hour forecast and predicted downstream flows such that by midnight on 10 January 2011 they were 1844m^3/s.[347] By that time, the modelled level in SIM F was over two metres lower than the actual level.[348] In Chapter 10, I found that from midnight on 10 January 2011 a flood engineer dealing with the actual lake levels had to increase outflows beyond 2000m^3/s even though that carried a risk of causing downstream flooding because otherwise there was a risk of the fuse plug being triggered. However I was not persuaded that releases had to be increased to the level modelled in SIM G of around 3200m^3/s as that carried with it an inevitability of exceeding the downstream flooding threshold of 4000m^3/s.[349] Consistent with that, and given the modelling and forecasts information available, the implementation of Strategy W4 would have required the making of releases from that time at a higher level than those modelled in SIM F.

174 I am satisfied that, from the commencement of Mr Malone's shift until midnight, a reasonably competent flood engineer would have implemented Strategy W4 (*CLA*; s 9(1)(c)). From that time, the probability that harm in the form of an exacerbation of downstream flooding would occur if that step was not taken was high and its likely seriousness significant (*CLA*; s 9(2)(a) and (b)). The burden of taking precautions included the effect of inundating the remaining bridges, the effect of which is discussed in Chapter 2. However, by that time it was inevitable that the remaining bridges would be inundated very soon. The only relevant burden of taking precautions was accelerating that closure. There was no possibility of compromising the water supply at this time. An increase in releases above that modelled in SIM F on the evening of 9 January 2011 carried a risk but not an inevitability of exceeding the 4000m^3/s downstream threshold but this was far outweighed by the consequences of not releasing more water (*CLA*; s 9(2)(b) and (c)).

[346] See Chapter 10 at [21].
[347] See Chapter 10 at [21].
[348] EL 67.51m AHD v EL 69.80m AHD: Simulation Analysis, EXP.ROD.015.0461 at .0847.
[349] Chapter 10 at [276] to [279].

Somerset Dam Operations on 9 January 2011

175 The balance of the plaintiff's submissions on breach regarding 9 January 2011 are directed to operations at Somerset Dam. The plaintiff submitted that given the magnitude of inflows, the Manual required the implementation of S3 at Somerset Dam (5ASOC [307(a), (c)]).[350] The plaintiff further submitted that "a reasonable engineer would have recognised on 9 January 2011 it was imprudent simply to fill Wivenhoe Dam by increasing releases from Somerset Dam without a corresponding increase in releases from Wivenhoe Dam" and that "[a] reasonable engineer would have ensured releases from Wivenhoe Dam were made at rates substantially exceeding the rate of inflow from Somerset Dam (5ASOC, … [307(d)])". Thus, the plaintiff submitted that "the actions of the Flood Engineers in increasing Somerset releases on 9 January, without significantly increasing Wivenhoe releases, breached their duty of care to the plaintiff and Group Members." Other than for 6 January 2011, these contentions represent the first point in the plaintiff's submissions that alleged negligence per se in the operation of Somerset Dam. For earlier periods, the plaintiff appears to have taken the position that operations at Somerset Dam were largely dependent on operations at Wivenhoe Dam. In any event, that is the approach I have adopted.

176 As noted in Chapter 7, three sluice gates at Somerset Dam were opened between 9.00am and 2.00pm on 9 January 2011. This meant that by 2.00pm five sluice gates were open and releasing around 1034m^3/s into Wivenhoe Dam, which was an increase from 412m^3/s at 8.00am.[351] Just before 2.00pm, the level of Somerset Dam rose above EL 100.45m AHD.[352] During the period the sluice gates were opened, releases from Wivenhoe Dam were around 1350m^3/s. As Wivenhoe Dam releases did not increase, the effect of increasing releases from Somerset Dam was to increase the rate at which Wivenhoe Dam filled.[353] By midnight, releases from the five sluice gates and from overflow above EL 100.45m AHD were being made at a rate of 1359m^3/s

350 Plaintiff subs at [1432] to [1433].
351 January FER at .0465 to .0466; Simulation Analysis, EXP.ROD.015.0461 at .0853; Chapter 7 at [187].
352 January FER at .0466.
353 Chapter 7 at [262] to [263].

and releases from Wivenhoe Dam were being made at a rate of 1462m^3/s with the result that releases from Wivenhoe Dam were having virtually no impact on addressing the inflows into Wivenhoe Dam of around 6500m^3/s from sources other than Somerset Dam.[354]

177 The plaintiff's submissions allege that the relevant failure on 9 January 2011 was a failure to "implement S3". As explained in Chapters 9 and 10, there are only two possible means of "implement[ing] S3", namely closing the crest gates at Somerset Dam (as in SIM I and SIM J) or closing the sluice gates (as in SIM F, although that approach was open in S2). It follows from the finding in Chapter 9[355] that I do not accept that a reasonably competent flood engineer would (or must) have adopted the precaution of closing the crest gates at Somerset Dam. Thus, if it is accepted that the crest gates did not have to be closed, then the only steps that could have been taken to "implement S3" were to close the sluice gates at Somerset Dam and allow uncontrolled discharge above EL 100.45m AHD. In the context of operations on 9 January 2011, this could only have meant closing all or most of the sluice gates causing Somerset Dam to rise as Dr Christensen undertook in SIM F from midnight on 8 January 2011.[356] (By contrast, with the much lower levels in Wivenhoe Dam in SIM C, Dr Christensen maintained Somerset outflows through two sluice gates on 9 January 2011.[357])

178 The plaintiff contended that Mr Malone's memorandum sent at 11.00am supported the engagement of Strategy S3, a contention denied by SunWater.[358] The findings in Chapters 7, 9 and 10 do not demonstrate that S3 was engaged at the time of that memorandum. Instead, given the actual heights of Wivenhoe Dam throughout 9 January 2011, a projection of a height above EL 75.5m AHD sufficient to engage S3 would not have occurred until the daily PMEs were available at 6.00pm on 9 January 2011, which were later reflected in the four-day PME available from midnight. Mr Giles' projected

[354] See Simulation Analysis, EXP.ROD.015.0461 at .0847: 7936m^3/s – 1359m^3/s; Chapter 7 at [187] and [262] to [263].
[355] Chapter 9 at [345].
[356] See Chapter 10 at [35].
[357] Chapter 10 at [181] to [182].
[358] SunWater subs at [2347].

four-day PME inflow volume using the flood engineers' loss rates as at midnight on 10 January 2011 was 988,000ML.[359] When that amount is added together with the actual height at 6.00pm of EL 68.86m AHD, this is sufficient to project a height of Wivenhoe Dam above EL 75.5m AHD.[360] Hence, any failure to implement S3 is only referable to the period into the evening of 9 January 2011.

179 The other alleged failure relied on by the plaintiff encapsulates what occurred throughout Mr Malone's shift on 9 January 2011, namely so much of 5ASOC [307(d)] which contends that a reasonably competent flood engineer "would not have … substantially increased releases from Somerset Dam into Lake Wivenhoe without … ensuring that the rate of outflow from Wivenhoe Dam substantially exceeded the rate of outflow from Somerset Dam".

180 SunWater contended that if Wivenhoe releases were increased to accommodate an increase in releases from Somerset Dam this "would have produced certain major flooding".[361] However, the average rate of Wivenhoe releases of 9 January 2011 was around 1350m^3/s and there was considerable scope on 9 January 2011 to increase releases without risking exceedance of the downstream flow threshold of 4000m^3/s.[362] Further, the pleaded allegation embraces the possibility of simply not increasing releases from Somerset Dam if there was a concern about the impact of Wivenhoe Dam releases. Otherwise, SunWater relied on Mr Fagot's analysis of the Manual's requirements of the Operating Target Line,[363] an analysis I have rejected.[364]

181 I am satisfied that during the course of Mr Malone's shift on 9 January 2011 a reasonably competent flood engineer "would not have … substantially increased releases from Somerset Dam into Lake Wivenhoe without ...

[359] See Appendix E.
[360] 1,376,494ML + 988,000ML = 2,364,494ML = EL 7581m AHD.
[361] SunWater subs at [2349]; Seqwater's submissions did not specifically address so much of the plaintiff's submissions that concerned Mr Malone and Somerset Dam operations: Seqwater subs at [1556], [1558] and [1602] to [1605].
[362] Compare releases in SIM F on 9 January 2011 in Appendix H with release of around 1350m^3/s in Table 7-1 in Chapter 7 at [262].
[363] SunWater subs at [2350].
[364] Chapter 3 at [366].

ensuring that the rate of outflow from Wivenhoe Dam substantially exceeded the rate of outflow from Somerset Dam" (*CLA*; 9(1)(c)). The increase in Somerset Dam outflows coupled with the failure to increase Wivenhoe Dam outflows increased the risk, which was now a likelihood bordering on a certainty, of Wivenhoe Dam levels rising above EL 74.0m AHD and forcing releases that could cause significant downstream flooding. By the time of the sluice gate openings, the probability of harm in the form of downstream flooding (or more likely an exacerbation of such flooding) would occur if releases were not increased was very likely (*CLA*; s 9(2)(a)). As noted, the likely seriousness of the harm if the risk materialised was very large (*CLA*; s 9(2)(b)). The burden of taking precautions, specifically the effect on downstream bridges, was addressed in Chapter 2 but, as noted, it was bordering on inevitable that they would be closed in any event. In relation to the precautionary burden of storing water in Somerset Dam by closing sluice gates, this would have (marginally) increased the risk of Somerset Dam failing and (marginally) increased the risk that to avoid a dam failure at Somerset large releases might have had to be made into Wivenhoe Dam at a time when it was making high amounts of releases downstream. However, as the analysis of Dr Christensen's simulations in Chapters 9 and 10 suggests, the relevant forecasts did not present any real risk of Somerset Dam overtopping and, more importantly, did not raise any real possibility that the risk of overtopping both dams could not be equalised before either of them was overtopped, especially when regard is had to the uncontrolled flows that would occur above EL 100.45m AHD with the sluice gates closed.[365] The same analysis applies to Mr Ayre and Mr Tibaldi's shifts in relation to the implementation of Strategy S3 by closing sluice gates.

Conclusion

182 I am satisfied that, in failing on the balance of his shift on 9 January 2011 to implement W4, Mr Tibaldi breached his duty of care (5ASOC [307(a) and (b)]).

[365] Chapter 9, section 9.9; Chapter 10 at [44] to [49].

183 I am satisfied that, in failing on the periods on which they were on duty on 9 January 2011 to implement Strategy W4, each of Mr Malone, Mr Ayre and Mr Ruffini breached their respective duties of care (5ASOC [307(a) and (b)]).

184 I am satisfied that, during the course of his shift on 9 January 2011, Mr Malone breached his duty of care by substantially increasing releases from Somerset Dam into Lake Wivenhoe without ensuring that the rate of outflow from Wivenhoe Dam substantially exceeded the rate of outflow from Somerset Dam (5ASOC [307(d)]).

185 I am satisfied that during the course of their shifts on the evening of 9 January 2011 Messrs Ayre and Ruffini breached their duty of care by failing to implement Strategy S3 for Somerset Dam (5ASOC [307(c)]). The balance of the allegations of breach for 9 January 2011 are rejected.

12.13: 10 January 2011 Breaches

186 The events of 10 January 2011 up to 5.00pm are described in section 7.4 of Chapter 7. Mr Ayre and Mr Ruffini continued on duty until 7.00am when they were relieved by Messrs Malone and Tibaldi who continued until 7.00pm.[366]

187 Throughout 10 January 2011, the flood engineers kept five sluice gates open at Somerset Dam which meant that, together with uncontrolled spillage above EL 100.45m AHD, it was releasing around 1359m^3/s into Wivenhoe Dam at midnight, 1627m^3/s at midday and 1693m^3/s at 5.00pm.[367] During that same period, releases from Wivenhoe Dam were only 1462m^3/s at midnight, 2053m^3/s at midday and 2277m^3/s at 5.00pm.[368] Thus, the outflows from Wivenhoe Dam net of Somerset Dam outflows during this period ranged from between 103m^3/s and 584m^3/s in circumstances where Wivenhoe Dam inflows, net of Somerset Dam releases, were 6577m^3/s at midnight,[369] 7399m^3/s at midday[370] and 3423m^3/s at 5.00pm.[371] The inflows into Somerset

[366] Chapter 7 at [290].
[367] January FER at .0466; Chapter 7 at [326].
[368] January FER at .0452 to .0453; Chapter 7 at [326].
[369] Chapter 7 at [262].
[370] Chapter 7 at [326].

Dam at those times were 3283m^3/s, 2732m^3/s and 1693m^3/s respectively.[372] From around 4.00pm on 10 January 2011, the level of Somerset Dam started to drop. As noted in Chapter 7,[373] for a substantial part of 10 January 2011 the tandem dam operations line trended almost vertically towards the Operating Target Line. The tandem operations line was above the Operating Target Line for the balance of the flood event from around 8.00pm on 10 January 2011 even with the sluice gates closed on 11 January 2011.[374]

188 It follows from the analysis in the preceding Chapters that the projected heights on 10 January 2011 were sufficient to engage Strategy S3.[375] Consistent with this, [328] of the 5ASOC pleads that a contributing cause of the rise in the level of Wivenhoe Dam was the actions of the flood engineers in releasing significant volumes of water from Somerset Dam into Wivenhoe Dam where "there were already large inflows into Wivenhoe Dam". It also alleges that the releases were unnecessary given the storage capacity of Somerset Dam. It follows from the above and Chapter 7 that I accept that contention.

Existence of Risk

189 The 5ASOC pleads the existence of a risk on 10 and 11 January 2011[376] to the effect that "… unless releases into Lake Wivenhoe from Somerset Dam and Splityard Creek Dam were immediately stopped there would be insufficient flood storage capacity in Lake Wivenhoe to store incoming flows should further rainfall occur in accordance with, or in excess of, that forecast by the Bureau of Meteorology" and that, without such capacity, "subsequent releases would be necessary in volumes that would cause urban flooding downstream of Wivenhoe Dam, or more such flooding than would otherwise be necessary if releases from Somerset Dam and Splityard Creek Dam were stopped on 10 and 11 January 2011".

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[371] Chapter 7 at [326].
[372] Chapter 7 at [326].
[373] Chapter 7 at [383] to [384]; Figure 7-1.
[374] Id.
[375] See Appendix E which operates on modelled levels that are at least 2m lower than actual levels.
[376] 5ASOC at [337].

190 The reference to operations at Splityard Creek Dam can be put aside given the limited storage capacity in that dam. Given the prevailing dam levels and forecasts throughout 10 January 2011, the likelihood of releases being made at some point from above EL 74.0m AHD which would cause downstream flooding throughout 10 January 2011 was very high.[377] Further, as the discussion in Chapter 10 illustrates,[378] the capacity to make releases during 10 January 2011 was compromised by the actual and predicted levels of downstream flows. It was further hampered by the approach of Messrs Malone and Tibaldi on 10 January 2011 in effectively substituting 3500m^3/s as the threshold for causing damage downstream, whereas the Manual stipulated that 4000m^3/s was the threshold for non-damaging flows.[379] In those circumstances, I am satisfied that to the extent that the pleaded risk refers to "more [urban] flooding [downstream] than would otherwise be necessary if releases from Somerset Dam … were stopped on 10 … January 2011", this risk was foreseeable and not insignificant (*CLA*; s 9(1)(a) and (b)).

Precautions

191 Paragraph 339 of the 5ASOC is the equivalent to [211] for 10 and 11 January 2011. It relevantly alleges that:

> "a reasonably prudent flood engineer responsible for Flood Operations at Somerset Dam and Wivenhoe Dam on 10 and 11 January 2011:
>
> a) would have complied with the Flood Mitigation Manual;
>
> b) would have significantly reduced releases from Somerset Dam into Lake Wivenhoe (to the extent possible);
>
> c) …
>
> d) …
>
> e) would have continued storing inflows in Lake Somerset by ensuring to the extent possible that releases from Lake Somerset were substantially less than the rate of inflow;
>
> …

[377] See Chapter 7 at [336]; Chapter 9 at [138], [235], [286]; Chapter 10 at [24]; Appendix E.
[378] Chapter 10 at [24] to [26].
[379] Chapter 7 at [328] and [336].

j) would have selected and input losses and continuing loss rates equal, or approximate, to those specified in the table below …..”

192 As noted in Chapter 7, the plaintiff’s submissions in respect of 10 January 2011 only make complaint in relation to the actions of the flood engineers up until around the late afternoon on 10 January 2011. The plaintiff’s submissions contended as follows:[380]

> “In the circumstances they faced on 10 January, which was itself the product of their earlier unreasonable conduct, the Flood Engineers’ only reasonable course of action was to implement W4 and commence storing water in Somerset Dam to the extent possible (5ASOC, PLE.010.001.0001, [339(a), (b)], (e)).
>
> As Dr Christensen’s Simulation G analysis shows, had the Flood Engineers reasonably assessed the situation that day, they would not have delayed increasing releases from Wivenhoe. If the Flood Engineers acted reasonably on 10 January, the magnitude of the flood releases on 11 January would have been less.”

193 It follows from the findings in Chapter 7[381] that I accept that the flood engineers were obliged to implement Strategy W4 and from the findings in Chapter 10[382] that they were obliged to increase releases from Wivenhoe Dam. However, 5ASOC [339] does not allege a failure to implement Strategy W4. The only part of the pleading that could encompass that allegation is 5ASOC [339(a)] which, when considered with 5ASOC [340(a)], alleges a failure to comply with the Manual. Even if that could be construed as a failure to implement Strategy W4, I accept that this would be devoid of content in relation to 10 January 2011. The releases made by the flood engineers after 8.00am on 10 January 2011 exceeded 2000m^3/s,[383] which was consistent with engaging Strategy W3 and arguably Strategy W4 while giving effect to the Strategy W3 objective of keeping downstream flow rates below 4000m^3/s.

194 Two related failures of the flood engineers on 10 January 2011 in relation to Wivenhoe operations was the failure to make higher releases (although not

380 Plaintiff subs at [1466] to [1467].
381 Chapter 7 at [336].
382 Chapter 10 at [276] to [279].
383 Simulation Analysis, EXP.ROD.015.0461 at .0470.

necessarily at the level modelled in SIM G)[384] and the conduct of Messrs Malone and Tibaldi in suspending gate openings from 9.00am because they in effect treated the threshold for non-damaging flows downstream as 3500m^3/s where the Manual stipulated that it was 4000m^3/s.[385] However, neither of those complaints are expressly pleaded in 5ASOC [339].

195 However, so much of the plaintiff's submissions set out above that complain about the approach to Somerset Dam operations on 10 January 2011 do reflect the pleaded case, specifically 5ASOC [339(b)] and [339(e)]. In addition to its complaint about the pleading being confined to a failure to undertake flood operations in accordance with Dr Christensen's simulations,[386] Seqwater also contended that, because 5ASOC [339] concerned both 10 and 11 January 2011, the plaintiff was somehow precluded from confining its submissions on breaches in the period up to 3.00pm on 10 January 2011.[387] This contention is without substance. A defendant has no cause for complaint in meeting a case that represents a narrowing of the pleaded case.

196 In relation to Somerset Dam operations, Seqwater contended that they were conducted in accordance with Strategy S2 set by Mr Ayre and it was not appropriate to operate in Strategy S3 in the absence of any expectation that projected heights would exceed EL 75.5m AHD.[388] However, as found in Chapter 3, the obligation to set strategy by reference to the available data is imposed on the DFOE and not constrained by anything set by the SFOE.[389] Further, the pleaded allegation of negligence does not depend on establishing an obligation to implement Strategy S3. Instead, it simply refers to reducing releases from Somerset Dam into Wivenhoe Dam. I have already accepted that the state of actual levels and the forecasts on 10 January 2011 was such as to engage S3 (see [188] above). All reasonable modelling of forecast rain

[384] Chapter 10 at [276] to [279].
[385] See Chapter 7 at [336].
[386] Seqwater subs at [1612] to [1619].
[387] Ibid at [1607] to [1608].
[388] Ibid at [1654].
[389] Chapter 3 at [326].

undertaken on a "no release" basis predicted a fuse plug breach.[390] Seqwater's submissions noted that in his second statement Mr Tibaldi referred to predicting Wivenhoe Dam levels based on a number of GOS spreadsheets which included a "with forecast" run (that used 50mm of rainfall).[391] The forecast run uses the afternoon QPF and appears to be referable to around 5.00pm on 10 January 2011. It predicted a peak level at Wivenhoe Dam of EL 74.95m AHD on the morning of 12 January 2011 after releases of around 2800m^3/s until that time. It is obvious that if the RTFM run that produced this GOS was undertaken on a "no release" basis or using forecasts for a longer period then the projected height for Wivenhoe Dam would have exceeded EL 75.5m AHD.

197 Seqwater submitted that Somerset Dam operations were undertaken "to meet the requirements" of the Operating Target Line, that the "release rate from Somerset Dam never exceeded the peak inflow into the dam" and "in fact, [the release rates] were substantially less than the rate of inflow, which is the reason why the lake level at Somerset Dam rose on 10 January, including over the period of Mr Tibaldi and Mr Malone's shift".[392] As noted above, for a period on 10 January 2011 releases from Somerset Dam exceeded inflows and the level of Somerset Dam dropped.[393] Otherwise, on 10 January 2011 releases from Somerset Dam were vastly disproportionate to releases from Wivenhoe Dam net of Somerset Dam inflows especially when regard is had to the volume of inflows into both dams. As for the "requirements" of Strategy S2 and the Operating Target Line, as the tandem dam operations line set out in Chapter 7 demonstrates,[394] the approach of the flood engineers on 10 January 2011 was to head towards that line in a vertical direction so much so that, critically on 11 January 2011, they remained stuck above that line even with all sluice gates closed and were thus unable to use Somerset Dam storage space to mitigate downstream flooding.[395] That was not required by

[390] See Appendix E with actual levels on 10 January 2011 at least 2m higher than the basis for those projections.
[391] Seqwater subs at [1654]; Tibaldi II, LAY.SEQ.014.0001 at [70] and [75(a)]; SEQ.001.0011.0084.
[392] Seqwater subs at [1655] to [1656].
[393] See Chapter 7 at [326].
[394] Chapter 7 at [383]; Figure 7-1.
[395] See Chapter 7 at [384].

Strategy S2. As submitted by the plaintiff, the approach adopted contributed to the rapid rise in Wivenhoe Dam levels.

198 Seqwater also submitted that "[h]ad releases been ceased completely on 10 January, Somerset Dam likely would have failed by 11 January".[396] It cited a post-event spreadsheet prepared by Mr Tibaldi in support of that contention.[397] The spreadsheet prepared by Mr Tibaldi closes all crest gates and sluice gates from midnight on 10 January 2011[398] and refers to a Somerset Dam failure level of EL 105.70m AHD, which could only be referable to the possible failure level with crest gates closed noted in Chapter 9.[399] However, the pleaded allegation only refers to reducing releases "to the extent possible". I have rejected the suggestion that a reasonably competent flood engineer would have closed the crest gates. Instead, the sluice gates could and should have been closed. As the simulated operations in both SIM F[400] and SIM G[401] demonstrate, with sluice gates closed the tandem operations line still trends towards the Operating Target Line with uncontrolled discharge above EL 100.45m AHD but without Somerset Dam approaching the overtopping level (much less exceeding the dam failure level).

199 In the end result, the flood engineers' approach to Somerset Dam operations on (9 and) 10 January 2011 represented the application of an approach to Strategy S2 that required a movement of the tandem dam operations line to the Operating Target Line in an almost vertical direction. This approach failed to have regard to that part of the Manual that referred to the Operating Target Line only generally being followed, the target point being based on the maximum levels determined by reference to, inter alia, forecasts and "[g]ate operations … enabl[ing] the movement of the duty point towards the target line in a progressive manner".[402] The perceived necessity to move towards the line as directly as possible took precedence over the concerns in the

[396] Seqwater subs at [1656].
[397] LAY.SEQ.014.0001 at [81]; LAY.SEQ.004.0001_2 at [728(b)].
[398] SEQ.004.015.0006.
[399] Chapter 9 at [342] to [343].
[400] Chapter 10 at [37].
[401] Chapter 9 at [356] to [357]; Figure 9-5.
[402] Manual at 42; Chapter 3 at [85] to [89], [366]; Chapter 8 at [118] to [121]; Chapter 9, section 9.9.

Manual about avoiding damaging downstream flows and around a time when there was no appreciable risk of the failure level of Somerset Dam being reached if the crest gates at Somerset Dam remained open.

200 Sub-paragraph [339(e)] of 5ASOC alleges that on 10 and 11 January 2011 a reasonably competent flood engineer "would have continued storing inflows in Lake Somerset by ensuring to the extent possible that releases from Lake Somerset were substantially less than the rate of inflow". This paragraph is only apposite to the period from around 1.00pm because until then rates of outflow at Somerset Dam were less than rates of inflow by amounts that varied between 800m^3/s and 2000m^3/s[403] which is arguably "substantially less".

201 Sub-paragraph [339(b)] better encapsulates the problem with Somerset Dam operations until later on 10 January 2011 in that it contends that a reasonably competent flood engineer "would have significantly reduced releases from Somerset Dam into Lake Wivenhoe (to the extent possible)". As was the case on 9 January 2011, the level of Somerset Dam outflows on 10 January 2011 contributed to the virtual certainty of Wivenhoe Dam levels rising (well) above EL 74.0m AHD thus forcing greater releases that would cause significant downstream flooding. During 10 January 2011, the level of releases from Somerset Dam into Wivenhoe Dam increased the probability of harm in that the higher that Wivenhoe Dam would rise above EL 74.0m AHD then the greater the level of downstream flooding. The likely seriousness of the harm if that risk materialised was very large (*CLA*; s 9(2)(a) and (b)). The burden of taking precautions in the form of closing sluice gates was the potential risk of Somerset Dam failing and the potential that to avoid dam failure large releases might have had to be made into Wivenhoe Dam at a time when it was making high levels of releases downstream. However, as the analysis of Dr Christensen's simulations in Chapters 9 and 10 suggests, the relevant forecasts did not present a risk of Somerset Dam overtopping in its own right, much less yield a situation where the risks of overtopping both dams could not be equalised before one of them overtopped (especially when regard is had to

[403] Chapter 7 at [326].

the uncontrolled flows that would occur above EL 100.45m AHD with the sluice gates closed). I am satisfied that on 10 January 2011 the flood engineers on duty were obliged, to the extent possible, to significantly reduce releases from Somerset Dam into Lake Wivenhoe.

Conclusion

202 I am satisfied that, in failing on their respective shifts up to late on the afternoon of 10 January 2011 to significantly reduce releases from Somerset Dam into Lake Wivenhoe to the extent possible, each of Messrs Ayre, Ruffini, Malone and Tibaldi breached their respective duties of care (5ASOC [339(b)]). The balance of the allegations of breach on that day are rejected.

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CHAPTER 13 – CAUSATION

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CHAPTER 13 - CAUSATION

1 Having found the existence of a duty of care, and breaches of that duty by the flood engineers, the next issue that arises is causation. Two significant issues were litigated in relation to causation. The first was the utility of Dr Altinakar's hydraulic modelling for the purpose of determining, on the balance of probabilities, what the level of inundation would have been had outflows from Wivenhoe Dam accorded with Dr Christensen's simulations, including SIM C. The second was whether causation in respect of all greater flooding could be established in respect of a particular flood engineer, specifically Mr Ruffini, who was only on duty for a limited period during the January 2011 Flood Event.

2 In relation to the first issue, I am satisfied that Dr Altinakar's modelling, specifically his "2017 Set Up", is sufficiently reliable that, when considered with the other evidence, it can support findings on the balance of probabilities as to whether or not the plaintiff's store would have been inundated by flood water if the flood engineers had conducted flood operations substantially in accordance with SIM C. Leaving aside Ms Harrison[1], the same applies in relation to Dr Altinakar's modelling of the inundation of the homes of the other sample group members, although it is not possible at this stage to address every aspect of the causation component of their cases. That must await the identification of the "particular harm" they each seek to recover damages in respect of. However, Dr Altinakar's modelling is not to be treated as determinative of the precise level of flooding under SIM C at every group members' property or downstream location. Instead, his modelling must be considered together with all the other evidence concerning flooding at a particular location.

3 In relation to the second issue, for the reasons set out in section 13.5, I am satisfied that each flood engineers' breaches of duty were necessary to complete a set of conditions that were jointly sufficient to account for the occurrence of the particular harm at the plaintiff's store and such other forms

[1] Ms Harrison's possessions were not inundated: see section 13.4.8

of particular harm at, or to, group members' property that is proven to be the result of the difference in outflows between the events that happened and SIM C. This is sufficient to satisfy s 11(1)(a) of the *CLA* (Qld) in respect of each flood engineer's breaches of duty. Subsection 11(1)(b) is also satisfied.

4 Otherwise, for the reasons set out in the balance of this Chapter, I am satisfied that:

(i) in respect of all of the loss and damage in fact proven to have been suffered by the plaintiff, causation has been established against each of the defendants;

(ii) in respect of such loss and damage that was occasioned to Ms Visser and Ms Lynch from the inundation of their homes (and Ms Lynch's shed and cottage) causation has been established against each of the defendants;

(iii) in respect of such loss and damages that was occasioned to Mr and Mrs Keller from the inundation of their home, causation has been established against each of the defendants;

(iv) it has not been established on the balance of probabilities that, but for the defendants' breaches, the flooding would not have reached above the ground level of the storage facility at which Ms Harrison's shipping container was stored;

(v) the balance of the causation issues in respect of the sample group members should be litigated at the same time as all quantum issues concerning them;

(vi) as stated, Dr Altinakar's modelling is not determinative of the precise level of flooding that would have ensued at every group members' property or downstream location under SIM C; and

(vii) the causation issues in respect of other group members should be litigated in a manner consistent with the observations in section 13.4.9.

13.1: Approach to Causation

Principles

5 Causation is governed by ss 11 and 12 of the *CLA* (Qld) which relevantly provided:

> "**11 General principles**
>
> (1) A decision that a breach of duty *caused particular harm* comprises the following elements—
>
> (a) the breach of duty was a necessary condition of the occurrence of the harm (factual causation);
>
> (b) it is appropriate for the scope of the liability of the person in breach to extend to the harm so caused (scope of liability).
>
> (2) In deciding in an exceptional case, in accordance with established principles, whether a breach of duty—being a breach of duty that is established but which can not be established as satisfying subsection (1)(a)—should be accepted as satisfying subsection (1)(a), the court is to consider (among other relevant things) whether or not and why responsibility for the harm should be imposed on the party in breach.
>
> (3) …
>
> (4) For the purpose of deciding the scope of liability, the court is to consider (among other relevant things) whether or not and why responsibility for the harm should be imposed on the party who was in breach of the duty.
>
> **12 Onus of proof**
>
> In deciding liability for breach of a duty, the plaintiff always bears the onus of proving, on the balance of probabilities, any fact relevant to the issue of causation." (emphasis added)

6 The equivalent provisions in the *CLA* (NSW) are ss 5D and 5E. It was not suggested that there was any relevant difference between those provisions and ss 11 and 12 of the *CLA* (Qld).

7 Under s 11(1) of the *CLA* (Qld) a finding that a breach of duty caused *particular harm* comprises a finding of factual causation, namely that the breach of duty was a necessary condition of the occurrence of the harm (s 11(1)(a)) and a finding as to scope of liability, namely that it is appropriate for the scope of the liability of the person in breach to extend to the harm so

caused (s 11(1)(b)). The test posed by s 11(1)(a) has been described by the High Court as "entirely factual, turning on proof by the plaintiff of the relevant facts on the balance of probabilities".[2] This task eschews policy or value judgments.[3] So far as proof of causation is concerned the test is "no more than that, upon a balance of probabilities, [an inference that a defendant's negligence caused the injury or harm] might reasonably be considered to have some greater degree of likelihood; it does not require certainty".[4]

8 In its written submissions,[5] the plaintiff noted the statement in *Robinson Helicopter Company Incorporated v McDermott* [2016] HCA 22; (2016) 90 ALJR 679 at [86] that "proof of causation may sometimes entail the robust, pragmatic drawing of inferences, … especially where there are a number of possible causes and there is difficulty in ascertaining which of them was the cause of damage suffered". That can be accepted although I note that it was qualified by the statement that "proof of causation still requires proof on the balance of probabilities that the alleged breach of duty was the cause of the damage suffered".

9 Subsection 11(1)(b) requires a determination that it is appropriate for the scope of the negligent person's liability to extend to the harm so caused. In contrast to s 11(1)(a), this provision involves a normative assessment. In particular, in accordance with s 11(4), it requires "consideration by a court of whether or not, and if so why, responsibility for the harm should be imposed on the negligent party".[6] This is addressed in section 13.5.5.

The Issues for Determination

10 It is necessary to identify the issues the Court must decide at this point in the proceeding in order to identify the findings that must be made for the purposes of applying s 11 of the *CLA* (Qld).

[2] *Wallace v Kam* (2013) 250 CLR 375; [2013] HCA 19 at [14] ("Wallace v Kam") citing *Strong v Woolworths* (2012) 246 CLR 182; [2012] HCA 5 ("Strong v Woolworths").
[3] *Wallace v Kam* at [15].
[4] *Tabet v Gett* (2010) 240 CLR 537; [2010] HCA 12 at [111], per Keifel J.
[5] Plaintiff subs at [251].
[6] *Wallace v Kam* at [14].

11 Two sets of issues that the Court had to determine are presently relevant. The first set of issues were identified in the orders made by the Court on 14 September 2018, namely “all issues of fact and law that arise from the claims brought by the plaintiff in its personal capacity” and “all issues of fact and law (except for assessment of damages) that arise from the claims by the Sample Group Members” namely Mr and Mrs Keller, Ms Lynch, Ms Visser and Ms Harrison.

12 As explained below, the plaintiff seeks loss or damage in respect of various forms of “particular harm” that resulted from the inundation of its store. It follows that it seeks a finding that the flood engineers’ breaches of duty were necessary conditions for the inundation of the store. (It is arguable that it could still recover some loss if it could only prove that the breaches of duty caused a lesser level of inundation of its store but that does not arise.) However, as explained below, with the sample group members, the separation of the assessment of damages from causation has the potential to be problematic. This is because, with their claims, it is either not the case, or at least not readily apparent, that whether or not they can recover is exclusively determined by a finding as to whether a particular building was inundated or not by reason of the flood engineers’ breaches of duty.

13 The second set of issues concerning causation also arises from the orders made on 14 September 2018. They are identified by common questions 18, 19 and 20, which ask[7]:

> “18) Did any breach of duty of care that is found to have occurred cause flooding or greater flooding downstream of Wivenhoe Dam than would have occurred otherwise?
>
> 19) Was the measure of that flooding or greater flooding that *determined* by the modelling of Dr Mustafa Altinakar?
>
> 20) Does the modelling of Prof Altinakar *determine* what the level of flooding would have been at locations downstream of Wivenhoe Dam if Wivenhoe and Somerset Dams had been operated substantially in accordance with Simulations A to J in Dr Christensen’s Response Report?” (emphasis added)

[7] SBM.500.001.0001 at .0010.

14 Questions 19 and 20 appear to represent an understandable attempt to obtain a finding that will simplify the determination of the balance of the group members' claims. However, as posed they are unconnected to any claim for loss or damage in respect of particular harm as referred to in section 11(1). Further questions 19 and 20 appear to require a finding that Dr Altinakar's modelling was determinative of the level of flooding that would have ensued under each of Dr Christensen's simulations. These issues are further addressed below.

The Plaintiff's Case on Causation: Overview

15 In its written submissions, the plaintiff contended that its case on causation was that "had one or more of the pleaded breaches not been committed, then the large volume releases from Wivenhoe Dam in the period 9 January to 19 January 2011 would not have been necessary or would have been of smaller volume" and that "had such large releases not been made, the geographic extent and depths of the flood waters downstream of Wivenhoe Dam would have been less".[8] The plaintiff stated that it "primarily relie[d]" on "(a) the expert evidence of Dr Christensen, to demonstrate that the large volume releases from Wivenhoe Dam in the period from 9 January to 19 January 2011 would not have been necessary, or would have been of smaller volume, had the breaches not been committed" and "(b) the expert evidence of Dr Altinakar, to demonstrate the geographical extent of the greater flooding".[9]

16 So far as the first step in this approach is concerned and, as noted in Chapter 12,[10] the plaintiff pleaded and contended that the reasonably prudent (counterfactual) flood operations that should have been undertaken were Dr Christensen's simulations.[11] In particular, the plaintiff contended that, although each of the allegations of breach by the flood engineers was to be assessed by referenced to the circumstances that confronted them at each point during

[8] Plaintiff subs at [243]; 5ASOC at [346] to [347].
[9] Plaintiff subs at [246].
[10] At [15] to [16].
[11] Save for matters sought to be left open, as discussed in *Rodriguez (No 9)* at [29] to [31].

the January 2011 Flood Event, including dam levels, causation was to be assessed by reference to the difference in dams levels and outflows between the most favourable of Dr Christensen's simulations that the Court finds should have been adopted and dam levels and outflows in the events that happened.[12] It follows from the findings in Chapters 10 and 12 that the relevant simulation for that purpose is SIM C. Further, as explained below, in response to a submission by the State concerning the supposedly de minimis contribution said to have been made by Mr Ruffini's breaches of duty to the inundation of the plaintiff's store and the property of the other group members, the plaintiff contended that a contribution by a flood engineer's breaches, or at least a material contribution, to the flooding was sufficient for that flood engineer's breaches of duty to satisfy s 11(1)(a) of the *CLA* (Qld).[13]

17 As for the second step, at one level of generality the plaintiff's contention, if established, suffices. However, as submitted by SunWater, "damage is the gist of the plaintiff's cause of action in both negligence and nuisance" and "greater flooding" of itself does not necessarily equate to damage in the required sense.[14] As explained below, in the case of the plaintiff's claims and those of the sample group members, the plaintiff seeks to prove the level of actual flooding by reference to their evidence and Dr Altinakar's modelling and the level of flooding on the appropriate counterfactual by reference to Dr Altinakar's modelling.

Defendants' Cases on Causation: Overview

18 Five points were raised in response by the defendants.

19 First, it was contended that for the purposes of causation it was necessary to demonstrate the reasonable precautions that a reasonably competent flood

[12] T 9302.30 to T 9304.33.
[13] T 9296.5; T 9297.41 to T 9298.3; T 10135.23.
[14] SBM.030.012.0001 at [003].

engineer would, and not just could, have taken.[15] That contention has already been accepted and the subject of findings.[16]

20 Second, Seqwater contended that there was a lack of coincidence between the alleged breaches of duty and Dr Christensen's simulations.[17] This was addressed in Chapter 12.[18] The reasoning and analysis underlying all the findings of breach corresponded with the reasoning and analysis that warranted the adoption of SIM C as the counterfactual flood operation.[19] As explained in Chapter 12, the reason that the gate operations modelled in SIM C from the middle to the end of the January 2011 Flood Event could not have been adopted by the flood engineers on duty at that time was because of the divergence in water levels between simulated flood operations and actual operations as time progressed.[20] For those later periods, the allegations of breach are informed by the approach adopted in other simulations especially SIM F.[21] However, all the findings were consistent with the approach in SIM C. The methodology of SIM F (and SIM H) is not relevantly different from SIM C save for the forecast period that was utilised to determine strategies. The analysis in Chapters 9 and 10 demonstrates how that difference is immaterial in light of the findings concerning the use of the four-day PME forecasts.

21 Third, all of the defendants contested the reliance on Dr Altinakar's modelling as a reliable basis for demonstrating any particular level of flooding at the plaintiff or anyone else's property under any of Dr Christensen's counterfactual flood operations. This is addressed next.

22 Fourth, the State contended that the case against it failed because it was said that the plaintiff failed to demonstrate that that "any breach by Mr Ruffini,

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[15] Eg Seqwater subs at [2485(a)]; SunWater subs at [2684].
[16] Chapter 8 at [2]; Chapter 10 at [1], [56] and [188]; Chapter 12.
[17] Seqwater subs at [2485(c)]; citing *John Pfeiffer Pty Ltd v Canny* (1981) 148 CLR 218 at 241-24; [1981] HCA 52 and *Metropolitan Gas Co v Melbourne Corporation* (1924) 35 CLR 186 at 194; [1924] HCA 46.
[18] At section 12.2 (especially [39]) and sections 12.5 to 12.13.
[19] See for example Chapter 12 at [64] to [65] and [82] to [87].
[20] Chapter 12 at [17] to [18].
[21] Eg Chapter 12 at [151].

taken on its own, … caused the alleged greater flooding and the extent to which it did".[22] It was contended that this was required by s 11(1)(a) of the *CLA* (Qld) and otherwise that s 11(1)(b) would exclude a finding of causation against the State in respect of the entire damage caused by the failure to undertake reasonably prudent flood operations in the form of SIM C. This submission raises an issue concerning the approach to be taken to cumulative contributions by successive tortfeasors to a state of affairs that results in damage. This point was not taken by either Seqwater[23] or SunWater.[24] As noted, the plaintiff submitted that it is at least sufficient if each flood engineer made a material contribution to the overall negligent endeavour conducted by the flood engineers. This is addressed in section 13.5.

23 Fifth, SunWater contended that, even if Mr Ayre had directed that flood operations be conducted below FSL, he would have been overruled by Seqwater management such that the "but for" test is not satisfied in respect of any breaches of duty by him referable to so much of Dr Christensen's simulations that operate below FSL.[25] This is addressed in section 13.6.

13.2: Dr Altinakar's Modelling

24 Dr Mustafa Altinakar is the Director and Research Professor at the National Centre for Computational Hydroscience and Engineering ("UM-NCCHE") at the University of Mississippi. His impressive qualifications are briefly summarised in Appendix C to this judgment.[26] There was no challenge to his expertise. I address the challenges to his evidence including his honesty as a witness and impartiality as an expert below and reject them. Dr Altinakar was a very impressive witness.

25 Using his "DSS-Wise" software Dr Altinakar undertook two-dimensional numerical modelling, simulation and mapping of the January 2011 Flood Event and the greater Brisbane area. The result of that exercise produced an

[22] State subs at [344].
[23] See Seqwater subs, Chapter X.
[24] SunWater subs; section 17.
[25] Ibid; section 17.5.
[26] Otherwise see EXP.ROD.016.0001; EXP.ROD.016.0004.

interactive mathematical model which could then be manipulated by altering the discharge flows from the Wivenhoe Dam to accord with Dr Christensen's simulations. The plaintiff contended that its modelling was sufficiently robust to enable findings to be made as to the fact of, and if so, the depth of, flooding for each location of 10m x 10m size within the area of the model under Dr Christensen's simulations, as well for the actual flooding that ensued during the January 2011 Flood Event.

13.2.1: Hydraulic and Hydrological Modelling and the BRCFS

26 In explaining the modelling process undertaken by Dr Altinakar and the defendants' criticisms, it is first necessary to note two matters.

27 The first is the difference between hydraulic and hydrological modelling. In short, "hydraulic" modelling uses mathematical formulae to replicate and predict the physical processes involved in water flows across and through the modelled area.[27] Dr Altinakar's model is a hydraulic model. Hydrological modelling is a simplification of a real-world system that does not necessarily seek to calculate or replicate the physical processes involved.[28] The difference between the two is exemplified by the description of Dr Altinakar's model set out in the balance of section 13.2 and the hydrological modelling of flows at Rifle Range Road explained in section 13.3.8.

28 The second is the Brisbane River Catchment Flood Study (the "BRCFS") and the hydraulic and hydrological modelling that it commissioned. The following discussion is expanded upon in the balance of this Chapter. The BRCFS was undertaken following a recommendation of the QFCI. The State's expert, Mr Collins described the BRCFS as "the most comprehensive, up-to-date and accurate assessment of Brisbane River riverine flooding for AEPs ranging from 1 in 2 to 1 in 100,000".[29] He stated that the "latest available data was used to develop hydrologic and hydraulic models, and these models were

[27] T 8674.6 to .8.
[28] T 8667.39.
[29] EXP.QLD.001.1285 at .1296.

validated by calibrating and verifying their results against well documented historical floods and tidal conditions”.[30]

29 One component of the BRCFS was the undertaking of a “Comprehensive Hydrology Assessment”.[31] As part of that assessment, a consultant, Aurecon, undertook a review of the URBS[32] hydrological model that had been developed by Seqwater for Wivenhoe and Somerset Dams after the January 2011 Flood Event.[33] Mr Malone was the “document approver” for the report that resulted in that model and a member of the team that undertook the study.[34] Aurecon also undertook a review of the “ratings curves” generated by Seqwater, the Department of Natural Resources and Mines (“DNRM”),[35] the BoM and other sources.[36] A ratings curve is a representation of flow rates at various depths at a particular point on a watercourse.

30 Aurecon’s review of the URBS model lead to a series of modifications to, and recalibrations of, the URBS model to make it suitable for use in the BRCFS.[37] The modified model is known as the “Aurecon URBS model”. In conducting its review, Aurecon calibrated the hydrological model to five flood events with the greatest impacts along the Brisbane River[38] and verified the model to 38 calibration events used by Seqwater when it calibrated the URBS model.[39] In its “Hydrologic Model Recalibration Report”[40] (the “Recalibration Report”), Aurecon stated that the “*calibration process has therefore been implemented to establish a single set of model parameters that achieve a reasonable calibration across a wide range of flood event types and magnitudes*”.[41] Mr

[30] Id.
[31] SEQ.093.005.0190 at .0198.
[32] “Unified Basin River Simulator model”: T 8665.26 and T 8666.29.
[33] SEQ.093.005.0190 at .0198.
[34] Malone I, LAY.SEQ.007.0001_2 at [513(e)].
[35] T 7483.9.
[36] Id.
[37] SEQ.093.005.0190 at .0198.
[38] 1974, 1996, 1999, 2011 and 2013.
[39] SEQ.093.005.0190 at .0206.
[40] SEQ.093.005.0190.
[41] Ibid at .0198.

Collins explained that the Aurecon URBS model combined a rainfall runoff routing model with a simple routing model.[42]

31 Another component of the BRCFS was the commissioning of a hydraulic model (the "BRCFS hydraulic model"). The hydraulic modelling was undertaken by a firm known as "BMT WBM".[43] It used the Aurecon URBS hydrological modelling as the source inputs for its inflow discharges at its boundaries. Mr Collins was the project director for the hydraulic modelling phase,[44] although he was not the author of any of the hydraulic modelling reports. Instead, he described his role as at a "much higher" level.[45] He said it involved interfacing with the government on logistics.[46] This modelling is further described in section 13.3.1. The BRCFS hydraulic model was not tendered in evidence.

13.2.2: Dr Altinakar's Reports

32 Four sets of reports were provided by Dr Altinakar.

33 The first set was supplied in 2015. In his report dated 25 September 2015 ("MAS1"),[47] Dr Altinakar, inter alia, described the mathematical foundations of flood modelling, the approach adopted by the DSS-WISE software, the data sources used to construct a simulation of the January 2011 Flood Event (the "2015 Set Up"), the calibration of the 2015 Set Up and the results of its modelling of the actual flood event. In his report dated 29 October 2015 ("MAS2")[48] Dr Altinakar described the outcome of the application of the 2015 Set Up to earlier versions of Dr Christensen's simulations. As the tender of material concerning those simulations was rejected,[49] all parts of MAS1 and MAS2 which modelled those simulations were not admitted into evidence. Apparently, one reason for the staggered dates between the reports was the

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[42] T 8667.26.
[43] T 8665.30.
[44] T 8665.34.
[45] T 8665.42.
[46] T 8665.46.
[47] EXP.ROD.005.0058.
[48] EXP.ROD.006.0005.
[49] *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 10)* [2018] NSWSC 149 ("Rodriguez (No 10)").

amount of time used by even powerful computers to rerun the models using revised inflows at the boundaries of the model, such as with Dr Christensen's simulations.

34 The second set of reports was produced in the second half of 2017. Dr Altinakar's report dated 11 August 2017 ("MAS4")[50] responded to various criticisms made by the defendants' experts. However, other than reports from Mr Collins, the reports of the defendants' experts were not tendered. Dr Altinakar's report dated 16 October 2017 ("MAS5")[51] responded to the balance of the criticisms and explained the recalibration of his modelling that was undertaken to address the various issues they raised. It also incorporated further data that had become available since MAS1, principally from the BRCFS. This yielded a revised configuration of the model (the "2017 Set Up"). Dr Altinakar's report dated 30 October 2017 ("MAS6")[52] described the results of the application of the 2017 Set Up to Dr Christensen's simulations, including simulations A to J.

35 Dr Christensen's third set of reports was provided in October 2018, specifically 9 October 2018 ("Revised Report 1")[53] and 22 October 2018 ("Revised Report 2").[54] The circumstances that lead to their preparation and tender are described in *Rodriguez (No 18)*[55] and further described below. It suffices to state that their present significance is threefold. First, they include a discussion of the outcome of the application of the 2017 Set Up to a revision of Dr Christensen's simulations B, D, F, G and J suggested by Mr Ickert in relation to flood operations above EL 74.0m AHD at Wivenhoe Dam.[56] Second, they include Dr Altinakar's explanation for using the so-called "rated" flows at the input boundary of the modelling at Rifle Range Road on Lockyer

50 EXP.ROD.016.0071; a report dated 9 March 2017 ("MAS3") was not tendered: EXP.ROD.007.0005.
51 EXP.ROD.016.0115.
52 EXP.ROD.016.0561.
53 EXP.ROD.017.0001; also referred to as "MAS7".
54 EXP.ROD.019.0001; also referred to as "MAS8".
55 *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 18)* [2018] NSWSC 1828 ("Rodriguez (No 18)").
56 See Chapter 9, section 9.7 at [324] – [333]; EXP.ROD.019.0001.

Creek.[57] Third, Revised Report 1 included a further set up (the "2018 Set Up") which was produced by Dr Altinakar in an attempt to calibrate his modelling to a hydrograph included in an affidavit sworn by Mr Malone on 9 April 2018[58] that purported to record the results of the Aurecon URBS modelling of the flows at Rifle Range Road (the "uncorrected Malone hydrograph") as well as a hydrograph from that modelling for the Bremer River.[59] The tender of that part of Revised Report 1 was rejected in *Rodriguez (No 18)*[60] but parts of it were later tendered and subject to an order under s 136 of the *Evidence Act* on 20 March 2019[61] as SunWater sought to deploy it to attack Dr Altinakar's credit.[62]

36 The fourth set of reports was provided in early 2019 in the circumstances described in *Rodriguez (No 20)*[63] and *Rodriguez (No 21)*[64]. They consist of a report from Dr Altinakar sworn 14 March 2019 (the "2019 Report")[65] and an accompanying report of the same date (the "2019 Results Report").[66] These reports were prepared following Dr Altinakar detecting an error in the uncorrected Malone hydrograph and his obtaining the correct data in digital format (the "corrected Malone hydrograph"). Again, these reports were directed to Dr Altinakar's explanation for using rated flows at the input boundary at Rifle Range Road on Lockyer Creek. However, they also applied the 2017 Set Up to the corrected Malone hydrograph by simply altering the inflow data at Rifle Range road to reflect the corrected Malone hydrograph (thus yielding a "2019 Set Up") and modelling its effect by reference to the

[57] See EXP.ROD.017.0001 at .0099.
[58] *Rodriguez No 18* at [16].
[59] See section 13.3.10.
[60] *Rodriguez No 18* at [69].
[61] *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 20)* [2019] NSWSC 287 ("Rodriguez (No 20)"); T 10512.37.
[62] See section 13.3.12.
[63] *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 20)* [2019] NSWSC 287.
[64] *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority trading as Seqwater (No 21)* [2019] NSWSC 294 ("Rodriguez (No 21)").
[65] EXP.ROD.021.0001.
[66] EXP.ROD.022.0001_3.

actual flooding at particular locations and under SIM I.[67] The circumstances in which these reports were adduced are also explained below.

37 In addition, the digital outputs from Dr Altinakar's DSS-WISE software utilised in his reports were tendered.[68] These files represent the outcome of his modelling exercise, that is a digitised model of the January 2011 Flood Event as well as a model that represents each of Dr Christensen's simulations.

38 Ultimately the configuration of the modelled version of the January 2011 Flood Event put forward by Dr Altinakar and relied on by the plaintiff is the 2017 Set Up, although Dr Altinakar contended that there is no material difference between the 2017 Set Up and the 2019 Set Up.

39 Dr Altinakar gave oral evidence on 11 and 12 April 2018 and further oral evidence from 18 to 20 March 2019.

13.2.3: Dr Altinakar's modelling: Overall Methodology

40 In MAS1, Dr Altinakar described his DSS-WISE system as "an integrated flow modelling and consequence analysis platform that combines a state-of-the-art two-dimensional numerical model with GIS-based[69] pre-processor and post-processor".[70]

41 He described the "pre-processor" as providing various "functionalities" to import different types of "geospatial data files to be used as input data and scenario set-up", including the importation of a Digital Elevation Model ("DEM") and the conditioning of it to be used as the computational domain (see below). The pre-processor also enabled Dr Altinakar to define initial water bodies and virtually fill them with water, to define hydraulic structures such as dams and levees and their breach conditions and to assign boundary conditions along the edges of the model.[71] Dr Altinakar also noted that

[67] *Rodriguez (No 20)* at [4]; EXP.ROD.021.0001 at [16]; EXP.ROD.022.0001_3.
[68] For a description of them see MAS1 at .0296.
[69] Geographic Information System, mapping software.
[70] MAS1 at [211].
[71] Ibid at [213].

controlled releases from "various types of structures, such as gated or non-gated spillways, bottom outlets, pumping stations" could be modelled. In relation to the "post-processor", Dr Altinakar noted that the various digital files[72] can be generated, exported and interrogated to enable modelling of loss of life, urban damage or the relative merits of flood mitigation techniques.[73]

42 In relation to the numerical model, as noted, Dr Altinakar's modelling of the January 2011 Flood Event utilising DSS-WISE is a form of "hydraulic" modelling. That is, it uses mathematical formulae to replicate and predict the physical processes involved in water flows across and through the modelled area.[74] At this point three matters should be noted about the numerical modelling.

43 First, the two-dimensional numerical models for unsteady free surface flow that are the basis for Dr Altinakar's DSS-WISE system "operate on a [discretised] representation of the complex real world topography, [being a so] called … computational mesh or computational grid" (the "computational mesh").[75] A computational mesh involves the subdividing of a continuous geometric space into discrete cells. The physical processes that take place across the larger geometric space can be calculated by performing calculations on each such cell and then calculating interactions between the cells. Meshes can use regular or irregular shapes. They can also be structured or unstructured, that is configured with a defined "connectivity" between cells.[76] DSS-WISE uses "a structured regular orthogonal quadrilateral computational mesh … to represent the topography in the computational domain".[77] Dr Altinakar provided the following diagrammatic representation of the computational mesh used in DSS-Wise:[78]

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72 So called "raster results files" which are a graphics format.
73 MAS1 at [214].
74 T 8674.6 to .8.
75 MAS1 at [171].
76 Id.
77 Ibid at [174].
78 Ibid at .0116.

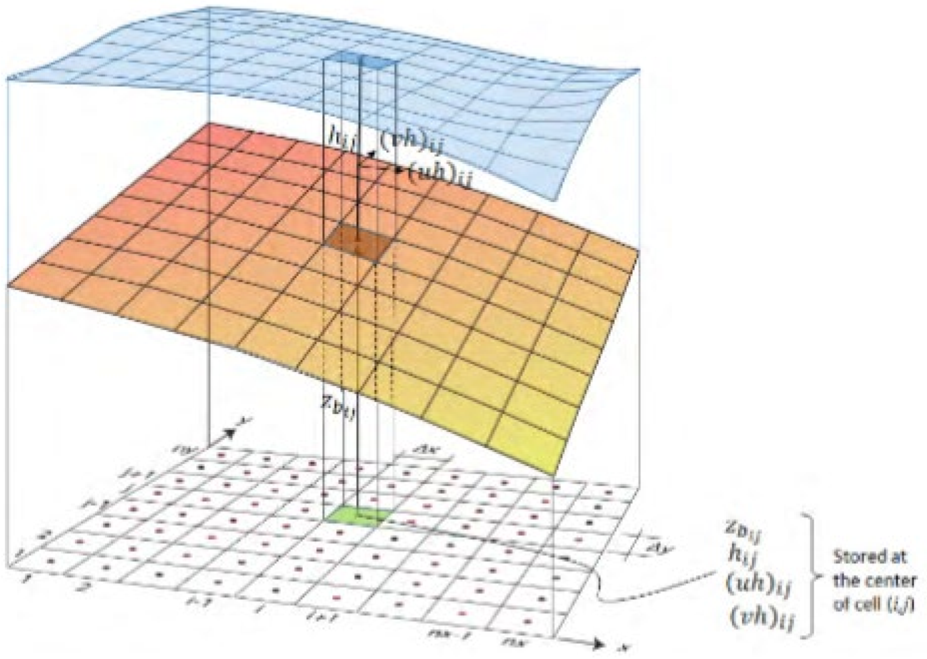

Figure 13-1: Structured regular orthogonal quadrilateral mesh used in DSS-WISE

44 Dr Altinakar stated that the mesh used in DSS-WISE is "cell centred", that is the bed elevation, and the three unknowns to be calculated, namely, flow, water depth, and discharge in the x and y directions respectively, are defined at the centre of the cell.[79]

45 Second, DSS-WISE uses massive computing power to solve, within the domain of the computational mesh, the "conservative form of shallow water [partial differential] equations (SWE) that govern the flood propagation over complex topography" namely:[80]

$$\frac{\partial h}{\partial t} + \frac{\partial uh}{\partial x} + \frac{\partial vh}{\partial y} = q_v$$

$$\frac{\partial hu}{\partial t} + \frac{\partial}{\partial x}\left(u^2 h + \frac{1}{2} g h^2\right) + \frac{\partial huv}{\partial y} = -ghS_{fx} - gh\frac{\partial z_b}{\partial x}$$

$$\frac{\partial hv}{\partial t} + \frac{\partial huv}{\partial x} + \frac{\partial}{\partial y}\left(v^2 h + \frac{1}{2} g h^2\right) = -ghS_{fy} - gh\frac{\partial z_b}{\partial y}$$

[79] Ibid at [175].
[80] Ibid at [215].

Figure 13-2: Shallow water equations

46 In these formulae, u and v are the local velocity components in the x and y directions, h is the flow depth, Z_b is the bed elevation, g is the constant of gravitational acceleration, and q_v is the “net source/sink discharge (or mass per cell area per unit [of] time) added without momentum input”. (The symbol ∂ is a reference to the differential so that, for example, $\partial h/\partial t$ is flow depth differentiated as to time).

47 Dr Altinakar stated that this system of equations is “closed”, that is reduced to a finite set of expressions, by assuming that the source terms due to friction, S_{fx} and S_{fy}, can be expressed using “Manning’s equation” for steady uniform flow as follows:[81]

$$S_{fx} = \frac{u\, n^2 \sqrt{u^2+v^2}}{h^{4/3}} \quad \text{and} \quad S_{fy} = \frac{v\, n^2 \sqrt{u^2+v^2}}{h^{4/3}}$$

Figure 13-3 Manning’s Equation

48 The figure “n” in these formulae is the so-called Manning’s coefficient or Manning’s value. This is a coefficient of “roughness” that depends on the “characteristics of the terrain and the land use/cover”.[82] It is further addressed below.

49 Third, in MAS1 Dr Altinakar sets out the formulae describing the inter-relationship between each cell in the computational mesh.[83] They are complex and were not the subject of challenge.

13.2.4: Construction of the Computational Mesh

50 In his modelling of the January 2011 Flood Event, Dr Altinakar used a Digital Elevation Model (“DEM”) as the computational mesh.[84]

[81] Ibid at [216].
[82] Ibid at [217] and [72] to [75].
[83] Ibid at .0219 - .0137, section 3.3.

51 Dr Altinakar explained that the computational mesh corresponded to a DEM with a resolution of 10m x 10m which he "accepted as a reasonable compromise providing the level of terrain accuracy needed to capture the important features … as accurately as possible and keeping the computational effort within reasonable bounds considering the size of the area to be modelled".[85] The modelled area is depicted in the red square in the following diagram:[86]

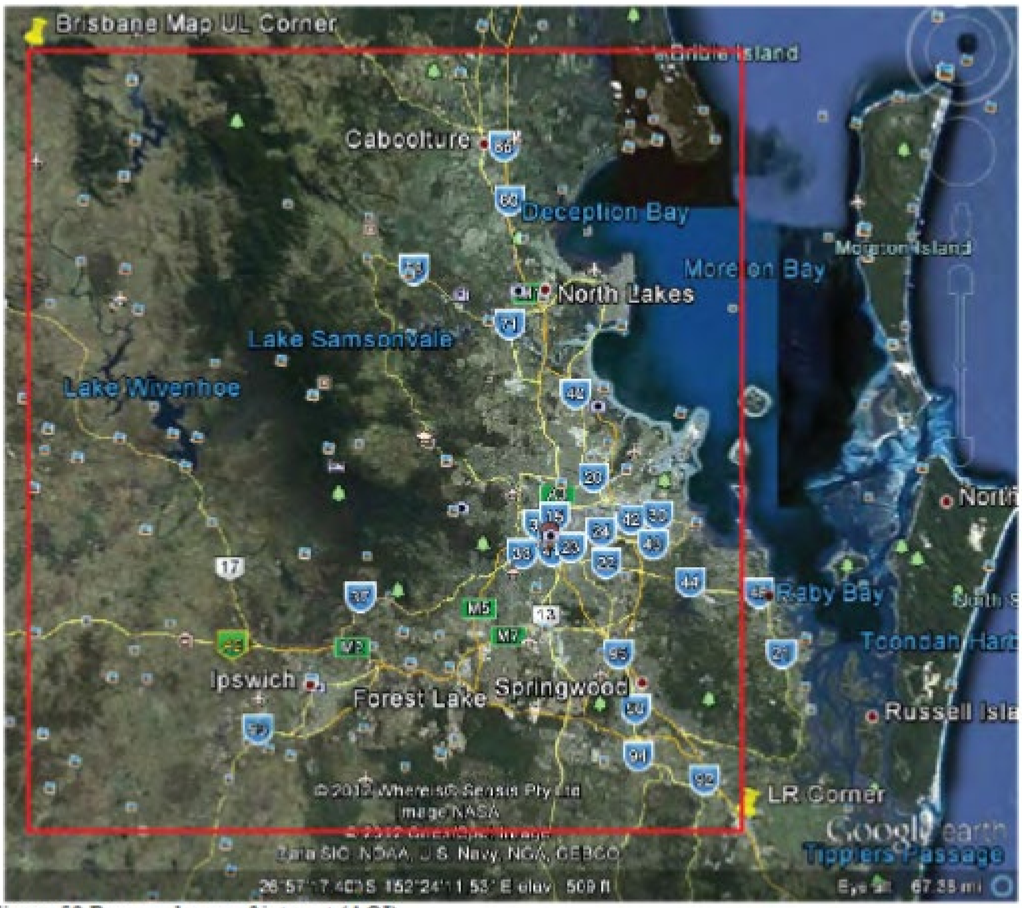

Figure 59 Proposed area of interest (AOI).

Figure 13-4: Area the subject of Dr Altinakar's modelling

52 The computational mesh was prepared using a number of data sources. The method of compiling the sources was described by Dr Altinakar as "burning", that is replacing the cells in the DEM produced by each level of data by any "better quality data" that is available at the next level. For the 2015 Set Up, Dr

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[84] Ibid at [278].
[85] Ibid at [286].
[86] Ibid at .0150.

Altinakar used seven layers of information or data sources beginning with a DEM received from an animation firm who had processed LIDAR data ("Light Detection and Ranging Data"). LIDAR is a remote sensing technique used for surveying topography and creating maps of various data entries based on the reflection of a pulsed near infra-red laser beam aimed at the ground from a drone, an aircraft or a satellite.[87]

53 For his 2017 Set Up, Dr Altinakar substantially revised the computational mesh used for the 2015 Set Up. In June 2017, Dr Altinakar received "a hard drive of data" from the BRCFS [with] its hydrological and hydraulic assessments.[88] Dr Altinakar explained that the drive contained important "topo-bathymetric" information, that is, information concerning the topography of the ground areas beneath water surfaces.[89] That topography was not measured by LIDAR as the infra-red sensor signals used to obtain the data did not penetrate water surfaces. In preparing the 2015 Set Up Dr Altinakar was obliged to use data from other sources and interpolate river bed data via various methods.[90]

54 Dr Altinakar stated that the "new data led me to conclude that the inflow discharges for the DSS-WISE model should be modified by including the contributions from several important tributaries and various catchment areas",[91] ie. revised boundary inflows. Dr Altinakar also received a series of discharge measurements taken from the Centenary Bridge at Jindalee during the January 2011 Flood Event.

55 Thus, for the 2017 Set Up, Dr Altinakar removed the old bathymetry layers and included the bathymetry data provided with the BRCFS data including for four creeks that discharged into Brisbane River.[92] In the end result, Dr Altinakar prepared the computational mesh for the 2017 Set Up using 19 layers. He explained that each "available 'source' data layer is treated by

[87] Ibid at [279].
[88] Ibid at [15].
[89] Id.
[90] Ibid, sections 4.7 and 4.8.
[91] Ibid at [15].
[92] Ibid at [151].

applying necessary procedures (such as correction, datum change, resampling, projection, etc.) to produce a 'processed' raster layer". When that was completed, they were "assembled in a hierarchical order from the bottommost to the topmost to obtain the final DEM, which is then used as [the] computational model".[93]

56 The data sources or layers used in the preparation of the computational mesh in order of ascending quality included the source (or ASCII) files prepared by the animation firm from the LIDAR data, a DEM at 5 metre resolution for the Lockyer Creek (which enabled the extension of the model further up Lockyer Creek to Rifle Range Road where an inflow discharge was imposed),[94] a high resolution elevation model for the Ipswich area,[95] contour data for the bottom topography at Moreton Bay,[96] and river bathymetry from the BRCFS.[97] On top of these layers Dr Altinakar made a series of manual adjustments which he described as "conditioning" to account for the fact that with a "two-dimensional model, such as DSS-WISE, [one] cannot see [water] passages under the road, crossing or bridge, the streams [or] the passageways [so that] water become[s] discontinuous".[98] To address, this Dr Altinakar had the benefit of a number of surveys conducted by an animation firm of particular structures including pipes and creek outlets.[99]

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[93] Ibid at [153] and MAS5 at [236].
[94] MAS5 at [179].
[95] Ibid at [180].
[96] Ibid at [182].
[97] Ibid at [157], Layers 8 to 18.
[98] Ibid at [232].
[99] Ibid at [233] to [235]; In his affidavit sworn 8 October 2015 (LAY.ROD.005.0001), Mr Todd Davis stated that in in 2014 he conducted a field survey of 94 pipe and creek outlets at the request of Dr Altinakar (at [66]) which was then manipulated into a digital format for inclusion in the ASCII DEM (at [69] to [83]). This was followed up with a request in May 2014 to ascertain the "invert elevation" (ie, the measurement for the lowest point of a pipe or outlet, taken from inside the outlet (at [77]) the results of which were digitised (at [80] to [83]). This was followed by two more surveys in August 2014 and March 2015 of invert elevations for outlets as well as the "locations and elevations of the inlets connected to those outlets" (at [84] and [96]). This involved, inter alia, consulting storm water network maps and the collection of data for 2 culverts, 553 inlets, 19 outlets and 8 roads (at [92]). In August 2014, Mr Davis and Mr Stuart visited the shopping complex that included the plaintiff's store and captured three dimensional measurements of the exterior area of the shopping centre (at [100]). Mr Stuart undertook a further survey in March 2015 and obtained three dimensional measurements of the interior of the shopping centre (at [104]).

13.2.5: Inflow Discharges and Boundary Conditions

57 The next aspect of the modelling process involved the selection of inflow hydrographs used for discharges at the boundaries of the modelled area.[100] The ultimate objective was to model a variation of one of those hydrographs, namely the outflows from Wivenhoe Dam, to allow Dr Christensen's simulated outflows to be modelled. The 2015 Set Up modelled inflow discharges from five sources, namely Wivenhoe Dam, the fuse plug (although its discharge was fixed at zero for the actual case), the Lockyer Creek discharge hydrograph at O'Reilly's Weir, the discharge from Manchester Dam via Cabbage Tree Creek and the discharge from Bremer River immediately downstream of its confluence with Warrill Creek.[101]

58 This was substantially revised in the 2017 Set Up as Dr Altinakar utilised the "hydrologic simulation results that were provided via the Aurecon/URBS model" as part of the BRCFS.[102] This involved the addition of inflows from further tributaries for the lower Brisbane River[103] and the movement of the modelled area of the boundaries further up the Bremer River and Lockyer Creeks.[104] Overall, 52 extra source areas for imposing tributary and watershed discharges were included in the 2017 Set Up.[105]

59 In the case of the changed inflow boundary in the Lockyer Creek, the new inflow boundary was fixed at a point upstream of the Rifle Range Road Alert.[106] Rifle Range Road is located about 26.681km upstream from the confluence of the Brisbane River with Lockyer Creek.[107] One of the issues raised with Dr Altinakar concerned the inflows he used at that source as well as the inflows he used on the Bremer River just below its confluence with Warrill Creek. In both cases he did not use a discharge hydrograph produced by the Aurecon URBS model.

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[100] MAS1, Chapter 5 at .0175; MAS5, Chapter 5 at .0246.
[101] MAS1, Chapter 5 at [332] – [373]; MAS5 at [274].
[102] MAS5 at [277].
[103] Ibid at Chapter 5, at .0246 - .0262 and Appendix D.1 (at .0439).
[104] Id.
[105] Ibid at [280].
[106] Ibid at .0264, Table 17 "locky-RIFLE-RA-Recd".
[107] Ibid at [324].

60 In his oral evidence in March 2019, Dr Altinakar identified one limitation on the accuracy of his modelling, namely that "[w]hen you introduce a discharge into the [two-dimensional] model within one or two kilometres downstream, one should not expect correct results, because this is the distance during which the flow is going to adapt itself to topography and roughness coefficients".[108]

13.2.6: Simulation Set Up

61 Five further aspects of the model set up for the January 2011 Flood Event by Dr Altinakar using the DSS-WISE software should be noted.

62 First, as DSS-WISE involves two-dimensional modelling, flows through pipes cannot be modelled by solving the shallow water equations. Dr Altinakar stated that DSS-WISE uses the "source-sink" method to represent the backflows through pipes (or similar structures). This method involves modelling a removal of a "quantity of volume of water in the sink area … from the computational domain at a given time step [with] the same volume of water simultaneously appear[ing] in the source area during the same computational time step".[109]

63 Second, Dr Altinakar configured the 2017 Set Up so that it had 78 "observation lines" which record the cross-sectional hydrograph at selected locations.[110] Some of the observation lines are placed where a stream gauge with measured discharge data is available so as to allow a comparison between the discharge computed by the modelling and the measured discharges. Dr Altinakar placed other observation lines at places where important hydraulic features are located. Dr Altinakar explained this was to "help … verify that the boundary conditions are correctly imposed at the boundaries of the model and/or to gain further insight into the unsteady flow hydrodynamics in the study reach". Observation lines were also placed at

[108] T 10405.32.
[109] MAS1 at [474].
[110] MAS5 at [307].

"locations of important landmark features, such as bridges, crossings, etc. along the study reach".[111]

64 Third, Dr Altinakar also defined seventy-two "observation points" in the modelling "to record the flow depth, ground elevation, and velocity components in the horizontal plane along x and y directions at selected locations".[112] The rationale for their placement was similar to the observation lines in that, amongst other reasons, the readings could be compared with the measured stage hydrographs.[113]

65 Fourth, Dr Altinakar explained that the 2017 Set Up included six "observation profiles" which record flow data at equally spaced points along the profile.[114] The 2017 Set Up included an observation profile representing the centreline of the Lockyer Creek to account for the movement of the inflow discharge boundary from O'Reilly's Weir in the 2015 Set Up to Rifle Range Road in the 2017 Set up.

66 Fifth, the crucial step of calibration for the modelling exercise was the adjustment of the Manning's coefficients (or values) for the river channels (ie, "n" in the formulae at [47]). Dr Altinakar configured the 2015 Set Up (and the 2017 Set Up) by enabling the assignment of different Manning's roughness coefficients to different reaches of the model. The "main channel and the adjacent left and right flood plain areas were divided into polygons" with the polygons in a streamwise direction being approximately 1,000m in length. Dr Altinakar explained that the width of the polygon for the channel area varied with the width of the main channel while the left and right floodplain polygons have a fixed width of about 160m. Dr Altinakar stated that there was a total of 1,240 polygons each of which was capable of having a different Manning's coefficient assigned. This enabled the allocation of a Manning's value at a "resolution of about 1,000 m in the longitudinal direction"[115] with one code

[111] Ibid at [308].
[112] Ibid at [317].
[113] Ibid at [315].
[114] Ibid at [322].
[115] MAS1 at [468].

reserved for the remaining area of the computational domain. In MAS5, Dr Altinakar did not state whether further polygons were added to account for the extension of the modelling up Lockyer Creek to Rifle Range Road (although that would appear to be necessary).[116]

13.2.7: Calibration of Manning's Coefficients

67 With the 2017 Set Up, Dr Altinakar explained that the Manning's coefficients were (initially) attributed a value based on classified land use maps received with the BRCFS data.[117] However, he also explained that the "assignment of the final values of Manning's values is accomplished following a trial and error procedure based on the available measured gage data and surveyed flood marks".[118]

68 Dr Altinakar explained[119] that the calibration of the Manning's coefficients "was accomplished" using the following criteria:

> "Computed stage data should match the measured gage data as closely as possible.
>
> Computed peak stage should match the peak stage measured at gages with a reasonable accuracy (±0.50 m).
>
> Computed peak stage should match the surveyed flood marks with a reasonable accuracy (±0.50 m).
>
> Computed inundation extent should match the observed flood extent."

69 These matters are addressed next. In cross-examination, Dr Altinakar explained that the calibration of the Manning's coefficients involved an adjustment process to not only match peak flood levels but also took "into account a whole host of other factors, which is the travel time of the wave throughout the entire Brisbane River from one end to the other".[120]

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[116] See MAS5 at section 6.2, at .0266.
[117] Ibid at [288].
[118] Ibid at [296].
[119] Ibid at [297].
[120] T 3499.21.

70 Dr Altinakar listed the Manning's coefficients that were derived for the 2017 Set Up in MAS5.[121] He stated that "[g]iven the limited time that was available for preparing this report, the values listed…constitute a reasonable set of n-values" but added that he was "confident that the calibration could be further improved if more time were available".[122] In cross-examination, he agreed that if he had more time he would have undertaken a closer calibration exercise.[123] However, his assessment was that the effect of such a closer calibration would only have yielded slightly different water levels at the loss locations[124] because resultant smaller differences in the peaks of the hydrograph along the river would dissipate as water moved inland from the rivers and tributaries.[125]

13.2.8: Verification of Calibration

Inundation Extent

71 In relation to the "inundation extent" noted above (at [68]), Dr Altinakar undertook a comparison of the modelling with a survey of the extent of the actual flooding in January 2011 in digital format that was created by Brisbane and Ipswich Council as well as a survey for the Fernvale area commissioned by the plaintiff's solicitors.[126]

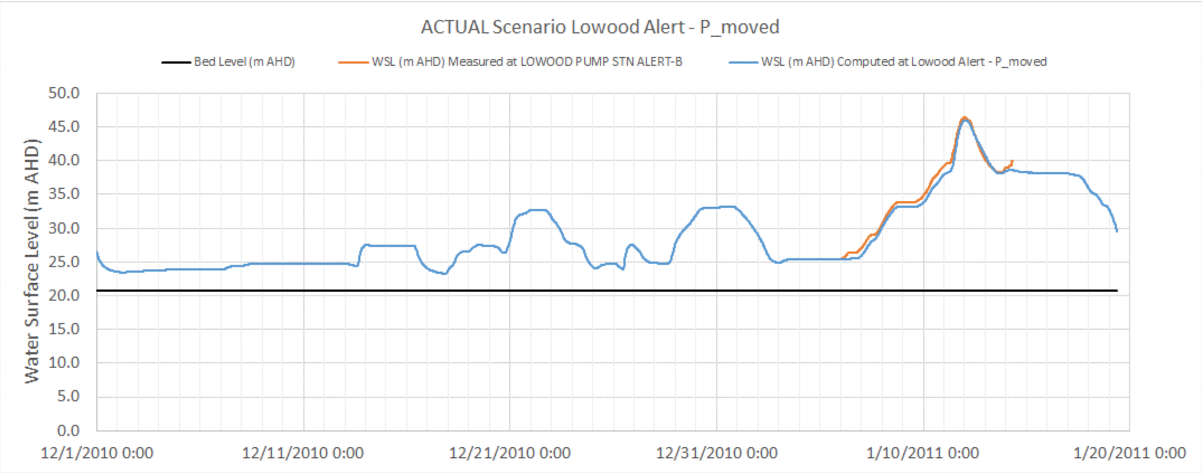
Comparison with Stage Hydrographs

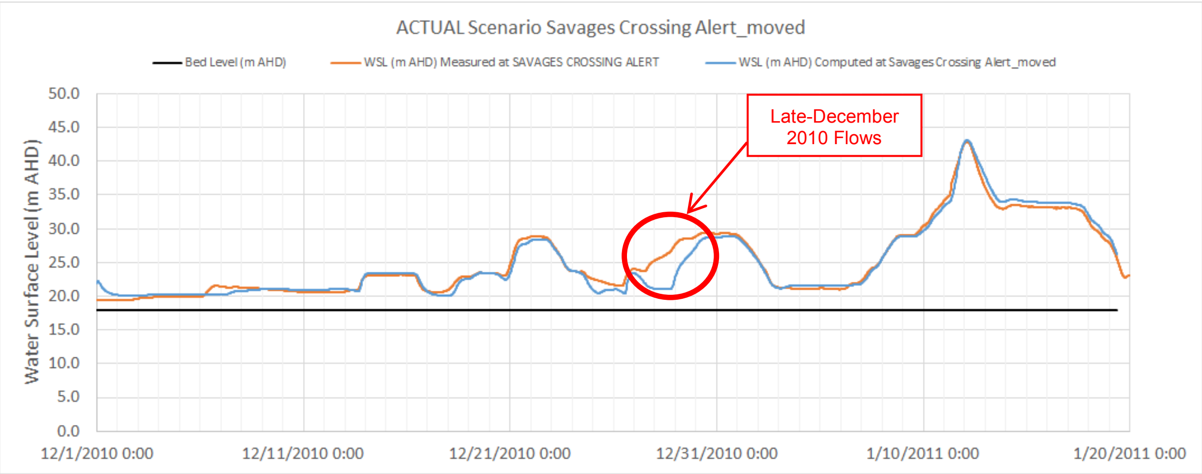
72 In MAS5,[127] Dr Altinakar sets out the results of a comparison between the computed hydrographs for 30 observation points produced by the 2017 Set Up for the "actual" January 2011 Flood Event and the measured hydrographs during the event for those locations. For some gauges, the measured data was incomplete or not available in which case Dr Altinakar compared the results to the equivalent hydrograph produced by the BRCFS hydraulic

[121] MAS5 at .0270; Table 21.
[122] Ibid at [298].
[123] T 3538.46.
[124] T 3539.31.
[125] T 3557.35 to T 3558.34.
[126] MAS1 at [461] to [467]; Report of Alissa Starkey dated 25 September 2015, LAY.ROD.006.0010.
[127] At section 8.1, at .0305.

model.[128] The hydrographs produced by the 2017 Set Up covered the period from 1 December 2010 to 19 January 2011 although Dr Altinakar explained that the first ten days of that period should be ignored as they related to the setup of the modelling.[129]

73 An example of the comparison exercise can be gauged from considering the following hydrographs which concern Lowood, Savages Crossing and Mt Crosby Weir Bridge:[130]





[128] MAS5 at [333] to [338].
[129] Ibid at [339].
[130] Ibid at [340].

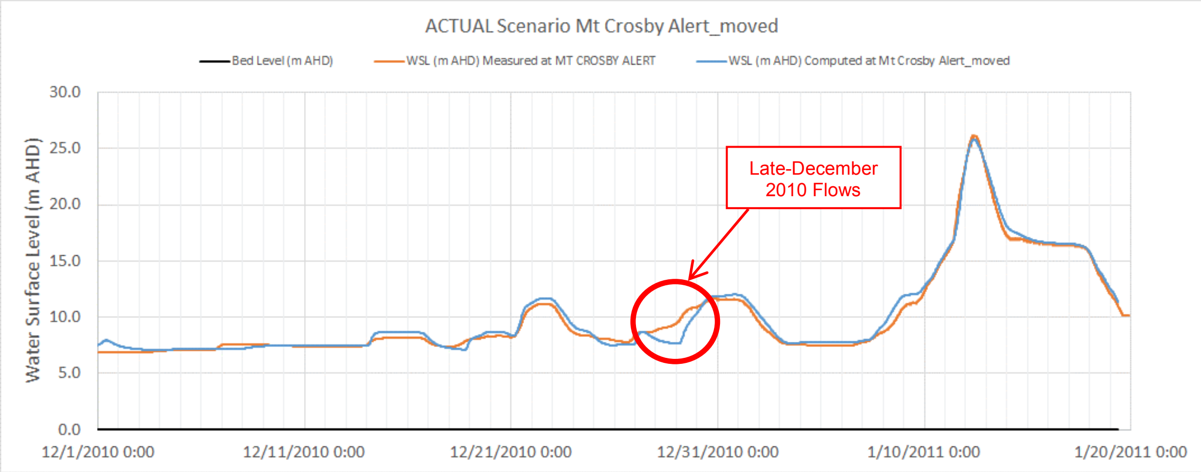


Figure 13-5: Comparison hydrographs for Lowood, Savages Crossing and Mt Crosby Weir alert

74 In each of these hydrographs the blue line is the modelled hydrograph at each of these locations produced by Dr Altinakar's modelling and the orange line is the measured data. With Lowood, the computed peak is 0.50m lower than the measured peak and data was not available for earlier in the January 2011 Flood Event.[131] With the Savages Crossing hydrograph, the computed peak was 20cm above the measured peak which Dr Altinakar described as a "good agreement".[132] With Mt Crosby Weir Bridge the computed peak is 40cm lower than the measured peak.[133] The circled areas in the Savages Crossing and Mt Crosby Weir Alert hydrographs emphasise a point made by Seqwater about the calibrations which are addressed below.

75 At the other end of the Brisbane River the comparison hydrograph for the Brisbane City Alert was as follows:[134]

131 Ibid at [340].
132 Ibid at [341].
133 Ibid at [344].
134 Ibid at [353].

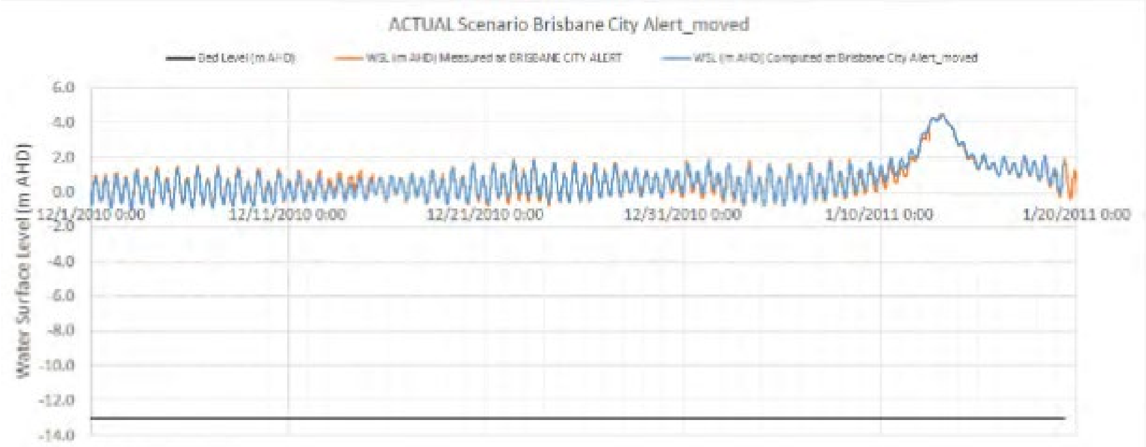


Figure 13-6: Comparison Hydrograph for Brisbane City Alert

76 The fluctuations in the hydrograph represent tidal fluctuations. Dr Altinakar described the "agreement" between these hydrographs as "excellent over the entire simulation duration".[135]

77 Not all comparisons between the measured hydrographs and Dr Altinakar's modelled hydrographs produced as close of an agreement as those set out above, although they were very much consistent at around the peak of the flood event.

78 Dr Altinakar's conclusion in relation to the process of calibrating to the measured hydrographs was:[136]

> "The comparisons of computed water surface elevations with measured data and/or with Detailed Model results showed good agreement overall. For the majority of the observation points, the difference in peak stage is within the acceptable range of ±0.50 m. It would be possible to reduce larger differences observed at a few observation points by improving and refining the calibration. However, this requires more calibration runs and takes more time. ……. Given the short time available for this report [until the trial commenced], a compromise had to be made to present the computational results within the imposed timeframe. The presented computational results represent this compromise."

79 The defendants' criticisms of the modelling are addressed below. At this point I note that Dr Altinakar's reference to the potential to "reduce larger differences observed at a few observation points by improving and refining the

135 Id.
136 Ibid at [369].

calibration" was taken up with him in cross examination on 11 and 12 April 2018.[137] Ultimately it was suggested to Dr Altinakar that, unless and until such a further calibration exercise was undertaken, it could not be determined what the likely effect would have been on modelled inundation levels at particular loss locations.[138] Dr Altinakar replied that he did not know the "exact values, but I have a guess".[139] The manner in which that answer was given suggests his reference to a "guess" was more than speculation and was instead the product of insight from someone who had an intricate understanding of the mathematical relationships within the 2017 Set Up. This observation is supported by his evidence in April 2018 and March 2019 concerning the effect of an alteration to the boundary discharge at Rifle Range Road[140] (see below).

80 In re-examination on this topic, Dr Altinakar explained the basis for this answer. He stated that he knew "the nature of the inland flooding and its causes" and the effect of any variation.[141] He stated that any error of 0.5m "would be diminished as we go inland, and probably the differences will not be greater than, say, I would say, 20 centimetres, certainly less than plus or minus 0.50".[142] The reference to "inland" is inland from the river. Earlier in his re-examination he stated that "since the small variations or improvements in the river would have [been] distributed, diluted over a large area that it is covering, those differences would become very small as we get to the locations where we are studying the water surface elevations".[143]

Comparison of Maximum Flood Elevations with Surveyed Flood Marks

81 The BRCFS data provided to Dr Altinakar included information on 601 surveyed flood marks, 507 of which were in the modelled area.[144] In MAS5, Dr Altinakar stated that he selected 485 for comparison as these "yielded

[137] T 3497.39 to T 3511.
[138] T 3541.3.
[139] T 3541.3.
[140] See section 15.3.7
[141] T 3559.9.
[142] T 3559.18.
[143] T 3558.24.
[144] MAS5 at [370].

values extracted from the maximum flood elevation raster" (ie, the model showed flooding at that location).[145]

82 Dr Altinakar extracted the computed elevation from the 2017 Set Up for the modelled 'Actual scenario' for those 485 flood marks which revealed that 397 flood marks were within ±0.5m of the surveyed figure.[146] In MAS5, Dr Altinakar included various graphical representations of the results of the comparison the accuracy of which depends on the chosen margin of error. Thus, if a scale of 10m is adopted on the x and y-axis, the line of agreement looks as follows:[147]

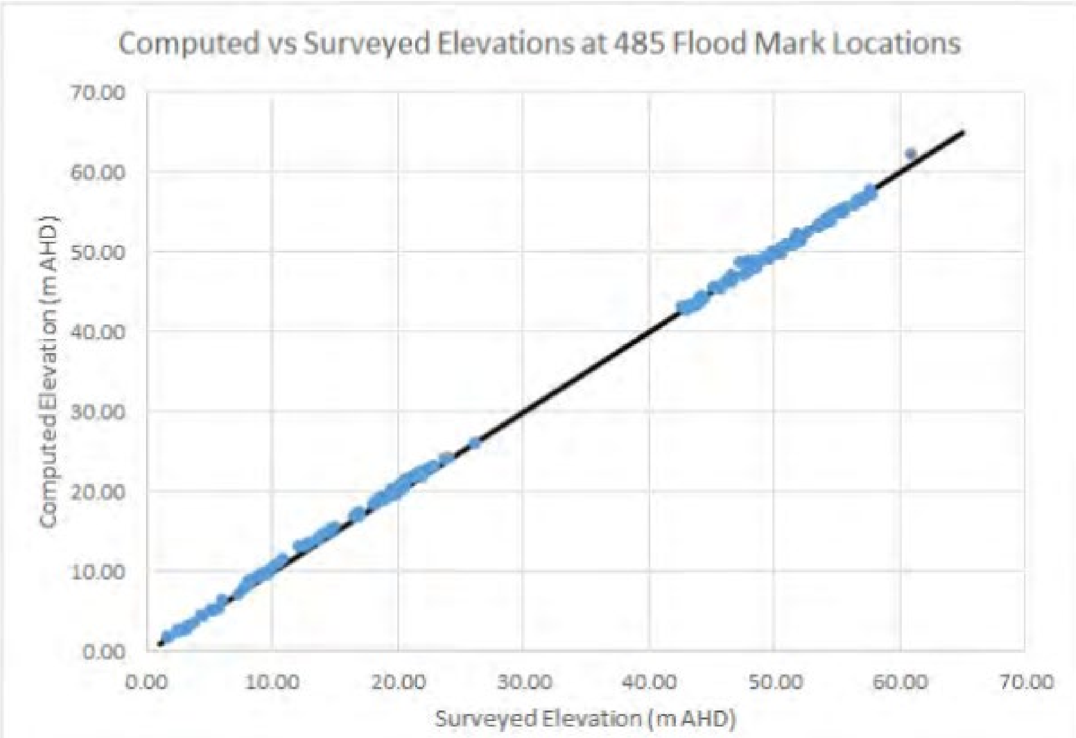


Figure 13-7: Graph of Survey versus Computed Elevations of Flood Mark Locations

[145] Ibid at [377] and at .0333.
[146] Ibid at [379].
[147] Ibid at .0331.

83 Dr Christensen selected a range of ±0.5m to illustrate the variation in the computed heights compared to the surveyed level. A histogram representation of that comparison was as follows:[148]

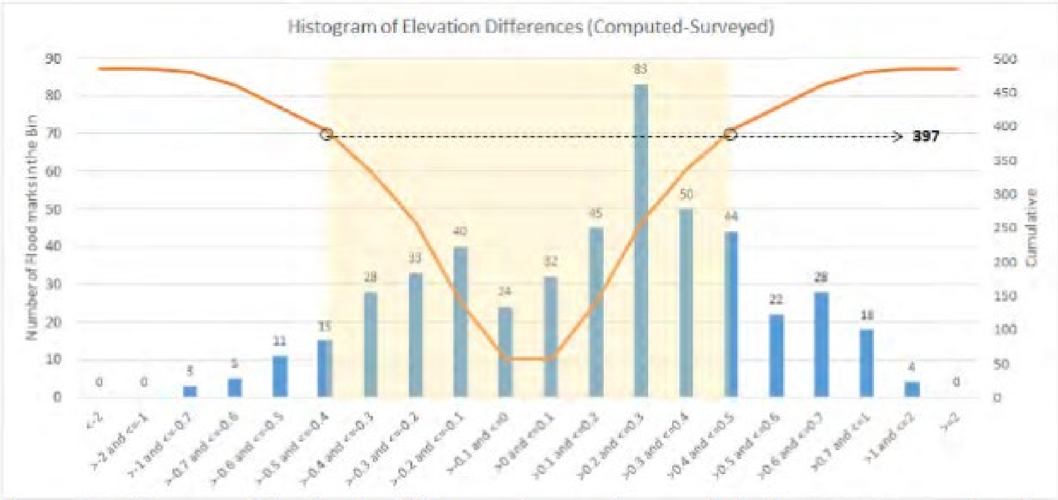


Figure 13-8: Histogram of Elevation Differences between 2017 Set Up and Surveyed Flood Marks

84 The area marked yellow represents the range of results that are within ±50cm of the surveyed result. The histogram indicates that 397 of the 485 (81.9%) of the results fell within that range (although the table on the previous page lists that figure as 394[149]). The blue rectangles to the left of the yellow shading represent computed results that are more than 0.5m *lower* than the surveyed result (being 19 or 4.5%) and the results to the right represent computed results that are more than 0.5m *higher* than the surveyed result (being 72 or 14.8%). Fifty three percent of the results are within 30cm of the surveyed results. Further, the breakdown of the results suggests that the computed heights might be skewed to overestimate various depths in that 326 (or 67%) of the computed flood levels were above the surveyed flood marks and 159 (or 33%) of the computed flood levels were below the surveyed flood marks. As noted below, in accessing the simulated levels of flooding at the plaintiff's store and the other sample group members' properties, Dr Altinakar referred

[148] Ibid at .0334.
[149] Ibid at .0333.

to the difference between the modelled level of flooding and nearby flood surveyed marks.[150]

Dr Altinakar's Conclusion on Calibration of the 2017 Set Up

85 Dr Altinakar expressed overall satisfaction with the calibration of the 2017 Set Up. He stated:[151] "[t]he good calibration results presented in this report and the results of the benchmarking simulations clearly demonstrate that DSS-WISE has the capability to accurately model a flood event in a complex tidal river system, such as the Brisbane River downstream of Wivenhoe Dam".

Revision of Comparison to Surveyed Flood Marks

86 In his Revised Report 2, Dr Altinakar noted that the modelling of the actual flood by the 2017 Set Up "inundate[s] 428 flood mark locations with 81% of those having an error in the maximum flood elevation within the acceptable range of ±0.50m".[152] In his oral evidence, Dr Altinakar explained that the difference in the number of flood survey marks between MAS5 and Revised Report 2 arose because some results were repeated (either because flood survey results from the BRCFS were "repeated several times"[153] or he accidentally introduced the duplicates[154]). He said that, after he removed the flood marks that were double counted,[155] the number of flood mark that were inundated were reduced to 428. Despite the reduction in the sample size, Dr Altinakar reiterated his confidence in the integrity of the results of the model.[156]

87 Dr Altinakar did not include in Revised Report 2 the equivalent diagrams for the survey marks to those set out above. However, Seqwater tendered a spreadsheet[157] that was said to analyse the data in the same way. The

[150] MAS6 at .0730 to .0734.
[151] Ibid at [383].
[152] Revised Report 2 at [110].
[153] T 10387.37.
[154] T 10402.30.
[155] T 10390.43; T 10407.32.
[156] T 10416.34 to .38.
[157] MSC.020.089.0001.

comparison line for that data is not relevantly different from that set out above. The histogram representation is as follows:

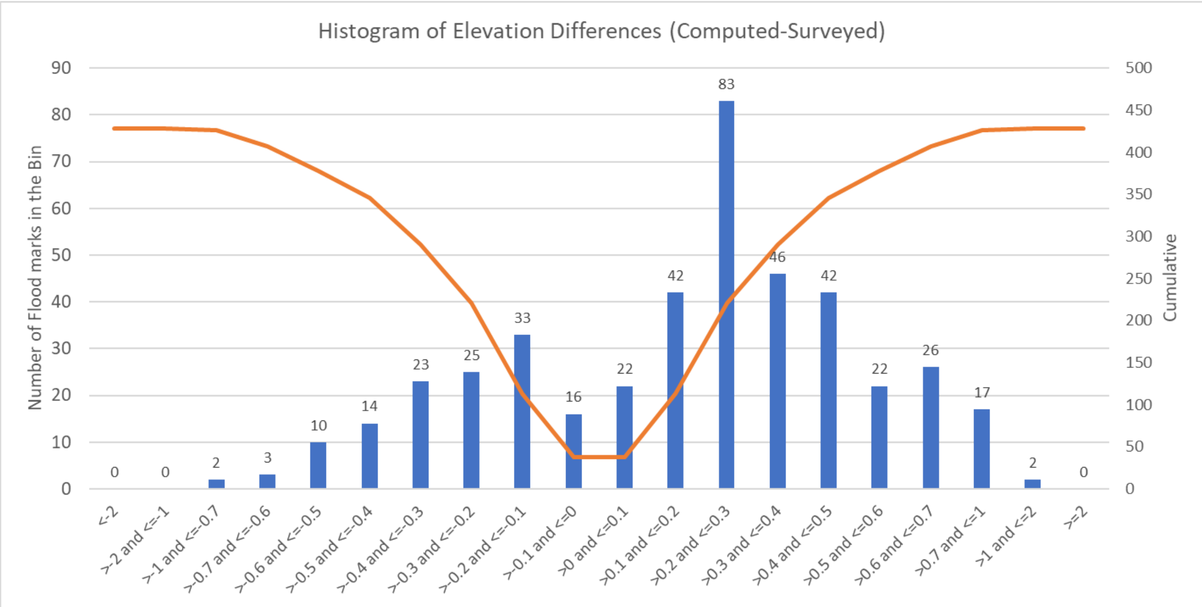


Figure 13-9: Revised Histogram of Elevation Differences between 2017 Set Up and Surveyed Flood Marks

88 An analysis of this histogram does not reveal any materially different results compared with Figure 13-8. The blue rectangles to the left of the “>0.5 and <=0.4” symbol represent modelled results that are more than 0.5m *lower* than the surveyed result (being 15 or 3.5%) and the results to the right of the “>0.5 and <=0.6” symbol represent modelled results that are more than 0.5m *higher* than the surveyed result (being 72 or 14.8%). Fifty two percent of the results are within 30cm of the surveyed results (221 results). Further, the breakdown of these results again suggests that the computed heights might be skewed to overestimate flood depths in that 302 (or 70%) of the computed flood levels were above the surveyed flood marks and 126 (or 30%) of the computed flood levels were below the flood marks.

13.2.9: Modelling the Effect of Dr Christensen’s Simulations on the Extent of Flooding

89 In MAS6, Dr Altinakar described the outcome of the application of the 2017 Set Up to each of Dr Christensen’s simulations as well as the difference between the modelled levels and actual levels at the plaintiff’s store and the

properties of the other sample group members. It follows from the findings in earlier Chapters that the relevant simulation is SIM C, although the results for other simulations should be noted. As noted, Revised Report 2 supplemented the results by adding the results of the application of Mr Ickert's variation on Wivenhoe Dam operations above EL 74.0m AHD to five simulations (B, D, F, G and J). For each of the simulations, including SIM C, Dr Altinakar provided stage and discharge hydrographs[158] as well as a table of peak discharges and arrival times for their observation lines.[159]

90 In terms of the extent of inundation, Dr Altinakar provided the following table in Revised Report 2:[160]

1	2	3	4	5	6	7
Scenario Name	Number of Inundated Cells	Number of Cells with Code 1	Number of Cells with Code 2	Number of Cells with Code 3	Percent Flood Area Reduction	Percent Flood Area Exceeded
ACTUAL-2017	2,356,014	-	-	-	-	-
A-2017	1,732,715	623,568	269	1,732,446	26.467	0.011
B-2017	1,868,810	487,219	15	1,868,795	20.68	0.001
B2-2017	2,008,104	347,924	14	2,008,090	14.767	0.001
C-2017	1,753,736	602,801	523	1,753,213	25.586	0.022
D-2017	1,870,373	485,731	90	1,870,283	20.617	0.004
D2-2017	2,010,582	345,522	90	2,010,492	14.666	0.004
E-2017	1,734,934	621,861	781	1,734,153	26.395	0.033
F-2017	1,874,963	481,070	19	1,874,944	20.419	0.001
F2-2017	1,997,841	358,192	19	1,997,822	15.203	0.001
G-2017	2,000,801	355,696	483	2,000,318	15.097	0.021
G2-2017	2,143,913	212,584	483	2,143,430	9.023	0.021
H-2017	1,875,298	480,735	19	1,875,279	20.405	0.001
I-2017	1,699,522	656,759	267	1,699,255	27.876	0.011
J-2017	1,841,946	514,088	20	1,841,926	21.82	0.001
J2-2017	1,945,675	410,358	19	1,945,656	17.417	0.001

Table 13-1: Comparison of Cell Inundations under 2017 Set Up between actual flood and Dr Christensen's Simulations

91 The reference to B2, D2, F2, G2 and J2 in the above is to simulations B, D, F, G and J as varied by adopting Mr Ickert's variation on flood operations above EL 74.0m AHD at Wivenhoe Dam. Column 2 of this table represents the total

[158] MAS6 at [67] to [68]; Appendix D1 and D2.
[159] Ibid at [69].
[160] EXP.ROD.019.0001 at .0064; updated from MAS6 at .0661.

number of 10m x 10m cells that are inundated by the actual scenario or the simulation as the case may be. Column 3 represents the number of such cells that are inundated by the actual scenario but not by the corresponding simulation. For example, 602,801 10m x 10m cells are inundated by the actual scenario but not by SIM C. Column 4 represents the number of cells that are inundated by Dr Christensen's simulations but not by the actual scenario. For example, 523 cells are inundated by SIM C but not by the modelling of the actual flood event. Column 5 represents the number of cells that are inundated by both the modelling of the actual flood and Dr Christensen' simulation. Column 6 indicates the percentage decrease in the area of inundation modelled using Dr Christensen's simulations[161] and column 7 represents the area of increased inundation modelled using Dr Christensen's simulations.[162]

92 Four observations made by Dr Altinakar about this data should be noted.

93 First, Dr Altinakar observed that the cells in column 4 occurred in locations where there was either no river bed topography data available of, if there was, it was of poor quality.[163] Dr Altinakar noted that "the number of cells [in column 4] are very small" and that "[t]hey represent one or two cells here and there along the river and they can be neglected".[164]

94 Second, Dr Altinakar observed that there was no material change in the maximum flood depths observed at the upstream part of the Lockyer Creek and Bremer River between the modelling of Dr Christensen's simulations and the modelling of the actual flood event. Dr Altinakar concluded that "that the flooding in the upstream reach of Lockyer Creek and Bremer River is controlled by the inflow discharges in the upstream reach" and "[t]hese areas

[161] Ie, the results in Column 3 divided by the total number of cells inundated by actual flooding (2,356,014).
[162] Ie, the results in Column 4 divided by the total number of cells inundated by actual flooding (2,356,014).
[163] MAS6 at [129], [130] and [134].
[164] Id; Revised Report 2 at [67] and [71].

are not influenced by backwater effects from the flooding in Brisbane River".[165]

95 Third, Dr Altinakar observed that the modelled peak stage of the flooding along the Brisbane River computed for Dr Christensen's simulations and the actual flood event showed significant differences as between the former compared to the latter. However, he observed that these differences "nearly vanish downstream of Brisbane River (river distance 140km from Wivenhoe Dam), where the maximum flood elevations are controlled mostly by tidal elevations from Moreton Bay and the tributary discharges in the downstream reach".[166]

96 Fourth, Dr Altinakar examined the effect of the modelling of Dr Christensen's simulations on the flood levels of the surveyed flood marks noted above. The modelling of the actual flood event computed that 428 of those flood marks were inundated.[167] In Appendix P to MAS6, Dr Altinakar marked the maximum depth at those flood mark locations under Dr Christensen's simulations.[168] Dr Altinakar noted that, for the modelling of Dr Christensen's simulations, the number of flooded flood mark locations was significantly less. In the case of SIM C only 139 of the survey marks were inundated. For SIM I, it was only 134.[169] Dr Altinakar observed that was "understandable given the fact that many flood marks are located near the periphery of the flood area for the actual flooding".[170] Dr Altinakar also observed that "many of the flood marks inundated by Scenario I are located at the upstream reaches of the Lockyer Creek and Bremer River or the lower reaches of the Brisbane River where the maximum flood levels are controlled only by the upstream inflow discharges and are not affected by the flood levels in the Brisbane River" and that "[s]ome other inundated flood marks are located in or near river (gauge locations), which are obviously inundated for all scenarios".[171] Having reviewed

[165] MAS6 at [14].
[166] Id.
[167] Ibid at [148].
[168] Id; Appendix P is at .1079.
[169] Ibid at .1089.
[170] Ibid at [148].
[171] Ibid at [149].

Appendix P to MAS6, this observation applies equally to SIM C, as almost all of the inundated survey marks for SIM C are the same as those for SIM I.

97 As noted, in MAS6 Dr Altinakar also addressed the inundation of the plaintiff and the sample group members' properties under each of Dr Christensen's simulations. This evidence is addressed in section 13.4.

13.3: Defendants' Criticisms

13.3.1: Mr Collins' Evidence and the BRCFS Hydraulic Model

98 The only expert evidence that was tendered in response to Dr Altinakar's reports concerning the 2017 Set Up were two reports from Mr Collins, one dated 30 October 2017[172] and the other dated 24 April 2018.[173]

99 Both reports were very brief and addressed only a few discrete aspects of the modelling process that produced the 2017 Set Up, namely his calibration to surveyed flood marks, the supposed necessity to calibrate to earlier flood events and some brief comments concerning the inflow discharges used by Dr Altinakar at Rifle Range Road and along the Bremer River. His opinions on these matters are addressed below. His only conclusion as to the 2017 Set Up's overall accuracy concerned the modelling of the level of inundation at the plaintiff's property that would result from the use of Wivenhoe Dam outflows that correspond to SIM F, G, H and J. This is also addressed below.

100 In his reports and evidence, Mr Collins referred to both the Aurecon URBS hydrological model and the BRCFS hydraulic modelling described above. As noted, Mr Collins was the project director for the hydraulic modelling phase.[174]

101 Perhaps unsurprisingly, in cross-examination Mr Collins sought to extol the virtues of the BRCFS hydraulic model. He said that the BRCFS hydraulic model covered the same or similar area as Dr Altinakar's modelling ("fairly

[172] EXP.QLD.001.1492
[173] EXP.QLD.002.0033; an earlier report briefly addressed the 2015 Set Up: EXP.QLD.001.1285.
[174] T 8665.34.

similar") including the location of the plaintiff's store.[175] He said that it had the capacity to model the effect of different outflows from Wivenhoe Dam on different locations downstream.[176] Mr Collins stated that it used a 20m x 20m grid compared to the 10m x 10m grid used in Dr Altinakar's modelling.[177] Mr Collins said that the BRCFS hydraulic model specified a tolerance of plus or minus 150mm to surveyed flood marks in about 95% of cases which he stated compared favourably to Dr Altinakar's model.[178] Mr Collins explained that the BRCFS hydraulic model also used the Aurecon URBS hydrological modelling as the input for its boundary inflows.

102 Mr Collins' opinion on the relative merits of the BRCFS hydraulic model compared to Dr Altinakar's modelling is exemplified by the following part of his evidence:[179]

> "Q. It is the case, isn't it, Mr Collins, that in the field of hydraulic modelling of a model of this scale and frequency, calibrating within 0.5metres of 80 per cent or more of flood marks is a very good result?
> A. No, I don't accept that. [Dr Altinakar] could have done better.
>
> Q. He could have done better. When you say that, do you mean with unlimited time and unlimited resources?
> A. He could have done better simply by in his later report adopting the Brisbane River Catchment Flood Study hydraulic model and using that, and we would have saved a lot of debate.
>
> Q. You're saying he should have used the BRCFS hydraulic model rather than create his own model?
> A. No, I said by the time he got to his last report, that model was available.
>
> Q. Yes.
> A. Rather than have a debate about the differences in the model and the accuracy, and if we'd gone through a normal joint expert meeting process we could have agreed on a modelling system to use at that point. Potentially, it would have removed a lot of debate, and we would have plus and minus 0.5 accuracy to 95 per cent [of cases in the] model and a lot of the debate we've been having in the last hour wouldn't have been happening."
>
> …

175 T 8740.26.
176 T 8740.36.
177 T 8738.23.
178 T 8736.37.
179 T 8739.43 to T 8740.43.

> As I said yesterday, I think, given the time that he had, the model that he built was *pretty impressive*. It's just that it's not as accurate as one that took two and a half years to build [being the BRCFS hydraulic model]." (emphasis added)

103 The defendants did not appear to share Mr Collins' enthusiasm for the BRCFS hydraulic model. Mr Collins' evidence suggests that the defendants, or at least one of them, could have proven the BRCFS hydraulic model, run Dr Christensen's simulated outflows through it and compared the modelled outcomes to those produced by the 2017 Set Up. They did not take that course. Three matters flow from that.

104 First, the substance of the above extract and the entire balance of Dr Collins' evidence was that, although Dr Altinakar's modelling was "pretty impressive", the hydraulic model constructed for the BRCFS was superior. However, in the absence of any attempt to prove the BRCFS hydraulic model, its supposed superiority is just an unproven assertion. What remains is the concession that Dr Altinakar's modelling is "pretty impressive'.

105 Second, even so, in a case where the plaintiff tenders a model that is described as "pretty impressive" then the fact, if it be the fact, that there may be a superior model in existence does not deny the utility of using the "pretty impressive" model to prove the relevant counterfactual contention on the balance of probabilities.

106 Third, the plaintiff submitted that the fact that the State "who called Mr Collins, did not adduce evidence of what the BRCFS hydraulic model would show if Dr Christensen's simulations were modelled gives rise to an inference that such evidence would not have been favourable to the defendants".[180]

107 Thus, in effect, the plaintiff invited the Court to draw a "*Jones v Dunkel*" inference[181] to the effect that the "uncalled evidence would not have assisted

[180] Plaintiff subs at [2076]; Plaintiff's Supplementary Causation Submissions, SBM.010.017.0001 at [15]; citing *Commercial Union Assurance Company of Australia Ltd v Ferrcom Pty Ltd* (1991) 22 NSWLR 389 at 418-419 per Handley JA ("Ferrcom") and *Kuhl v Zurich Financial Services Australia Ltd* (2011) 243 CLR 361; [2011] HCA 11 at [63] ("Kuhl").
[181] *Jones v Dunkel* (1959) 101 CLR 298; [1959] HCA 8.

the [State's] case".[182] There are significant limits on such reasoning and it is contentious whether it can be applied to a context where a party has failed to adduce the results of a mathematical model where the modelling may have been available to all.[183] The present context might be better analysed by reference to Lord Mansfield's dictum in *Blatch v Archer*[184] that "[i]t is certainly a maxim that all evidence is to be weighed according to the proof which it was in the power of one side to have produced, and in the power of the other to have contradicted" in that at the very least the State could have sought to contradict Dr Altinakar's modelling by proving and running the BRCFS hydraulic model. However, in the end result, the findings that are set below are made without the necessity to draw on those principles. Instead they are made in a context where, except for the very limited areas in which Mr Collins opined on, Dr Altinakar's evidence was uncontradicted and his modelling was acknowledged by the only other relevant expert that was called to be "pretty impressive".

13.3.2: Seqwater's Criticisms of the Hydrograph Calibration

108 In its further submissions on causation, Seqwater submitted that "even a cursory review of the hydrographs comparing Prof Altinakar's results of his modelling of the ACTUAL scenario and the observed water levels demonstrate how poorly his model is calibrated for the period December 2010 to January 2011".[185] SunWater made a similar submission in respect of calibration of Dr Altinakar's modelling to flows at lower levels than the peak flow during the January 2011 Flood Event.[186]

109 At the outset it should be noted that there are limitations on any resort to a "cursory review" of an output such as a hydrograph. As Figure 13-7 demonstrates, the appearance of correlation from the presentation of data in graphical form can often be a product of the scales that are adopted on the x

[182] *Kuhl* at [63].
[183] *Australian Securities and Investments Commission v Hellicar* (2012) 247 CLR 347; [2012] HCA 17 at [165].
[184] (1774) 1 Cowp 63 at 65; 98 ER 969 at 970.
[185] SBM.020.019.0001 at [29].
[186] SBM.030.011.0001 at [97] to [99].

and y axes. In assessing the quality of correlation to a measured hydrograph, I attached considerable weight to the evidence of the modellers on the topic. Dr Altinakar's opinions have already been outlined and are further addressed below. Mr Collins did not address this topic at all. Thus, not only are his opinions and explanations uncontradicted by any other expert, the only witness called by the defendants who could have addressed the topic was silent.

110 Seqwater cited as an example a number of hydrographs that were said to support its submission. The first was the hydrograph for Savages Crossing which is the second hydrograph in Figure 13-5. Seqwater submitted that Dr "Altinakar, appropriately, acknowledged the poor calibration in cross-examination where he agreed that the difference between the measured and computed heights was about 6.5m – 7.0m and agreed that "*would not be a good fit*"" and that "[a]fter 3 January and leading up to the peak, the modelled level is inconsistently above and below the observed level".[187]

111 Seqwater's submission does not accurately record the effect of Dr Altinakar's evidence. The difference in height being referred to in this passage of evidence is the difference in the hydrographs for the period from 28 to 31 December 2010 (ie, the circled area in the second hydrograph in Figure 13-5). Seqwater's submission refers to the following question and answer:[188]

> "Q. And that would not be a good fit, would it?
> A. *Not at that particular time,* and that probably indicates that there is some missing discharge in the hydrograph"
>
> His Honour: Q. Around that time?
> A. Around that time." (emphasis added)

112 Later when cross-examined on a similar discrepancy at the same time in the hydrographs for Burtons Bridge, Kholo Bridge and Mt Crosby Weir Bridge (ie, the third hydrograph in Figure 13-5 above), Dr Altinakar explained that there is

[187] SBM.020.019.0001 at [30(a)].
[188] T 3469.44 to T 3470.7.

a "systematic difference, when you look at, it just before 12/31, in that peak [for Mt Crosby Weir Bridge] … and I'm thinking that it is because there is a problem with the discharges".[189] Dr Altinakar said that the late-December discrepancy was not important to the calibration process[190] and that the discrepancy occurs in a period before the January 2011 Flood Event and disappears very quickly in his model.[191] Dr Altinakar said that with the computed hydrographs "the peak discharges are pretty good captured and the overall shape is captured".[192]

113 In its supplementary causation submissions, the plaintiff suggested that the discrepancy in the hydrographs involving the period of the Late December Flood Event was explicable by reference to "the fact that there was a significant rain event over the catchment in late December 2010, with the highest rainfall totals recorded in the Lockyer and Bremer catchments in the 24 hours to 9.00am on 27 December 2010" but, as there was no discharge data for the Lockyer Creek catchment and other smaller tributaries prior to January 2011, "the flows resulting from this rain event are not accounted for in Dr Altinakar's model".[193] This may be the explanation but it is not necessary to resolve it at this point. It suffices to state that many of the hydrographs show a discrepancy in that period but are followed by a well calibrated hydrograph for the January 2011 Flood Event.[194] In the absence of any comment from Mr Collins on this topic, there is no reason not to accept Dr Altinakar's explanation.

114 The balance of Seqwater's submissions on the topic point to eight hydrographs that are said to show poor calibration.[195] With four of them, the only discrepancies of substance between the hydrographs concern the period in late December 2010 or a period after the relevant gauge failed, otherwise the hydrographs appear well calibrated and were said to be so by Dr

[189] T 3508.24; see also T 3519.8.
[190] T 3553.28.
[191] T 3553.32 (Dr Altinakar).
[192] T 3518.39 (Dr Altinakar).
[193] SBM.010.017.0001 at [30].
[194] MAS5 at [342], [343], [344], [345] and [348].
[195] SBM.020.19.0001 at [30(b) to (i)].

Altinakar.[196] Of the remainder, the hydrograph for Ipswich does not calibrate well for the period from 11 December 2011 to 3 January 2011 but calibrates very well to the peak of the flood with the computed peak exceeding the measured peak by only 9cm.[197] The hydrograph for Brassall calibrated reasonably well until the peak when there was a 1.29m discrepancy. Dr Altinakar observed a similar discrepancy between the computed peak taken from the BRCFS hydraulic model and the measured peak.[198] With the Moggill hydrograph, Dr Altinakar noted that the computed peak stage was 0.9m higher than the measured peak, and that the computed stage data was higher than the measured stage data in the period from 11 December 2010 to 3 January 2011.[199]

115 With Jindalee Bridge, Dr Altinakar's modelling matches the timing of the peak, but his hydrograph exceeded the BRCFS hydraulic model hydrograph (although otherwise they appeared well calibrated to each other).[200] However, the flow rate and height data was closely measured at the bridge during the January 2011 Flood Event. A comparison of that data with Dr Altinakar's modelling cuts both ways.[201] Dr Altinakar's estimated peak flow rate was 9869m^3/s which compares well with the measured flow rate of 10085m^3/s.[202] However, Dr Altinakar measured a peak flood level of 13.06m AHD[203] whereas SunWater pointed out that the measured peak height was 12.07m AHD.[204] SunWater contended that this suggested the modelling was unreliable.

116 Dr Altinakar was fully cognisant of these differences but maintained his assessment of the accuracy of the 2017 Set Up (while allowing for the potential to increase its accuracy had more time been available). I accept that

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[196] MAS5 at [342] (Burtons Bridge); MAS5 at [343] (Kholo Bridge); MAS5 at [344] (Mt Crosby Weir) and MAS5 at [345] (Colleges Crossing).
[197] Ibid at [346].
[198] Ibid at [347].
[199] Ibid at [348].
[200] Ibid at [351].
[201] LAY.SEQ.008.0001 (Corbett).
[202] MAS5 at .0336; LAY.SEQ.008.0001 at [3].
[203] MAS5 at .0338.
[204] SunWater subs at [2719]; SEQ.090.001.0030.

evidence. The defendants' submissions do not warrant an acceptance that the 2017 Set Up is "unreliable".[205]

13.3.3: Mr Collins' Criticism of the Computed Results Against Surveyed Flood Marks

117 As noted, Mr Collins' report dated 30 October 2017 addressed the calibration of the 2017 Set Up to the surveyed flood marks. In an earlier report, Mr Collins selected 15 particular flood marks and noted that, for 12 of them, Dr Altinakar's computed level of actual flooding using the 2015 Set Up was outside a range of ±0.5m compared to the surveyed result.[206] In relation to the 2017 Set Up only one of the original 15 marks remained outside the ±0.50 m range.[207] Mr Collins selected four additional marks falling outside the ±0.50 m range.[208] The basis for the selection of the points was not stated. No particular conclusion was expressed save for the observation that the modelled result at Jindalee Bridge exceeded the surveyed debris mark by .826m and this was "particularly concerning".[209]

118 Three matters should be noted about this aspect of Mr Collins' evidence.

119 First, a surveyed flood mark is not necessarily determinative of the maximum level of flooding at that location. Mr Collins explained that a surveyor will measure the flood level "pick[ing] whatever [s]he can find" with a "mud mark" being "quite clear", although, say, flood debris in a tree is more difficult.[210] Mr Collins agreed with a statement from the user guide for the BRCFS hydraulic model which stated:[211]

> "Occasionally, survey marks in close proximity sometimes show notable differences in elevation, beyond that which would be expected from hydraulic gradients so a degree of caution should be exercised when interpreting the results. Emphasis should be placed on achieving a desirable match across

[205] Cf SBM.020.019.0001 at [33].
[206] Collins 3, EXP.QLD.001.1285 at .1290.
[207] Collins 4, EXP.QLD.001.1492 at .1495.
[208] Id.
[209] Ibid at .1498.
[210] T 8733.30.
[211] T 8734.25.

> multiple flood marks rather than an overreliance on individual points which may compromise the overall calibration."

120 Second, in any event, Mr Collins' assessment of the error rate in relation to the comparison with surveyed flood marks rose no higher than what is stated above, namely that Dr Altinakar's modelling was not as well calibrated to surveyed flood marks as the BRCFS hydraulic model was. Mr Collins did not proffer any general guidelines as to the calibration requirements for such modelling. Dr Altinakar expressed confidence in the level of calibration for the model's purpose. I accept that evidence.

121 Third, in his report dated 21 December 2017,[212] the only conclusion that Mr Collins expressed as to the overall accuracy of the 2017 Set Up concerned the modelling of the level of inundation at the plaintiff's store that would result from the use of Wivenhoe Dam outflows that correspond to SIM F, G, H and J. Mr Collins stated that flooding at the plaintiff's store for those simulations was within the stated accuracy (ie, ±0.5m) and "could have been higher under [other simulations]".[213] Mr Collins concluded:[214]

> "The refined model results are over 700mm low over parts of the model, and in other areas, 1.5m too high. Dr Altinakar states that 80% of flood levels predicted are within ±0.5m, and that all results are within +1.5m / -0.7m accuracy. The model, therefore is not considered accurate or reliable in assessing flooding levels at individual properties under the actual event, or under scenarios F, G, H and J."

122 To similar effect, in its submissions the State relied[215] on the following passage from Mr Collins' oral evidence where he addressed the significance of discrepancies between Dr Altinakar's modelled results of the actual flooding at a particular location and the corresponding survey mark as follows:[216]

> "Q. It may not change the process, but in ultimately trying to achieve a good calibration across a larger area, it might mean that you accept tolerances that are different to what you might take if you were using a very small area?

[212] EXP.QLD.001.1492.
[213] Ibid at .1513.
[214] Ibid at .1514.
[215] State subs at [570].
[216] T 8739.8 to .41.

A. Well, the tolerances that you're prepared to accept need to be defined based on the sensitivity of the answers you're trying to get. So if you're interested in flood levels absolute at specific properties under both the 2011 flood and under altered flow scenarios, that tolerance is fairly important, because if it's large it could make the difference between the property being out of flood or in flood under a range of scenarios. *So I think the accuracy limits set on the calibration is very important in this matter, because if you have a model that is plus or minus, or plus 1.5 and minus 0.7, you've got to have some concerns if you actually drill down to an assessment of damage at a specific property*.

Q. Mr Collins, it is the case, though, isn't it, that simply from looking at the five flood marks in your table 2-1, those results are not a sufficient basis upon which one could form any view as to the reliability of Professor Altinakar's model?

A. They were put in as an example of the range of answers that - range of accessories [sic] that he was getting, but I think more importantly is what he has actually put in his report himself regarding the outlier points being *1.5 metres too high and 0.7 metres too low*, but even more important is the 91 points [that are] [sic. ‘out of’] 481 where his results were more than 500 above or below the actual surveyed flood marks, and that says to me that at the very best he's plus or minus 0.5, but probably not when you've got that higher proportion. *So when you look at an individual property, you have to take that into account.”* (emphasis added)

123 If this passage was intended to suggest that, because across the breadth of the entire model there is a deviation between Dr Altinakar’s modelling and a survey mark of +1.5m at one point and a -0.7m deviation at another point, then the modelling is of no assistance in ascertaining the level of flooding for any purpose at a specific location then I reject it. That process of reasoning does not reflect the proposition that proof need only be established on the balance of probabilities or that findings about the actual and counterfactual flooding levels are to be made based on all the evidence and need only be made to the level of precision required to determine if the alleged “particular harm” was caused by the relevant breach(es) of duty. Once it is accepted, as I do, that there is a reasonable degree of accuracy in Dr Altinakar’s modelling, then the issue becomes what is the appropriate finding at a particular location, having regard to all of the evidence. In undertaking that task it is appropriate, as Mr Collins stated, to “take ... into account” the range of readings, but that is different from rejecting the modelling in its entirety as the defendants urge.

124 This is illustrated by Mr Collins' conclusion about the plaintiff's store and the modelled flooding under SIM F and SIM H. Mr Collins' conclusion appears to be in part based on the misapprehension that the ground level in the shopping centre relevant to the inundation of the plaintiff's store varied between 6.43m AHD and 7.00m AHD.[217] The former figure is for the south east corner of the shopping centre outside the building[218] whereas the floor level of the shopping centre is at EL 7.00m AHD.[219] Dr Altinakar modelled SIM F and SIM H reaching a maximum height of EL 6.56m AHD just near that location.[220] Otherwise, Mr Collins does not appear to have considered Mr Rodriguez's evidence. As discussed below, he observed "a residual ring of mud starting [on] the shop walls up to about 1.2 metres high"[221] which compares favourably to Dr Altinakar's computed height of flooding of 1.00m. This suggests a reasonably strong correlation between Dr Altinakar's modelling and the level of actual flooding. This would be sufficient to support a finding on the balance of probabilities that flood operations conducted in accordance with SIM F and SIM H would not have inundated the plaintiff's store, although the relevant counterfactual is SIM C.

125 The State ultimately submitted that the margins for error in Dr Altinakar's modelling had the consequence that it would not be possible to determine whether or not Mr Ruffini's breaches caused additional damage to the property of the plaintiff or any other class member.[222] I do not accept that the results of his calibration have that effect at all. Instead, as explained below, it is a matter for assessment by reference to the particular loss or damage said to have been suffered and the entirety of the evidence about flooding at that location. Further, to the extent that Dr Altinakar identifies the level of expected flooding on the relevant counterfactual to the nearest centimetre then there is no reason to commence with an assumption that the computed level of flooding is either too high or too low.

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[217] EXP.QLD.001.1492 at .1512.
[218] MAS6 at .0721; .0727; Revised Report 2 at .0093 and .0096.
[219] Revised Report 2 at .0096; MAS6 at .0721.
[220] Revised Report 2 at .0095, Table 7, row F-2017, "Plaintiff NW Corner".
[221] LAY.ROD.001.0001 at [100].
[222] State subs at [580].

13.3.4: Seqwater and SunWater's Submissions on Surveyed Flood Marks

126 Both Seqwater and SunWater contended that Dr Altinakar's modelling did not calibrate well to surveyed flood marks.[223] In its supplementary submissions on causation,[224] Seqwater pointed out that in Revised Report 2 Dr Altinakar referred to the number of flood marks that were the subject of the comparison exercise as 428 without providing any explanation for the change in figures from 485 flood marks in MAS5 or providing the same supporting analysis that was provided in MAS5 such as Figures 13-7 and 13-8.[225] Seqwater submitted that Dr Altinakar realised he made a mistake but "did not reveal that openly, contrary to his obligations as an expert because he was seeking to assist the plaintiff".[226] In cross-examination, Dr Altinakar denied the allegation[227] and I accept his denial. He noted that the results were "staying approximately the same",[228] a contention that is confirmed by Figure 13-9.

127 Seqwater pointed to Dr Altinakar's evidence that the reduction in sample size in this case did not cause him to question the conclusion about the overall accuracy of the model because "some of them are doubles and I'm counting the same thing twice to get there".[229] Seqwater contended that this explanation was "inadequate because when he gave the conclusion in … his 16 October 2017 report[230], he did not know there were duplicates". I have difficulty in understanding this submission. Dr Altinakar was simply saying that, even though he removed the duplicate flood marks, the "error rate" was the same, which it was save that the sample size was smaller.

128 Seqwater also submitted that the results of the revised analysis, including the fact that just over 51% of the computed results were within ±0.30m of the surveyed result, the fact that Dr Altinakar calibrated in the available time against an error range of ±0.50m and his evidence that if he had "even more

[223] Seqwater: SBM.020.019.0001 at [35] - [41]; SunWater subs at [2735] – [2743].
[224] SBM.020.019.0001 at [35] to [41].
[225] Ibid at [42].
[226] Ibid at [43].
[227] T 10394.34.
[228] T 10394.12.
[229] T 10416.18.
[230] Ie, MAS5 at [379].

time" he "would be going towards perhaps plus or minus 0.05 metres",[231] warranted a rejection of his conclusion that the 2017 Set Up "describe[s] quite well the real flow conditions during the 2011 flood event".[232] Again, I do not accept that submission. Save for the limited evidence given by Mr Collins on this topic noted above, Dr Altinakar's evidence on this topic was uncontradicted. He was the best, and to an extent only, qualified person to express an opinion on this topic.

129 Lastly, Seqwater referred to the 79 flood marks represented by the difference between the 507 flood marks first identified by Dr Altinakar as within the area of his modelling and the 428 flood marks the subject of the comparison exercise noted above.[233] Dr Altinakar explained that 79 survey flood marks were excluded because his modelling "did not extract any value of flood elevation at [the] location" of the flood mark when the survey had returned a record of flooding.[234] Seqwater noted that "those flood marks are objective evidence of the extent and level of flooding which actually occurred at those 79 specific locations during January 2011" and that "[Dr] Altinakar's model fails to inundate these 79 locations which were known to be flooded in January 2011". It submitted that "[r]ather than investigating why his modelling of the [actual] scenario failed to inundate those marks, [Dr] Altinakar simply chose to disregard them". Seqwater contended that the result is that "[t]he only evidence which the Court has to assess the calibration by reference to flood marks is that which shows that only 346 flood marks of the 507 total, being about 68%, were inundated within [an] error range of ±0.50m" and that "[o]f the remaining 161 flood marks, either they were inundated outside that error range or they were not assessed at all". Seqwater submitted that the fact that Dr Altinakar "did not assess the 79 he eliminated does not assist the plaintiff in seeking to establish that the model is reliably calibrated".[235]

[231] T 3497.25.
[232] MAS5 at [379]; T 10416.31 to .34; SBM.020.19.0001 at [47] to [48].
[233] SBM.020.019.0001 at [49].
[234] T 10490.9.
[235] SBM.020.019.0001 at [49].

130 At one level Seqwater is correct in asserting that the 79 excluded flood marks potentially reflect upon the validity of the calibration exercise. However, I do not accept that Dr Altinakar ignored them or that they are of much significance. Two related points should be noted.

131 First, Dr Altinakar stated that the 79 flood marks were excluded from the verification exercise because, in the absence of a computed flood level from his modelling, it was not possible to ascertain whether a computed flood level was within ±0.5m of the surveyed flood level.[236]

132 Second, included in the materials tendered with MAS5 were electronic files that projected the location of the surveyed flood marks onto Dr Altinakar's modelling of the extent of actual inundation.[237] By reference to a document prepared from that material, Dr Altinakar explained that the 79 surveyed flood marks were "generally close to the edges" of flood inundation.[238] In re-examination, Dr Altinakar explained that with survey marks at the edge of the inundation area, the actual flooding at those locations would likely have been very small.[239] He explained that each 10m by 10m cell is treated as having a single elevation for the purposes of determining whether it is inundated and each cell is treated as either being completely inundated or not based on this average elevation.[240] Dr Altinakar stated that this meant that a particular 10m by 10m cell in the model may be modelled as not being inundated, even though a part of that cell was, in fact, inundated during the January 2011 Flood Event.[241] Dr Altinakar concluded that the "model was performing quite well" and the excluded flood marks "were flooded very, very little" and are at the very edge of the "computational domain" such that "this simulation is correct".[242]

[236] T 10491.19 to .28.
[237] T 10488.28 to T 10489.7.
[238] T 10491.41; T 10492.5; T 10492.16; T 10492.46; MSC.020.089.0001.
[239] T 10493.11.
[240] T 10493.19.
[241] T 10493.2 – .26.
[242] T 10494.2.

133 This aspect of the modelling casts some doubt about the extent to which Dr Altinakar's modelling can be relied on to prove the fact of or level of actual flooding at the edge of the area of his computed inundation for the actual flood. However, it does not raise any issue in relation to the matters currently being addressed. The manner of proof of actual flooding is addressed in section 13.4.2. None of the issues raised concerning the plaintiff or the other sample group members involve the use of Dr Altinakar's modelling to prove actual flooding in any area at the edge of the area of computed inundation for the actual flood.

13.3.5: Modelling to Historical Flooding

134 Seqwater and SunWater contended that the reliability of Dr Altinakar's modelling was undermined by his failure to calibrate it to historical flooding in the Brisbane River basin.[243]

135 In MAS5,[244] Dr Altinakar referred to the idea of calibrating to multiple historical events as "theoretically attractive" but noted the difficulties posed by potential changes in circumstances between the past flood and the modelled event. He stated that the "purpose of the calibration of a flood model is to be able to use the calibrated model for another event without changing any calibration parameters, such as roughness coefficients and singular losses at structures bridges, bends, etc". He noted that this "cannot be achieved unless the topo-bathymetry, land use/cover and built-environment remained the same from one historical event to another". Dr Altinakar stated that, if the model had to be recalibrated from one historical flood to another, then he considered that "the purpose of model calibration is lost".

136 In his report dated 21 December 2017, Mr Collins stated that it was "critical to a flood model's credibility that it be able to accurately reproduce recorded flood levels, flows and flood wave timing across a range of historical flood events with a coverage from small up to severe events, across the full flow

[243] SBM.020.019.0001 at [50] to [57]; Seqwater subs at [2503(b)]; SunWater subs at [2705] to [2711].
[244] EXP.ROD.016.0115 at [52] – [53].

range".[245] Mr Collins referred to a series of local, state and national guidelines for flood assessment that referred to calibrating to historical flood events.[246] Mr Collins did not nominate which historical floods he was referring to but in cross-examination he appeared to accept that calibrating to the 1974 flood event was appropriate, along with the flooding in 1999.[247] He agreed that there was no comparative flooding in the period 1999 to 2011.[248] Mr Collins accepted that modelling the 1974 and 1999 floods would require a reconfiguration of the topology (ie, the DEM) to allow for known changes in bathymetry,[249] hydraulic structures (including buildings)[250] and land use changes.[251] In the case of the 1974 flood, he agreed that Wivenhoe Dam would have to be removed from the model altogether and adjustments made for its absence.[252] In the case of Dr Altinakar's modelling, that would result in the production of three different DEMs and computational meshes, one for each of the 1999, 1974 and 2011 floods. It would also require the calibration of those revised meshes to those particular floods which would involve three sets of Manning's coefficients.[253]

137 Mr Collins was cross-examined on the state, national and international guidelines he referred to. Each of them referred to calibrating to historical floods so that the modelling could be used for the assessment and management of flood risks, drainage systems and the like going forward.[254] They were not directed to using the modelling to assess what the flood impact of a particular past flood would have been had one inflow discharge been lower. Mr Collins agreed that this case represented a "fairly unique set of

[245] EXP.QLD.001.1492 at .1498.
[246] Ibid at .1498 to .1502.
[247] T 8641 to T 8642.
[248] T 8642.32.
[249] T 8639.29.
[250] T 8641.31.
[251] T 8642.45.
[252] T 8643.6.
[253] T 8641.20.
[254] State: MSC.010.532.0001 at .0002, .0003, .0008, .0012 and .0020: T 8645 to T 8649; MSC.010.535.0001; T 8649.53 to T 8651; MSC.010.537.0001: T 8651 to T 8654; MSC.010.534.0001: T 8654 to T 8655; MSC.010.523.0001: T 8655 to T 8657; National: EXP.QLD.001.1492 at .1501: "[i]n studies where more frequent flooding maybe appropriate"; MSC.010.525.0001: T 8660 - 8662.1; EXP.QLD.001.1492 at .1501; re floodplain management: T 8662.21; International: EXP.QLD.001.1501 to .1502: T 8662.37 to T 8663.12.

criteria" which is "why there may not be guidelines".[255] In that context I note that the Australian Rainfall and Runoff document "Two Dimensional Modelling in Urban and Rural floodplains" referred to by Seqwater elsewhere in its submissions[256] states that the "primary consideration is that the calibration process should reflect the purpose for which the model is intended".[257]

138 The plaintiff submitted that Mr Collins could not identify "any sound reason" for his contention that the model should be calibrated to historical events.[258] I do not accept that. Mr Collins said that the absence of calibration to historical floods meant that Dr Altinakar had not "calibrated [his model] to floods that were smaller"[259] bearing in mind that Dr Christensen's simulations necessarily involve smaller outflows than the peak releases made during the January 2011 Flood Event. However, by extending his modelling back to early-to-mid-December 2010, Dr Altinakar was calibrating to lower flows. Mr Collins accepted Dr Altinakar "ran a very long term simulation".[260] Mr Collins was then asked:[261]

> "Q. Isn't the substance of what he has done to calibrate, as you say, over a range of flows, over a duration and, indeed, in circumstances where catchment conditions are unlikely to have changed, so it's a very good test for how the model calibrates at both low and high flows?
>
> A. I think it's a limited test. I don't think it is a comprehensive test. It's not as comprehensive a test as was applied to the Brisbane River Catchment Flood Study, for example. It was required to calibrate to a larger range of historic events."

139 Thus Mr Collins reiterated his preference for the process of calibration undertaken as part of the BRCFS hydraulic study (although he accepted that it was prepared for future planning decisions[262]). The difficulty with the line of reasoning that simply points to the superiority of the BRCFS hydraulic model has already been outlined.

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[255] T 8663.23.
[256] SBM.020.019.0001 at [58].
[257] MSC.010.525.0001 at .0070.
[258] Plaintiff subs at [2034].
[259] T 8659.6.
[260] T 8659.44.
[261] T 8660.8 to T 8660.17.
[262] T 8660.25.

140 In his oral evidence, Dr Altinakar explained that, by reason of the change in the Manning's coefficients and the DEM, recalibrating to a historical flood such as the 1974 flood would have simply yielded a calibrated model for that flood[263] but not the January 2011 Flood Event. He accepted that he could have also calibrated to a flood event in 2013[264] although I note that Mr Collins did not mention that event. In re-examination, Dr Altinakar explained that, given the use that his modelling was being put to in this case, calibration to a historical event is "a desperate act which is done when you do not have any data for the particular flood event you are studying" and that all of the suggested floods, including the 2013 flood event, would have required a recalibration of the entire modelling exercise resulting in a set up of little or no utility.[265]

141 I am unpersuaded that there was any utility in Dr Altinakar reconstructing the DEM for 1974 or 1999 or even 2013 conditions and recalibrating the Manning's values to reproduce the circumstances of those different floods for the purpose of his modelling exercise. Dr Altinakar's modelling was directed to assessing what the flood impact in January 2011 would have been if one inflow discharge, namely outflows from Wivenhoe Dam, had been lower. The only substantive reason that was advanced for incorporating historical events concerned the difficulties in modelling lower flow levels. Dr Altinakar's chosen method, namely calibrating to a longer period which included lower flow levels, seems far superior for this purpose than calibrating to a different flood, including a flood such as 1974 when Wivenhoe Dam did not exist.

142 The balance of Seqwater's submissions on this topic addressed three particular aspects of his modelling or calibration exercise.[266] First, it was noted that the inflow hydrographs that Dr Altinakar used for the December 2010 flood events did not include any flows from downstream tributaries (except the Bremer River and Cabbage Tree Creek). Dr Altinakar explained that those discharges were not available but said they were generally

[263] T 3514.5.
[264] T 3516.42.
[265] T 3551.
[266] SBM.020.019.0001 at [55].

"negligible" for the December 2010 flood events.[267] As noted, the absence of discharge data for Lockyer Creek appears to correspond with the modelled flows for the period from 27 to 30 December 2011 being less than the actual flows. However, leaving that aside, the modelled hydrographs for the period from 10 December 2011 to that time displayed a reasonable to good level of correlation to the measured flows.[268]

143 Seqwater's second point related to the modelled flows in the late December 2010 period,[269] which has already been addressed.

144 With its third point, Seqwater contended that Dr Altinakar's model did not use the most reliable data for the Lockyer Creek and Bremer River inflow boundaries during January 2011. This is addressed in sections 13.3.7 to 13.3.10.

13.3.6: Sensitivity Testing

145 Seqwater contended that Dr Altinakar's modelling was undermined by his lack of sensitivity testing.[270] Dr Altinakar acknowledged the existence of two-dimensional modelling guidelines suggesting that such testing should be undertaken but noted that they provided that it "should be [undertaken] to quantify model uncertainties only 'where a model's calibration is non-existent or poor'".[271] Dr Altinakar concluded that such testing was not required "[g]iven the revised model has been adequately calibrated…[the] time constraints and the fact that such a test would not provide any useful information".[272]

146 Three matters should be noted about this explanation. First, Mr Collins did not comment on this aspect of the modelling or Dr Altinakar's explanation for not conducting sensitivity testing.

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[267] T 3516.15; T 3552.16.
[268] MAS5 at .0307 - .0323.
[269] SBM.020.019.0001 at [55(c)].
[270] Ibid at [58] to [63].
[271] MAS5 at [75]; MSC.010.525.0001 at .0070.
[272] MAS5 at [76].

147 Second, the only scrutiny of Dr Altinakar's conclusion that such testing "would not provide any useful information" was some brief cross examination to the effect that sensitivity testing might show the impact of changes in Manning's coefficients to compensate for the omission of bridges on the Brisbane River.[273] Dr Altinakar explained that ascertaining the effect of increasing or decreasing the Manning's coefficients by a set percentage would be meaningless.[274] In its submissions, the only variation in inputs that Seqwater referred to for the purposes of sensitivity testing concerned the dispute over inflows at Lockyer Creek and the Bremer River which are addressed below.[275]

148 Third, otherwise, Seqwater contended that sensitivity testing was warranted because the modelling was not well calibrated,[276] a proposition I reject.

13.3.7: Rifle Range Road and the Materiality of Inflow Discharges

149 Seqwater contended that Dr Altinakar's "inflow boundaries for the Lockyer Creek at Rifle Range Road and Bremer River at Amberley are not based on the best available, or most reliable, data (being that derived using the Aurecon URBS model)".[277] This section addresses the inflows at Rifle Range Road.

Background

150 To address this contention and a number of other contentions it is necessary to further explain the background to the production of Revised Report 1, the 2018 Set Up, the 2019 Report and the 2019 Results Report. The course of events is described in *Rodriguez (No 18)* at [4] to [31] and *Rodriguez (No 20)* which should be read together with this part of the judgment.

151 As explained earlier, in preparing the 2017 Set Up Dr Altinakar stated that he utilised the Aurecon URBS hydrological model for inflow discharges but not at Rifle Range Road (or the upper Bremer River). The source of the hydrographs

[273] T 3522.27.
[274] T 3555.39.
[275] SBM.020.019.0001 at [62].
[276] Ibid at [60].
[277] Ibid at [66]; Seqwater subs at [2505] to [2511].

for Rifle Range Road was the “rated flow” for that location, that is a flow calculated from the height of the waterway.

152 On 10 April 2018, Seqwater filed an affidavit from Mr Malone[278] which included what he stated was a hydrograph of the flows at Rifle Range Road as produced by the Aurecon URBS model (ie, the uncorrected Malone hydrograph).[279] The next day, Dr Altinakar was cross examined on Mr Malone’s affidavit.[280] During the cross-examination it was suggested that there was a difference in peak flow of 761m^3/s between the uncorrected Malone hydrograph and the figures used by Dr Altinakar based on the rated flows. Dr Altinakar was asked:[281]

> “Q. A difference in peak flow of about 761 m^3/s] at this location can't be dismissed as immaterial; do you agree?
>
> A. Very difficult to say. It is difficult to say where we have to also consider, because these are highly non-linear processes, and without doing a simulation, it would be very hard for me to tell. *But I would guess that as you would go more and more downstream, the effect would be negligible, practically*.” (emphasis added)

153 In August 2018, the solicitors for the plaintiff sought to obtain a digital version of the uncorrected Malone hydrograph but that request was refused by Seqwater’s solicitors.[282] Instead, Dr Altinakar digitised the hydrograph from Mr Malone’s affidavit. Using that data and data for the Bremer River inflows he produced the 2018 Set Up which involved a revised set of Manning’s values and a breakdown of the Brisbane River channel from two sections into sixteen sections which each could then have separate Manning’s coefficients applied to them to achieve greater granularity.[283]

154 In *Rodriguez (No 18)*, I found that the course of events that lead to the late production of Mr Malone’s affidavit was contrary to a Court direction and a previous statement by Seqwater’s solicitors that no evidence would be relied on in response to Dr Altinakar’s reports. I found that this had occasioned

[278] LAY.SEQ.015.0001.
[279] Ibid at [11]; *Rodriguez (No 18)* at [16].
[280] T 3343; *Rodriguez (No 18)* at [20].
[281] T 3454.6.
[282] *Rodriguez (No 18)* at [30].
[283] Ibid at [33].

unfairness to the plaintiff such that it should be allowed to adduce evidence from Dr Altinakar explaining why it was appropriate to use the rated flows at Rifle Range Road.[284] However, I rejected an application by the plaintiff to tender the 2018 Set Up because I found that it was directed to the proposition that the difference in inflows at Rifle Range Road was immaterial and the parties had already made considered forensic decisions as to what evidence to adduce on that topic.[285]

155 However, that was not the end of the matter. After I rejected attempts by the defendants to tender expert material in response to Dr Altinakar's Revised Report 2,[286] the plaintiff became aware that the uncorrected Malone hydrograph for Rifle Range Road included in Mr Malone's affidavit was (arguably) misleading in that the time specified for the start of each day was not 00:00 hours but 9.00am.[287] As noted, the plaintiff had sought the digitised version of that hydrograph in August 2018 but that request had been refused by Seqwater.

156 In March 2019, the plaintiff's solicitors obtained the corrected Malone hydrograph in digital form and provided it to Dr Altinakar. Leave was granted to the plaintiff to tender that part of his 2019 Report which updated his opinion as to why his use of the rated flows at Rifle Range Road was preferable to the hydrograph produced by the Aurecon URBS hydrological model by reference to the corrected Malone hydrograph.[288] However, I rejected the plaintiff's attempt to introduce the results of modelling the 2017 Set Up that was modified by using the figures from the corrected Malone hydrograph (the "2019 Set Up"). This was rejected on the basis of the previous finding that the plaintiff had made a forensic choice as to the extent to which it would seek to prove the materiality (or lack thereof) of the differences in discharge figures at Rifle Range Road.[289]

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[284] Ibid at [70] to [74].
[285] Ibid at [69].
[286] *Rodriguez (No 19).*
[287] *Rodriguez (No 20)* at [5].
[288] EXP.ROD.021.0001 at [1] to [15] and [18]; *Rodriguez (No 20)* at [12].
[289] *Rodriguez (No 20)* at [10].

157 Again, the matter did not end there. After (and despite) that ruling, Dr Altinakar was then cross-examined on the materiality of the difference between using the rated flow figures at Rifle Range Road and the corrected Malone hydrograph. As a consequence, in re-examination the plaintiff was permitted to read the balance of the 2019 Report which addressed that issue[290] and to tender the 2019 Results Report which addressed the materiality of the difference in discharge inflows at Rifle Range Road by reference to the 2019 Set Up[291] (even though its tender had previously been rejected).[292]

Materiality

158 In light of the tender of the balance of the 2019 Report and the 2019 Results Report, the plaintiff contended that the debate over the use of the rated flows at Rifle Range Road compared to those provided by the Aurecon URBS hydrological model was irrelevant as the differences in computed results between the 2017 Set Up and the 2019 Set Up were "immaterial".

159 The relevant part of the 2019 Report which addressed the materiality of the differences between the use of the rated flows at Rifle Range Road and the corrected Malone hydrograph stated as follows:[293]

> "I have also run the DSS-WISE model using the correctly timed hydrograph instead of the rated hydrograph for Rifle Range Road that I used in my 2017 Setup. I did not make any other changes to the digital elevation model or the modelling inputs that I used in the 2017 Setup. I also did not recalibrate the model. The results confirm that the evidence I gave during my cross-examination in 0. 2018 (Trans. 3454.6-19) was correct. While the corrected hydrograph has a higher peak, the effect is only felt locally in the vicinity immediately downstream of Rifle Range Road to the confluence with Brisbane River. As the flow travels further downstream, the effect is practically negligible. By the time it reaches Lowood, there is almost no effect. The elevation differences obtained by subtracting the maximum flood elevation from the simulation using the correctly timed hydrograph (which will hereafter be referred to as the 2019 Simulation) from that of the 2017 simulation is within the range of -2 [cm] to +4 [cm] along the entire modelled reach of the Brisbane River from Wivenhoe Dam to Moreton Bay.

[290] EXP.ROD.021.0001 at [16] to [17].
[291] EXP.ROD.022.0001_3; *Rodriguez (No 21)* at [39].
[292] *Rodriguez (No 20)* at [12].
[293] EXP.ROD.021.0001 at [16] to [17].

> I have performed the same comparison of the results for Scenario I calculated with the 2017 simulation and the 2019 Simulation. A summary of the results of my simulation using the correctly timed hydrograph is provided as Appendix A to this report, along with a complete set of supporting electronic documents containing the results files."

160 The evidence at "Trans 3454.6 -19" to which Dr Altinakar is referring in this passage is his evidence on 11 April 2018 set out above (at [152]).

161 Appendix A to the 2019 Report is the 2019 Results Report.[294] It sets out various results obtained from the 2019 Set Up (i.e., using the 2017 Set Up with the corrected Malone hydrograph as the inflow discharge at Rifle Range Road instead of the rated flows). The 2019 Results Report provides a range of results for the modelling of actual flooding and Simulation I.[295] It includes observation profiles which compare the maximum water surface elevations generated by Dr Altinakar's 2019 Set Up for the actual flood along the Brisbane River, Lockyer Creek and Bremer River, with the maximum water surface elevations produced by the 2017 Set Up for the actual flood for those rivers and creeks.[296] The report also presents flood inundation maps that were colour-coded to show the difference in water surface elevation between the 2017 Set Up and 2019 Set Up when modelling the actual flood.[297] Dr Altinakar also produced comparisons for the 2017 Set Up and 2019 Set Up's modelling of the actual flood against the measured stage hydrographs for the 30 observation points noted above.[298]

162 Consistent with Dr Altinakar's oral evidence on 11 April 2018 and the passage from the 2019 Report set out above, this material revealed that there was virtually no difference in flood elevations from using the two hydrographs, save for the upper part of the Lockyer Creek just downstream of Rifle Range Road where there are differences of around 30cm in the modelling of actual

[294] EXP.ROD.022.0001_3.
[295] Cf Seqwater's further submissions on causation, SBM.020.019.0001 at [99], which assert "Professor Altinakar expresses no opinion at all as to what are the results of the modelling for Simulation I show".
[296] EXP.ROD.022.0001_3 at .0003, .0005, .0007.
[297] Ibid .0012 to .0019.
[298] Ibid at .0031 - .0060; cf Seqwater's further submissions on causation, SBM.020.019.0001 at [97], which incorrectly asserts that Dr Altinakar "does not address the variation in water level that occurs at any other stage in the hydrograph".

flooding between the two set ups. However, that differential reduces markedly about 2.5km downstream of Rifle Range Road, where the maximum water surface elevation deviations thereafter are never greater than 15cm.[299]

163 Dr Altinakar performed a similar exercise comparing the outcomes of each of the 2017 Set Up and the 2019 Set Up as applied to SIM I.[300] For SIM I, the 2019 Set Up produced an increase in the maximum water surface elevations of just under 38cm near the confluence of the Lockyer Creek and the Brisbane River.[301] This difference progressively reduced as the modelling moved downstream such that below Mt Crosby Weir Bridge, the differences are 10cm or less. Below the confluence of the Brisbane and Bremer Rivers the differences are 5cm or less.

164 Dr Altinakar modelled the differences between the two hydrographs at the location of the plaintiff's store and the properties relevant to the sample group members.[302] His results showed that using the corrected Malone hydrograph for inflows at Rifle Range Road compared to the rated flows resulted in an increase of 3.8cm and 3.7cm in the modelled level of actual flooding at Mr and Mrs Kellers' properties and an increase of 1.3cm at Ms Lynch's property. It resulted in a decrease of 2.8cm in the modelled level of actual flooding at Ms Visser's property, a decrease of 2.3cm at the location at which Ms Harrison's property was stored and a decrease of 3.8cm at the plaintiff's store. None of these properties are inundated by SIM I under either the 2017 Set Up or the 2019 Set Up save for a location described as the "north west corner" which is a point *outside* the shopping centre where the plaintiff's store was located. That point is computed to experience 2.1cm less flooding using the 2019 Set Up compared to the 2017 Set Up. While the submissions debated the "materiality" of these differences, none of them are material to the findings in section 13.4.

[299] Ibid at .0005 and .0013; cf Seqwater's further submissions on causation, SBM.020.019.0001 at [97(a)].
[300] EXP.ROD.022.0001_3 at .0004, .0006 and .0008; and .0021 to .0028.
[301] Ibid at .0022.
[302] Ibid at .0010.

165 Four further points should be noted about the balance of Seqwater's submissions on this topic.

166 First, Seqwater's submissions noted that the difference in inflow figures had "effects as far reaching as the upper reaches of the Bremer River"[303] which is said to be a particular concern because of the issue raised with the boundary discharge on the Bremer River addressed below.[304] However, those "effects" were minimal, being a variation of 5cm in the upper reaches of the Bremer River in modelling actual flooding which dissipates downstream[305] and between 10 and 12cm in SIM I.[306] The differences at Ms Visser's property at North Booval, which is affected by the Bremer River, are between 0cm for SIM I and 2.8cm for the actual flood.[307]

167 Second, Seqwater's submissions contended that there is an absence of evidence addressing the materiality of the different inflows at Rifle Range Road for all simulations other than SIM I (which would include SIM C).[308] It submitted that the accuracy of the flows is vital to the results of the modelling, "the cause of which is not dominated by flows from Wivenhoe Dam"[309]. It contended that a consistent trend would be unlikely considering the timing and magnitude of the peak release on 11 and 12 January 2011 is different in each. However, SIM I and the actual scenario represent two ends of a spectrum of outflows so far as Dr Christensen's simulations are concerned. For example, SIM C outflows from Wivenhoe Dam are greater than SIM I outflows for the entirety of the period from 10.00am on 11 January to 2.00pm on 13 January 2011.[310] The results of the 2017 Set Up at all of the affected properties indicate that at every location SIM I produces a lesser amount of inundation than SIM C. Otherwise, Dr Altinakar relied on his analysis to confirm the opinion he gave when he first gave evidence, as set out in the extract at [152] above. In context, that answer and his subsequent verification

[303] SBM.020.019.0001 at [97(b)].
[304] Ibid at [98].
[305] EXP.ROD.022.0001_3; figure 5, figure 7 and figure 11.
[306] Ibid at figure 6 and figure 15.
[307] Ibid at .0010.
[308] SBM.020.019.0001 at [104(b)].
[309] Ibid at [100] to [101].
[310] Compare Simulation Analysis, EXP.ROD.015.0461 at .0631 with .0983.

of that answer is directed to the materiality of the difference in flows under all scenarios. It is implicit in Dr Altinakar's choice of SIM I that he understood that to represent a lower limit of the discharges from Wivenhoe Dam for all the counterfactual scenarios.

168 Third, Seqwater contended that there is no evidence as to how the difference in inflows at Rifle Range Road "would affect the model results for any of Dr Christensen's or Mr Ickert's simulations at any of the other group members' properties" bearing in mind the "causation case requires [an] assessment of a vast geographic area and over 6,000 Group Members".[311] Save for what may be envisaged by common question 19, this stage of the proceedings did not involve any determination of the causation case of over 6000 group members but only that of the plaintiff and aspects of the sample group members' cases. However, even if I was to conclude that Dr Altinakar should have used the Aurecon URBS model inflows at Rifle Range Road, Dr Altinakar's 2017 Set Up is in evidence, as is the corrected Malone hydrograph. Thus, on any assessment of an individual group members' claims, the plaintiff would be entitled to deploy the results of the application of the 2017 Set Up using the corrected Malone hydrograph as part of the proof of that group members' claim for recovery of loss or damage in respect of "particular harm".

169 Fourth, Seqwater appeared to experience technical difficulties in accessing Dr Altinakar's reports and replicating and reconciling his results.[312] These technical difficulties cannot be addressed at this point. The basis upon which any subsequent contested determination of individual group members' claims should proceed from a causation perspective is addressed below. While the defendants will be bound by their forensic choices, the Court expects the parties to cooperate in accessing and applying Dr Altinakar's modelling.

170 Finally, as noted above, in his report dated 24 April 2018 Mr Collins briefly addressed the alleged underestimate of inflows used by Dr Altinakar at Rifle Range Road and along the Bremer River. The only relevant evidence he gave

[311] SBM.020.019.0001 at [104(c)].
[312] Ibid at [103].

was that because “Dr Altinakar has underestimated the flow contribution from Lockyer Creek by 800m^3/s and from the Bremer River flooding by 250m^3/s” then that was “material to the modelling simulations carried out by Dr Altinakar on the dam operation scenarios by Dr Christensen because of the relativity of dam flow contributions to the flooding compared to inflows downstream of the dam”.[313] In relation to the materiality of any underestimate of inflows at Rifle Range Road, Mr Collins accepted that the question of materiality ultimately had to be determined by hydraulic modelling.[314] The hydraulic modelling is now available and confirms that it is not material.

13.3.8: Use of Rifle Range Road Ratings Curve

171 In light of the above findings concerning the materiality of the differences between the corrected Malone hydrograph and the rated figures used by Dr Altinakar to Dr Altinakar’s modelling, it is arguably not necessary to address Dr Altinakar’s preference for the latter (at least so far as the plaintiff and the sample group members are concerned). However, as it may have the potential to affect other group members, it is appropriate to make findings on that topic at this point.

The Aurecon URBS Model and Rifle Range Road

172 The “Recalibration Report” described the area of the lower Lockyer Creek including Rifle Range Road as follows:[315]

> “The lower Lockyer floodplain has unique characteristics. A deep channel with banks perched above the floodplain level runs through a wide, flat floodplain. At Glenore Grove the flow divides between main channel flow and floodplain flow. Breakout from the channel commences at approximately 600 m³/s and increases rapidly as the flowrate increases. The maximum channel capacity peaks at under 1,000 m³/s.
>
> Although there are several opportunities for flow to transfer between the channel and floodplain where tributaries enter the channel, *the elevated overbanks mean that the channel and floodplain flows act almost completely independently*. The floodplain is several kilometres wide, but may average less than 0.6 m deep even during extreme events, and floodplain flow

[313] EXP.QLD.002.0033 at .0037.
[314] T 8747.10, T 8748.4, T 8748.35.
[315] SEQ.093.005.0190 at .0215.

velocities would be expected to be significantly lower than the main channel." (emphasis added)

173 This description of the area of the lower Lockyer Creek is reflected in the assessments of the performance of the ratings curve for Rifle Range Road. The Recalibration Report described that point as a "[p]erched channel in [a] wide floodplain with unreliable and potentially inconsistent response above bank-full capacity" such that there was a "[r]easonable fit of flow gauging data up to 15.85m (830m^3/s)" but the "[r]ating should not be used above bank-full (15.5m approx)".[316]

174 To address the difficulties with the topography of the lower Lockyer Creek and the problems with the ratings curves, the Aurecon URBS hydrological model used the following schematisation to represent flows in the area:[317]

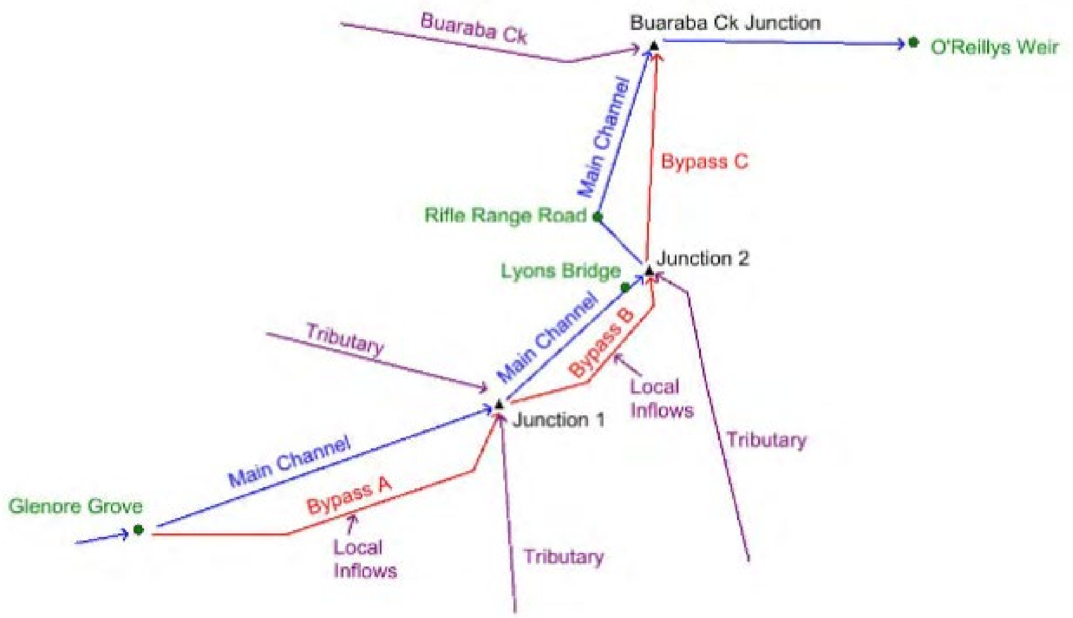

Figure 13-10: Aurecon URBS model schematisation of Lockyer Creek flows

175 O'Reilly's Weir, in the top right corner of this diagram, is located just prior to the confluence of Lockyer Creek and the Brisbane River. The flow of water through the main channel of Lockyer Creek is represented by the blue line.

[316] Ibid at .0202; see also the "Data, Rating Curve and Historical Flood Review Report": SEQ.093.005.0001 at .0069; see T 10342 to T 10343 (Dr Altinakar).
[317] SEQ.093.005.0190 at .0216.

Each of the red lines marked "Bypass A", "Bypass B" and "Bypass C" represent the flows that occur outside the main channel of Lockyer Creek. It can be seen that Bypass C notionally takes excess flood waters from around Lyons Bridge to Buaraba Creek Junction.

176 The Recalibration Report noted several key features of this schematisation,[318] including that "100% of flow above 980m^3/s were routed through the bypasses" and that local inflows between Glenore Grove and the Buaraba Creek Junction were included in the bypass channel rather than the main channel. In fact, all flows above 850m^3/s at Rifle Range Road are routed through Bypass C by the Aurecon URBS model.[319] The description in the Recalibration Report includes reference to the "reach length" factors which were selected for the bypasses which govern the flow times for water through these channels.[320] It follows that flow times may be, and most likely will be, different between the bypasses and the main channels. The Recalibration Report stated that "[a] reach length factor of 3.3 [was used] on the floodplain bypasses" and that "[t]his was selected as it gave the best overall calibration results at Savages Crossing".[321] Savages Crossing is approximately three hours downstream of the confluence of Lockyer Creek and the Brisbane River.[322]

177 The Recalibration Report included a comparison of the performance of the Aurecon URBS model against Seqwater's URBS model and the rated flows for various points on Lockyer Creek.[323] In relation to Rifle Range Road, the Recalibration Report stated:[324]

> "Seqwater summarised the performance of the Lockyer Creek sub-catchment model at Lyons Bridge and Rifle Range Road. However, as indicated from the rating curve review the rated flows at these sites for events with flow rates in excess of bankfull flow (800-900 m^3/s) are very uncertain and, apart from the February 1999 flood event, the other events considered in the recalibration

[318] Id.
[319] T 10342.7.
[320] SEQ.009.003.0359 at .0448; T 8669; T 8674 (Collins).
[321] SEQ.009.003.0190 at .0216.
[322] Chapter 2, Figure 2-6.
[323] SEQ.093.005.0190 at .0216 to .0219.
[324] Ibid at .0218.

> are far in excess of this threshold. Therefore, the comparison with the Seqwater model performance has been performed using the Glenore Grove site which was adopted as a primary site during the rating curve review."

178 In relation to the calibration against the measured flows at Glenore Grove, the Recalibration Report concluded that a "better calibration" was achieved by the Aurecon URBS model compared to Seqwater's URBS model.[325] However, it added:[326]

> "It is difficult to assess the overall performance of the model calibration for the Lockyer Creek sub-catchment model given the uncertainty associated with the rating curves especially in the higher flow range for the stream gauges situated in the lower reaches of this catchment. Calibration performance of the lower reaches has been reviewed through the Lower Brisbane model calibration at Savages Crossing."

179 Another feature of the Aurecon URBS hydrological model is the use of so-called conceptual or notional storages. The Recalibration Report noted that modelling the Lower Brisbane River presented a number of challenges including that the "the river responds differently at different flow rates".[327] It noted that the URBS model "attempted to account for [the difficulties with] flow patterns" by including "additional storage volume" to a known flow rate in the river (ie, conceptual or notional storage).[328] One such notional storage area was in the Lockyer Creek and was known as Conceptual Storage A. The Recalibration Report described that conceptual storage and the changes made to the URBS model by the Aurecon review in relation to it as follows:[329]

> "Conceptual storage A represents the storage around the confluence of Lockyer Creek and the Brisbane River. In the initial Seqwater modelling this storage also included areas and effects that are technically part of the lower Lockyer floodplain within the domain of the Lockyer URBS model. The revised schematisation of the lower Lockyer model and the increased reach length factors included in the floodplain bypass channels mean that these storage effects are now partly represented in the Lockyer Creek model, and the adopted storage volumes are therefore typically lower than those used by Seqwater, particularly for larger events as shown in Figure 3-11.

[325] Ibid at .0219.
[326] Id.
[327] Ibid at .0229.
[328] Ibid at .0230.
[329] Ibid at .0231 to .0232.

It should be cautioned that the behaviour of the floodplain storage areas in the lower Lockyer can be complicated depending on the magnitude and timing of Lockyer Creek and Brisbane River flows. The adopted storage profile appears to perform well under most of the examined calibration flood events, however large flows from the Upper Brisbane with little coincident flow in Lockyer Creek (eg releases from Wivenhoe) can flow back up Lockyer Creek. The URBS model cannot represent this type of flow behaviour and the storage volume would need to be increased to compensate."

Not Seeking to Replicate Flows Between Calibrated Points

180 In considering Dr Altinakar's explanation for preferring the rated flows compared to a combination of the flows in Bypass C and the main channel under the Aurecon URBS hydrological model, it is necessary to note that the Aurecon URBS hydrological model did not seek to replicate flows between the calibrated points. Rifle Range Road is not a calibrated point in the Aurecon URBS model.

181 The BRCFS Comprehensive Hydrologic Report stated that the Aurecon URBS model "represents the general catchment characteristics, as measured at the main calibration locations, but individual sub-areas within the model have not been explicitly represented or calibrated".[330]

182 Mr Collins' evidence was consistent with this. He had some familiarity with the Aurecon URBS hydrological model as that model provided the inflow hydrographs for the boundary conditions of the BRCFS hydraulic model with which he was familiar. Mr Collins agreed that the above schematisation was designed to broadly replicate previously observed water elevations or peak times, but it did not do that by modelling the precise route that water moved along through the catchment.[331] Mr Collins confirmed that the model was seeking to replicate flow heights at particular locations but not at every location:[332]

"Q. And again, to the extent that's done, the model wouldn't in fact be replicating the true physical conditions of the catchment, but it might nevertheless be matching travel times?

[330] ROD.519.008.0001 at .0048.
[331] T 8670.
[332] T 8674.46 to T 8675.9.

A. Well, I guess the proof may be in the pudding in that if the model is attempting to replicate flow time histories down the system and flow height systems at *discrete locations* down the systems, that's a method that has been used to achieve that outcome, but it's not physically real, what they've done, but it's a method of adjusting in the hydrologic model to get the calibration." (emphasis added)

183 Later he confirmed that the hydrological modelling "reached a high level of accuracy in terms of predicting flows, levels of relationships at specific places along the system" but added "*they can't do it everywhere"*.[333]

Dr Altinakar's Evidence on Rifle Range Road

184 As noted above, Dr Altinakar gave oral evidence in April 2018. He agreed that the boundary discharge he used for Lockyer Creek at Rifle Range Road had a peak flow rate of 3,674.99m^3/s,[334] and was sourced from the file "locky_tot.q"[335] within the Aurecon URBS model.[336] He agreed those figures were based on a rated flow derived from its rating curve[337] and the rating curve warned that the "*[r]ating should not be used above bank-full (15.5m approx)*"[338] which was exceeded during the January 2011 Flood Event. Dr Altinakar stated that in preparing his 2017 Set Up he reviewed the Recalibration Report[339] and from that he understood that the model assumed a flow in the main channel and routed a flow routed through a bypass (ie Bypass C).[340] However Dr Altinakar stated he could not access the data for the flow through the bypass because he could not execute the relevant computer program.[341]

185 According to Mr Malone's affidavit sworn 9 April 2018, if Dr Altinakar had been able to access the relevant figures they would have revealed a flow of 850m^3/s in the main channel and a peak flow of 3,581m^3/s in the bypass,

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333 T 8679.8.
334 T 3436.5 - .7. (Altinakar)
335 MSC.020.081.0001; T 3435.18 - .44.
336 T 3430.40 – T 3433.23.
337 T 3436.13 – .31.
338 Malone 4, LAY.SEQ.015.0001 at .0004.
339 SEQ.093.005.0190 at .0215 - .1216.
340 T 3442.13 to T 3443.9.
341 T 3447.25 - .29.

giving a total flow of 4,431m^3/s.[342] Thus the difference between the Aurecon URBS combined peak flows and the rated peak flow was 756m^3/s.[343]

186 In Revised Report 2, Dr Altinakar expressed the opinion that using the uncorrected Malone hydrograph resulted in an overestimation of the flows from the Lockyer Creek and that the "inflow hydrograph I used for that location in my 2017 Setup more closely reflects the true Lockyer Creek flows during the January 2011 Brisbane Flood".[344] As noted, by the time he prepared his March 2019 Report, Dr Altinakar had received the corrected Malone hydrograph. After he considered that, he affirmed his opinion about the use of the rated flows at Rifle Range Road.[345]

187 In explaining this conclusion, Dr Altinakar noted that the Aurecon URBS hydrological model used "additional storage volume" or notional storages as outlined above.[346] Dr Altinakar also noted that the various adjustments were made to match the hydrographs at the "main calibration locations". Dr Altinakar concluded that Aurecon URBS model "was not intended to model the true flows for each location or sub-area in that model".[347] That conclusion accords with the above findings. Dr Altinakar also noted that there was an "adjustment" made in the Aurecon URBS model "which has the effect of conceptually storing water [flowing through Lockyer Creek or the floodplain] before the confluence with the Brisbane River".[348] Dr Altinakar considered that using the (uncorrected and corrected) Malone hydrographs without the adjustment for notional storage in the Aurecon URBS model would result "in an overestimation of the flows immediately upstream of O'Reilly's Weir".[349] There is no equivalent of a conceptual or notional storage in a hydraulic model. As stated, it seeks to replicate the physical process of water flow through a catchment.

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[342] Malone 4, LAY.SEQ.015.0001 at [11].
[343] 4431m^3/s – 3675m^3/s = 756m^3/s.
[344] Revised Report 2 at [116].
[345] 2019 Report, EXP.ROD.021.0001 at [11].
[346] Revised Report 2 at [117] to [119].
[347] Ibid at [119].
[348] Ibid at [120]. In cross-examination on 19 March 2019, Dr Altinakar corrected this so that conceptual storage A extends from Glenore Grove past O'Reilly's Weir to Lowood: T 10457.37 to .41 When asked about its materiality of that difference he said "not much": T 10456.38.
[349] Ibid at [130]; 2019 Report at [15].

188 Dr Altinakar ultimately concluded:[350]

> "Mr Malone's hydrograph may be relevant to the modelling framework Aurecon has used to calibrate the hydrologic model, but one has to refrain from adopting this hydrograph for two-dimensional numerical simulations given the complex schematization of the Lockyer Creek area and the fact that the Aurecon URBS Model is calibrated to match the main calibration locations within the model and is not necessarily taking into account the true flows between those main calibration locations, as DSS-WISE™ does."

189 Dr Altinakar identified three quantitative assessments that justified his opinion concerning the use of rated flows at Rifle Range Road in his hydraulic modelling.

190 First, Dr Altinakar undertook an analysis that involved cumulating the Aurecon URBS hydrographs for Rifle Range Road and the other Lockyer Creek sub-catchments and sub-catchment local flows. This yielded a cumulated peak of 5047.7m^3/s. Dr Altinakar compared that to a cumulation of those hydrographs although he substituted the rated hydrograph for Rifle Range Road for the Aurecon URBS hydrograph. That summation yielded a cumulated peak of 4682m^3/s. Dr Altinakar noted that the latter figure was a closer match to the Aurecon URBS calculated peak of 4373m^3/s at O'Reilly's Weir than the former.[351] Dr Altinakar acknowledged that this analysis did not "adjust for travel time or the dynamic of the true flows in the catchment".[352]

191 Second, Dr Altinakar compared the peak flow at O'Reilly's Weir produced by the 2017 Set Up of his hydraulic model with the peak flow calculated by the Aurecon URBS hydrological model at the same point. Dr Altinakar noted that his hydraulic model produced a peak of 4,331m^3/s and the Aurecon URBS model produced a peak of 4,373m^3/s.[353] Based on this, Dr Altinakar stated that he concluded that the 2017 Set Up "was not significantly underestimating the flow from Lockyer Creek".[354]

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[350] Revised Report 2 at [130].
[351] Ibid at [125]; 2019 Report, EXP.ROD.021.0001 at [13]-[14].
[352] Revised Report 2 at [123]; 2019 Report at [11].
[353] Revised Report 2 at [128].
[354] Ibid at [128]; 2019 Report at [15].

192 Thirdly, in his oral evidence, Dr Altinakar observed that his hydraulic model closely matched the measured stage hydrograph for Savages Crossing during the January 2011 Flood Event.[355] Dr Altinakar considered that this suggested that his hydraulic model was correctly modelling the flows at O'Reilly's Weir.[356]

193 Various criticisms of this analysis were made by Seqwater which are addressed below.

Mr Ayre's Evidence

194 Seqwater placed reliance on part of Mr Ayre's evidence that was said to contradict Dr Altinakar's evidence in relation to the use of rated flows at Rifle Range Road.[357]

195 Mr Ayre was the project leader for the hydrology phase of the BRCFS.[358] He was briefly cross-examined on this topic by Senior Counsel for Seqwater.[359] He was taken to the passages from Aurecon's "Data, Rating Curve and Historical Flood Review Report" that addressed the accuracy of the rating at Rifle Range Road.[360] He confirmed its conclusions and added that "[o]ur preference was to rely on some of the gauges further upstream, which were a little bit more confined and not as vulnerable to out-of-bank flows, as such, yes".[361]

196 In relation to Bypass C in the Aurecon URBS model, Mr Ayre was asked as follows:[362]

> "Q. So is it right that the model produces an estimate of both the main channel at Rifle Range Road and also Bypass C?
> A. Yes, it would have flows in both those channels, provided the overflow level for the bypass is achieved, yes.

[355] T 10498.42 to T 10499.15, T 10502.35 - .40; MAS5 at [341].
[356] T 10503.28.
[357] SBM.020.019.0001 at [75(a)] and [80].
[358] T 7482.43.
[359] T 7481 to T 7485.
[360] SEQ.093.005.0001 at .0069.
[361] T 7483.40.
[362] T 7484 to T 7485.

Q. And they join at the Buaraba Creek junction, do they?
A. Yes, I think that was - *just for convenience,* they were all reattached, I suppose, before they discharged through O'Reilly's Weir.

…

Q. Would it be right that the model estimate produced by the URBS model, combining the main channel for Rifle Range Road and Bypass C would be a better estimate than a flow derived from the DNRM rating [ie, the rated flow] for Lockyer Creek at Rifle Range Road?
A. Yes, we certainly believed the arrangement that we incorporated into the runoff routing model *gave a more realistic overall assessment of particularly the high flow estimates*.

MR POMERENKE: Thank you, Mr Ayre.

HIS HONOUR: Q. Mr Ayre, is Bypass C effectively a mathematical construct, or is that actually where it is expected water would flow?
A. It's - *well, it is, I suppose, a conceptual arrangement that's been incorporated into the model.* Simply, it's representing flows out on to the floodplain, which are potentially rather shallow and extensive.

Q. Which end up in the river somewhere?
A. They do, yes, find their way back in, yes." (emphasis added)

197 In their supplementary submissions on causation, Seqwater and the plaintiff debated the effect of this evidence from My Ayre. Seqwater contended that Mr Ayre agreed that the "modelled estimate produced by the Aurecon URBS model, combining the main channel for Rifle Range Road and Bypass C, would be a better estimate than a flow derived from the rating curve for Lockyer Creek at Rifle Range Road".[363] Seqwater contended that Mr Ayre's evidence was in direct conflict with the evidence of Dr Altinakar noted above. The plaintiff contended that, read in context, all that Mr Ayre said was that he considered that the "schematisation of the lower Lockyer [Creek] in the Aurecon URBS model produced more realistic *overall* results" presumably for the lower Lockyer Creek area.[364] The plaintiff contended that Mr Ayre did not "endorse the proposition that the exercise performed by Mr Malone in his

[363] SBM.020.019.0001 at [75(a)] citing T 7483.13 - .43 (when presumably it was intended to cite T 7485.5 to T 7485.13).
[364] SBM.010.017.0001 at [86].

fourth affidavit produced a more reliable result at Rifle Range Road than would be produced using the rated flow".[365]

198 While I accept that Mr Ayre's answer was an expression of a *preference* "overall" for the combined main channel and bypass flows at a place like Rifle Range Road (as compared to the rated flow), I do not accept the next step in Seqwater's argument, that his evidence on this is in "direct conflict" with Dr Altinakar's evidence. The extract from Dr Altinakar's Revised Report 2 set out at [188] above makes it clear that his preference for the rated flows was stated in the context of using it as an input for his hydraulic model (which does not have any conceptual or notional storages or bypasses). Mr Ayre's answers were not given in the same context. Instead, Mr Ayre's answers make clear what is otherwise apparent from the Recalibration Report and Mr Collins' evidence, namely that this aspect of the Aurecon URBS model is only a schematisation of the flows in the Lockyer Creek, which incorporates bypass channels as a "conceptual arrangement" that seeks to represent flows on the floodplain and "reattach" them at Buaraba Creek Junction "just for convenience". It does not seek to undertake the function of a hydraulic model and calculate the flows at each specific location. The implication of "reattach[ing]" them "just for convenience" at Buaraba Creek Junction is that they could have been reattached anywhere provided that it was before Mt Crosby Weir, and provided that the calibration to the "gauges further upstream" and downstream (at Savages Crossing) were reasonable. At least so far as considering the suitability of inflow figures for use in Dr Altinakar's hydraulic model, Dr Altinakar is in the best position to express an opinion on the appropriate inflow discharge to use.

Seqwater's other Criticisms of Dr Altinakar's Use of Rated Flows

199 Seqwater contended that Dr Altinakar's defence of his use of the rated flows at Rifle Range Road was inconsistent with his oral evidence in 2018 concerning the general superiority of the inflows from the Aurecon URBS

[365] Id.

model.[366] I do not accept that there is any such inconsistency. Dr Altinakar expressed a preference for the Aurecon URBS figures generally but when he was (eventually) given the opportunity to examine one particular hydrograph he preferred the rated flows. At no stage did Dr Altinakar state that he uncritically accepted all of the Aurecon URBS flows at the boundaries of his modelling.

200 Seqwater made a number of submissions to the effect that relying on the rating for depths above 15.5m for Lockyer Creek at Rifle Range Road was an unreliable basis for estimating flow rates.[367] However, as noted by the plaintiff,[368] unreliability in this context is a question of degree and the comparison exercise undertaken by Dr Altinakar addresses the extent of it in the context of his hydraulic modelling.

201 Seqwater contended that "[Dr] Altinakar agreed that the Aurecon URBS model treats independently, and computes independently, flows through the Lockyer Creek channel and flows through the flood plain through what Aurecon describes as Bypasses A, B and C".[369] It also contended that "he … accepted that by use of the bypasses, the Aurecon URBS model overcomes the challenges caused by the topography of the Lockyer Creek floodplain between Glenore Grove to the junction of Buaraba Creek".[370] The first of these propositions is no more than a recitation of the purpose of the schematisation approach noted above. The evidence said to support the second proposition was the following exchange:[371]

> "Q. What I would suggest to you is that what the model does, by use of the bypasses, is to overcome the challenges caused by the topography of the Lockyer Creek floodplain between Glenore Grove to the junction of Buaraba Creek?
> A. Yes.
>
> Q. So the model, insofar as it does that, doesn't have any shortcomings?

[366] SBM.020.019.0001 at [74] and [85].
[367] Ibid at [80].
[368] SBM.010.017.0001 at [90].
[369] SBM.020.019.0001 at [84].
[370] Ibid at [84], citing T 10310.44 - T 10311.1; T 10314.29 – T 10315.11; T 10316.19 - .24; T 10323.1 - .5.
[371] T 10323.1 - .9.

A. I cannot assume that."

202 In the first answer Dr Altinakar simply accepted how the model sought to overcome the challenge posed by topography of the area. In the second answer he did not (necessarily) accept that it had done so.

203 Seqwater also contended that the arrival of the timing of the peak at Glenore Grove, which occurred after the arrival of the peak of the rated flow at Rifle Range Road, suggested that the latter was unreliable.[372] It contended that the timing of both the rated and the modelled peak flow at Glenore Grove was accurate because the estimated travel time between Glenore Grove and O'Reilly's Weir is 11 hours. Seqwater noted that a peak flow at Glenore Grove at around 5.00pm to 6.00pm on 11 January 2011 would have an estimated arrival time at Mt Crosby Weir at around 5.00am on 12 January 2011. Mr Collins' estimate of the arrival time of the peak at Mt Crosby Weir was at around 7.00am on 12 January 2011.[373] Seqwater contrasted that with Dr Altinakar's modelling of a peak flow at O'Reilly's Weir arriving at around midnight on 12 January 2011,[374] which it contended was inconsistent with the estimated travel time from Glenore Grove to O'Reilly's Weir.[375]

204 As noted, there is a strong correlation between Dr Altinakar's modelling of the peak flow rate at O'Reilly's Weir with that produced by the Aurecon URBS hydrological model (4331m^3/s for the 2017 Set Up v 4373m^3/s for Aurecon URBS). However, there is a discrepancy as to the timing of the peak (midnight v 7.00am). One step in Seqwater's reasoning is to assume the correctness of the timing of the peak flow at O'Reilly's Weir calculated by the Aurecon URBS hydrological modelling compared to Dr Altinakar's hydraulic modelling. The only evidence that bears upon the timing of the peak at O'Reilly's Weir was given by Mr Keller whose property is located at the confluence of Lockyer Creek and the Brisbane River. Mr Keller stated that the flood "water peaked at approximately 11.00 pm [on 11 January 2011] and, finally, started to decline

[372] SBM.020.019.0001 at [86] – [87].
[373] Ibid at [87]; EXP.QLD.001.1285 at .1295; T 10369.20 – .22 (Altinakar).
[374] T 10370.30 - .40.
[375] SBM.020.019.0001 at [87] and [88(d)].

in the early morning”.[376] This supports the timing of the peak as modelled by Dr Altinakar. Otherwise, when he was asked about the peak at Rifle Range Road occurring prior to Glenore Drive, Dr Altinakar acknowledged that this could be reflective of the unreliability of the rated flows but noted that it could also be the result of “other discharges joining [the watercourses before] Rifle Range Road”.[377] Given the level of correlation achieved by the 2017 Set Up, the timing of the measured peak at Glenore Grove does not undermine Dr Altinakar’s use of rated flows in the 2017 Set Up.

205 Seqwater submitted that Dr Altinakar’s summation analysis described above (at [190]) does not provide any reasonable justification for the use of the rated flows at Rifle Range Road.[378] Seqwater noted Dr Altinakar’s description of that exercise as “simple”[379] and his acknowledgement that “*simply adding hydrographs does not adjust for travel time or the dynamic of the true flows in the catchment*”.[380] Thus, it contended that merely adding the peak flows in the sub-catchments does not address the time at which they would have combined so that a comparison of the final cumulated sums to the calculated peak at O’Reilly’s Weir does not assist in deciding between using the rated flow at Rifle Range Road or the flow calculated by combining the channel flow rate and bypass flow rate in the Aurecon URBS hydrological model.[381]

206 In cross-examination, Dr Altinakar explained that his “simple” summation approach was undertaken as part of a qualitative assessment concerning the absorption of flow within the lower Lockyer Creek area.[382] He said that when he obtained the uncorrected Malone hydrograph he had difficulty in understanding how, even allowing for attenuation, timing differences and the topography of the area, a difference of around 979m^3/s between the combined hydrograph peak flows and the Aurecon URBS hydrological model

[376] LAY.ROD.008.0001 at [46].
[377] T 10378.21.
[378] SBM.020.019.0001 at [88].
[379] Revised Report 2 at [123] and see, e.g., T 10363.39 - .40.
[380] Revised Report 2 at [123].
[381] SBM.020.019.0001 at [88].
[382] T 10379 – T 10380.

peak flows at O'Reilly's Weir could be absorbed across the floodplain.[383] He said that, based on his experience, the difference he produced of around 309m^3/s was more likely to be the correct figure.[384] The same reasoning applies, although with less force, in relation to the corrected Malone hydrograph. By itself, this approach may not justify Dr Altinakar's preference for the use of the rated flows in his hydraulic modelling, but when taken with the other matters he relied on it does.

207 The last point made by Seqwater in relation to this topic was that it disputed Dr Altinakar's reliance on a comparison of the hydrograph calculated by his modelling for Savages Crossing compared to the measured hydrograph for that location.[385] It proffered four criticisms.

208 First, it contended that this justification for Dr Altinakar's reliance on the rated flows arose in re-examination that itself arose out of a part of his cross-examination that compared the modelled hydrograph at Savages Crossing produced by the 2017 Set Up with the modelled hydrograph at Savages Crossing produced by the Aurecon URBS hydrological model. Seqwater contended that Dr Altinakar's comparison exercise was between his modelling and the measured hydrograph at Savages Crossing. It submitted that it was not based on anything to do with the Aurecon URBS modelling or any examination of the rating and thus amounted to "comparing apples with oranges".[386]

209 If anything, this amounts to comparing apples with a slightly different apple. Dr Altinakar compared his calculated flows at Savages Crossing under the 2017 Set Up with the measured flows which were derived from the DNRM rating.[387] The Recalibration Report described the rating at Savages Crossing as providing a "reasonable fit of flow gauging, steady flow release and hydrological model data".[388] Aurecon recalibrated that rating and estimated

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[383] 5352m^3/s from summation method compared with 4373m^3/s at O'Reilly's Weir.
[384] T 10379.
[385] SBM.020.019.0001 at [90] to [95].
[386] Ibid at [92].
[387] MAS5 at [341]; MAS1 at [335].
[388] SEQ.093.005.0190 at .0203.

that its rating produced a variation of between only -2 to +7% on the original DNRM rated peak flow.[389]

210 Further, in its submissions in reply, the plaintiff compared both the Aurecon rerated hydrograph at Savages Crossing and the Aurecon URBS model calculated hydrograph at Savages Crossing with the hydrograph for that location produced by Dr Altinakar's 2017 Set Up.[390] The plaintiff contended that it showed that Dr Altinakar's model calibrates very well with both hydrographs such that "his model simply cannot be regarded as materially underestimating the flows from the Lockyer Creek as compared to the Aurecon URBS model".[391] Those contentions should be accepted.

211 Second, Seqwater contended[392] that, in his evidence explaining the correlation between the calculated flows at Savages Crossing under his 2017 Set Up and the measured flows,[393] Dr Altinakar wrongly compared his results with the measured results for a combination of the main channel of the Brisbane River and a breakout channel.[394] It contended that Dr Altinakar should have compared his modelled flow with the measured discharge hydrograph for the main channel of Brisbane River (ie, he should not have included the flow in the breakout channels).[395] I am not persuaded that this was an error. Dr Altinakar's hydraulic model sought to model all flows both inside and outside the river channel and thus the relevant comparator should have been the combined flows.

212 Third, in any event, Seqwater contended that the 2017 Set Up showed a poor calibration to the measured hydrograph at Savages Crossing.[396] I have already rejected that proposition.

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[389] Ibid at .0204.
[390] SBM.010.017.0001 at [96].
[391] Ibid at [97].
[392] SBM.020.019.0001 at [93].
[393] T 10504.1.
[394] Being Observation Line 9 as depicted in MSC.010.559.0001.
[395] Being Observation Line 10; see MAS5 at .0279.
[396] SBM.020.019.0001 at [94].

213 Fourth, Seqwater contended that there was a discrepancy between the timing of the peak flow at O'Reilly's Weir under the 2017 Set Up, namely midnight on 12 January 2011, and the timing of the peak flow at Savages Crossing derived using the revised rating for Savages Crossing, which was also midnight.[397] Seqwater noted that Savages Crossing is approximately 3.75 hours flow time downstream from O'Reilly's Weir. Seqwater appeared to suggest that this meant that under Dr Altinakar's modelling the peak from Lockyer Creek would be expected to arrive at Savages Crossing at around 4.00am. The plaintiff noted (correctly) that the Aurecon URBS hydrological model calculated peak at Savages Crossing (as opposed to the rerated peak) closely coincides with the peak in Dr Altinakar's modelling.[398] Otherwise, even if it was based on valid comparators, the point made by Seqwater is not really a "discrepancy" when it is remembered that flows at Savages Crossing include both the flow through Mt Crosby Weir from Lockyer Creek and releases from Wivenhoe Dam. Seqwater appeared to acknowledge this when it was stated that "[t]he only reasonable conclusion suggested by these matters is that releases from Wivenhoe were a greater contributor to the peak at Savages Crossing than the flow from Lockyer Creek".[399] That may be correct but it does not undermine Dr Altinakar's reliance on the rated flows at Rifle Range Road.

214 Finally, it is necessary to address one contention made by SunWater in support of its submission that the boundary condition for Dr Altinakar's hydraulic model should have been moved to Glenore Grove.[400] SunWater noted (correctly) that the Aurecon URBS hydrographs for O'Reilly's Weir and Rifle Range Road were not calibrated at those locations. It contended that comparing an uncalibrated output from the Aurecon URBS model at O'Reilly's Weir to an "uncalibrated calculation", being the rated flows at Rifle Range Road, was "meaningless".

[397] Ibid at [95].
[398] SBM.010.017.0001 at [99].
[399] SBM.020.019.0001 at [95].
[400] SBM.030.011.0001 at [28] to [33].

215 To address this, it is necessary to recall why Dr Altinakar went down this path in the first place. In Revised Report 2, Dr Altinakar prefaced his explanation of the justification for using the rated hydrograph at Rifle Range Road by reference to the Aurecon URBS model calculated hydrograph at O'Reilly's Weir by expressly noting (correctly) that it was Mr Collins' evidence that the latter was "likely to be accurate".[401] Hence, he compared the hydrograph produced by the 2017 Set Up to the Aurecon URBS hydrograph for that location. In answer to questions posed by the Court, each of the defendants adopted Mr Collins' estimates of the inflows into Lockyer Creek which were based on the Aurecon URBS modelling at O'Reilly's Weir.[402]

216 SunWater's submissions attack Dr Altinakar's credit for using the Aurecon URBS model figures for this purpose in circumstances where he also stated that he could not say with certainty that the Aurecon URBS calculated results at O'Reilly's Weir were accurate.[403] Dr Altinakar agreed he had not read any material from Aurecon asserting that it was likely to be accurate and reliable.[404] SunWater contended that it was a matter adverse to Dr Altinakar's credit that he was prepared to act on an assumption he did not believe to be true and that otherwise his evidence was "marked by evasion".[405]

217 I do not accept these submissions. This aspect of the analysis simply involved Dr Altinakar addressing a criticism that he modelled an inflow discharge at a particular point, namely Rifle Range Road, without using the rated flow nominated at that point by a particular model, the Aurecon URBS model. He responded to that criticism by stating that the figure he used, namely the rated flow, produced a reasonable comparison to the result produced by that model at the next significant point just downstream, namely O'Reilly's Weir. Dr

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[401] Revised Report 2 at [122]; T 8724.14 to .19 (Collins).
[402] As noted by the plaintiff, SBM.010.017.0001 at fn 14: "In response to Question 9(a), the State identified the approximate peak flow from Lockyer Creek in the 2011 event as 4,400 m³/s, referring to Mr Collins' October 2017 correction report (AID.500.027.0001 at .0004). This response was adopted by Seqwater (AID.500.023.0001_2 at .0006_2) and SunWater (AID.500.037.0001 at .0004) in their responses to Question 9. This reference was later clarified as Figure 3-1 in the May 2017 report (T 10232.45; T 10234.16). The State confirmed that Figure 3-1 was based on data sourced from O'Reilly's Weir (MSC.010.384.0001)."
[403] T 10459.32.
[404] T 10460.21; see also T 10460.32 to .40.
[405] SBM.030.011.0001 at [36].

Altinakar was doing no more and no less than addressing the framework of the criticism levelled against him.[406]

218 Otherwise, I do not accept that Dr Altinakar was “evasive”. To the contrary, I was impressed with his candour and his lack of frustration about this topic. This entire debate only arose because an affidavit containing the uncorrected Malone hydrograph was served just prior to his giving evidence in April 2018. It was served and relied on contrary to court directions and a statement by the party who served it that would not be relying on evidence in response to Dr Altinakar’s reports.[407] When Dr Altinakar came to address the hydrograph, he was denied access to it and was forced to use an (arguably) misleading version.[408] Dr Altinakar was only able to obtain the corrected Malone hydrograph in March 2019. He sought to address the criticism of him that he should have used a hydrograph derived from the Aurecon URBS model. He sought to answer that criticism by reference to the next relevant hydrograph downstream produced by that very model. He was then accused of partiality for doing so.

13.3.9: Movement of Boundary Location from Rifle Range Road to Glenore Grove

219 As just noted, SunWater contended that Dr Altinakar “ought to have dealt with the defendants’ criticisms [of his inflow data at Rifle Range Road] by modifying the 2017 Set-Up so as to utilise calibrated data from the Aurecon studies to extend his boundary conditions to Glenore Grove”, that being the boundary of the Aurecon URBS hydrological model. The Aurecon URBS model was calibrated at that point.[409] SunWater’s submissions include trenchant criticism of Dr Altinakar’s credit for adopting the approach he did.[410] That attack has just been addressed.

[406] See T 10459 to T 10461.
[407] *Rodriguez (No 18)* at [14].
[408] *Rodriguez (No 20)* at [2].
[409] SBM.030.011.0001 at [29] to [39].
[410] Ibid at [29] – [39].

220 The suggestion that the boundary of the 2017 Set Up should have been moved to Glenore Grove was not supported by any expert evidence. Mr Collins did not suggest that the boundaries should be moved. When it was suggested to Dr Altinakar in cross-examination that he should have used Glenore Grove as the boundary condition, Dr Altinakar stated that "2D model[s] and 1D[s] model are totally different things and I have other types of considerations … when I'm setting the boundaries of my model".[411] Dr Altinakar's model is a two-dimensional model. The Aurecon URBS hydrological model is a one-dimensional model.

221 In re-examination, Dr Altinakar explained that the "other considerations" affecting the extension of the boundary condition included the "quality of the topographic data", the impact of moving the boundary on the computation time of the model, whether the extra area being included was of interest to the users of the model and the elevation of the boundary condition.[412] Thus, Dr Altinakar explained that upstream from Rifle Range Road, the channel narrows and becomes harder to resolve in a two-dimensional hydraulic model, even using a 10-metre resolution.[413] He also stated that extending the model to Glenore Grove would have involved the addition of "1.5 or 2 million additional cells" which would have lengthened the computational time by several days and been unnecessary because it was not an area of interest in the litigation.[414] Finally, Dr Altinakar stated that "we had decided that […] Rifle Range Road should be the boundary because also I was able to extend a line, as the boundary of my 2D model, and attach it to the left and right side of the river to a higher elevation, preventing any water that I'm applying towards downstream to return and then come to the upstream of the point of application".[415]

222 I accept Dr Altinakar's explanation.

[411] T 10464.11.
[412] T 10543.12 to T 10543.47.
[413] T 10543.14.
[414] T 10543.28
[415] T 10543.36 to .42.

13.3.10: Bremer River Inflows

223 Seqwater contended that Dr Altinakar did not use the most reliable information so far as his modelling incorporated inflows from the Bremer River.[416] To address this, it is necessary to explain further the boundary conditions he adopted for the Bremer River in the 2017 Set Up.

224 In MAS5, Dr Altinakar provided the following figure identifying the source areas he adopted along the Bremer River:[417]

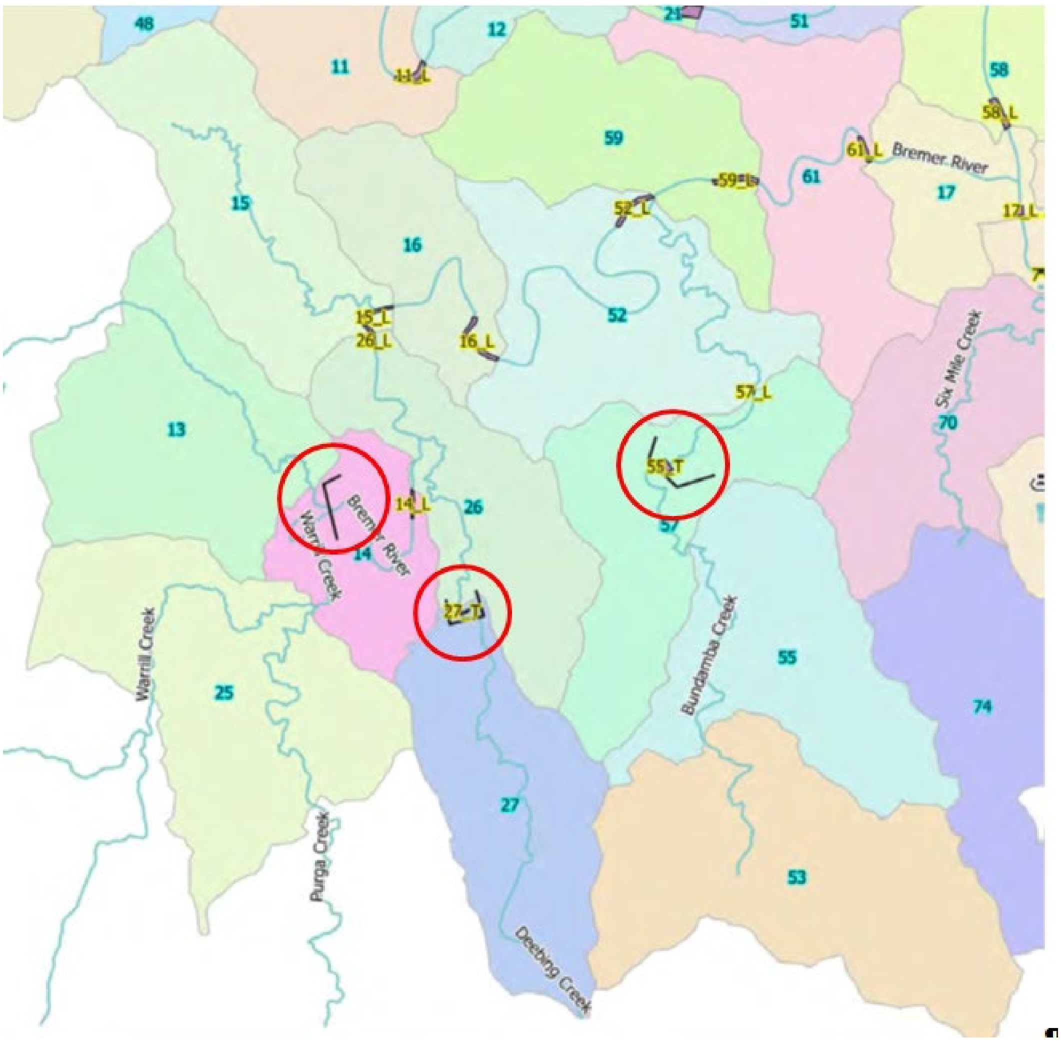

Figure 13-11: Source areas along the reach of the Bremer River modelled by Dr Altinakar.

225 The Bremer River joins the Brisbane River in the top right corner of this diagram. The three black lines that are enclosed in red circles represent the

416 SBM.020.019.0001 at [107]; Seqwater subs at [2512] to [2516].
417 MAS5 at .0262.

boundary conditions adopted by Dr Altinakar for flows in the Bremer River. The black line on Deebing Creek that has the code "27_T" represents the source data for inflow discharge at that point. The code "27_T" corresponds to the total of inflows of all tributaries upstream from that point taken from the Aurecon URBS model.[418] Similarly, the black line on Bundamba Creek with the code "55_T" represents the source data for inflow discharge at that point. The code "55_T" corresponds to the total inflows of all tributaries upstream from that point taken from the Aurecon URBS model.[419] The other circled black line, just past the confluence of Warrill Creek and the Bremer River, represents the boundary condition "BND05" adopted by Dr Altinakar.[420] The other figures in black with the suffix "L" represent local flows. The numbers in particular areas correspond with the area codes used in the Aurecon URBS model.

226 For the local flows, as well as 27_T and 55_T, Dr Altinakar utilised the inflow discharge from the Aurecon URBS model. However, for BND05 he used the same discharge hydrograph that he used in his 2015 Set Up.[421] There were two sources of information for that hydrograph. For the period prior to 9.00am on 5 January 2011, Dr Altinakar used a summation of the flows from three tributaries upstream of BND05 being Bremer River at Walloon,[422] Warrill Creek at Amberley[423] and Purga Creek.[424] For the period after 9.00am he used a worksheet of figures prepared by Mr Ayre.[425] He produced a combined hydrograph from those figures as follows:

[418] MAS5 at .0264.
[419] Ibid at .0264.
[420] Id.
[421] MAS5 at .0265; MAS1 at .0200.
[422] MAS1 at .0191.
[423] Ibid at .0194.
[424] Ibid at .0196.
[425] Ibid at .0199, [373].

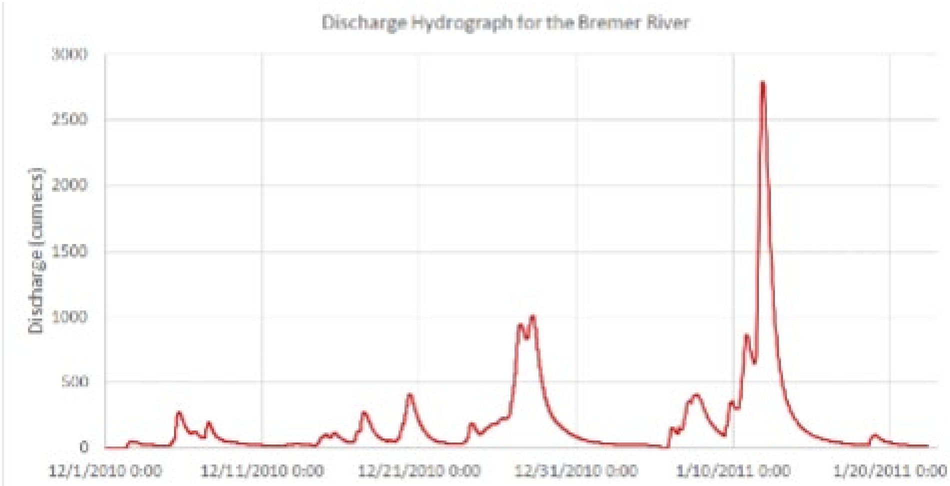

Figure 13-12: Hydrograph used by Dr Altinakar at Boundary condition BND05

227 On 11 April 2018, Dr Altinakar was cross-examined on the use of the figures in this hydrograph compared to the figures produced by the Aurecon URBS hydrological model. Five matters should be noted about the cross-examination.

228 First, Dr Altinakar explained that between his 2015 Set Up and 2017 Set Up he retained the hydrograph in Figure 13-12 because it was a "well-constructed hydrograph, which was starting at a date much earlier than that which was available in the [Aurecon URBS] hydrologic simulations".[426]

229 Second, Dr Altinakar was taken to the Aurecon URBS hydrograph figures for a point described as "14_T" in a spreadsheet that was shown to him, namely MSC.020.082.0001, which is referable to the total flows coming <u>out</u> of the area marked "14" in Figure 13-11.[427] Dr Altinakar placed BND05 at the point in which flows <u>enter</u> area 14. The spreadsheet that he was cross-examined on identified a peak flow of 3045m^3/s for 14_T at 10.00pm on 11 January 2011.[428] The transcript records that the cross-examiner suggested that the peak of the hydrograph in Figure 13-12 was "in the order of 2700m^3/s" and the difference between the peak flow in Figure 13-2 and the peak flow for 14_T

[426] T 3464.27.
[427] T 3459 to T 3460.
[428] MSC.020.082.0001; column BR; row 246; T 3460.18; see email from Seqwater's solicitors to the Court on 13 November 2019.

was "about 250m^3/s" to which Dr Altinakar agreed.[429] This may be a typographical error in the transcript as the difference between those figures is more "about 350m^3/s" and the figure of 2700m^3/s as recorded in the transcript is wrong. In MAS1, Dr Altinakar explained that the peak of the hydrograph in Figure 13-12 is 2793m^3/s[430] which occurs at 9.00pm on 11 January 2011.[431] This yields a difference of 252m^3/s which is close to what the cross-examiner suggested and Dr Altinakar accepted.

230 However, to add to the confusion, in its submissions the plaintiff referred to a spreadsheet with flow rates[432] from the Aurecon URBS model which included a column for 14_T that had a peak at 11.00pm on 11 January 2011 of 2991m^3/s.[433] In November 2019, the parties clarified that this was the correct spreadsheet for the Aurecon URBS discharge figure at 14_T on the Bremer River.[434]

231 Third, in relation to the difference between the Aurecon URBS figures and the figures he used, Dr Altinakar noted that some of that difference would be reduced because BND05 was located at the beginning of the Bremer River's flow within area 14 whereas "14_T" was located at the end of the river's flow within area 14 and so his modelling would pick up local flows for area 14 (ie, "14_L").[435] To that end the plaintiff submitted that the relevant comparator to the figures used by Dr Altinakar was a summation of the flows from area 13 and 25[436] as that would exclude the local flows added after BND05. The plaintiff contended that the difference in the peak flow rate at 9.00pm on 11 January 2011 between those flows and the peak of the hydrograph in Figure 13-12 was 194m^3/s.[437]

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[429] T 3461.3.
[430] MAS1 at [372].
[431] Spreadsheet attached to email from plaintiff's solicitor dated 5 November 2019; combination to use "tab", row 3557; column B.
[432] MSC.010.542.0001; SBM.010.017.0001 at [108].
[433] Column BS; row 231.
[434] See email from Seqwater's solicitor to the Court dated 13 November 2019.
[435] T 3461.21 to .27.
[436] SBM.010.017.0001 at [108].
[437] Which appears to be calculated as follows: the sum of column BP, row 230 and column BG, row 230 in MSC.010.542.0001 = 881.45m^3/s + 2105.72m^3/s – 2793m^3/s = 194m^3/s.

232 Fourth, in cross-examination of Dr Altinakar it was suggested that he had applied the inflow discharges from Mr Ayre's worksheet (ie Figure 13-12) at the wrong location.[438] Dr Altinakar explained that it was his understanding that Mr Ayre's discharge figures were to be applied "at the model boundary, which is immediately downstream of the confluence with Warrill Creek".[439] Dr Altinakar was then asked:[440]

> "Q. But if Mr Ayre's estimate was actually an estimate of the discharge from the Bremer River *at O'Reilly's,* so that it was already picking up downstream tributaries between your boundary BND05 and *O'Reilly's Weir* - if you were to take Mr Ayre's estimate and apply it back at BND05 and then add in again downstream tributaries, there would be an element of double-counting; do you agree?
>
> A. That's exactly my point. Not exactly, because the difference between Mr Ayre's peak value and the summation of the peaks of the three gauges I was using to construct - they are very close to each other. That means that even if Mr Ayre took into account the downstream values, the difference was almost - very small." (emphasis added)

233 Of course, O'Reilly's Weir is not to be found at the confluence of the Bremer River and Brisbane River. Instead, it is located at the confluence of Lockyer Creek and the Brisbane River. However, the import of the questioning was to suggest that Mr Ayre's figures were referable to the discharge at the confluence of the Bremer and Brisbane Rivers. Dr Altinakar's answer was to the effect that there was little difference because the downstream inflows after BND05 were "very small".[441] In fact, Mr Ayre's figures were not referable to the confluence of the Bremer River and the Brisbane River but to the flow at the Dave Trumpy Bridge in Ipswich.[442] That is in area 52 of Figure 13-11 and before the confluence of Bundamba Creek with the Bremer River. On the one hand it meant that Dr Altinakar double counted the inflows between BND05 and that point (ie, the local flows and 27_T), however on the other, that double counting mitigated the difference between the Aurecon URBS discharges at the end of region 14 and the figures used by Dr Altinakar, as the discharge at the commencement of region 14.

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[438] T 3462 – T 3465.
[439] T 3462.11.
[440] T 3463.16.
[441] See T 3463.7 and T 3463.28 (Altinakar).
[442] T 7482.30 (Ayre).

234 Fifth, as noted by the plaintiff in its submissions,[443] at no stage was any question directed to Dr Altinakar as to the materiality or even the potential materiality of the difference between the Aurecon URBS flows and the flows Dr Altinakar used or the difference in locations between Mr Ayre's hydrograph and Dr Altinakar's location of BND05. This is contrast to the cross-examination concerning the inflows at Rifle Range Road when Dr Altinakar was specifically asked about the potential materiality of a difference of flow of approximately 750m^3/s. As noted above, when he was asked that Dr Altinakar suggested it was unlikely to be material and that any effect would quickly dissipate as the flow moved downstream. His subsequent modelling with the corrected Malone hydrograph confirmed that assessment.

235 Seqwater contended that it should be found that Dr Altinakar did not use the most reliable information for flows at BND05.[444] It was also submitted that he used Mr Ayre's hydrograph at the wrong location and at the wrong time,[445] specifically that he applied it at the confluence of Warrill Creek and the Bremer River which was said to be four hours upstream of David Trumpy Bridge.[446] I accept that the use of the Aurecon URBS figures for the beginning of region 14[447] during the peak of flooding was the better course and Dr Altinakar acted on the wrong basis as to where to apply the hydrograph produced by Mr Ayre.

236 Seqwater further contended that it should be found that the "differences in the competing [hydrographs at BND05] do have a *material* effect in terms of the downstream flooding predicted by [Dr] Altinakar's model".[448] The basis for this contention was that the 2018 Set Up sought to address both the uncorrected Malone hydrograph and the Aurecon URBS hydrograph at BND05 and as the calibration exercise involved a change in Manning's values along the Bremer

[443] Plaintiff subs at [2070]; SBM.010.017.0001 at [110].
[444] SBM.020.019.0001 at [107].
[445] Ibid at [109].
[446] Id; see Chapter 2, Figure 2-6.
[447] I.e. the combination of regions 13 and 25.
[448] SBM.020.019.0001 at [117].

River, then it should be inferred that the application of a different hydrograph at BND05 drove those changes.[449]

237 While I accept that a difference of just under 200m^3/s at the peak along the Bremer River is a matter that introduces a degree of uncertainty in placing exclusive reliance on Dr Altinakar's exact modelled levels of inundation under Dr Christensen's simulations in the areas surrounding the Bremer River, I otherwise do not accept Seqwater's contention. I note five matters.

238 First, as just noted, at no stage was Dr Altinakar given the opportunity to address the materiality of the differences between hydrographs at BND05. An approximate difference in the peak flow rates of 250m^3/s was isolated in the cross-examination of him on 11 April 2018 and that occurred after he was expressly asked about the potential materiality of a difference of approximately 750m^3/s at Rifle Range Road noted above (at [152]). Yet no question was directed to Dr Altinakar concerning the potential effect of the difference in inflows at BND05, much less was the line of reasoning in the submission about materiality that is now made by Seqwater taken up with him.

239 Second, I am doubtful that a proper evidential foundation for Seqwater's submission on materiality has been properly laid. The admission of evidence of the revised Manning's values under the 2018 Set Up as set out in Revised Report 1 was subject to an order under s 136 of the *Evidence Act* 1995 that they are only to be treated as evidence that Dr Altinakar *stated that* he determined those figures but not as evidence of the contents of the statement,[450] ie, they are not evidence that Dr Altinakar in fact determined those Manning's values as opposed to him simply stating that he did.

240 Third, even if Revised Report 1 were admissible to prove the facts relied on by Seqwater, then the relatively minor changes in Manning's values for the

[449] Ibid at [115].
[450] T 10513.4.

Bremer River that were made for the 2018 Set Up[451] could have been referable to a calibration of the Bremer River flows to meet the effect of the uncorrected Malone hydrograph for Rifle Range Road.

241 Fourth, to the extent that it is known, the difference between the combination of the Aurecon hydrographs for region 13 and region 25 in Figure 13-11 on the one hand and the hydrograph used by Dr Altinakar around the peak period appears to be of the order of around 194m^3/s. Both hydrographs peaked at 9.00pm on 11 January 2011. Both hydrographs had constant (high) flows for a period of five hours around the peak period and there were little additional flows into the Bremer River between BND05 and Ipswich.

242 Fifth, as noted above, Dr Altinakar's modelled result calibrated very well to the measured hydrograph at Ipswich during the peak of the flood with the computed peak exceeding the measured peak by 9cm.[452] As noted above, Mr Ayre's hydrograph calculated the discharge at Ipswich.

13.3.11: Alleged Misuse of Manning's Co-efficients with 2017 Set Up

243 In its written submissions, SunWater contended that Dr Altinakar's calibration of Manning's coefficients was inappropriate.[453] SunWater contended that Manning's values are simply meant to reflect the topography and features of the river but that "Dr Altinakar use[d] Manning's values so as to artificially force the model to replicate what actually occurred in January 2011". It submitted that Dr Altinakar did not use "Manning's values in the way [they were] commonly used ([namely to reflect] "*topography and features of the particular river*"[454]) … [but]… instead, … us[ed] them to compensate for the inability of the DSS-WISE model to appropriately represent the flow in the Brisbane River".[455]

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[451] EXP.ROD.017.0001 at [37]; table 1.
[452] MAS5 at [346].
[453] SunWater subs at [2697].
[454] Citing Dr Altinakar's evidence at T 3485.51; SunWater subs at [2702].
[455] SunWater subs at [2697] to [2704].

244 These submissions refer to the following passage in Dr Altinakar's cross-examination:[456]

> "Q. What you were doing in your first report is using the Manning coefficient for something other than its regular purpose, weren't you?
> A. To some extent, I would say, not always the same, because Manning's coefficient in numerical models is used as a catch-all parameter for taking into account everything that has not been modelled. I mean, *every hydraulic modeller would tell you that*.
>
> Q. The Manning coefficient is intended to be a coefficient that's referrable to the topography and features of the particular river in question, isn't it?
> A. Yes.
>
> Q. What you did in your first report was initially use the Manning coefficient in that way and then obtain some interim results, you realised that that did not provide a calibration and therefore used the Manning coefficient as a further adjustment factor to get you closer to what you would claim to be a calibrated result; that's right, isn't it?
> A. Yes.
>
> Q. In fact, the first model [ie the 2015 Set up] didn't calibrate well to observed data, did it?
> A. I think the answers to those questions are not easy, in the sense that they're not just simple "yes" or "no" questions, because *I believe there is a misunderstanding of what a Manning's coefficient represents.*
>
> Q. The first model, in fact, didn't calibrate well to observed data, did it?
> A. It did, to some extent, yes. I couldn't match everything, so I had to adjust the values in order to be able to get a better match, *and this is a normal practice which is done with the best available data*." (emphasis added)

245 Twice in this passage Dr Altinakar referred to the approach he adopted as normal or usual practice. Further, Dr Altinakar expanded on the misunderstanding that is the premise of the questioning in re-examination.[457] He explained that Manning's coefficients have been assigned based on "past experience" by reference to two "cross-sections which are significantly apart" (around "300 to 400 metres") and then considering the "general characteristics of the river, whether there are stones, sand or other features like trees, bushes" etc.[458] He said that if, for the purpose of modelling, the relevant section of the river is shortened (or lengthened), then the Manning's

[456] T 3485.32 to T 3486.21.
[457] T 3547.
[458] T 3547.9 to .33.

values have to be altered. Dr Altinakar stated that a “Manning coefficient is not a universally accepted value and has to be considered within the specificities of the problem at hand” and “adjustment has to look into assigning reasonable values which are within professionally accepted ranges in order to be able to match water surface elevations”.[459]

246 Dr Altinakar’s evidence in this respect was uncontradicted. Mr Collins did not address Dr Altinakar’s use of Manning’s coefficients. Thus he did not suggest that any of the coefficients used by Dr Altinakar in any of his set ups were outside the range of reasonable values. I do not accept that there was anything inappropriate in the manner in which Dr Altinakar utilised and adjusted the Manning’s coefficients to produce either the 2017 Set Up or the 2015 Set Up.

247 Two further points should be noted about SunWater’s submissions on this topic.

248 First, SunWater sought to contrast Dr Altinakar’s silence on the Manning’s coefficient values in the 2018 Set Up with a comment in MAS1 about the 2015 Set Up in which he “described an increase in roughness values between St Lucia and [the] Pacific Motorway [as] ‘quite strange’”.[460] The relevant comment in MAS1 concerned the difference between the final calibrated Manning’s value and an initial value based on “professional experience”.[461] That observation is irrelevant to a consideration of the differences between the Manning’s values used in the 2017 Set Up and the 2018 Set Up in circumstances where it is normal practice to calibrate them in the manner stated by Dr Altinakar and none of the Manning’s values in either set up were said to be unreasonable.

249 Second, SunWater submitted that “the Court cannot take comfort in the fact that the 2017 Set-Up calibrates to ± 0.5 metres notwithstanding the use of the unreliable rate[d] flow at Rifle Range Road because, as is revealed in MSA07

[459] T 3547.38.
[460] SBM.030.011.0001 at [49].
[461] MAS1 at [469].

and MSA08, the DSS-WISE model can be adjusted (using the Manning's values) to accommodate even the *most incorrect of inputs* (i.e., the [uncorrected] Malone Hydrograph)".[462] The question of the location of the boundary at Rifle Range Road, the appropriate flow and the materiality of the competing flows is addressed above. Otherwise this submission takes the matter nowhere. All that the admissible evidence in relation to the 2018 Set Up shows is that Dr Altinakar is capable of applying his DSS-WISE modelling system in the way he states, namely by calibrating the Manning's values to the relevant hydrographs. He was given an incorrect hydrograph, could not adequately calibrate the 2017 Set Up to that hydrograph and instead recalibrated it. The results of that recalibrated set up (ie, the 2018 Set Up) when applied to the claimant locations or to assess the extent of flooding are not in evidence.

13.3.12: Alleged Failure to Disclose Results of Malone Hydrograph Modelling

250 In its supplementary submissions on causation, SunWater referred to the circumstances surrounding the production of the 2018 Set Up as revealing that Dr Altinakar had provided misleading evidence.[463] SunWater contended that it demonstrated that Dr Altinakar had lost "objectivity", was "exposed as a partisan witness", acted "contrary to his obligations as an expert witness" and thus had been "shown to be unreliable as an independent expert witness".[464] I reject all of these contentions.

251 The background to the production of the 2018 Set Up is outlined above. SunWater's submission about Dr Altinakar's credit concerns the recalibration of the 2017 Set Up to create the 2018 Set Up. SunWater contended that Dr Altinakar "knowingly participated" in a forensic decision made by the plaintiff not to disclose the outcome of the 2017 Set Up when it used the uncorrected

[462] SBM.030.011.0001 at [51].
[463] Ibid at [5] and [46].
[464] Ibid at [5] to [8].

Malone hydrograph.[465] Given the seriousness of the allegation it is necessary to set out the passages of transcript relied on by SunWater:[466]

"Q. You received the Malone hydrograph that you describe now as the wrong hydrograph. You understand what I'm talking about?
A. Yes.

Q. Did you model that on your 2017 set-up to see --
A. No.

Q. -- what the results were?
A. Oh, yes, yes.

Q. And it came up with some results that didn't look good for the plaintiff's case, didn't it?
A. Not - of course not, yes.

Q. And you chose not to disclose that modelling exercise in your 2018 report, didn't you?
A. You are wrong, because that's why I had to undertake a calibration study, because it does not work with the original 2017 set-up.

………

Q. And the results that it showed were unhelpful for the plaintiff's case, weren't they?
A. They were not correct, yes.

…

HIS HONOUR: Q. What do you mean by they were not correct?
A. They were not correct.

Q. How did you know they were not correct? What was being revealed by them?
A. Because the peak of the hydrographs, arrival time of the hydrographs and various other things were not correct. One could see that the discharge is being released too early from Rifle Range Road and that is creating a problem all along the river, starting from Lockyer, all the way down to Moreton Bay.

…
Q. You believed that if Mr Malone's original hydrograph was correct, that would invalidate the 2017 set-up?
A. Sir, I am an independent expert. I do not believe in those kinds of things. I was asked to try another hydrograph which was being considered as the correct hydrograph. I included in my model and I saw that there is a problem with it. Then I tried to see whether it can be resolved using a recalibration of the model and even that did not work completely to my satisfaction, unfortunately. To some degree I

[465] Ibid at [46].
[466] Ibid at [47]; T 10476.7 to T 10480.18.

was able to get the peaks, but there were still a lot of problems and that's when I started doing all kinds of analysis, trying to see why it is not working, and we know now why.

…

[HIS HONOUR] *Q. When you say you were having problems, was the problem that the results you were getting on the 2017 set-up were not calibrating well to those hydrographs?*

A. When using Malone's incorrect hydrograph, yes, it was not correctly aligning.

MR WILLIAMS: Q. And you didn't understand at that time that it was an incorrect hydrograph, did you?

A. I did not.

Q. If you were truly operating as an independent expert, you would have revealed to the court that if Mr Malone's hydrograph was correct, then that meant that your model results were not reasonably calibrating, that's what I suggest to you?

A. No, I continued to do further analysis to see whether it could be calibrated.

Q. And you found that it couldn't?

A. Yes.

…

Q. You didn't reveal in any of your October 2018 reports that if the Malone hydrograph was correct, that would invalidate your 2017 modelling results, did you?

A. I think –

Q. Did you?

A. -- it was implicit from the fact that I had to redo a calibration, and it was mentioned in my 2018 report and the conclusion was that there is something wrong with the hydrograph I am given.

…

Q. You didn't state, expressly or impliedly, that that would invalidate your 2017 set-up, did you?

A. I explained it **by implying it** because I had to recalibrate, which means that I was not able to match the results using the 2017 set-up.

Q. What I want to suggest to you is if you truly were an independent expert you would have expressly revealed that when you applied Mr Malone's hydrograph to your 2017 set-up, if Malone's hydrograph was correct your set-up for 2017 was invalidated?

A. **I did so by recalibrating**." (emphasis in bold in SunWater submissions; italicised emphasis added)

252 SunWater was dismissive of so much of Dr Altinakar's evidence that suggested that it was implicit in the recalibration of the 2017 Set Up to

account for the uncorrected Malone hydrograph that the 2017 Set Up did not calibrate well when that inflow discharge data was applied.[467] On the contrary, I regard that as manifestly obvious to any reasonable reader of his reports. In his first report, Dr Altinakar explained that the calibration process involved alterations to the Manning's coefficients to match the peak and timing of the designated hydrographs.[468] In Revised Report 1 he made it clear that he did not accept the validity of the revised hydrographs used in the report (i.e., the uncorrected Malone hydrograph)[469] and stated that he was presenting a revised set up following the adoption of alternative inflow discharges for the Lockyer Creek and Bremer River.[470] He also stated that there is a "relationship between the inflow assumptions, Manning's coefficients and modelled water levels" and that it was "not usually possible to make changes to inflow discharges without also *considering the need* to adjust Manning's values". [471] If such a consideration lead to a recalibration and the production of the 2018 Set Up then what else could that mean to the reasonable reader of his reports other than the original set up was not calibrating at least *well enough* with the new hydrograph and that further calibration was required?

253 All that Dr Altinakar was saying in the above evidence was that it was or should have been obvious that he recalibrated the 2017 Set Up because it was not calibrating well with the new hydrograph as that is the very reason why one undertakes a new calibration. Critically he did not say, and it was not established, that he recalibrated the 2017 Set Up because when the uncorrected Malone hydrograph was applied it produced "unhelpful results" in relation to the inundation of the plaintiff's store or the other properties relevant to the sample group members. The allegations of dishonesty and partiality levelled at Dr Altinakar by SunWater are not made out.

[467] SBM.030.011.0001 at [48] to [50].
[468] MAS1 at [469].
[469] Revised Report 1 at [3].
[470] Ibid at [1].
[471] Ibid at [22] to [23].

13.3.13: Conclusion

254 I reject all of the defendants' challenges to Dr Altinakar's credit. Beyond raising some degree of uncertainty concerning a difference of around 200m^3/s in peak flows in the upper part of the Bremer River, none of the defendants' criticisms of his modelling approach undermine reliance on Dr Altinakar's hydraulic modelling.

13.4: Individual Properties and Common Causation Questions

13.4.1: Reliability and Margin for Error

255 Much of the defendants' criticisms and the plaintiff's responses were directed to the question of whether some fact or circumstance was "material" to the level of flooding at a particular location determined by Dr Altinakar's modelling (ie, the 2017 Set Up) or whether the modelling was otherwise "unreliable". The defendants' (extreme) position was that the modelling was of such little utility that it was worthy of no weight at all and the plaintiff and all group members simply failed to prove the occasioning of any loss or damage anywhere. Although not expressly stated, by urging a "yes" answer to question 20,[472] the plaintiff was contending that Dr Altinakar's modelling should be taken as *determinative* of the precise level of flooding to the nearest centimetre at *every location* downstream of Wivenhoe Dam under Dr Christensen's simulations and that is the case irrespective of how well the modelling of the actual flood calibrated to, say, flood marks near that location or accorded with the observed flood levels.

256 I do not accept either position. Instead, it follows from the analysis in section 13.1 that the relevant finding, including its degree of precision, necessary to establish causation in turn depends on the "particular harm" for which recovery is sought. Thus, for the plaintiff, all of its heads of damage are prima facie recoverable if it is found on the balance of probabilities that its store and the shopping centre that it formed part of would not have been inundated if flood operations had been undertaken in accordance with SIM C.

[472] See plaintiff's proposed answers to common questions, SBM.500.001.0001 at 0011, Q20.

As explained below, that finding can be made without the necessity to make a finding about the precise water level that would have resulted under SIM C. However, the points of claim concerning Mr and Mrs Keller articulate heads of damage that include "soil damage, soil erosion and land degradation caused by the extent of the inundation".[473] In light of the evidence concerning their properties, the resolution of the entirety of their claims might require findings as to the precise level of flooding across their property, or at least a finding expressed in terms of being satisfied that flooding under SIM C would have been not more than a particular level.

257 One part of SunWater's submissions on causation adverted to the difficulty in asking whether Dr Altinakar's modelling is "reliable" without inquiring into the context in which that question was being posed.[474] SunWater submitted this issue could only be addressed "by reference to the statutory language" namely "can the Court be satisfied on the balance of probabilities that the plaintiff (and sample group members) would not have been flooded, on a particular simulation, on the assumption that the Court were to find that reasonable care and skill required the Flood Engineers to operate the Dams substantially in accordance with that simulation".[475] For some group members that may be the correct question, but only if the "particular harm" for which loss and damage is claimed is that which is said to have been caused by the inundation of a building. It would not be the correct question if, say, it was contended that the harm suffered was the saturation of personal property stored above a certain height in a building or the degradation of an area of farming land.

258 SunWater further contended that, if its primary submission that Dr Altinakar's modelling should be rejected as being "too unreliable to be relied upon for [any] purpose of determining causation" is rejected, then given the limitations and level of calibration of Dr Altinakar's modelling, it would be "counter intuitive and unrealistic" to find that the modelling is accurate to the nearest

[473] PLE.010.003.0001 at .0003; Particular 3F.
[474] SBM.030.011.0001 at .0014, [60].
[475] Id.

centimetre.[476] As noted above, the State made a similar submission. SunWater submitted that the "logical approach" would be to adopt a margin of error of ±0.5m, which corresponds to the measure of calibration that Dr Altinakar utilised.[477] SunWater effectively submitted that a margin of minus 0.5m was applicable, in that on its approach each of the counterfactual flood levels in Table 13-2 below would have 0.5m added plus some unspecified further margin for each simulated level of flooding under Dr Christensen's simulations. It was submitted that, if that was not done, it would not be possible for the Court to be satisfied that, but for the breaches, the relevant property would not have been flooded.[478]

259 In support of this contention, SunWater referred to the matters raised above concerning the level of calibration of Dr Altinakar's modelling. SunWater's submissions set out a table of the observation points with a comparison of the computed peak height against the measured peak height[479] with a similar table for the properties relevant to the plaintiff and other sample group members.[480] SunWater contended that there is no "pattern" to the underestimates and overestimates.[481] It also pointed to an answer given by Dr Altinakar when he was cross-examined about the blank entries in Table 13-2 below for certain properties under a particular simulation which indicated that the property would not be inundated. He was asked:[482]

> "Q. But you can't tell from your report, for instance, whether it's 1cm below or 2 metres below, can you?
> A. I would say with statistical probability, it will be plus or minus 0.5."

260 Two matters should be noted about this. First, Dr Altinakar did supply information which, depending on the topography of the particular land, enables a determination of whether under Dr Christensen's simulations the flooding was "1cm below or 2 metres below" the ground elevation for the affected property. Second, for Dr Altinakar to state with "statistical probability"

476 Ibid at [101] to [102].
477 SBM.030.011.0001 at [103].
478 Ibid at [108].
479 Ibid at [74].
480 Ibid at [76].
481 Ibid at [75], [80] and [83].
482 T 3542.3.

that the simulated height is within 0.5m of the "true" position is completely different from an assessment, undertaken on the balance of probabilities, that the level of flooding under one of Dr Christensen's simulations would not have been more than the ground level at a particular location.

261 The fundamental difficulty with SunWater's submission that 0.5m (or more) should be automatically added to every flood level modelled by Dr Altinakar for Dr Christensen's simulations is that, in a context where the standard of proof is only the balance of probabilities, it assumes that there is some systemic underestimate of flooding in Dr Altinakar's modelling. No such systemic error has been shown. It follows that to adopt a blanket rule of the kind suggested by SunWater would be to impose a higher standard on the plaintiff than the balance of probabilities. As noted by the plaintiff, the significance of Dr Altinakar's assessment against a range of ±0.5m was "simply the tolerance that [Dr] Altinakar, in his opinion as an expert in hydraulic modelling, is prepared to allow in relation to results at one particular location compared to the *actual* results at that same particular location, to satisfy himself that the model *as a whole* is capable of modelling flooding in the Brisbane River basin *generally*".[483]

262 The plaintiff went further and submitted that the results of the model should be taken "as the best possible prediction of the flooding that would have occurred at any given location on an alternative hypothetical scenario".[484] Again, that can be accepted as a general proposition but even then, it would not follow that the Court would necessarily treat a predicted level given by the modelling as determinative of the precise level of flooding that would result under Dr Christensen's simulations. Instead, all the evidence must be considered, including a consideration of how accurately the model calculated the actual flooding at, and in the vicinity of, the relevant property. It would also include a consideration of whether the relevant location represented some part of the modelled area where there was a particular reason to doubt the accuracy of the modelling; eg, whether it was close to a discharge at a boundary.

483 SBM.010.017.0001 at [14(a)].
484 Ibid at [14(b)].

13.4.2: Use of Dr Altinakar's modelling to Prove the Level of Actual Flooding

263 There was a debate in the submissions as to the means by which the plaintiff sought to prove the level of actual flooding at affected properties.[485] In oral submissions, Senior Counsel for the plaintiff stated that it did not rely on Dr Altinakar's modelling to demonstrate the actual level of flooding at a particular property but instead relied on the evidence of the plaintiff (and the sample group members) who gave evidence of their observations.[486] The plaintiff stated that it relied on Dr Altinakar's evidence to demonstrate the level of flooding under Dr Christensen's simulations.[487] In its supplementary submissions on causation, the plaintiff submitted that, to the extent that it was considered that there was "a deficiency in the proof of actual flood levels", then the output of Dr Altinakar's modelling of the actual scenario is evidence the Court could act upon.[488]

264 Seqwater contended that this approach was inconsistent with the 5ASOC at [346], which pleads the occasioning of greater flooding. The particulars to [346] describe the "approximate geographic extent" of greater flooding by reference to a map attached to the 5ASOC, state that the depth of greater flooding could be inferred from the geographic extent of such flooding and state that "[f]urther particulars of the precise extent of Greater Flooding … [would be] provided upon service of the plaintiff's expert hydrology evidence", which apparently did not occur.[489] None of these particulars purport to restrict the means by which the plaintiff was able to prove the extent of actual flooding at a particular property to the extent that had to be done to recover damages in respect of "particular harm" as referred to in s 11(1) of the *CLA* (Qld). The allegation of loss or damage to the plaintiff is pleaded in 5ASOC at [347]. Particular A to that paragraph refers to the inundation of the plaintiff's business premises on or around 12 January 2011. Particular C alleges that the "plaintiff suffered loss and damage as a result of the inundation". Again,

[485] Seqwater subs at [2492ff].
[486] T 9461.30 to .34.
[487] T 9461.4.
[488] SBM.010.017.0001 at [17(e)].
[489] SBM.020.019.0001 at [12]; 5ASOC at [346(b), particulars A to D].

none of these particulars purport to restrict the means by which the plaintiff could prove that inundation.

265 Seqwater further contended that the plaintiff's approach was inconsistent with its proposed answer of "yes" to common question 19, namely "[w]as the measure of that flooding or greater flooding that determined by the modelling of Dr Mustafa Altinakar".[490] I have already referred to the difficulties with the common question. Even so, the proposed answer is directed to the extent of flooding by Dr Christensen's simulations. It does not preclude reliance on group members' evidence (and Dr Altinakar's modelling) to prove the extent of the actual flooding experienced at a particular property.

266 Seqwater also contended that the evidence from Ms Lynch and Ms Harrison did not "provide any specificity [of] the extent of the actual flood level at their respective properties".[491] Their evidence is addressed below. In short, their evidence and the evidence of the other sample group members is more than sufficient to demonstrate the extent of the actual flooding necessary to make the relevant findings at this stage of the proceedings.

13.4.3: Dr Altinakar's Modelled Levels of Inundation at Affected Properties

268 Dr Altinakar's Revised Report 2 presented the results of the application of the 2017 Set Up with all of Dr Christensen's simulations to the plaintiff's store and the other properties relevant to the sample group members as follows:[492]

	Claimants	John and Betty Keller_1	John and Betty Keller_2	John and Betty Keller_3	Lynette Lynch	Sharon Visser	Lynette Harrison	Plaintiff: Rodriguez & Sons Pty Ltd				
								Plaintiff_NW Corner	Plaintiff_NE Corner	Plaintiff_SE Corner	Plaintiff_SW Corner	Plaintiff_Centre of Building
	Address	XX6 XXXX Road, Lowood	XX8 XXXX Road, Lowood	XX4 XXX Road, Lowood	XXXX Fernvale Qld	XXX, North Booval Qld	XXX Musgrave Road, Coopers Plains Qld	180 Fairfield Rd, Fairfield QLD 4103	180 Fairfield Rd, Fairfield QLD 4103	180 Fairfield Rd, Fairfield QLD 4103	180 Fairfield Rd, Fairfield QLD 4103	180 Fairfield Rd, Fairfield QLD 4103
	Ground Elev (m AHD)	46.28	45.95	46.38	40.77	17.59	7.25	4.77	6.93	6.43	6.53	7.00

[490] Ibid at [18].
[491] Ibid at [19].
[492] Revised Report 2; longitude and latitudes deleted. Home addresses deleted.

2017 Simulations h_{max}(m AHD)	ACTUAL-2017	2.41	2.75	2.27	2.35	1.49	2.42	3.22	-1.07	1.57	1.46	1.00
	A-2017						0.16	1.28				
	B-2017		0.17				0.80	1.77			0.00	
	B2-2017	0.67	1.03	0.52			1.33	2.25	0.10	0.44	0.49	0.02
	C-2017						0.26	1.37				
	D-2017		0.19				0.81	1.77			0.00	
	D2-2017	0.70	1.06	0.55			1.32	2.24	0.09	0.30	0.48	0.02
	E-2017						0.17	1.29				
	F-2017		0.20				0.83	1.78			0.02	
	F2-2017	0.61	0.97	0.45			1.31	2.23	0.08	0.00	0.47	0.01
	G-2017	0.23	0.58	0.08		0.22	1.45	2.30	0.15	0.65	0.54	0.08
	G2-2017	1.12	1.48	0.98	0.42	0.59	1.92	2.79	0.63	1.13	1.03	0.56
	H-2017		0.20				0.83	1.78			0.02	
	I-2017							1.15				
	J-2017		0.03				0.68	1.69				
	J2-2017	0.35	0.71	0.18			1.07	2.01			0.25	

Table 13-2: Table of the plaintiff and sample group members together with the maximum flood depths computed with 2017 Set Up for all 15 simulated scenarios.

269 The figures in the rows below the "Ground Elev" row represent the water levels above ground elevation modelled by the 2017 Set Up for the actual flood and each of Dr Christensen's simulations. The reference to B2, D2, F2, G2 and J2 is to simulations B, D, F, G and J altered to take into account Mr Ickert's variation on flood operations above EL 74.0m AHD at Wivenhoe Dam. The blank cells indicate that water levels would not inundate those properties. The results for locations in and near the plaintiff's store are indicated by the last five columns. On these results the plaintiff's store would not have been flooded under SIM C and nor would the three (adjacent) dwellings owned by Mr and Mrs Keller, as well as the homes owned by Ms Lynch and by Ms Visser. The location at which Ms Harrison's property was stored is still flooded but the level of inundation under SIM C is less than actually occurred.[493] To address this further, it is necessary to address the evidence concerning the layout and elevation at each of these properties, as well as the actual and modelled flooding that occurred there.

13.4.4: The Plaintiff's Store

270 As already stated, the plaintiff conducted a sporting goods and sportswear store at a shopping centre at 180 Fairfield Road, Fairfield. Fairfield is located

[493] MAS6 at [195]; Revised Report 2 at [111].

on the south eastern side of the Brisbane River, well past Moggill and Jindalee Bridge towards Moreton Bay.

271 An aerial map that explains the measurements in the above table for the plaintiff's store was set out in Revised Report 2 as follows:[494]

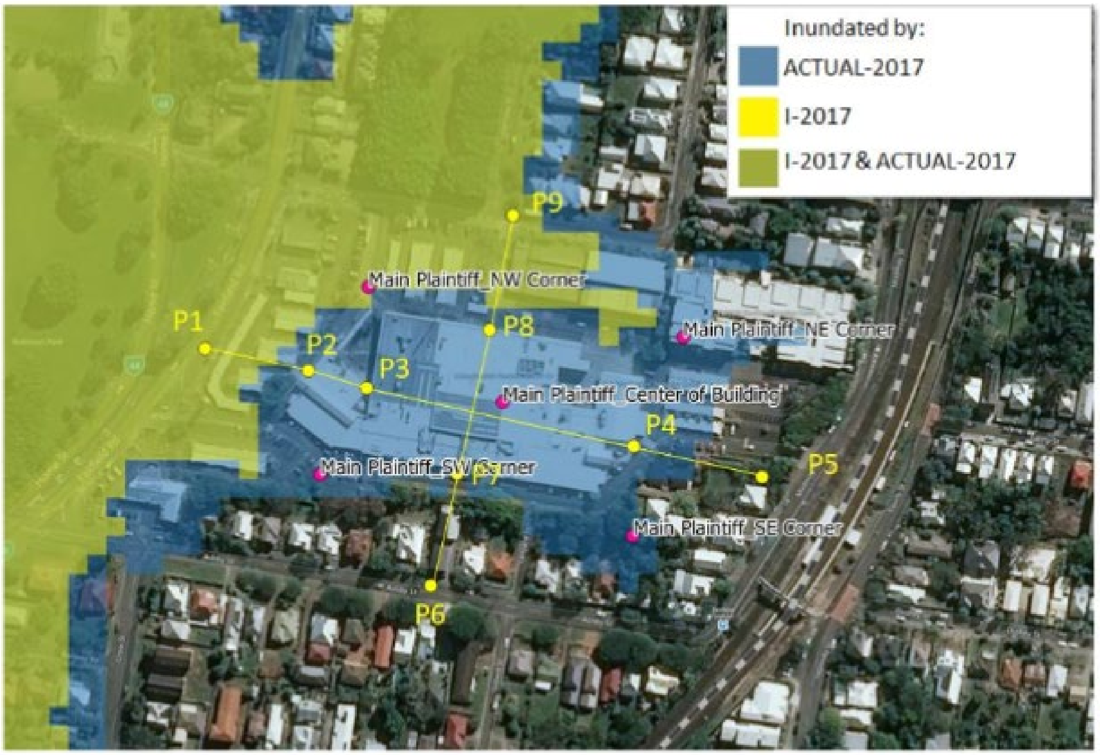

Figure 13-13: Aerial photograph of plaintiff's store

272 The closest bank of the Brisbane River is to the west-north-west of the intersection of the yellow lines in this photograph. The area in green corresponds to area that Dr Altinakar's modelled as having been inundated by both the January 2011 Flood Event *and* as would have been flooded by SIM I (and accordingly SIM C, although it would have extended further). The blue area corresponds to the area which Dr Altinakar's modelled as inundated by the January 2011 Flood Event *but which would not* have been flooded by SIM I.[495] The five red dot points correspond to the cell readings in the last five columns in Table 13-2. Those readings indicate that the modelled level of actual flooding in the middle of the shopping centre was 1.00m above ground

[494] Revised Report 2 at .0093.
[495] Id.

elevation and the north-west corner was inundated to the level of 3.22m above ground level.

273 Transverse sections of the elevation of this area including inside the shopping centre were included in MAS6.[496] It was also intended to be included in Revised Report 2 but that report appears to accidentally include the results of the 2018 Set Up when it should have included the 2017 Set Up.[497] The following east-west cross section stretching from points P1 to P5 is taken from MAS6 with the location of P1 to P5 included by cross referring to the equivalent diagram in Revised Report 2:[498]

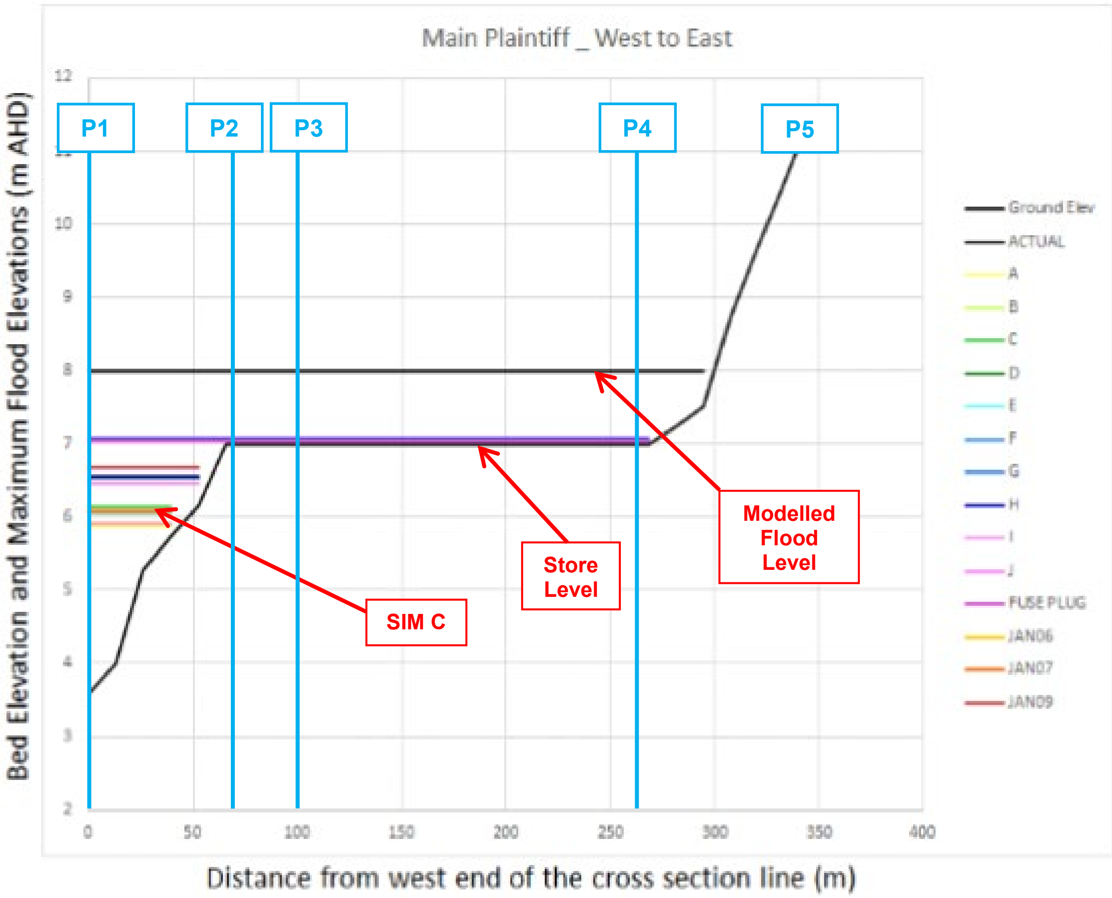

Figure 13-14: Transverse section of plaintiff's store elevation – west to east.

[496] MAS6 at .0728 and .0729.
[497] Revised Report 2 at .0094.
[498] Id.

274 Points P2 and P3 correspond to the westerly entrances to the shopping centre and P4 to the eastern side of the building. The black line is the ground elevation and shows the level of the shopping centre, including the plaintiff's store, at EL 7.00m AHD. The modelling of the actual flood shows the shopping centre inundated to a level of 1.0m. The black line to the left of P2 shows a fall away in the ground elevation between P1 and P2 on the above map. Dr Altinakar's modelling shows flood waters in SIM C only encroaching on the land somewhere in that region, almost a metre below the ground level of the shopping centre.

275 The following north-south cross-section stretching from points P6 to P9 is taken from MAS6,[499] with the location of P6 to P9 included by cross referring to the equivalent diagram in Revised Report 2:[500]

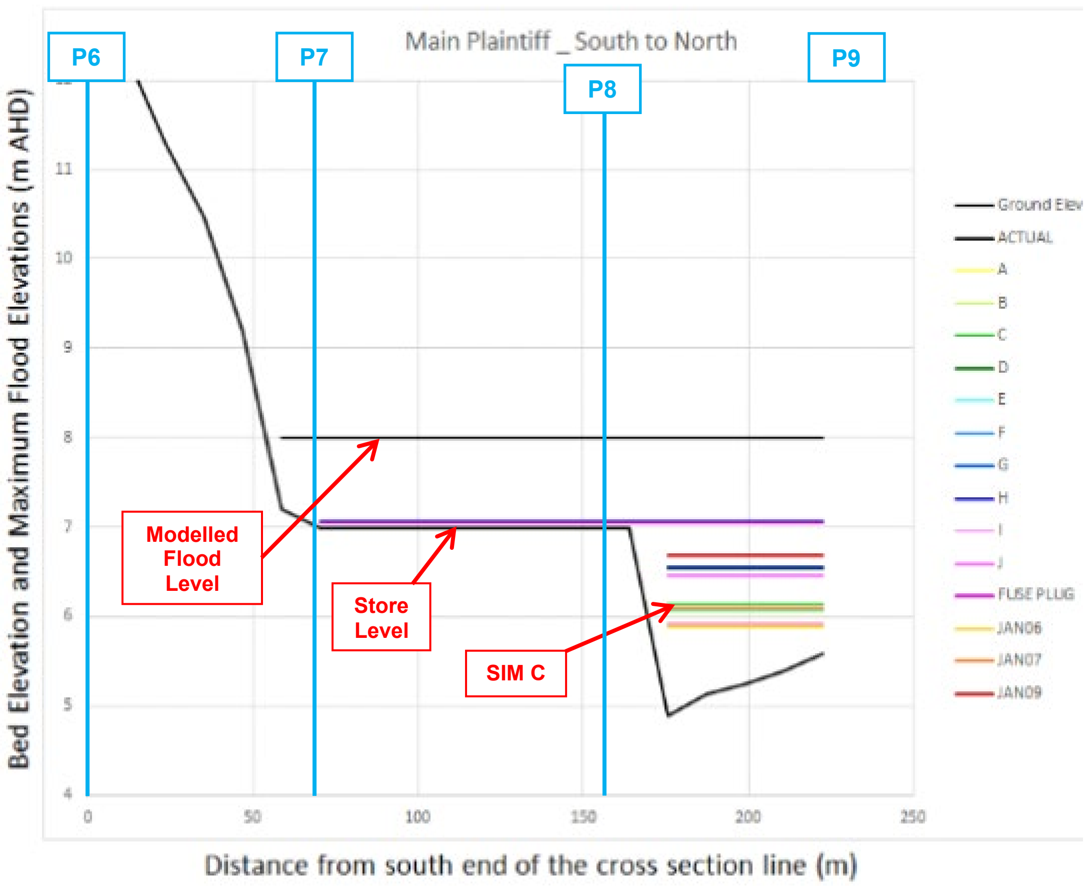

Figure 13-15: Transverse section of plaintiff's store elevation – south to north.

[499] MAS6 at .0729.
[500] Revised Report 2 at .0097.

276 Points P7 and P8 correspond to the northern and southern wall of the shopping centre respectively. The diagram shows a steep decline in elevations just beyond the north wall. Again, Dr Altinakar's modelling shows flood waters in SIM C only encroaching on the land somewhere in that region, being around 800mm below the ground level of the shopping centre.

277 For each of the properties addressed in this phase of the proceedings, Dr Altinakar examined nearby survey marks to compare his modelling of the actual flood at those locations to those marks.[501] There were no flood marks close to the plaintiff's store. However, Dr Altinakar noted that two flood marks near the riverbank adjacent to the premises showed "an error level of ±0.15m", which Dr Altinakar described as a "close agreement".[502] Seqwater nominated the closest "observation point" to the plaintiff as having a computed peak of 0.19m higher than the measured peak.[503]

278 As noted, Dr Altinakar's modelling of the actual flood event fixed the level of flooding above the flood of the centre at 1.00m (and in the north eastern corner at 1.07m). In his affidavit sworn 19 June 2015, Mr Rodriguez stated that when he returned to the store on 16 January 2011 after the water had receded there was "a residual ring of mud and debris staining the walls *up to about 1.2 metres high*".[504] Various photographs taken by Mr Rodriguez on the day are consistent with a level of flooding to approximately the level suggested by that observation and Dr Altinakar's modelling. Given the margins between the simulated level of SIM C in the above cross sections and the ground floor then that level of agreement between the modelling and Mr Rodriguez's observations strongly supports a finding that the shopping centre would not have been inundated under SIM C.

279 I am satisfied on the balance of probabilities that, if flood operations had been undertaken substantially in accordance with SIM C, the plaintiff's store and the shopping centre it formed part of would not have been inundated.

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[501] MAS6 at [186]; at .0728 to .0734.
[502] MAS6 at .0734.
[503] SBM.030.011.0001 at [74] and [76]; "Oxley Mouth Alert-moved"; cf SBM.030.011.0001 at [77(e)].
[504] LAY.ROD.001.0001 at [100].

13.4.5: Ms Lynch's Property

280 At the time of the January 2011 Flood Event, Ms Lynch owned a property at XXXX[505] Street, Fernvale.[506] She lived there with her husband in a home she designed. It has one storey and four bedrooms.[507] Fernvale is located just outside of the Wivenhoe "pocket" downstream of Lowood and close to Savages Crossing.

281 The aerial photo of the Harrison's property superimposed with the modelled extent of flooding during the January 2011 Flood Event and the modelled extent of flooding under SIM I is as follows:[508]

Figure 13-16: Aerial Photograph of Ms Lynch's property

282 The building at P6 to P7 is Ms Lynch's home. There is also a shed to the north of the home and a small cottage on the property[509] which appears to be

505 Address information removed.
506 LAY.ROD.009.0001 at [7].
507 Ibid at [8].
508 Revised Report at .0087.
509 LAY.ROD.009.0001 at [9] to [10].

the small building closest to P5. In her affidavit, Ms Lynch explained that to the rear of her property (i.e. below the arc between P5 and P4) and approximately 100m from her home and the Cottage, there is an indent in the land, known as the “Drain”. Ms Lynch stated that excess water from a local lagoon flows down to Ferny Gully which connects to the Brisbane River to the east.[510] Ms Lynch stated that the Drain was usually dry. Ferny Gully is located approximately a further 20m away from her home towards the Drain. There is a sharp drop in the land elevation towards the Drain.

283 The transverse section of the modelled flooding across points P1 to P4 is as follows:[511]

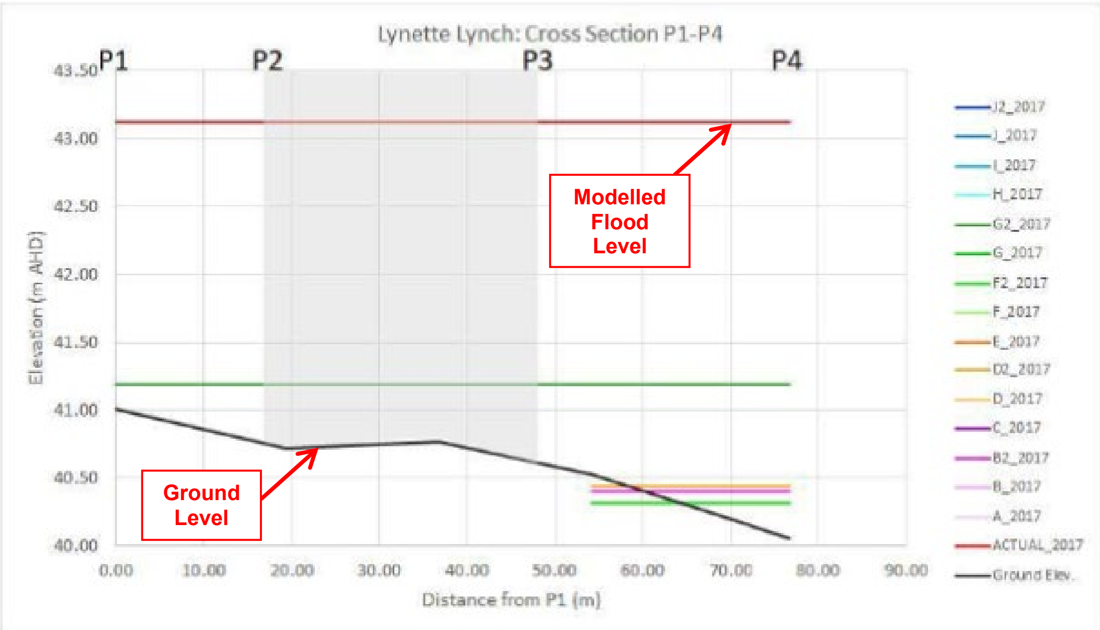

Figure 13-17: Transverse section of Ms Lynch’s property showing elevations.

284 The transverse section of the modelled flooding across points P5 to P9 is as follows: [512]

[510] Ibid at [12].
[511] Revised Report 2 at .0088.
[512] Id.

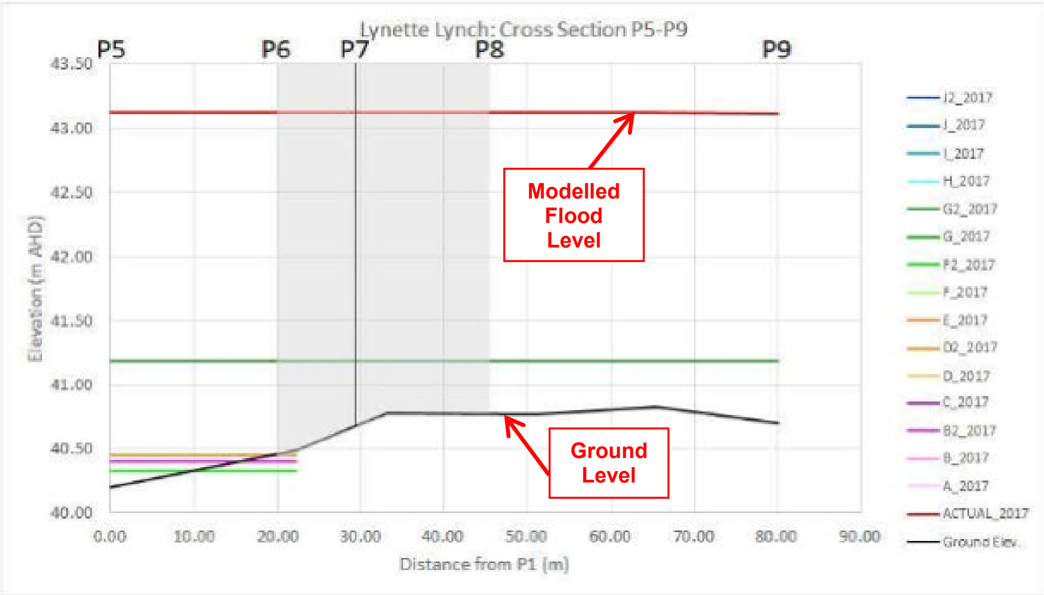

Figure 13-18: Transverse section of Ms Lynch's property showing elevation

285 The sharp drop off in the ground elevation around Ms Lynch's home starts in the area between P3 and P4 in the first of these transverse sections and the area between P5 and P6 in the second. Dr Altinakar explained that the grey highlighted areas represent the approximate limits of the building (presumably her home).[513] It is not clear whether that includes the shed as described by Ms Lynch but it does not matter.

286 As with the transverse sections for the plaintiff's property, the black line represents the ground elevation at Ms Lynch's property. The red line represents the modelled level of actual flooding. The red dot in Figure 13-16 is found near P8 and represents the modelled flood level above ground level in Table 13-2 above ie, 2.35m. The transverse section indicates a variation in the level of flooding above ground level in the area of the building of between 2.35m and approximately 2.65m.[514]

287 Three matters should be noted about the modelling of the area of actual flooding of Ms Lynch's property.

[513] Ibid at .0087.
[514] At the point P6.

288 First, the extent of the flooding across the area shown in the above image (ie, Figure 13-16) is consistent with Ms Lynch's description of the extent of flooding in the area.[515]

289 Second, the photographic evidence and Ms Lynch's description of the extent of flooding is strongly consistent with Dr Altinakar's modelling of the extent of inundation (ie, 2.35m to 2.65m above ground level). A photograph depicts flooding of her home up to the ceiling.[516] Ms Lynch stated that the "house had been inundated up to the gutters".[517] Photos of the damage reveal mud on the underside of the awnings.[518] The internal ceilings do not appear to be very high.[519]

290 Third, Dr Altinakar's examination of survey marks near to Ms Lynch's property revealed differences with his modelling of between -0.30m and 0.50m.[520] SunWater identified the closest observation point as Savages Crossing and noted that Dr Altinakar computed a peak that was 20cm higher than the measured peak.[521] Dr Altinakar's modelling calibrated well against Savages Crossing.

291 Dr Altinakar only marked the level of flooding modelled by SIM B2, D2, F2 and G2 on the above transverse sections because only they reach any of the ground elevation levels depicted in the above diagrams. Consistent with the steep elevation in that area, and as suggested by the modest area of flooding modelled for SIM I in Figure 13-16, the modelled level of flooding for the other simulations does not come close to the buildings on Ms Lynch's property. This outcome is consistent with Dr Altinakar's observation that, in the area of the Brisbane River closer to Wivenhoe Dam, the level of flooding was significantly affected by outflows from Wivenhoe Dam. Ms Lynch described the timing of the inundation of the area as occurring from the evening of 11 January 2011

[515] LAY.ROD.009.0005 at [52] to [62]
[516] ROD.005.001.0659; LAY.ROD.009.0001 at [53].
[517] LAY.ROD.009.0001 at [58].
[518] ROD.005.001.0202.
[519] ROD.005.001.0399; cf SunWater's submissions on causation, SBM.030.011.0022 at [105(g)]; "Ms Lynch ... gave no evidence from which actual flood levels at [her property could be determined]".
[520] MAS6 at [186].
[521] SBM.030.011.0001 at [74] and [76] to [77].

to the following morning[522] which would generally coincide with the arrival of the large outflows from Wivenhoe Dam at Savages Crossing and their attenuation as the river broke its banks.

292 This material overwhelmingly demonstrates that, had flood operations been conducted in accordance with SIM C, then neither Ms Lynch's home nor her shed or cottage would have been inundated by any flood waters. I so find. As discussed above, whether a more precise or a different finding is required to resolve all the heads of damage claimed by her must await a further stage of the proceedings.

13.4.6: Mr and Mrs Keller's Properties

293 Mr and Mrs Keller own five properties that are adjacent to, or nearby, XXXX Road, which is just near the confluence of Lockyer Creek and Brisbane River at Lowood.[523] Together the properties comprise 223 acres and are bordered on three sides by Lockyer Creek and the Brisbane River.[524] The properties are best described by reference to the following aerial photographs:[525]

[522] LAY.ROD.009.0001 at [45] to [53].
[523] LAY.ROD.008.0001 at [8].
[524] T 878.46; LAY.ROD.008.0001 at [11].
[525] LAY.ROD.008.0001 at [7].

Figure 13-19: Aerial photographs of the Kellers' properties

294 The black box in the first photo is expanded upon in the second photograph. The first photograph shows the location of those buildings relative to the highest point on all of the properties being the shed within the brown circle, known as Jensen's shed. The horizontal line of trees at the top of the first photograph depicts the banks of Lockyer Creek. The river running vertically on the right of the first photograph is the Brisbane River.[526]

295 The property circled in red in the second photograph is Mr and Mrs Keller's home located at XX6 XXXX Road ("XX6"). It is a two-storey house. Just behind that home is a cottage circled in blue. The property circled in green is a rental property owned by Mr and Mrs Keller at XX8 XXXX Road ("XX8"). Behind these two properties is what Mr Keller described as the "Home farm" which is bound by the orange lines in the first photograph and stretches to the

[526] T 880.31 and .36 (Mr Keller); see also SUN.008.001.0008.

Brisbane River.[527] Across the road from XX6 and XX8 is a farm Mr Keller called Lewis Farm. It is 22 acres and bound in blue in the first photograph.[528]

296 The building circled in pink in the second photograph is found at XX4 (and was known by Mr and Mrs Keller as the XX4 Rental House). Mr Keller described it as two-bedroom dwelling.[529] The area of property bounded in pink below the Home farm was known as Jensen's farm. The shed at the top of that property circled in brown is Jensen's shed and, as noted, was apparently the highest point on the Kellers' land.

297 In his affidavit, Mr Keller stated that at 7.00am on 11 January 2011 he observed water running over the road and filling up "hollows" on their property. He said they were isolated.[530] At around midday he observed water "starting to come in across the fields".[531] In the meantime, he and Mrs Keller had been accumulating property on the second storey of their home as well as at Jensen's shed.[532] Eventually the family retreated to Jensen's shed and they were evacuated by helicopter at 6.00am on the morning of 12 January 2011.[533] As previously noted, Mr Keller described the peak of the flooding as having occurred at around 11.00pm on 11 January 2011,[534] which is broadly consistent with the expected timing of large releases from Wivenhoe Dam combining with peak flows emanating from Lockyer Creek. Mr Keller said the flooding peaked at Jensen's shed at about four feet high.[535].

527 LAY.ROD.008.0001 at [8].
528 Id.
529 Id.
530 LAY.ROD.008.0001 at [34].
531 Ibid at [40].
532 Ibid at [35] to [43].
533 Ibid at [43] to [47].
534 Ibid at [46].
535 Id.

Mr and Mrs Keller's Home at XX6 XXXX Road

298 Dr Altinakar's aerial photograph of Mr and Mrs Keller's home at XX6 XXXX Road superimposed with the modelled extent of actual flooding and the modelled extent of simulated flooding under SIM I is as follows:[536]

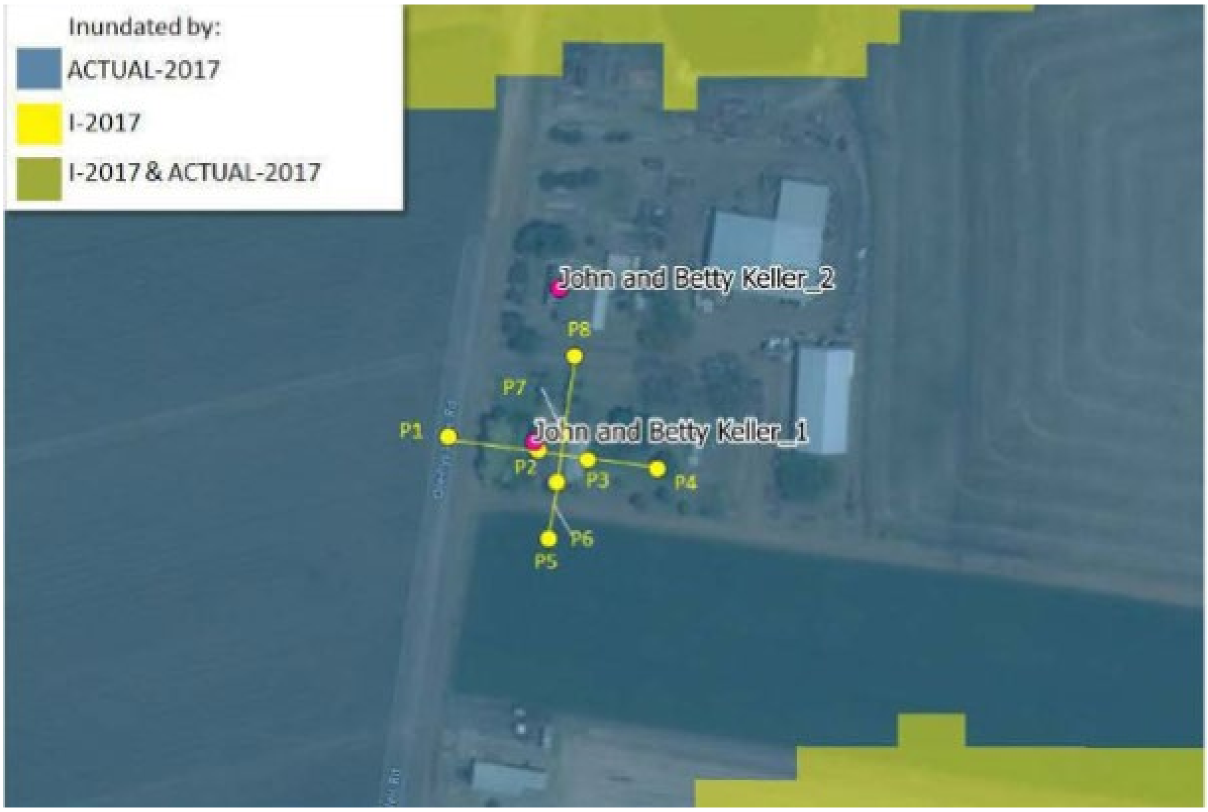

Figure 13-20: Dr Altinakar's flood inundation superimposed on aerial photograph of Mr and Mr Keller's home

299 The transverse sections for this property provided by Dr Altinakar are as follows. The shaded grey areas correspond to the area of Mr and Mrs Keller's home (ie, XX6):[537]

[536] Revised Report 2 at .0081.
[537] Ibid at [92].

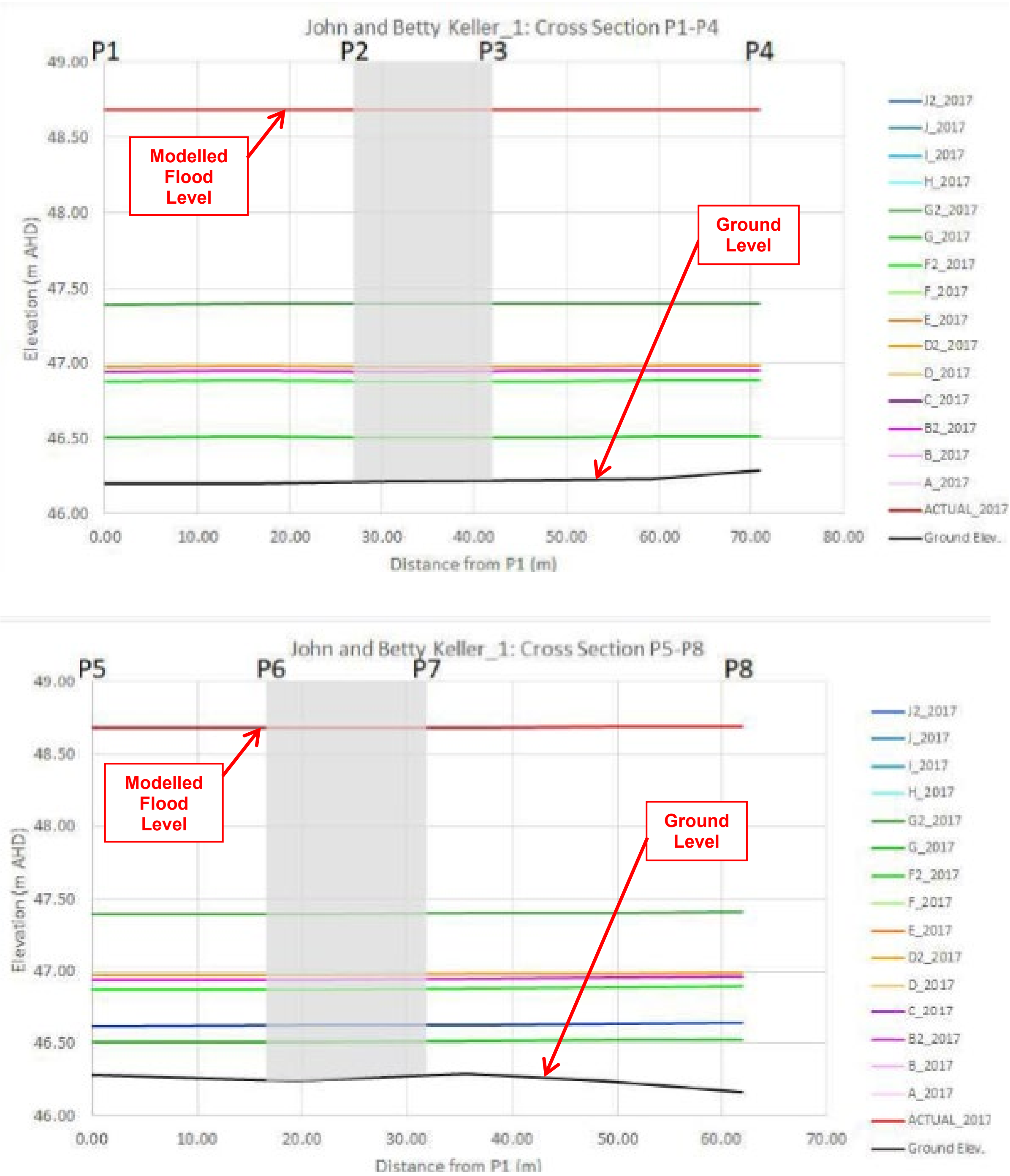

Figure 13-21: Transverse sections for Mr and Mrs Keller's home

300 Dr Altinakar noted that none of SIM A, C, E or I inundated Mr and Mrs Keller's home. Neither of these transverse sections depicts the effect of SIM C. Given that Dr Altinakar's modelling of SIM C does not inundate XX8 which is lower than Mr and Mrs Keller's home (ie, XX6; see Table 13-2), I accept that there is considerable tolerance between the simulated level of flooding under SIM C and over the floor flooding of their home.

301 Two further matters should be noted about the assessment at this point.

302 First, an analysis of the level of actual flooding shown in the above transverse sections suggests a level of flooding at Mr and Mrs Keller's home of around 2.45m to 2.5m which is consistent with what is suggested by Table 13-2 namely flooding at a ground elevation near P2 of 2.41m. In his affidavit, Mr Keller stated that on his inspection of his home on 13 January 2011, he observed that "[o]ur home was inundated up to just below our second storey, almost eight feet high on the inside or approximately an inch and a half below the ceiling of the first floor".[538] Eight feet is just under 2.44m.

303 Second, Dr Altinakar's examination of survey marks near Mr and Mrs Keller's property revealed differences between the modelled heights of actual flooding and the survey marks of between ±0.15m,[539] which is clearly a high level of agreement. Seqwater noted that the computed peak at Lowood observation point was 0.5m lower than the measured peak,[540] although there was a strong correlation between Dr Altinakar's modelled hydrograph and the measured hydrograph at that point.[541]

304 Given the agreement between the modelled level of actual flooding, the survey marks and Mr Keller's observations, I am satisfied on the balance of probabilities that had flood operations been conducted in accordance with SIM C, then Mr and Mrs Keller's home (ie, XX6) would not have been inundated with any flood waters.

XX4 and XX8 XXXX Road

305 In Revised Report 2, Dr Altinakar included similar diagrams for the other Keller homesteads, namely XX4 and XX8. However the transverse sections appeared to cross-reference the simulated levels of flooding under the 2018 Set Up, the tender of which was rejected in *Rodriguez (No 18)*.[542] This

[538] LAY.ROD.008.0001 at [52].
[539] MAS6 at [186] and at .0730.
[540] SBM.030.011.0001 at [76] and [77].
[541] MAS5 at .0306, [340] to [341].
[542] EXP.ROD.019.0001 at .0084 and .0086.

appears to be more than a typographical error as the inundation levels for the actual scenario in that diagram appear to be different from Table 13-2 set out about above, suggesting that Dr Altinakar has accidentally transposed the results of the application of the 2018 Set Up to these properties in this part of his report.[543] Given what appears to be an error in Dr Altinakar's reports, this issue should be addressed as part of any determination of the quantum of Mr and Mrs Keller's claim. In light of the finding made in relation to XX8, it is inevitable that Mr and Mrs Keller will recover some amount. Also, given their particulars of loss, the completion of the assessment of their claim would also appear to require findings about the actual and simulated inundation at Jensen's shed, as well as the inundation across the farming properties given the claim for loss of topsoil.

13.4.7: Ms Visser's Home at North Booval

306 Ms Visser is the owner of a property at XXXX North Booval where she lives with her family.[544] North Booval is located on the eastern side of Ipswich near the Bremer River and is not far from its confluence with the Brisbane River. Ms Visser described the house on the property a "low set, one storey brick house with a front and back yard, situated on a 607m^2 block of land".[545]

307 The location and topology of her home and its surrounding area is best explained through the following aerial photograph:[546]

[543] The level of inundation for XX8 suggested by EXP.ROD.019.0001 at .0084 is around 2.45m compared to 2.75m in the above table. The level of inundation for XX4 suggested by EXP.ROD.019.0001 at .0086 is about 2.15m compared to around 2.27m in the above table.
[544] LAY.ROD.010.0001 at [5] and [10].
[545] Ibid at [11].
[546] Ibid at .0004.

Figure 13-22: Aerial photograph of Ms Visser's home

308 The red rectangle sets out the approximate boundaries of Ms Visser's property. The green line shows the approximate boundaries of her parents' property who live directly behind her. The blue line is Bundamba Creek which runs into the Bremer River. The Bremer River is to the left of this image. It joins the Brisbane River downstream.[547] Ms Visser said that "[u]sually, the section of Bundamba Creek behind [her parents'] property only has some water in it". Ms Visser said that the distance between her property and the creek is approximately 120m. It is a steep embankment.[548]

309 Ms Visser stated that on the morning of 11 January 2011 she and some friends packed up many of their possessions.[549] During the course of the day, Ms Visser and her parents monitored the rising levels of Bundamba Creek.[550] At some point they were provided with sandbags which they placed "over all of the external doorways around the house".[551] At around 8.00pm Ms Visser and her family accepted police advice to evacuate. They left in "vehicles … packed to capacity".[552] Ms Visser returned at around 7.30am on 13 January 2011 to find the water had inundated her home with "silty mud" inside and

[547] SUN.800.001.0009; SUN.800.001.0035.
[548] LAY.ROD.010.0001 at [12] to [13].
[549] Ibid at [21].
[550] Ibid at [27].
[551] Ibid at [26].
[552] Ibid at [32].

outside the house.[553] Ms Visser said that the inside walls were "stained grey to about 1.2m high".[554] She also observed that "[g]arden mulch and bark chips from the garden were up the side of the brickwork on the outside of the house, up to about 1.2m high".[555]

310 As with the other properties, Dr Altinakar superimposed on the aerial photograph indications of the modelled extent of actual flooding compared to the modelled extent of flooding under SIM I:[556]

Figure 13-23: Aerial photograph of Ms Visser's property superimposed with Dr Altinakar's extent of flooding.

311 The transverse sections for this property provided by Dr Altinakar are as follows. The shaded grey areas correspond to the approximate limits of the building on the property:[557]

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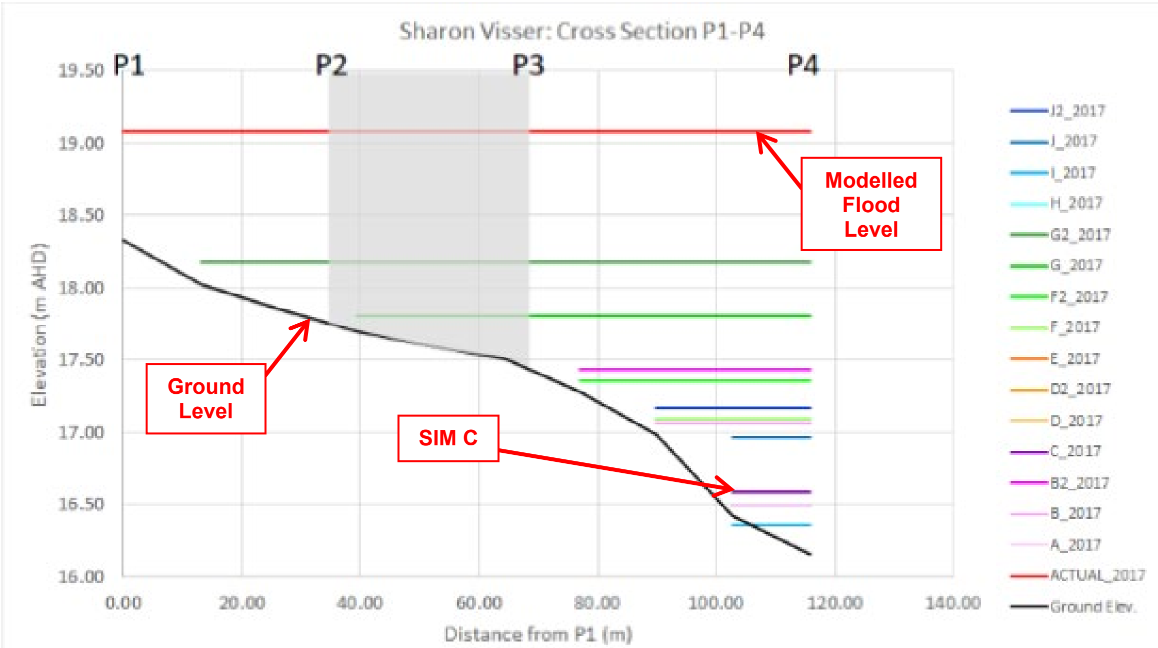
[553] Ibid at [45].
[554] Id.
[555] Ibid at [42].
[556] Revised Report 2 at .0089.



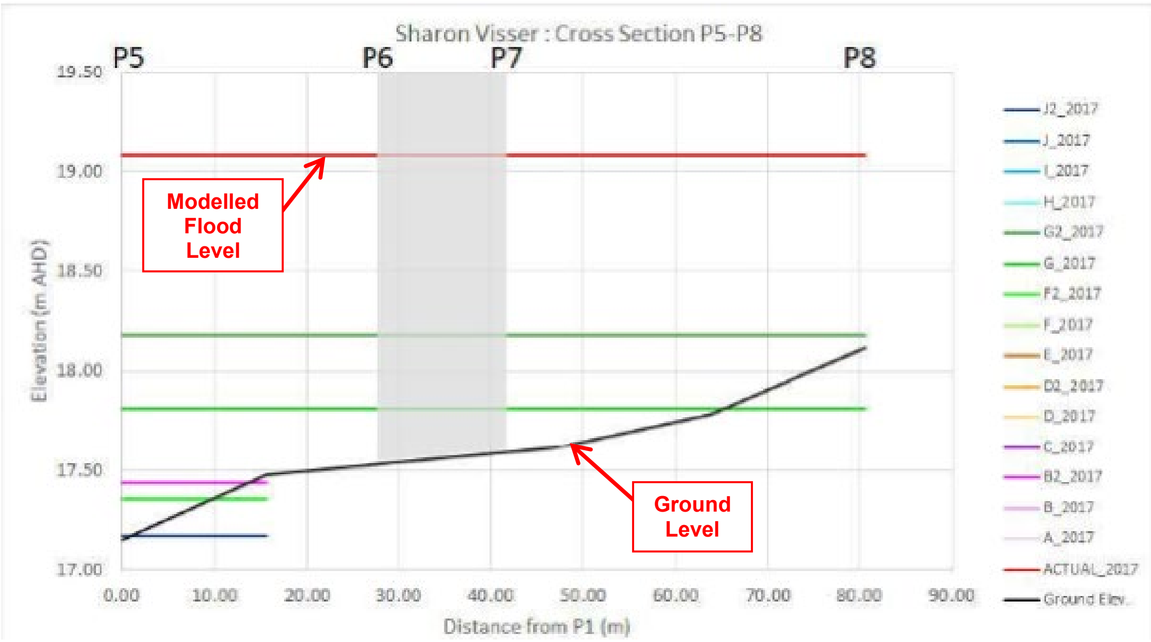


Figure 13-24: Transverse Sections of elevations at Ms Visser's property

312 The sharp drop in the elevation to the east, and to an extent to the south, of Ms Visser's house is evident in these transverse sections. The first shows the projected height of SIM C being almost a metre below the ground elevation of her home. The second indicates that the projected height of SIM C is at least 60cm below the ground elevation or her home (and likely much more). The red dot in Figure 13-23 corresponds to the entry in Table 13-2 for Ms Visser's

557 Revised Report 2 at [100].

property. That table indicates a level of inundation during the actual flood at 1.49m above ground level. The above diagrams indicate that the actual level of flooding above ground level varied between about 1.40m and 1.60m depending on the ground level. All of these measures are completely consistent with Ms Visser's observations as to the height of staining *inside* her house of "about 1.2m" (as the difference would allow for the height of the floor above ground level).

313 Two of the hydrographs that Dr Altinakar calibrated his 2017 Set Up to were located on Bundamba Creek.[558] For both of them the correlation with the peak period of the flooding is very close. One had a computed peak that was .32m lower than the measured peak[559] and the other had a computed peak that was 0.10m higher than the measured peak. One of them was correlated to flow data for the period from 11 December 2010 to 3 January 2010. Dr Altinakar described that correlation as "fair".[560] With the other, the hydrological data only begins on 2 January 2011. For the period from 6 to 9 January 2011 the computed peak level exceeds the measured peak but it correlates well thereafter.

314 In MAS6, Dr Altinakar reviewed his modelling of actual flooding by the 2017 Set Up to flood marks near Ms Visser's property. He concluded that the "[m]ajority of the nearby flood marks … show an error in elevation within ±0.15m", although "[t]here [were] also some flood marks with an error level of .30 to 0.50m".[561] SunWater noted that the nearest observation point was on Bundamba Creek and Dr Altinakar's modelling of the actual flood was 32cm less than the peak at that point. Otherwise, I note that this property was potentially affected by the issue raised above concerning Bremer River flows but that concern is significantly moderated by the strength of the correlation of Dr Altinakar's modelling with the peak of the hydrograph at Ipswich.

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[558] MAS6 at [359] to [360].
[559] Ibid at [359].
[560] Id.
[561] MAS6 at [186].

315 Thus a consideration of the performance of the 2017 Set Up's measurement of actual flooding in the vicinity of Ms Visser's home does not undermine but instead reinforces a finding, on the balance of probabilities, that had flood operations been conducted in accordance with SIM C then Ms Visser's home would not have been inundated by any flood waters. I so find.

13.4.8: Ms Harrison's Stored Possessions

316 As at January 2011, Ms Harrison was retired. She owned a home at Springfield Lakes in south-western Brisbane. During 2010 she rented out her home while she lived with her mother in Melbourne. In June 2010, her personal possessions were removed from her home and packed in a shipping container. They were taken to a professional storage facility in Coopers Plains, Queensland.[562] Coopers Plains is located south of the central business district of Brisbane some distance from the Brisbane River. By January 2011, Ms Harrison had returned to Brisbane but her possessions remained in storage as her house was still tenanted.[563]

317 On or about 13 or 14 January 2011, Ms Harrison attended at the storage facility. It had been badly affected by the flooding.[564] She inspected the container with her possessions which was apparently stored at ground level.[565] She noticed that the door had already been partially opened.[566] She was not allowed to inspect the container but she observed that the "boxes had moved around and were topsy-turvy' and there "was a brown watermark about three quarters of the way up the container walls".[567]

318 Dr Altinakar superimposed on an aerial photograph of the storage facility projections of the modelled extent of actual flooding compared with the modelled extent of flooding under SIM I.[568]

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[562] LAY.ROD.007.0001 at .0003 to .0004.
[563] Ibid at [19].
[564] Ibid at [23].
[565] Ibid at [26].
[566] Ibid at [27].
[567] Ibid at [29].
[568] Revised Report 2 at .0091.

Figure 13-25: Aerial photograph of storage facility in Coopers Plains superimposed with extent of flooding

319 The transverse sections provided by Dr Altinakar for this property are as follows. The shaded grey areas correspond to the approximate limits of a building on the property:[569]

[569] Revised Report 2 at [102] and at .0093.

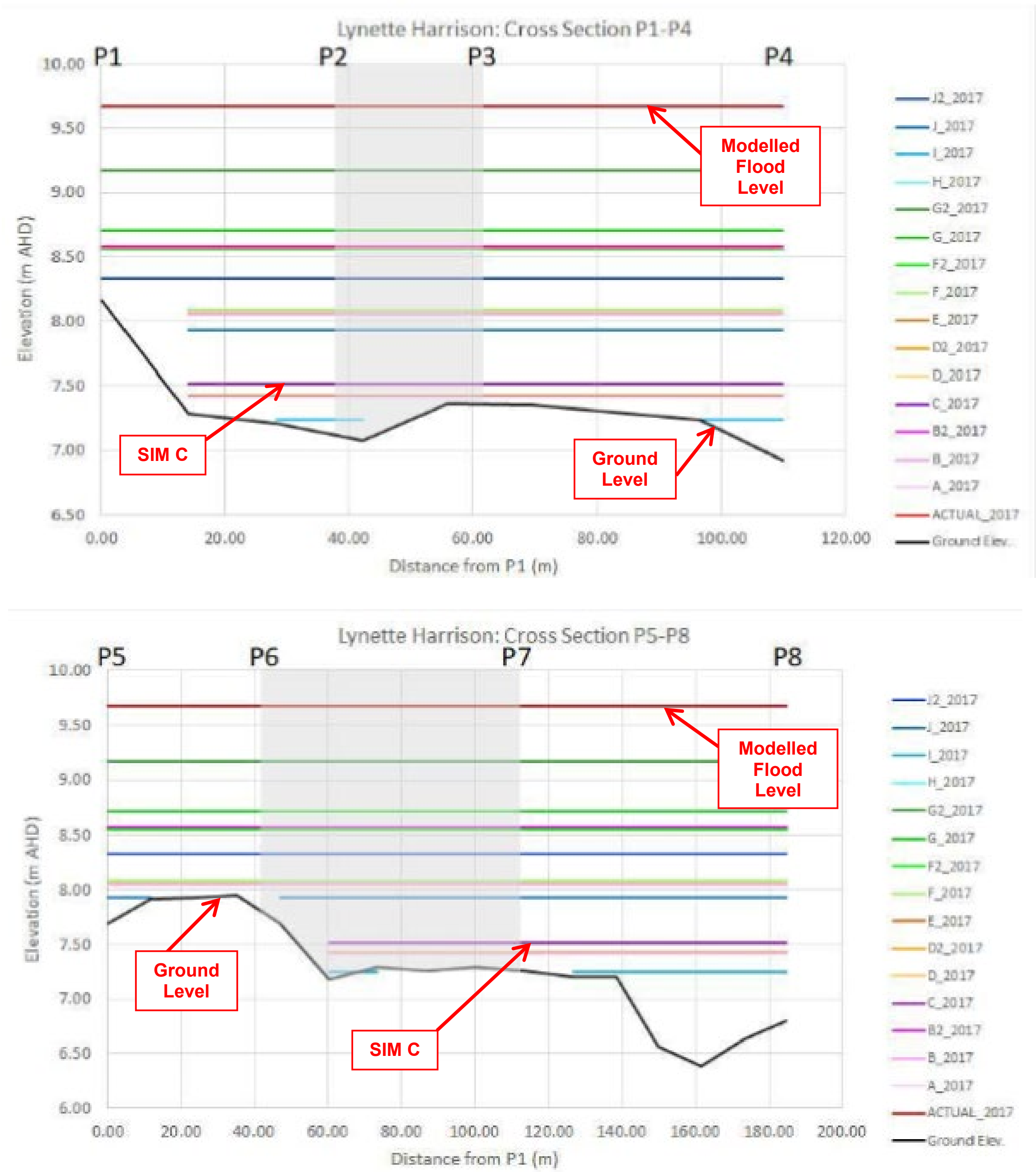

Figure 13-26: Transverse section for flooding at storage facility in Coopers Plains

320 The red dot in Figure 13-25 corresponds to the entry in Table 13-2 for the inundation of the storage facility to the level of 2.42m above ground level. This corresponds with these transverse sections, allowing for variations in ground level. The modelled level of actual flooding is consistent with Ms Harrison's observation of the dirt mark inside the shipping container noted above. Dr Altinakar compared the computed levels of actual flooding with nearby survey

marks which he said showed an error level of 0.30m to 0.50m.[570] This supports the relative accuracy of Dr Altinakar's modelling. Table 13-2 indicates that Dr Altinakar's modelling showed that flood operations in accordance with SIM C would have yielded flooding at the point of the red dot above ground level of 26cm. With the variation in ground level, flooding under SIM C appears to range between about 15cm and 40cm.

321 At present, the only finding that is sought concerns whether the adoption of SIM C would have resulted in flooding that did not reach above the ground level of the storage facility at which Ms Harrison's shipping container was stored. Based on this material I am not satisfied, on the balance of probabilities, that had flood operations been conducted substantially in accordance with SIM C then the flooding would not have been above that level. As discussed above, that finding is not necessarily dispositive of Ms Harrison's claim for damages. Depending on how such a claim is formulated and presented, it may be that a further finding not inconsistent with that finding might result in her recovering some damages.

13.4.9: Conclusion and Future Assessments

322 Subject to the matter addressed next, it follows that s 11(1)(a) of the *CLA* (Qld) has been established in respect of all forms of "particular harm" suffered by the plaintiff that result from the inundation of its store. Similarly, s 11(1)(a) has been established in respect of all forms of particular harm suffered by Ms Lynch and Ms Visser that result from the inundation of their homes (as well as Ms Lynch's shed and cottage). The same applies in relation to Mr and Mrs Keller's home at XX8 XXXX Road. It has not been established on the balance of probabilities that, but for the defendants' breaches, the flooding would not have reached above the ground level of the storage facility at which Ms Harrison's property was stored in a shipping container.

323 Two further issues arise. First, as noted above, these findings are not necessarily determinative of the claims made by the sample group members.

[570] MAS6 at [186].

The balance of their claims will need to be determined and that can only be done by litigating all remaining causation and quantum issues in their matters together.

324 Second, it follows from the above analysis that Dr Altinakar's modelling cannot be taken as determinative of the precise level of flooding under SIM C at every location within the modelled area. Instead, any assessment for a particular location must be made having regard to all the evidence relevant to that location and bearing in mind the level of precision that is necessary to address a claim for the "particular harm" that is said to have been suffered. However, in conducting any such assessments for group members then, absent agreement to the contrary or a compelling case for the grant of leave, all the parties will be held to the forensic choices they have made in the litigation to this point. They will also be bound by the findings made about Dr Altinakar's modelling (and other matters) in this judgment. That said, if it is the case that the defendants have hydraulic modelling of their own available to them, then they are obliged under s 56 of the *Civil Procedure Act 2005* to consider the outcome of such modelling for a particular group member before putting matters relevant to causation for that group member in issue.

13.5: Mr Ruffini: Section 11(1)(a) and Successive Tortfeasors

13.5.1: Submissions

325 In its written submissions, the State contended that the plaintiff had to show that "any breach by Mr Ruffini, *taken on its own*, *as it must be*, caused the alleged greater flooding and the extent to which it did". It contended that the "real question is what would have happened in the absence of Mr Ruffini's alleged negligent acts or omissions, given the existence of the other Flood Operations Engineers and of the general strategy determined by the Senior Flood Operations Engineer".[571] The State submitted that the only simulations that could be relied on so far as Mr Ruffini was concerned was SIM F, SIM H, SIM J and SIM G, as the start time for those simulations coincided with periods that Mr Ruffini was on duty. In respect of SIM F, it noted that, if Mr

[571] State subs at [344].

Ruffini commenced releases in accordance with SIM F from its commencement time at midnight on 8 January 2011, then, by the conclusion of his shift at 7.00am on 8 January 2011, the difference between the simulated Wivenhoe Dam levels and the actual level would have been only 13cm (or 14,629ML).[572] For his second shift from 7.00pm on 9 January 2011 to 7.00am on 10 January 2011, it submitted that the only difference in reservoir levels would have been 1cm.[573]

326 The State submitted that these variations in Wivenhoe Dam levels were de minimis, especially having regard to the alleged "modelling error of plus or minus 0.5m in flood levels accepted by [Dr] Altinakar in modelling the Christensen simulations",[574] and that Mr Ruffini was under Mr Ayre's supervision and obliged to act in accordance with his "general strategy".[575]

327 The State also submitted that the "test of causation is whether the defendant's breach of duty caused or materially contributed to the plaintiff's injury" (citing *Bonnington Castings Ltd v Wardlaw* [1956] AC 613; "Bonnington Castings"). It submitted that the threshold of materiality was not met because "[i]f the modelling produces tolerances of half a metre, then the difference of centimetres in dam levels which might have been occasioned by Mr Ruffini's alleged breaches have not been shown to be material".[576] However, in supplementary written submissions, it contended that, in light of the plaintiff disclaiming reliance on s 11(2) of the *CLA* (Qld) in oral submissions[577], there was no scope to rely on the concept of "material contribution", which it apparently assumed was only accommodated by that provision.[578] Instead, it submitted that the 'but for' test had to be applied to Mr Ruffini's breaches of

[572] Simulation Analysis, EXP.ROD.015.0461 at .0846 - .0847.
[573] Id; State subs at [345(a)].
[574] State subs at [351].
[575] Ibid at [355].
[576] Ibid at [358] - [360].
[577] See T 9297.41.
[578] SBM.040.005.0001 at [3].

duty considered alone. It otherwise maintained its contention that the contribution of Mr Ruffini to any downstream flooding was de minimis.[579]

328 As noted, in responding to this point, Senior Counsel for the plaintiff maintained that its case on causation against each of the flood engineers and those vicariously liable for their conduct satisfied s 11(1)(a) of the CLA (Qld). He disclaimed reliance on s 11(2).[580] He submitted that in a case in which all the flood engineers were "involved in the one endeavour" and "[if there is a] finding that the overall endeavour was negligent … then the individual components contribute to it and those responsible for the individual components are liable".[581] He placed particular reliance on a passage from *Strong v Woolworths* (at [20]) set out below.[582]

329 Thus, the State's submission raises an issue about the materiality of a breach by one of a succession of tortfeasors to an assessment of causation. It has been found that SIM C represents the appropriate counterfactual for reasonably prudent flood operations during the January 2011 Flood Event. It follows from the above analysis that the plaintiff has established that the difference in dam levels or retained volumes in Wivenhoe Dam during 11 and 12 January 2011 between SIM C and the events that happened was causative of the inundation of its store and all the loss and damage that was occasioned as a result of that inundation. As noted, from that point the plaintiff's case is that a contribution by a flood engineers' breaches, or at least a material contribution, to that difference was sufficient for that engineer's breaches of duty to satisfy s 11(1)(a) of the *CLA* (Qld).[583] According to the plaintiff, the same position applies so far as other group members seek recovery in respect of "particular harm".

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[579] The State also made a series of submissions in support of the contention that SIM F could not have been implemented in the form it was by Dr Christensen from midnight, which are addressed in Chapter 10: SBM.040.005.0001 at [19] – [34].
[580] T 9297.41; T 10135.23.
[581] T 9296.30.
[582] T 9296.4.
[583] T 9296.5; T 9297.41 to T 9298.3; T 10135.23.

13.5.2: Assessment of Mr Ruffini's Contribution

330 Before addressing the legal issues, four matters should be noted about the factual foundation for the State's submission.

331 First, the State's submission proceeds on the misapprehension that the breaches of duty alleged against Mr Ruffini are tied to a failure to adopt one of Dr Christensen's simulations. This contention was rejected in Chapter 12.[584] Instead, Dr Christensen's simulations, including Simulation F, inform the breach analysis and the reasoning underlying all the findings of breach correspond with the reasoning that warranted the adoption of SIM C as the counterfactual flood operation. The State's submission also overlooks that Mr Ruffini's shift commenced at 7.00pm on 7 January 2011, some five hours prior to the commencement of SIM F. The reasoning that warranted releases being made in SIM F sufficient to inundate the remaining bridges commencing from midnight on 8 January 2011 was equally applicable to flood operations from 7.00pm on 7 January 2011. The findings of breach in Chapter 12 concerning that part of his shift on that evening reflect the necessity to adopt Wivenhoe Dam gate operations consistent with those undertaken in SIM F and SIM H from 7.00pm on 7 January 2011.[585]

332 A rough approximation of the difference in the volume of water retained in Wivenhoe Dam at the end of Mr Ruffini's shift at 7.00am on 8 January 2011 that is attributable to his breaches of duty during that shift is calculated in Appendix J to this judgment. Appendix J calculates the effect of a shift of the gate openings that are modelled in SIM F and SIM H from midnight in SIM F back to 7.00pm on 7 January 2011. It sets out a calculation of the approximate difference in the volume of releases across the 12 hours of Mr Ruffini's shift between what was actually released and what should have been released. It does not take into account the fact that gates may have been opened progressively over an hour and the differences in outflows for the same level of gate openings due to different reservoir levels in each scenario.

[584] Chapter 12, section 12.2.
[585] Chapter 12 at [135], [139].

Its degree of accuracy can be gauged by comparing its calculation of the difference between the extra volume released in SIM F and SIM H to 7.00am in column F of Appendix J to 7.00am on 8 January 2011 (15,410ML) with the 14,629ML determined by Dr Christensen's own (and more accurate) modelling.[586]

333 Appendix J yields an approximate difference in the retained volume of water in Wivenhoe Dam at the conclusion of Mr Ruffini's 12-hour shift at 7.00am on 8 January 2011 of 38,120ML. This figure does not include any consideration of the lower rate of releases from Somerset Dam into Wivenhoe Dam under SIM F compared to the events that happened as under SIM F all the Somerset Dam sluice gates are closed from midnight. The following analysis proceeds by reference to an estimate of 35,000ML as the approximate contribution made by Mr Ruffini's breaches of duty during his shift on 7 and 8 January 2011 to the extra volume of water retained in Wivenhoe Dam compared to SIM C. At dam levels of approximately EL 68.50m AHD, that corresponds to a height differential of approximately 30cm.

334 Second, the assessment of Mr Ruffini's contribution involves a consideration of the cumulative effect of all of his breaches of duty. Mr Ruffini performed another shift on the evening of 9 January 2011 and into the morning of 10 January 2011. In Chapter 12 it was found that, during his shift on the evening of 9 January 2011, Mr Ruffini breached his duty of care by failing to implement Strategy W4,[587] and that required an immediate increase in releases necessary to inundate the remaining open bridges which would have been above the level of releases in SIM F but less than the level of releases in SIM G from midnight on 10 January 2011.[588] Appendix K to this judgment contains an indicative calculation of the likely contribution that those breaches made to the extra volume of water retained in Wivenhoe Dam as at midnight on 10 January 2011. Column E to Appendix K sets out a calculation of the volumetric difference in amounts released between SIM F and SIM H on the

[586] Simulation Analysis, EXP.ROD.015.0461 at .0846; 1,331,487ML – 1,316,858ML.
[587] Chapter 12 at [173].
[588] Id.

one hand and the actual releases on the other for the period from 7.00pm on 9 January 2011 to midnight on 10 January 2011. It is doubtful that from 7.00pm gates at Wivenhoe Dam could have been opened sufficiently rapidly to match the release rate at 7.00pm in SIM F but they could certainly have matched SIM F's rate of around 2000m^3/s by 9.00pm (in which case the volumetric difference would have been at least 7000ML).[589] Column H of Appendix K sets out a rough calculation of the set of releases that approximates to the analysis of breach. It yields an estimate of a further volume difference of around 14,000ML. The following analysis proceeds by reference to an estimate of 10,000ML as the approximate contribution made by Mr Ruffini's breaches of duty in relation to Wivenhoe Dam releases during his shift on the evening of 9 January 2011 to the extra volume of water retained in Wivenhoe Dam compared to SIM C.

335 Third, in Chapter 12 it was also found that Mr Ruffini breached his duty of care on the evening of 9 January 2011 by failing to implement Strategy S3[590] and specifically failing to close the sluice gates at Somerset Dam.[591] Similarly, in respect of the balance of his shift to 7.00am on 10 January 2011, it was found that Mr Ruffini breached his duty of care by failing to reduce releases from Somerset Dam into Wivenhoe Dam.[592] An estimate of the likely reduction in the volume of water in Wivenhoe Dam that would have resulted from closing the sluice gates at Somerset Dam at 7.00pm on 9 January 2011 until the end of Mr Ruffini's shift at 7.00am on 10 January 2011 can be gauged by examining the difference in retained volumes in Somerset Dam between modelled operations under SIM G for the 12-hour period from midnight on 10 January 2011 to midday on 10 January 2011 and actual flood operations. The Somerset Dam levels prevailing in that 12-hour period are sufficiently similar to Mr Ruffini's shift to enable the former to be used as a proxy for the latter for this purpose.

[589] 2.28ML + 1.86ML + 1.4ML + 1.45ML = 6.99ML.
[590] Chapter 12 at [178] and [185].
[591] Chapter 12 at [177].
[592] Chapter 12 at [202].

336 SIM G commenced at midnight on 10 January 2011 and simulates an immediate closure of the sluice gates at Somerset Dam. Thus, as at midnight on 10 January 2011 the modelled volumes in Somerset Dam were the same as the actual volumes. Dr Christensen modelled retaining an additional 39,439ML in Somerset Dam by midday on 10 January 2011 in SIM G from closing the sluice gates.[593] If Dr Christensen had not modelled closing the sluice gates in SIM G but instead adopted the flood engineers' flood operations for Somerset Dam, then a volume approximating to that figure would have been released into Wivenhoe Dam during that time (although it would have been less as water would have spilled over EL 100.45m AHD at a greater rate). Over the ensuing period that difference would have reduced as the higher levels in Dr Christensen's simulated operations at Somerset Dam would have caused higher rates of spillage above EL 100.45m AHD than in the events that actually transpired. However, some of the difference would have been retained. The following analysis proceeds by reference to an estimate of 25,000ML as the approximate contribution made by Mr Ruffini's breaches of duty in relation to Somerset Dam during his shift on the evening of 9 January 2011 into the morning of 10 January 2011 to the extra volume of water actually retained in Wivenhoe Dam compared to what would have been retained in SIM C.

337 Fourth, as noted, the plaintiff has established that the difference in dam levels and retained volumes in Wivenhoe Dam during 11 and 12 January 2011 between SIM C and the events that happened was causative of the inundation of its store in that "but for" that difference the plaintiff's store would not have been inundated. Based on the above figures, a rough assessment can be made of the minimum contribution that Mr Ruffini's breaches of duty made to that differential.

338 Appendix L to this judgment sets out a comparison of the dam levels and retained volumes in Wivenhoe Dam from 7.00am on 10 January 2011 under SIM C compared to the events that happened. As at 7.00am on 10 January 2011, being the end of Mr Ruffini's last shift in which he breached his duty of

[593] Simulation Analysis, EXP.ROD.015.0461 at .0899; 637,806ML – 598,367ML = 39,439ML.

care, that difference was 532,562ML or 4.44m. A volume of 70,000ML[594] represents around 13% of that volume or approximately 52cm at the prevailing dam level.[595] As at 5.00pm on 10 January 2011, that difference was 568,507ML or 4.33m at the prevailing dam level. A volume of 70,000ML represents over 12% of that volume or approximately 48.6cm at the prevailing dam level.[596] As at 1.00pm on 11 January 2011, that difference was 491,896ML or 4.01m. A volume of 70,000ML represents over 14% of that volume or approximately 45cm at the prevailing dam level.[597] As at 7.00pm on 11 January 2011, being the time of peak outflows from Wivenhoe Dam, that difference was 418,333ML or 2.79m at the prevailing dam level. A volume of 70,000ML represents 16.7% of that volume or approximately 44cm at the prevailing dam level.[598] By midnight on 12 January 2011, that difference was 31,3334ML or 2.06m at the prevailing dam level. A volume of 70,000ML represents over 22% of that volume or approximately 43cm at the prevailing dam level.[599]

339 Of these various comparisons the first and second are probably the most valid because, as the difference between SIM C and the actual levels started to narrow due to the greater releases in the events that happened throughout 11 January 2011, the amount of the differential referable to Mr Ruffini's breaches of duty was effectively reducing as well. Otherwise, another relevant factor is the relative importance of a reservoir height differential of at least 40cm or more as dam levels climb above EL 74.0m AHD as they did on 11 January 2011.

13.5.3: Successive Tortfeasors and Section 11(1)(a)

340 Even allowing for the roughness of these calculations, it is evident that the State's submission that any contribution of Mr Ruffini's breaches was de minimis cannot be sustained. Even so, it is still necessary to address how, if

[594] 35,000 + 10,000 + 25,000.
[595] Or around 66cm at the simulated levels in SIM C at that time.
[596] Or around 59cm at the simulated levels in SIM C at that time.
[597] Or around 53cm at the simulated levels in SIM C at that time.
[598] Or around 49cm at the simulated levels in SIM C at that time.
[599] Or around 48cm at the simulated levels in SIM C at that time.

at all, contributions by a successive tortfeasor to a state of affairs that is causative of loss or damage in the but for sense are accommodated by s 11 of the *CLA* (Qld).

341 *Strong v Woolworths* addressed, inter alia, s 5D(1)(a) of the *CLA* (NSW) which, as noted, is the equivalent provision to s 11(1)(a) of the *CLA* (Qld). French CJ, Gummow, Crennan and Bell JJ stated (at [18] to [20]):

> "The determination of factual causation under s 5D(1)(a) is a statutory statement of the "but for" test of causation ….: the plaintiff would not have suffered the particular harm but for the defendant's negligence.
>
> …
>
> Under the statute, factual causation requires proof that the defendant's negligence was a necessary condition of the occurrence of the particular harm ….. A necessary condition is a condition that must be present for the occurrence of the harm. However, there may be more than one set of conditions necessary for the occurrence of particular harm *and it follows that a defendant's negligent act or omission which is necessary to complete a set of conditions that are <u>jointly</u> sufficient to account for the occurrence of the harm will meet the test of factual causation within s 5D(1)(a)* ….. In such a case, the defendant's conduct may be described as contributing to the occurrence of the harm." (underlined and italicised emphasis added)

342 Their Honours then addressed how the concept of a breach of duty making a "material contribution to the harm" suffered by a plaintiff related to s 5D(1)(a) and s 5D(2). Their Honours noted[600] the decision in *Bonnington Castings*, in which an employee developed lung disease from exposure to three sources in the workplace in circumstances where their employer was only legally responsible for one source. Even though the cause of the disease was not wholly attributable to one source or another, the employer was held liable because the employer's breaches had "materially contributed" to the disease being contracted.[601] Unlike this case, *Bonnington Castings* did not involve contributions to the harm suffered as a result of the actions of multiple tortfeasors, but instead was a case in which were there several contributors only one of which was a tortfeasor. In addition, in this case the approximate level of contribution can be quantified.

[600] *Strong v Woolworths* at [23].
[601] *Bonnington Castings* at 621.

343 After discussing *Bonnington Castings*, the plurality in *Strong v Woolworths*[602] referred to s 5D(2) (ie, s 11(2)) and returned to the concept of "a set of conditions necessary for the occurrence of the harm", stating as follows:[603]

> "The authors of the Ipp Report and Allsop P in *Zanner v Zanner* assume that cases exemplified by the decision in *Bonnington Castings* would not meet the test of factual causation under s 5D(1)(a). However, whether that is so would depend upon the scientific or medical evidence in the particular case, a point illustrated by the decision in *Amaca Pty Ltd v Booth* with respect to proof of causation under the common law …. *In some cases, although the relative contribution of two or more factors to the particular harm cannot be determined, it may be that each factor was part of a set of conditions necessary to the occurrence of that harm*." (emphasis added)

344 The second sentence in this passage leaves open the possibility that a case like *Bonnington Castings* would fall within s 5D(1)(a) and suggests that *Amaca Pty Ltd v Booth* (2011) 246 CLR 36; [2011] HCA 53 ("Amaca") was such a case. In *Amaca*, a finding of causation based on the material contribution of different periods of exposure to asbestos to contracting mesothelioma was upheld.[604]

345 The emphasised portion of the extract from *Strong v Woolworths* set out at [343] reinforces the earlier statement that "a defendant's negligent act or omission which is necessary to complete a set of conditions that are jointly sufficient to account for the occurrence of the harm" will satisfy the factual test of causation.[605] This concept embraces the circumstance of such acts or omissions combining with the negligent acts or omissions of other tortfeasors to complete the requisite "set of conditions".

346 The footnote to the emphasised passage from *Strong v Woolworths* set out at [341] above cites Fleming, *The Law of Torts* (Ninth edition, 1998, The Law Book Company) at 219 ("Fleming") and *March v Stramare (E & MH) Pty Ltd* (1991) 171 CLR 506 at 509; [1991] HCA 12, per Mason CJ ("March v Stramare").[606] In *March v Stramare* at 509, Mason CJ noted that "at law, a

602 *Strong v Woolworths* at [24].
603 Ibid at [27].
604 At [51] per French CJ and at [83] per Gummow, Hayne and Crennan JJ.
605 *Strong v Woolworths* at [20].
606 As well as Hart and Honoré, *Causation in the Law* (Clarendon Press, 2nd Edition, 1985) at 18.

person may be responsible for damage when his or her wrongful conduct is one of a number of conditions sufficient to produce that damage". Similarly, in *Fleming* at 219 the author stated that: "[w]hether a particular condition qualifies as a causally relevant factor will depend on whether it was necessary to complete a set of conditions jointly sufficient to account for the given occurrence." Later in discussing this concept, the author stated: [607]

> "The same test [ie necessary to complete a set of conditions jointly sufficient to account for the given occurrence] confirms that, in a case of pollution from several sources, all can be regarded as causal, even if none was necessary nor independently sufficient for the injury. Suppose that five units of pollution were necessary and each of seven defendants discharged one unit. Although each defendant's unit was neither necessary nor sufficient, it was necessary for the sufficiency of a set of conditions that included any four others [citing *Crossley and Sons v Lightowler* (1867) LR 2 Ch App 478; *Barker v Permanent Seamless Floors Pty Ltd* [1983] 2 Qd R 561]"

347 The example in this passage is directly applicable to Mr Ruffini's circumstances. The second of the authorities cited by Fleming in this passage, *Barker v Permanent Seamless Floors Pty Ltd*, is of particular relevance. *Barker v Permanent Seamless Floors Pty Ltd* was an appeal from a decision to grant an extension of the limitation period to a sufferer of a terminal illness contracted through the cumulative effect of constant exposure over a period of time to five toxic chemicals, one of which was shown to have been supplied by the appellant.[608] That appellant contended that, as it supplied only one of the five toxic chemicals to which the prospective plaintiff was exposed and as any one of the other four might have caused or contributed to the damage he sustained, there was no evidence to establish a cause of action against it and the extension order should not have been granted.[609] This argument was characterised by Connolly J in the Full Court of the Supreme Court of Queensland as follows:[610]

> "It happens from time to time that damage is sustained as a result of the independent activity of a number of tortfeasors. The argument commonly advanced in this sort of situation is that it is not demonstrated that the plaintiff would not have suffered his damage without the contribution concededly

[607] *Fleming* at 222.
[608] *Barker v Permanent Seamless Floors Pty Ltd* at 562.
[609] Ibid at 564D.
[610] Ibid at 564G.

made by the particular defendant. This superficially attractive argument, taken to its logical conclusion, would mean that although the probability is that the plaintiff suffered damage by the co-operating faults of a number of defendants, none of them is liable."

348 By reference to authority from the United Kingdom[611], Connolly J, with whom Douglas and Macrossan JJ agreed, rejected this "superficially attractive argument".[612] The headnote records the decision as authority for the proposition that where damage is sustained as a result of the activity of several concurrent tortfeasors, "it is unnecessary to demonstrate that the injured party would not have suffered his damage without the contribution made by a particular party in order that that party may be held liable". I accept that this is the effect of the decision. It confirms the proposition discussed in *Fleming* and it is an example of an application of the proposition stated in *Strong v Woolworths*. The position in this case is stronger than what is reflected in the above passage from *Barker v Permanent Seamless Floors Pty Ltd* in that the conduct of flood operations by the four flood engineers was not truly "independent activity".

349 Otherwise, in addressing the phrase "caused" in s 34(2) of the *CLA* (NSW) in the context of "concurrent and successive tortious acts", in *Hunt & Hunt v Mitchell Morgan Pty Ltd* (2013) 247 CLR 613; [2013] HCA 23 at [45], French CJ, Hayne and Keifel JJ noted that the proposition that such acts "may each be a cause of the plaintiff's loss and damage is reflected in the proposition that a plaintiff must establish that his or her loss or damage is 'caused or materially contributed to' by a defendant's wrongful conduct" and "[m]aterial contribution has been said to require only that the act or omission of a wrongdoer play some part in contributing to the loss".

13.5.4: Conclusion on section 11(1)(a) and Mr Ruffini

350 As noted, Dr Altinakar's modelling (and the other evidence) demonstrates that the difference in water volumes and dam levels between SIM C and the actual events was causative of the damage suffered by the plaintiff in that, but for

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[611] *Pride of Derby & Derbyshire Angling Association Ltd v British Celanese Ltd* [1952] 1 TLR 1013; *Blair v Deacon* (1877) 57 LT 522 and *Thorpe v Brumfitt* (1873) LR 8 Ch App 650.
[612] *Barker v Permanent Seamless Floors Pty Ltd* at 566F.

that difference in water volume being retained in Wivenhoe Dam, the plaintiff's store, and the shopping centre it formed part of, would not have been inundated by flood water. It follows that, according to *Strong v Woolworths* at [20], that difference in volume and consequently water levels was "sufficient to account for the occurrence of harm" occasioned to the plaintiff.

351 Mr Ruffini's conduct on his two shifts were part of a series of breaches of duty by himself and the other flood engineers that resulted in the difference in retained water volumes and water levels in Wivenhoe Dam between SIM C and the events that happened. As stated, at a minimum Mr Ruffini's breaches of duty contributed approximately 70,000ML or around 50cm in water levels to that differential. This amount was clearly material, especially when regard is had to the changes in dam operations that occur when water levels climb above EL 74.0m AHD. It follows that Mr Ruffini's breaches of duty were "*necessary to complete a set of conditions*", namely all the breaches of duty by the flood engineers which together yielded the total difference in retained water volume and thus dam levels between SIM C and the events that happened. Thus, all the breaches were "*jointly sufficient to account for the occurrence of the harm"* to the plaintiff (see *Strong v Woolworths* at [20]; see [341]). Mr Ruffini's breaches of duty were a "factor" that was part of the "set of conditions necessary to the occurrence of that harm" (*Strong v Woolworths* at [27]; see [343]). This is sufficient for his breaches to meet the test of factual causation in s 11(1)(a) of the *CLA* (Qld).

13.5.5: Scope of Liability – section 11(1)(b)

352 In its supplementary written submissions on causation, the State disputed that s 11(1)(b) was satisfied in relation to it or Mr Ruffini.[613] In particular, it pointed to the following six matters as not warranting the scope of the liability of the person in breach to extend to the harm so caused.[614]

353 First, the State contended that it "was not involved in the operation of the dams" and had no practical control over the selection of flood strategies.

[613] SBM.040.005.0001 at [51] - [57].
[614] Ibid at [57].

Second, the State repeated its puzzlement as to how a failure to lower Wivenhoe Dam by 13cm was causative of the damage which occurred on 12 January 2011. Third, it contended that there "were a series of intervening events between the time Mr Ruffini was first on duty and the time the Plaintiff's property was flooded" being the activity of the other flood engineers, the "exceptionally heavy un-forecasted rainfall" and the contribution of downstream flows to the flooding. Fourth, it was submitted that there "was no temporal connection between the alleged breach by Mr Ruffini and the flooding of the Plaintiff's property". Fifth, it was submitted that by analogy "if not adopting a Christensen simulation was a breach of duty, Mr Ruffini's dam operations on the first period he was on duty in the Flood Operations Centre may be likened to the situation of a truck driver whose excessive speed 20 minutes before an intersection causes the truck to arrive at a single lane bridge at the same time as another truck and the two collide". Sixth, it was submitted that it was questionable whether "Mr Ruffini would have been permitted to unilaterally move to a different strategy and release more water from Wivenhoe Dam".

354 If the first matter is directed to the position of the State as opposed to Mr Ruffini then it appears to amount to an attempt to deny the doctrine of vicarious liability, something which is well outside the ambit of s 11(1)(b). If it is directed to Mr Ruffini then it is inconsistent with the findings that have been made as to the duties and powers of a DFOE. The second point has been addressed above. In relation to the third matter, the so-called "intervening events" consisted of the conduct of the other flood engineers. The foreseeability of the rainfall is addressed in Chapter 6.[615] Otherwise, this point is addressed below. The fourth point is a variation on the third point. The fifth point is a restatement of a scenario suggested by Mason CJ in *March v Stramare.*[616] In light of the analysis below, there is no analogy between that situation and Mr Ruffini's or the State's position. The sixth point echoes a submission made by SunWater addressed in section 13.6. In short, if Mr Ruffini had directed a different approach to flood operations and been

[615] Section 6.2
[616] *March v Stramare* at 516.

overruled or even removed from his position, then he would not have been in breach of his duty but the extent of Seqwater's liability would have been greater that it will be as a result of the findings in this judgment.

355 The analysis of the equivalent provision to s 11(1)(b) in *Wallace v Kam* involved four distinct steps. The first was that if a case falls "within an established class" then the question posed in s 11(1)(b) is answered by the "application of precedent".[617] No such precedent was suggested. Second, the Court noted that a "limiting principle of the common law is that the scope of liability in negligence normally does not extend beyond liability for the occurrence of such harm the risk of which it was the duty of the negligent party to exercise reasonable care and skill to avoid".[618] Thus, a medical practitioner "is not liable to a patient for physical injury that represents the materialisation of a risk about which it is beyond the duty of the medical practitioner to warn".[619] However, that is not this case. Widespread urban flooding resulting from the combination of large dam outflows and downstream flows represented the materialisation of the very kind of risk that the proper discharge of the flood engineers' duty was directed to avoiding.

356 Third, in *Wallace v Kam*, the Court stated that within the limiting principle just noted:[620]

> "... the scope of liability for the consequences of negligence is *often* coextensive with the content of the duty of the negligent party that has been breached. That is because the policy of the law in imposing the duty on the negligent party will ordinarily be furthered by holding the negligent party liable for *all harm* that occurs in fact if that harm would not have occurred but for breach of that duty and *if the harm was of a kind the risk* of which it was the duty of the negligent party to use reasonable care and skill to avoid." (emphasis added)

357 This is directly applicable to Mr Ruffini and the State. The harm that materialised was "*a kind the risk* of which it was the duty of [a flood engineer] to use reasonable care and skill to avoid", namely over the floor flooding or

[617] *Wallace v Kam* at [22].
[618] Ibid at [24].
[619] Ibid at [25].
[620] Ibid at [26].

greater flooding. Thus the "policy of the law in imposing the duty on the negligent party will ordinarily be furthered by holding the [flood engineer] liable for *all harm* that occurs in fact".

358 Fourth, in *Wallace v Kam* the Court nevertheless noted that the scope of liability is not always coextensive with the content of the duty and that "[f]urther analysis is required".[621] In *Wallace v Kam*, that analysis focused on the fact that it was a case "involving the materialisation of one of a number of distinct risks of physical injuries".[622] In such a case, the "underlying policy ... is to protect the patient from the occurrence of physical injury the risk of which is unacceptable to the patient".[623] The Court found that the scope of liability should reflect that policy. In *Wallace v Kam*, it meant that the plaintiff could not recover in respect of the materialisation of a risk that he was prepared to assume. There is no analogy in this case.

359 In light of the above findings, the State's submissions in respect of s 11(1)(b) reduces to the supposed inappropriateness of the scope of the liability of a single flood engineer, who was one of team of flood engineers on duty during the January 2011 Flood Event, extending to the harm caused by all of them. Two related matters rebut that contention. First, their actions were not completely independent of each other but instead were part of a co-ordinated response which involved, in many respects, a common and unreasonably held misconception of the requirements of the Manual.

360 Second, the State's submission overlooks the effect of the apportionment provisions in the *CLA* (Qld) addressed in Chapter 14. Their application means that the State will not bear the entirety of the loss that was occasioned. An outcome that attributes the scope of liability for all the harm caused to Mr Ruffini but only results in the State bearing such liability as the "court considers just and equitable having regard to the extent of [its] responsibility for the loss or damage"[624] is far more "appropriate" than an outcome that

[621] Ibid at [27].
[622] Ibid at [36].
[623] Id.
[624] *CLA* (Qld); s 31(1)(a).

might deprive the plaintiff of recourse against any employer of the flood engineers because the individual contributions of each flood engineer's breaches might not satisfy the but for test, despite the combined effect of them certainly doing so.

361 Accordingly, I reject the State's submissions. Subsection 11(1)(b) is satisfied in respect of Mr Ruffini and all of the flood engineers.

13.6: Causation and Operations below FSL

362 SunWater submitted that, even if Mr Ayre had set a release plan to take Wivenhoe Dam below FSL, "[i]t is obvious that Seqwater would have intervened and not permitted [that] to happen".[625] SunWater contended that, in that event, the "particular harm" would still have occurred as the dams would have been operated in the same way.[626]

363 The evidentiary foundation for this submission is an email sent by Mr Borrows to Mr Drury on or about 30 December 2010 stating that "for this current event, we release down to FSL only",[627] along with the evidence of Messrs Malone and Mr Tibaldi to the effect that they did not believe releases below FSL were permitted.[628] Their evidence is addressed in Chapter 5. It was not accepted so far as Messrs Malone and Tibaldi were concerned.[629] Otherwise, I do not accept that it is "obvious" that such a direction would have been given to Mr Ayre as SFOE. Such a direction would have been inconsistent with the vesting of responsibility in the SFOE by the Manual. If Seqwater had purported to give such an instruction it would have risked losing the protection afforded by s 374 of the *Safety and Reliability Act*. Further, it is doubtful whether Seqwater could have given SunWater an instruction to direct Mr Ayre that was inconsistent with the Manual given the power to issue such

[625] SunWater subs at [2767].
[626] Ibid at [2768].
[627] SEQ.016.014.2190.
[628] SunWater subs at [2765].
[629] Chapter 5 at [141] and [157].

instructions in the SLA concerns the "performance of the Service"[630] and the "Service" is defined by reference to the Manual.[631]

364 In any event, this submission is simply another way of addressing the submission that just has been addressed in relation to Mr Ruffini. Even if such an instruction was given and had the result suggested by SunWater then it would only mean that Seqwater would bear a greater proportion of the liability to the plaintiff than it otherwise will. In that event, Seqwater would then be responsible for its even greater contribution to the "set of conditions that are jointly sufficient to account for the occurrence of the harm".[632]

365 Subsection 11(1)(a) is to be applied by considering whether the breaches of duty were "necessary to complete a set of conditions that [were] jointly sufficient to account for the occurrence" of the particular harm. It is not to be applied by speculating about whether, but for one of the individual defendant's breaches, another tortfeasor might have committed additional breaches of duty.

366 Accordingly I reject SunWater's submission.

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630 SLA, SEQ.001.022.8933; clause 3.2(c).
631 Ibid at .8955 to .8970; Chapter 11 at [141] – [148]; cf SunWater subs at [2769].
632 *Strong v Woolworths* at [20].

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CHAPTER 14: QUANTUM, CROSS-CLAIMS AND THE LIMITATION PERIOD

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CHAPTER 14: QUANTUM, CROSS-CLAIMS AND THE LIMITATION PERIOD

1 Three topics remain to be addressed, namely certain quantum issues relating to the plaintiff's claim, some of which are the subject of common questions,[1] the cross-claims between the defendants and the effect of the institution of these proceedings on the running of the relevant time limit provided for in the *Limitation of Actions Act 1974* (Qld).

14.1: Quantum Issues

Issues to be Determined

2 Consistent with the pleading,[2] the plaintiff claimed various heads of damage which are interrelated, namely damage to fixtures and fittings, damaged or lost stock and loss of "sales and profits". As noted in Chapter 13,[3] once it is found that, but for the defendants' breaches the plaintiff's store would not have been inundated, then prima facie those heads of damage are recoverable. Ultimately the parties agreed that there were only five matters that needed to be decided and that based on the findings on those topics the parties could then calculate the quantum of the plaintiff's damages, including interest.[4]

3 The five issues are: (i) the projected growth in sales figures that would have been occasioned to the plaintiff's store but for the defendants' breaches of duty; (ii) the value of certain "out of date stock" that was retained by the store but destroyed in the flooding; (iii) whether the plaintiff's damages should be reduced by taking into account certain payments it received from the Queensland Rural Adjustment Authority (the "QRAA"); (iv) whether the plaintiff can recover the commercial cost of its director's time and certain volunteer labour that cleaned up a significant amount of the plaintiff's damaged stock (the so-called "mud army"); and (v) whether the plaintiff's claim is affected by the provision of free storage for affected stock, rent abatement offered by its landlord, free stock provided by a supplier and a payment from Suncorp Bank

[1] Questions 31 to 33: SBM.500.001.0001 at .0016 to .0017.
[2] 5ASOC at [347], Particular D.
[3] Chapter 13 at [12].
[4] T 9472 (Plaintiff); T 9766 to T 9768 (Seqwater); T 10046.43–10047.2 (State).

of $5000. The issues concerning payments from the QRAA and the provision of volunteer labour are the subject of common questions as presumably they affect a number of group members.

Background

4 The plaintiff's store opened in June 2004 at Fairfield Gardens.[5] Fairfield Gardens is approximately 5km south east of the Brisbane Central Business District.[6] There were approximately 30 specialty stores in the centre together with a Coles supermarket.[7] The plaintiff entered into a lease in June 2004 and renewed that lease on 15 May 2009 for the period 1 June 2009 to 31 May 2015.[8] From around May 2004 to October 2011 the plaintiff was a member of a branded retail buying group called "Sports Power".[9] From October 2011 the plaintiff was a member of another retail buying group called "Sportsfirst".[10]

5 The plaintiff was the trustee of the Rodriguez family trust (the "Trust") and ran the store for the beneficiaries of the Trust.[11] For the first three years the store traded, namely 2004 to 2007, the Trust incurred losses in running the store but before-tax profits were earned each financial year thereafter until the January 2011 Flood Event.[12]

6 The circumstances of, and the extent of, the flooding to the plaintiff's store were referred to in Chapter 1 and Chapter 13.[13] Although Mr Rodriguez and his family were able to remove some stock from the store to their home, the majority of that stock was destroyed when their home was inundated.[14] As noted, Mr Rodriguez was able to access the store on 16 January 2011.[15] He described the store as a "mess". He said that the entire floor of the store was littered with shoe boxes and other stock and everything "was covered in mud".

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5 LAY.ROD.001.0001 at [11].
6 Ibid at [48].
7 Id.
8 Id at [49] to [50].
9 Id at [37].
10 Id at [44].
11 Id at [22] to [24].
12 Id at [34].
13 Chapter 13 at section 13.4.4.
14 Ibid at [94].
15 Ibid at [96].

He said "[a]ll the boxes we had stacked on tables had collapsed and fallen into the floodwaters". He also stated that "the stock that had been positioned on shelves above the level of flooding had remained dry, however...much of that stock was still damaged due to humidity".[16]

7 The clean-up of the store commenced from 16 January 2011. On 17 and 18 January 2011, between 10 and 15 volunteers assisted the store. For a considerable time approximately six volunteers (ie, the "mud army") collected damaged shoes, clothing and sporting goods, cleaned them and then returned them to the plaintiff.[17] The plaintiff incurred additional storage costs for some of the stock that was saved, however other stock was stored at the homes of friends and relatives.[18] It sold some stock for a discount at local schools and football clubs.[19] The plaintiff purchased replacement stock and office furniture. The store eventually reopened on 26 May 2011[20] and continued trading until it closed on 13 June 2015[21] which was around the time that its lease ended.

Sales Growth Figures

8 The annual sales figures for the plaintiff's store from 2006 onwards were as follows:[22]

Financial year	Sales Revenue ($)	Percentage Change (%)
FY2006	397,977	
FY2007	453,800	+14.0
FY2008	461,334	+1.7
FY2009	507,484	+10.0
FY2010	505,864	-0.3
FY2011	301,393	-40.4
FY2012	413,597	+37.2
FY2013	419,114	+1.3
FY2014	466,348	+11.3

Table 14-1: Sales revenue figures for the plaintiff's store

[16] Ibid at [99].
[17] Ibid at [105], [109].
[18] Ibid at [116] to [120].
[19] Ibid at [133].
[20] Ibid at [154].
[21] Ibid at [159].
[22] Cairns 1, EXP.ROD.008.0013 at .0037.

9 The figures for the financial year ending 30 June 2011 show a collapse in sales revenue associated with the flooding and the closure of the store from January 2011 to May 2011.

10 Each of the plaintiff and Seqwater engaged an accountant to consider the quantum of the claim, being Mr Martin Cairns and Mr Michael Potter respectively. They disagreed over the appropriate predicted percentage growth figure applicable to the sales figure for financial year 2010 (and beyond) to reflect the performance of the plaintiff's store but for the defendants' breaches of duty (the "but for" case).

11 The competing growth figures were:[23]

Financial year	Cairns growth figure	Potter growth figure
FY2011	1.8%	-6.3%
FY2012	4.5%	0.7%
FY2013	4.5%	4.7%
FY2014	4.5%	7.0%

Table 14-2: Comparison of Potter and Cairns proposed sales growth rates

12 Mr Cairns determined his figures by considering the historical performance of the business during the period that it was not closed due to flooding.[24] He noted that the store experienced compound annual growth rates of 6.2% over financial years 2006 to 2010[25] and the same rate during financial years 2012 to 2014. He analysed the seasonal performance of the business for the financial years 2006 to 2010. He said that this revealed a significant increase in sales during the period from December to April each year[26] (presumably to coincide with Christmas, holiday sport activity and the preparation for winter sport seasons).

13 In relation to the first half of financial year 2011, Mr Cairns noted that the sales revenue for those six months was $204,984 which he contended was

[23] EXP.ROD.009.0005 at .0045 (Cairns); EXP.SEQ.007.0154 at .0168 (Potter).
[24] EXP.ROD.008.0013 at .0038 to .0040.
[25] At [109] and [111].
[26] At .0040.

"materially in line with the first six months' sales revenue for FY2009 being [$]206,493".[27] Mr Cairns stated that he considered it "reasonable to assume a small increase during [the second] six months given the previous periods' sales revenues were increasing".[28] Thus, he determined a sales figure for financial year 2011 of $515,000, being a 1.8% increase from financial year 2010.

14 Mr Potter derived his growth rates from two sources. For the second half of financial year 2011, Mr Potter assumed a continuation of the (negative) "rate of growth experienced by the business in the first half of the financial year" (ie, -6.3%) which he considered was "consistent with available industry data".[29] For financial years 2012 to 2014, Mr Potter said he adopted as benchmarks the "rates of growth experienced in the sporting goods retail industry" for that period.[30]

15 In view of the approaches adopted by both accountants it is appropriate to first describe their analysis of the second half of financial year 2011 and then the subsequent years, although those matters are clearly related.

16 In relation to financial year 2011, Mr Potter pointed out that the sales figures for the six months to December 2010 of $204,984 constituted a 6.33% reduction from the sales figures for the corresponding six months to December 2009.[31] He analysed the sales performance of the business in six month periods from 2007 onwards and concluded that there was a relatively small variance in sales revenue over the first six months of each financial year but "the sales in the second half of the financial year had far greater variance".[32] He concluded that it was not appropriate to assume that, absent

[27] Ibid at [112].
[28] Ibid at [114].
[29] EXP.SEQ.007.0154 at .0168, [2.17.1].
[30] Ibid at .0168, [2.17.2].
[31] Ibid at .0183, [5.4].
[32] EXP.SEQ.007.0001 at .0196, [5.56].

the flooding of the shopping centre, "the sales in financial year 2011 would follow a similar pattern to financial year 2009".[33]

17 In his reply report dated 16 December 2016, Mr Cairns broke down the sales figures for the first six months of financial year 2011 on a monthly basis.[34] This revealed that until the end of November the business experienced a modest increase in sales over the corresponding five months from the previous year but that there was a 30% drop in revenue in December 2010 from the previous year, leading to an overall 6.3% reduction for the six-month period. Mr Cairns posited that the high levels of rainfall in December 2010 may have been responsible for that drop. He noted that the rainfall returned to its seasonal average for the period February to May 2011.[35]

18 In his reply report dated 22 June 2017 Mr Potter observed that to achieve Mr Cairns' proposed annual rate of growth for financial year 2011 of 1.8%, the business would have had to achieve an increase in sales of 8% over the corresponding period in financial year 2010 (to compensate for the drop of 6.3% to 31 December 2010).[36] Both by reference to his industry comparison and his analysis of the business' performance, Mr Potter disagreed with that assumption.[37]

19 In relation to subsequent years, it is necessary to explain Mr Potter's industry benchmarking approach in more detail. Mr Potter divided the plaintiff's historical sales records into three categories, clothing, footwear and other recreational goods, to determine a proportionate weighting of sales across those categories. He then calculated annual sales growth rates for those categories of goods from industry reports, specifically "IBISWorld 2015 Industry Reports"[38] and sales growth data for those subcategories provided by the Australian Bureau of Statistics ("ABS").[39] He then used the weighting

[33] Ibid at [5.59].
[34] EXP.ROD.009.005 at .0050, [191].
[35] Ibid at .0051, [196] to [198].
[36] EXP.SEQ.011.0005 at .0015, [3.10].
[37] Ibid at .0016 to .0017.
[38] EXP.SEQ.007.0154 at .0184, [5.8.1].
[39] Ibid at [5.8.2].

he determined for those three categories for the business to extrapolate an "Industry Reports Benchmark Rate" and an "ABS Benchmark Rate".[40] In turn he averaged the two rates[41] to produce a "CIGR" (Combined Industry Growth Rate).[42] Mr Potter then used the CIGR to determine his counterfactual sales growth rates for financial years 2012 to 2014.

20 In his reply report, Mr Cairns set out Mr Potter's various figures and compared them to the actual growth rates experienced by the plaintiff's business as follows:[43]

FY	Business	IBISWorld	ABS	Potter CIGR	Difference between Business v Potter CIGR
FY2007	14.02	7.70	3.09	5.39	**8.63**
FY2008	1.66	9.35	6.11	7.73	**- 6.07**
FY2009	10.00	- 1.07	6.63	2.78	**7.22**
FY2010	- 0.32	3.17	- 5.43	- 1.09	**0.77**
FY2011	- 40.41	- 3.27	- 3.81	- 3.54	**- 36.87**
FY2012	37.32	- 0.68	2.00	0.66	**36.57**
FY2013	1.33	4.08	5.26	4.67	**- 3.34**
FY2014	11.27	3.49	10.46	6.98	**4.29**

Table 14-3: Sales growth benchmarks determined by Mr Potter (financial year of Flood Event highlighted)

21 It can be seen that Mr Potter selected his proposed growth rates from his CIGR rates for financial years 2012 to 2014.

22 In his report dated 1 June 2016, Mr Potter also broke down the ABS figures to quarterly and half yearly figures and compared them to the plaintiff's sales figures.[44] Mr Potter stated that the data showed a "reasonable degree of consistency" before and after the flood event.[45] In circumstances where the Court is required to determine between the rates he proposed and those

[40] Ibid at .0184 to .0188.
[41] T 4165.28.
[42] EXP.SEQ.007.0154 at .0189, [5.25].
[43] EXP.ROD.009.005 at .0057, [226].
[44] EXP.SEQ.007.0154 at .0191, Table 25; and .0192, Table 27.
[45] Ibid at .0193, [5.38].

suggested by Mr Cairns I do not agree they show any such consistency. The consistency shown by his tables was more a product of the scales adopted than any trends in the data.

23 In his reply report, Mr Cairns criticised Mr Potter's selection of the three categories noted above,[46] the process of averaging the ABS figure and the industry figure[47] and the selection of IBISWorld Reports as the appropriate source for industry data.[48] Of most significance is his contention that none of the indices, especially the CIGR figure, adequately correlate to the historical performance of the business.[49] This is evident from the above table, especially for the period from 2007 to 2010. On average Mr Potter's figures were 2.64% less than the business'.[50] Mr Cairns also compared the data for increases in sales of the three subcategories of products in the ABS and IBISWorld figures with the corresponding sales figures for the plaintiff's business for those categories of goods in the period up to 30 June 2010. The degree of correlation for those figures was also poor.[51]

Submissions and Finding

24 The plaintiff's submissions described the process by which Mr Potter produced his CIGR index rate as "convoluted".[52] The submission referred to the criticisms of that rate made by Mr Cairns, including its lack of correlation to the performance of the business.[53] Seqwater's written[54] and oral submissions[55] on this topic emphasised the points made by Mr Potter concerning the unlikelihood of there being sufficient growth in sales in the second half of financial year 2011 to offset the poor performance in the first half, especially having regard to the poor performance of the industry and the

46 EXP.ROD.009.005 at [214] to [217].
47 Ibid at [218] to [223].
48 Ibid at [266] to [270].
49 Ibid at [224] to [245].
50 Ibid at .0059, [230].
51 Ibid at .0063 to .0068.
52 Plaintiff subs at [2108].
53 Ibid at [2109] to [2110].
54 Seqwater subs at [2547] to [2551].
55 T 9770.38.

ABS benchmarks during that period.[56] Seqwater contended that Mr Potter's figures for financial years 2012 to 2014 should be adopted.[57] The State adopted Seqwater's submissions.[58]

25 Subject to one significant matter I find Mr Cairns' approach overall more persuasive. Without traversing all of the criticisms of Mr Potter's benchmarking approach, in the end I considered it significant that there was a lack of any correlation between his figures and the performance of the plaintiff's business. This left me unpersuaded that the figures were worthy of much weight save for their confirmation of depressed industry conditions in financial year 2011 which presumably in part reflected the effect of flooding in Brisbane.

26 The matter of exception is that both experts appeared to proceed on the assumption that the "but for" case assumes that there was effectively no flood at all in the area of the plaintiff's store. However, the "but for" case only assumes that the plaintiff's store and the shopping centre was not inundated. Under SIM C, significant parts of the surrounding area, including the car park to the shopping centre, would have been inundated.[59] It is likely that the inundation of local areas and other parts of Brisbane, including the damage to sporting fields, would have appreciably affected trading conditions over at least the month following the flood. If there was an unusual dip in trading conditions in December 2010 due to poor weather then there would likely have been a similar effect on trading conditions from the far worse weather situation in January 2011. As noted, Mr Cairns concluded that the period of December to April was the most important period of trading months for the business. Even under the "but for" case, the period from early January to late February 2011 was likely to be significantly affected, although it can be expected that conditions would improve significantly thereafter. In those circumstances, it is not realistic to assume that in the second half of financial year 2011, the business would have achieved an increase in growth of around

[56] Seqwater subs at [2551(d) and (e)].
[57] Ibid at [2552].
[58] T 10047.7.
[59] See Chapter 13, section 13.4.4.

8% on the corresponding period in 2010. Instead, I consider something akin to the 6.3% reduction in the first half of the year would have carried over into the second half of the year. Accordingly, I find that the appropriate sales growth figure for financial year 2011 is minus 6%.

27 However, if the store and the shopping centre had not been inundated during the January 2011 Flood Event, then it would have been well poised to rebound the following year. I consider that growth of positive 6% is the appropriate figure for that year, noting that this would still leave the level of sales slightly less than the figure for the financial year ended 30 June 2010.[60] Thereafter I accept Mr Cairns' growth figures of 4.5% as the best estimate of the likely increase in sales.

Out of Date Stock

28 In his report dated 1 June 2016, Mr Potter identified inventory that had been written off by Mr Rodriguez after the flooding of his store that had a value of $8159 that had been purchased in financial year 2009 or earlier but had not been sold.[61] Mr Potter concluded that the stock was unlikely to have any sale value or that it may have been disposed of without properly being recorded.[62] He identified an example of such an item as a "surf fin" purchased in 2004.[63] Mr Potter adjusted the amount claimed by allowing for no recovery in respect of these items. In his report dated 16 December 2016,[64] Mr Cairns stated that he undertook a "limited analysis of the historical turnover of the Business' inventory" which indicated that 10% of inventory was sold after being held for 18 months or longer.[65] His analysis of the types of stock held for that period and then later sold included cricket bats which were held for a number of years but then sold at full price.[66]

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[60] $505,864 x .94 = $475,512.16 x 1.06 = $504,042.89 (EXP.ROD.008.0013 at [108]).
[61] EXP.SEQ.007.0001 at [4.19].
[62] Id.
[63] Ibid at [4.20].
[64] EXP.ROD.009.0005.
[65] Ibid at [136] to [138].
[66] Ibid at [139].

29 The plaintiff noted[67] that Mr Rodriguez was not cross-examined about these items and that, in cross-examination, Mr Potter accepted that Mr Rodriguez may have been able to address whether that stock had a realisable value.[68] Mr Potter also accepted that another way of accounting for this stock would be to factor in its sale at a discounted price rather than reducing its value to zero.[69]

30 Given the small amount in dispute, the limited evidence on the topic and the fact that it only relates to the plaintiff's individual claim, I propose to deal with it by way of a discount. Using a discount effectively assumes that some of the stock would have been sold, some would have been sold at a discount and some would have never been sold. Some people prefer a bargain to the most recent fashion. Some wear out-of-date fashion items as a badge of pride and adopt the same approach with sporting goods. Others do not care that much, just as long as the clothing or item is functional. I will allow 20% of the value recorded in the inventory for these items, ie $1632.[70]

Tortious Damages and Voluntary Payments

31 The "settled principle governing the assessment of compensatory damages, whether in actions of tort or contract, is that the injured party should receive compensation in a sum which, so far as money can do, will put that party in the same position as he or she would have been in if the contract had been performed or the tort had not been committed".[71] However, there are circumstances in which payments and benefits received by the innocent party after the tortious act and which would not have been received but for the tortious act will not be brought to account in assessing their damages. One example is insurance payments, these being "the result of a contract [the innocent party] made before the loss occurred and by the express or implied terms of that contract they were to be provided notwithstanding any rights of

[67] Plaintiff subs at [2118].
[68] T 4205.8.
[69] T 4205.17.
[70] Ie, $8159 x 0.2 = $1631.80.
[71] *Haines v Bendall* (1991) 172 CLR 60 at 63; [1991] HCA 15, per Mason CJ, Dawson, Toohey and Gaudron JJ; "Haines v Bendall".

action [they] might have" (*National Insurance Company of New Zealand Ltd v Espagne* (1961) 105 CLR 569 at 599; [1961] HCA 15, per Windeyer J ("Espange")). Another category of such payment was described by Windeyer J in *Espagne* as "cover[ing] a variety of public charitable aid and some forms of relief given by the State as well as the produce of private benevolence".[72] His Honour stated that the "decisive consideration is, not whether the benefit was received in consequence of, or a result of the injury, but what was its character" which is to be determined "by the intent of the person conferring the benefit" with the test being "by purpose rather than by cause".[73] His Honour added that the determination of the purpose of the payment "must depend on the terms of the particular contract, pension scheme, charitable benefaction or statute governing the benefit conferred".[74]

32 As for the relevant purpose that is being inquired into, Dixon CJ in *Espagne* noted that payments that are not brought to account have the "distinguishing characteristic [that] they are conferred on [the innocent party] not only independently of the existence in him of a right of redress against others but so that they may be enjoyed by him although he may enforce that right", they being "product of a disposition in his favour intended for his enjoyment and not provided in relief of any liability in others fully to compensate him."[75] Thus, both Dixon CJ and Fullagar J referred to the provision of charitable funds to an injured person as an example of a payment that would not be brought to account,[76] such a payment being intended "to benefit the injured man and not to affect the wrongdoer's liability".[77]

33 The principles stated in *Espagne* have been consistently affirmed in the High Court since it was decided.[78] Given that such payments can include both payments under statutory schemes and the provision of money or services by

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[72] *Espagne* at 600.
[73] Ibid.
[74] Ibid.
[75] Ibid at 573.
[76] *Espagne* at 573 per Dixon CJ and at 599 per Windeyer J.
[77] *Espagne* at 599 per Windeyer J.
[78] *Redding v Lee* (1983) 151 CLR 117 at 135-139; [1983] HCA 16; "Redding v Lee"; *Haines v Bendall* at 74; *Manser v Spry* (1994) 181 CLR 428 at 434 to 436; [1998] HCA 50; ("Manser v Spry"); *Zheng v Cai* (2009) 239 CLR 446; [2009] HCA 52 at [19]-[20] ("Zheng v Cai").

private individuals, separate approaches to analysing "the intent of the person conferring the benefit" have been developed.

Statutory Benefits

34 The judgment in *Manser v Spry* at 436 to 437 is an authoritative statement as to the approach to be adopted in determining whether a statutory benefit possesses the "distinguishing characteristic" identified by Dixon CJ in *Espagne*. Six points from *Manser v Spry* should be noted. First, the inquiry is to discover the intention of the legislature.[79] Second, three possible indicia of the relevant legislative intention are the financial source of the benefit, the presence of a provision which requires repayment of the statutory benefit out of any award of damages and the "nature of the benefit".[80] Third, if the source of the benefit was at least in part contributed to by the injured party, then that will support a finding of the requisite intent. Fourth, a statutory provision requiring repayment of the benefit out of any award for damages is usually decisive that the damages are not to be reduced on account of the benefit.[81] Fifth, in relation to the nature of the benefit, their Honours in *Manser v Spry* referred to the following passage from the judgment of Gibbs CJ in *Redding v Lee* (at 125) concerning the circumstance in which the statute provides no express indication of the relevant form of intent:[82]

> "In many cases, however, the statute under which the benefit is provided will give no assistance of this kind. Then it will be necessary to consider closely the *nature of the benefit itself*. The conclusion that the benefit is intended for the plaintiff personally and not in reduction of the damages may more readily be drawn when it is seen that the receipt of the benefit is not dependent on the loss of wages or earning capacity ... for which the plaintiff claims damages (cf. *Parry v Cleaver* [(1970) AC at 42, per Lord Wilberforce]) and is not intended to replace the lost wages or remedy the loss of earning capacity." (emphasis added)

[79] At 436.
[80] At 436.
[81] At 436.
[82] At 437.

35 Sixth, in *Manser v Spry* their Honours noted that "if all indicia of intent fail" then the "settled" principle noted above (at [31]) must be applied.[83]

36 The various cases illustrate how the relevant statutory scheme and, in particular, the nature of the benefit relates to the discernment of legislative intention as to whether or not the statutory benefit is to be "enjoyed independently of, and cumulatively upon, [a] right to damages". They also demonstrate the significance of both whether the benefit was co-extensive with some head of damage the subject of the claim and whether the benefit was one to which the injured party was entitled or whether its conferral was discretionary. Thus, in *Manser v Spry*, various workers' compensation payments were all found to be "made in respect of the same matters as are taken into account in assessing damages in tort" and that this, in part, warranted a conclusion that the legislation was not "designed to confer benefits to be added to the damages to which the worker might otherwise be entitled at common law for a loss caused by an event which is not work related".[84] In *Espagne*, the Court held that the grant of a blind (or invalid) pension did not diminish an award for personal injury damages in circumstances where the pension was not payable as of a "strict right" but was only payable as a matter of discretion and only after there was "consideration of the position or situation in which the applicant stands"[85] which could allow consideration of any damages claim.

37 The conclusion in *Espagne* that an invalid pension should be disregarded when awarding damages was upheld again by Mason and Dawson JJ in *Redding v Lee* despite an argument that legislative changes had removed the discretionary element of the decision to award a pension and removed any consideration of the applicant's personal circumstances.[86] Mason and Dawson JJ found that the legislation still permitted a consideration of the existence of a damages claim in determining the rate of the pension and that this was a legislative indication that such pensions should be disregarded

[83] At 437.
[84] At 438 to 439.
[85] At 574 per Dixon CJ.
[86] *Redding v Lee* at 127 and 143.

from the quantum of damages.[87] Gibbs CJ,[88] Brennan[89] and Deane JJ[90] saw no reason to depart from *Espagne*.

38 However, at the same time that *Redding v Lee* was decided, a majority of the High Court (Mason, Dawson, Wilson and Deane JJ) in *Evans v Muller* (1983) 151 CLR 117; [1983] HCA 16 found that unemployment benefits should be deducted from any award of damages. Mason and Dawson JJ distinguished such benefits from invalid pensions on the basis that the grant of the benefits were "not dependent on the exercise of any large area of discretion" on the part of the decision-maker,[91] such that "[i]n a real sense, therefore, it may be said that the applicant for an unemployment benefit who satisfies [the criteria] is entitled as of right to the payment of the benefit".[92] Their Honours concluded that the payment is a "benefit paid in lieu of what could have been earned in employment if suitable employment had been available".[93] Wilson and Deane JJ agreed.[94] Each of Gibbs CJ, Murphy and Brennan JJ separately found that unemployment benefits were no different to the invalid (or blind) pension considered in *Espagne.*[95]

39 One passage from the judgment of Mason and Dawson JJ's analysis in *Redding v Lee* in relation to the invalid pension should be noted, as it concerns the significance of a statutory provision that renders a person ineligible because they are insured:[96]

> "Section 25(1)(d) provides, as we have seen, that an invalid pension shall not be granted to a person 'if he has an enforceable claim against any person, under any law or contract, for adequate compensation in respect of his permanent incapacity'. The words 'claim . . . under any law . . . for adequate compensation' do not include a common law claim for damages. By this omission the legislature indicated, and has continued to indicate in a manner now underlined by *Espagne*, an intention that the grant of an invalid pension

[87] At 143.
[88] At 128.
[89] At 158.
[90] At 168.
[91] At 146.
[92] At 146.
[93] At 146.
[94] At 159 and 168.
[95] At 132 to 133 per Gibbs CJ, at 151 per Murphy J and at 165 to 166 per Brennan J.
[96] At 144.

to an injured person is for the benefit of that person notwithstanding any common law claim for damages which he might have in respect of his injury and that the invalid pension payments are not to operate in relief of the liability of any person liable to pay those damages." (citations omitted)

40 Wilson J disagreed that this provision and its continuation unamended after *Espagne* was decided was indicative of any such intention.[97]

Private Benefits

41 Insofar as private or charitable benefits are concerned, the judgment in *Zheng v Cai* confirms that the inquiry about intention is the same as with statutory benefits noted above.[98] However, the ascertainment of such an intention is undertaken from a consideration of the factual context and not via the discernment of any legislative intention.[99] In *Zheng v Cai*, the injured person performed voluntary work for her Church. She received payments from the Church. A representative of the Church said these payments were "provided [as] financial support to [her] for her daily living and accommodation expenses to allow her to function more effectively as a volunteer worker".[100] The High Court held that the "critical question" was whether the payments by the Church were "intended by it to operate in the interest[s] of the [tortfeasor] and to diminish the damages he otherwise would be liable to pay".[101] In *Zheng v Cai*, it was found that they did not.[102] Earlier,[103] the Court referred to a passage from Windeyer J's judgment in *Espagne* concerning charitable benefits, in which his Honour stated:[104]

> "If, out of sympathy for a man unfortunately responsible for a motor accident, someone gives money to the victim, stating that he does so in the interest of the tortfeasor and to diminish the damages he must pay, effect must be given to his intention. If, on the other hand, the donor's expressed intention is that the injured man shall enjoy his bounty in addition to whatever rights he may have to recover damages from the tortfeasor, effect must in my opinion, be given to that intention. And if nothing be said, the intention of the giver may be inferred from the circumstances."

[97] At 156.
[98] At [29].
[99] *Zheng v Cai* at [27].
[100] At [13].
[101] At [23].
[102] At [26] to [30].
[103] At [20].
[104] *Espagne* at 598 to 599.

42 Both common sense and the cases suggest that the occasions when an intention to diminish the recovery of damages in the interest of the tortfeasor will be inferred from the actions of third parties are likely to be uncommon. Thus, in *Powercor Australia Ltd v Thomas* [2012] VSCA 87 ("Powercor"), Osborn JA (with whom Warren CJ and Bongiorno JA agreed) upheld a finding that the respondent was able to recover the commercial cost of repair work to fixtures, fencing and buildings destroyed by fire that had been undertaken by volunteers.[105] His Honour[106] quoted from a passage from the judgment of Mason and Dawson JJ in *Redding v Lee*[107] to the effect that "benefits … resulting from benevolence … spring from a desire to assist the plaintiff, not from any wish to relieve against the tortfeasor's liability".

QRAA Payments

43 The defendants contended that there should be deducted from any damages otherwise payable to the plaintiff, or at least payable by the State to the plaintiff, amounts the plaintiff received by way of grants from the QRAA. As explained below, the plaintiff received grants totalling $25,000 in 2011. Consistent with the above analysis, it is necessary to consider the statutory scheme closely to ascertain whether the legislative intent is that payments under it are "to be enjoyed independently of, and cumulatively upon, [any] right to damages".[108]

44 As in force in 2011, s 3(1) of the *Rural and Regional Adjustment Act 1994* (Qld) (the "RRA Act") specified that the object of the Act was to establish the QRAA "to administer assistance schemes that foster the development of a more productive and sustainable rural and regional sector in Queensland". Subsection 3(2) provided that the QRAA could also support the State's economy by administering schemes to give assistance to small businesses "in periods when they are experiencing temporary difficulty" or "to otherwise benefit the State's economy" (*RRA Act*; s 3(2)(a)). The QRAA was established

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[105] *Powercor* at [91].
[106] At [90].
[107] At [138].
[108] *Manser v Spry* at 436.

under s 5 and conferred with the status of a body corporate under s 6. Section 7 stated that it represents the State. Section 10 provided that the QRAA could only give financial assistance under an "approved scheme", that being a scheme approved under a regulation (s 11(1)(c)). Subsection 12(1) provided that, in administering such a scheme, the QRAA could, inter alia, assess and decide applications for assistance, cancel the provision of assistance and put conditions on the giving of assistance. However, this was subject to the requirements that QRAA comply with the statutory scheme and observe agreements entered with persons receiving assistance under the scheme (s 12(2)).

45 The relevant grants to the plaintiff were made pursuant to the "Special Disaster Assistance (November 2010 to January 2011) Scheme" (the "Scheme") which was provided for in Part 29 of the Rural and Regional Adjustment Regulation 2000 (Qld).[109] Within Part 29, clause 284 provided that the "objective of the scheme is to provide, under an agreement between the Commonwealth and the State of 3 January 2011, assistance to eligible business entities that have suffered direct damage caused by the flood event".[110] The scheme extended to primary producers (clause 289) and small business owners (clause 290). In the case of a small business, the eligibility criteria included a requirement for the QRAA to be satisfied that the applicant intended to re-establish their small business (clause 290(f)). Clause 298 obliged the QRAA to consider and then to decide to approve or refuse each application for assistance.

46 Clause 285(1) specified the purpose of the assistance provided by the Scheme was "to help an eligible business entity *pay for costs arising out of direct damage caused by the flood event*". Subclause 285(2) provided that "assistance under the scheme is not intended to compensate eligible business entities for loss of income suffered because of the flood event".

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[109] LAW.700.039.0001.
[110] Where flood event is defined as "the floods, caused by heavy rains in Queensland between November 2010 and January 2011, that have affected the prescribed (November 2010 to January 2011) flood disaster area" (clause 286).

47 Subclause 288(1) provided that the nature of the assistance under the Scheme was "the provision of a grant to help eligible business entities clean and restore their small businesses… that have suffered direct damage caused by the flood event". Subclause 288(2) provided that "[i]n particular, *assistance is to be provided* under the scheme to help an eligible business entity to cover the *costs* of the following". Thereafter, various categories of costs were listed, including, for example, "engaging a person to clean premises or a property" (clause 288(2)(b)), "clearing or disposing of debris, damaged goods or injured or dead livestock" (clause 288(2)(c)) and "repairing or reconditioning essential plant or equipment" (clause 288(2)(g)).

48 The maximum amount that could be granted under the scheme was $25,000 (clause 293). Clause 291 provided:

> "(1) An applicant is eligible for assistance of more than $5000 under the scheme only if-
>
> (a) the applicant provides evidence to the authority, in the form of tax invoices, official receipts for payment or bank statements, that all amounts claimed by the applicant under the *scheme have been paid by the applicant*; or;
>
> (b) the applicant demonstrates financial hardship under section 292 and provides evidence to the authority, in the form of quotations for work, equipment or materials, that all amounts claimed by the applicant under the scheme are needed for cleaning and restoring the applicant's small business or primary production enterprise. (emphasis added)
>
> (2) Subsection (1) applies to an applicant even if the applicant makes more than 1 application under the scheme.
>
> Example –
> An applicant makes a claim under the scheme for $5000 for a small business and makes a second claim for $4000. The applicant is not eligible for the further assistance of $4000 unless the applicant provides the evidence to the authority as required under the scheme that the total amount of $9000 claimed has either been paid by the applicant or, if the applicant has demonstrated hardship, is necessary for cleaning and restoring the small business." (emphasis added)

49 Subclause 294(2) specified that payment of assistance was subject to various conditions, including that the applicant consent to an audit to "verify that amounts given to the applicant under the scheme have been used in

accordance with the claim for assistance". Subclause 296(2) and (3) provided that, in respect of claims for more than $5000, an "applicant is not eligible to receive a grant under the scheme to cover particular costs of cleaning and restoring a primary production enterprise or small business if the applicant receives, or is entitled to receive, an insurance amount to cover the costs".

50 Thus, the Scheme was highly focussed on providing reimbursement for specific cost items incurred by eligible applicants during the flooding. The scope of all such payments was restricted to the specific costs in subclause 288(2) and specifically excluded any amount for loss of income (clause 285(2)), which would include profits. The Scheme provided for two tiers of payment, namely grants up to $5000 and then grants for amounts in excess of $5000. An application for the first tier grant did not depend on the expenditure having been incurred. However an applicant could only obtain a grant for more than $5000 if either, they had actually incurred the costs the subject of their application, as evidenced by invoices or receipts for items that fell within clause 288(2) (clause 291(1)(a)) or, if they were in a position of financial hardship and had not yet incurred the expenditure, they could provide quotes for the items that would fall within subclause 288(2) (clause 291(1)(b)).

51 In respect of so much of any grant that represents reimbursement for costs invoiced or paid for, then it follows that any grant funds would have been used to meet the designated costs the subject of the application. In respect of so much of the grant that represented payment for costs not yet incurred, which could be the first tier grant of $5000 or hardship applications that fell within clause 291(1)(b), there was no express condition that the grant had to be used for that purpose. However, there was a condition to allow an audit to verify that the grant was used to meet designated costs (clause 294(2)(c)).

52 Further, although it is not expressly stated, on their proper construction these provisions conferred an entitlement on an applicant who (genuinely) met the relevant criteria to receive assistance. As noted, the QRAA was obliged to consider and decide on applications (clause 298). Subclause 288(2) was

expressed in mandatory terms ("assistance is to be provided"). None of the provisions, including s 12 of the *RRA Act*, conferred any discretion to refuse the application or otherwise provided for the exercise of any normative judgment in considering an application beyond strictly applying the Scheme's criteria for eligibility and assistance. Section 12(1) of the *RRA Act* conferred a power to cancel such assistance but that power was confined by s 12(2), which requires the QRAA to observe the terms of any scheme and agreement made under such a scheme. This power was directed to such circumstances as applicants who were discovered to not be eligible under a scheme or who contravened its terms; ie, the powers in s 12(1) were directed to enforcing a scheme and not removing the benefits a scheme provided for.

53 Once the "nature of the benefit[s]"[111] provided by the Scheme are analysed in this way then, subject to addressing four matters, it follows that the scheme does not exhibit the "distinguishing characteristic"[112] of conferring benefits that are intended to be "enjoyed independently of, and cumulatively upon"[113] any right to damages in respect of the same cost items the subject of a grant under the Scheme. The Scheme was closely calibrated to providing grants by way of reimbursement for specific cost items that represented forms of "direct damage" suffered as a result of flooding. The entire focus of the Scheme was compensation for reimbursing specific forms of loss. It would be a remarkable outcome to find that the Legislature intended that a person could be reimbursed twice for exactly the same invoice or cost item.

54 In the passage from *Redding v Lee* set out above, Gibbs CJ identified the circumstance in which "the receipt of the benefit is not dependent on the loss of wages or earning capacity ... for which the plaintiff claims damages … and is not intended to replace the lost wages or remedy the loss of earning capacity" as a matter suggesting that the benefit was "intended for the plaintiff personally". In this case, the receipt of the benefit was dependent on incurring the cost "for which the plaintiff claims damages" and was "intended to replace"

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[111] *Manser v Spry* at 436.
[112] *Espagne* at 573 per Dixon CJ.
[113] *Manser v Spry* at 436.

or redress that particular loss. Moreover, the fact that the Scheme conferred on eligible applicants an entitlement to recoup those losses supports the conclusion that the legislature did not intend a recipient to be able to recover twice in respect of the same cost.

55 Four matters remain to be addressed.

56 The first matter to address before affirming this conclusion is so much of the Scheme that exempts an applicant for eligibility if they had insurance cover for the same items (ie, clause 296). In the passage from the judgment of Mason and Dawson JJ in *Redding v Lee* set out above, their Honours considered that a similar provision in the *Social Security Act 1947* (Cth) supported the conclusion that invalid pensions were not intended to relieve the liability of a person required to pay damages.[114] None of the other judgments endorsed that view and Wilson J expressly disagreed.[115] At least in this Scheme, I do not derive the same conclusion from the presence of clause 296. That clause only makes it clear that the first resort for reimbursement of the costs the subject of the Scheme was a person's own insurer and, failing that, the taxpayer. In its submissions the plaintiff noted that "there is nothing in the instruments about the grants being affected by an insurance policy or having to be repaid if the claimant successfully asserts rights of redress against a party that contributed to the same damage".[116] The first point of this submission is incorrect while the second point is true. However, this only reinforces the above analysis. If there was such a provision then that would dictate that there should not be any reduction in the plaintiff's damages. Its absence means that one is left with the inherent unlikelihood that the legislature intended that a person such as the plaintiff could recover precisely the same cost twice.

57 The second matter concerns the reliance in the plaintiff's submissions[117] on the decision in *Wollington v State Electricity Commission of Victoria* (*No 2*)

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[114] *Redding v Lee* at 144.
[115] *Redding v Lee* at 156.
[116] Plaintiff subs at [2097].
[117] Ibid at [2090], fn 853.

[1980] VR 91 ("Wollington"). The State's submissions addressed *Wollington* in detail.[118] In *Wollington*, the Full Court of the Victorian Supreme Court held that ex gratia payments made by the State government to bushfire victims should not be deducted from damages payable to the plaintiff by a tortfeasor responsible for the fire. Responsibility for the distribution of funds was conferred on a committee consisting of a Minister and various public servants. There was no statutory support for the committee's work.[119] The funds were the subject of an *Appropriation Act*[120] but otherwise there was no legislative support for the scheme.[121] The stated intention by the Government was that the grants were to be made "for the relief of personal hardship and distress for those in necessitous circumstances" and that relief would cover various costs including "emergency food, clothing and accommodation, essential repairs" with "[e]ach case … viewed on its merits and the ability of the individual to rehabilitate himself from his own resources … taken into account".[122]

58 The Full Court accepted that, as there was only an *Appropriation Act* to support the scheme, it was not a matter of ascertaining any legislative intention.[123] Their Honours decided to determine the character of the payment rather than specifically focussing on the intent of the payer.[124] Their Honours concluded that the payment had the "distinguishing characteristic" that it was received independently of the existence of a right in the plaintiff against others and it was intended to be enjoyed independently of that right.[125] Considered in context, *Wollington* is more of an example of a private charitable payment made by the State rather than the administration of a statutory scheme of benefits such as in *Redding v Lee* and *Manser v Spry*. This case is in the latter category.

[118] State subs at [689] to [698].
[119] *Wollington* at 94.
[120] At 94 and 98.
[121] At 94.
[122] At 94.
[123] At 98 to 99.
[124] At 99.
[125] At 100.

59 Further, in *Wollington*,[126] the Full Court identified a number of indicia that supported its conclusion about the character of the payment in that case, namely (i) the payment was only made after a consideration of the injured party's own resources to rehabilitate himself; (ii) the injured party had no entitlement to the benefit; (iii) there was no suggestion that the payment was made in part compensation for a tortious act and there was no connection between the wrongdoer and the payment; (iv) the object of the ex gratia scheme was to relieve personal hardship; (v) the payment was not related to the value of any goods lost but calculated by reference to standard replacement costs of certain items; (vi) the injured party was free to use the payment as they chose; and (vii) there was no stipulation that the injured part had to refund the costs if damages were later recovered.

60 In this case, the first of the indicia was only an aspect of the Scheme to the extent that it excluded costs covered by insurance and in cases of hardship allowed for a claim above $5000 based on quotes and unpaid invoices. In relation to the second matter I have found that there was an entitlement to a grant. I address the third matter next but I accept that in relation to this scheme there was no such connection either. In relation to the fourth and fifth matters, the Scheme was focussed on the reimbursement of costs actually incurred so that there is potentially an exact coincidence between the costs and any subsequent damages claim. The sixth matter has been addressed above. In short, the Scheme's beneficiaries were not free to use the funds as they chose. The seventh matter is equally applicable to this matter. Bearing in mind these differences, the decision in *Wollington* does not affect the above analysis.

61 Third, in its submissions the State emphasised that Scheme payments were made by one of the defendants in the proceedings.[127] As I understand it, this point was made not just in support of the proposition that payments made under the Scheme should be deducted from the plaintiff's damages, but in support of the State's proposed answer to common question 31 which is to

[126] At 100 to 101.
[127] State subs at [688(d)] and [698].

the effect that the payments "reduce the amounts *the State* is otherwise liable to pay to the plaintiff".[128]

62 I do not accept that the fact that the State, in the form of the QRAA, both made the payments and is a defendant affects their treatment. It can be accepted that the fact that a payment to a potential plaintiff emanated from an actual or potential tortfeasor would ordinarily bear upon an assessment of whether any such payment was "intended by the tortfeasor to operate in the interest[s] of the [tortfeasor] and to diminish the damages he otherwise would be liable to pay".[129] Not surprisingly, the inference is often available that private parties make payments to further their own private interests. However that reasoning has no application in this context. The fact that the plaintiff and the State are now plaintiff and defendant is happenstance so far as any assessment of the legislative intention behind the Scheme is concerned. The payments under the scheme were all made to eligible applicants without any regard to the potential for any of them to later sue the State. The payments were made as part of the relationship of the State qua citizen and not by a potential tortfeasor qua a potential plaintiff. This has the consequence that such payments under the Scheme which are to be deducted from the plaintiff and group members' damages will not reduce the State's apportioned liability. Instead, subject to the next point, it will be deducted from the relevant head of damage before judgment amounts are apportioned between the defendants.

63 Fourth, in light of the above analysis of the Scheme, it is necessary to identify exactly how the deductions from the plaintiff and group members' damages will be calculated. As stated, the Scheme was closely focussed on reimbursing eligible applicants for particular direct costs associated with the clean-up and repair following flooding. It follows from the above analysis that the deduction for grants received under the Scheme will only be made from that part of the plaintiff's or group members' claim for damages to the extent they seek recovery of a cost that was the subject of the application for the grant. In the case of those group members who received a grant of more than

[128] SBM.500.001.0001 at .0016, Q31.
[129] *Zheng v Cai* at [23].

$5000, those costs will be identified by that part of the application that addresses clause 291 of Part 29. In the case of those group members who received a grant of $5000 or less, those costs are identified by the subject matter of subclause 288(2).

64 For example, if a group member received a second tier of grant of $15,000 after applying under clause 291(1)(a) they will have already identified the cost items they sought reimbursement in respect of (and will have already identified how the grant of $5000 was applied). The grant cannot then be offset against different heads of damage or against different costs the subject of the claim for damages that were not the subject of the grant application. Thus, for example, an applicant's own labour costs could not be the subject of an application for a grant and could not be paid out as a grant. Amounts paid as a grant cannot be deducted from any claim for the commercial costs of that labour. This is so because, while I accept that the intention of the Scheme was that grant recipients would not be paid twice for incurring a particular cost, I do not accept that the intention of the Scheme was that grant amounts paid or payable in respect of one cost would be used to offset amounts recoverable in respect of other costs, much less other heads of damage.

65 Finally, it should be noted that this analysis is only directed to payments made under the Scheme. The relevant common question concerning these payments is not limited to payments under the Scheme but is drafted sufficiently wide to include payments made under other schemes administered by the QRAA under the *RAA Act*. There was no evidence or submissions concerning payments under any such schemes. Accordingly, the answer to the common question will confine itself to payments under the Scheme.

QRAA Grants to the Plaintiff

66 Sometime around late January 2011 a claim form was submitted on behalf of the plaintiff seeking the first-tier payment of $5000.[130] Section 5 of the form concerns claims for payments up to $5000 and stated as follows:[131]

> "Please provide a detailed breakdown of the known or estimated eligible expenditure (refer to guidelines) to re-establish your enterprise (e.g. damage to office desks, chair and cabinet; replacement of 10 bags of grass seed). Note that your own labour cost or dry hire of your own equipment is not eligible (fuel used is eligible)."

67 This part of the plaintiff's form was completed as follows:[132]

"**Expense Details**	**Total Payments**
Replacement of internal walls (Estimate only)	3,000.00
Replacement of some racks and fittings (estimate only)	2,000.00"

68 On 10 February 2011, Mr Rodriguez received a letter addressed to himself and his wife as the proprietors of Sportspower from the QRAA advising him that a grant of $5000 had been paid.[133] The letter stated:

> "Please note that this assistance has been provided to your small business or primary production enterprise, *for costs associated with flood damage only*, on the basis that your business is a commercial enterprise and provides you with the majority of your income, and that you spend the majority of your time operating this business. If you earn a higher income from salary, wages or other investments, you may not be eligible for this assistance." (emphasis added)

69 Tendered in evidence were two "subsequent" claims apparently submitted by the plaintiff seeking an additional grant.[134] One of the forms is incomplete in that it indicates that no supporting invoices were provided.[135] The other form was stamped as received on 17 June 2011 and I infer that this form was processed.[136] The form indicates that invoices were attached,[137] although

[130] ROD.001.018.0003.
[131] Ibid at .0004.
[132] Ibid.
[133] ROD.001.018.0011.
[134] ROD.001.018.0021; ROD.502.001.0008.
[135] ROD.001.018.0021 at .0023.
[136] ROD.502.001.0008.
[137] Ibid at .0010.

they were not included in the material tendered in this Court. The form disclaims reliance on the hardship provisions.[138] Section 10.1 of the form was completed as follows:[139]

> "Please provide a detailed breakdown of the expenditure incurred to dean up and restore your business (including any previous claims to QRAA for your business). If any of these costs relate to work done with your own equipment or fuel supplied to a contractor, please calculate and detail in Section 10.2 below.

Expense details	Total payments
Replace/repair store equipment (please see details in separate sheet)	4,598.85
Repairs/replace store fitting/accessories cost (please see details in separate sheet)	2,937.93
Replace lost/damaged stock essential to restart trading (please see details in separate sheet)	17,463.22
We have provided invoices for more than this amount just in case any are rejected.	
Total costs from 10.2 below	
TOTAL	$25,000.00
Less previous grant payment	$5000.00
Balance payout (this claim)	$20,000.00"

70 On 6 July 2011, the plaintiff received another letter from the QRAA advising him that a $20,000 grant had been paid.[140] The letter did not specify the purpose of the payment but instead stated that the "amount consists of … [l]ist of paid invoices provided".

71 This material reveals that the plaintiff's applications were processed in a manner consistent with Part 29. An initial grant of $5000 was provided. To obtain that grant it was not necessary to demonstrate that expenditure had been incurred, only that it was paid to the plaintiff to meet costs that fell within clause 288(2), specifically the replacement of internal walls and the replacement of racks and fittings. Thereafter the plaintiff applied for a further grant and complied with subclause 291(1)(a) by submitting invoices to

[138] Ibid at .0008.
[139] Ibid at .0009.
[140] ROD.001.018.0009.

demonstrate that it had expended the amount sought and the amount previously granted had been incurred on items that fell within subclause 288(2). It sought reimbursement for those invoices; ie, those designated costs. Those invoices have not been tendered but I infer that their subject matter and value were as specified in the application form noted above.

72 It follows from the above analysis that, to the extent that the plaintiff's damages includes the cost of replacing and repairing store equipment, then then an amount of up to $4598.95 will be deducted before apportionment. To the extent that the plaintiff's damages includes the cost of replacing or repairing store fittings and accessories, then an amount of up to $2937.93 will be deducted before apportionment. To the extent that the plaintiff's damages includes the cost of replacing lost or damaged stock, then an amount of up to $17,463.22 will be deducted before apportionment.

Payment from Suncorp

73 On or about 11 April 2011, the plaintiff received a payment of $5,000 from Suncorp Bank as part of its "Back to Business Grant".[141] The letter advised that the business had been selected by the bank's "judging panel". Mr Rodriguez stated that the grant was made after some of his neighbours in Graceville nominated him and his wife for a financial donation which was being given by the bank to people in need.[142]

74 The State submitted that the payment was not "entirely charitable" in that in part Suncorp was motivated by self-interest in maintaining a relationship with a customer.[143] Be that as it may, there is nothing in the material to suggest that the payment was related to any aspect of a claim for compensable loss by the plaintiff. Even allowing for Suncorp's own interests, it still falls into the category of charitable payments noted above. There is no basis for finding that the payment was "intended ... to operate in the interest of the

[141] ROD.001.020.0005.
[142] LAY.ROD.001.0001 at [155].
[143] State subs at [703].

[defendants] and to diminish the damages [they] otherwise would be liable to pay".[144] There should be no deduction from the plaintiff's damages for the amount paid by Suncorp.

Cost of Own Labour and Volunteer Labour on Clean-up and Repair

75 One of the issues which the parties were in dispute about concerned the plaintiff's claim for the recovery of the commercial costs of Mr Rodriguez's own labour, that of his family as well as that of the "mud army" volunteers for the clean-up of the store in the aftermath of the flood as well as the cleaning of damaged stock. The plaintiff also sought recovery in respect of the commercial cost of certain storage that was provided free of charge at the homes of friends.[145] In addition, the parties were in issue about the treatment of rental abatement which was proffered by the landlord of the Fairfield shopping centre for the period that the store was closed[146] as well as certain free stock that was provided by one of the company's suppliers.[147]

76 Although in their submissions the parties addressed these items collectively, there are important differences between them. In particular, it is critical to first identify how each item relates to a particular form of harm in respect of which damages are sought.

77 The position with the "free" labour in respect of cleaning up stock is relatively straightforward. On the findings that have been made, the defendants' negligence was causative of damage to the plaintiff's chattels, namely its stock. The measure of damages for such loss was the reasonable commercial cost of repairing or reinstating that stock or, in the alternative, replacing the stock.[148] The loss represented by the damage to the stock was suffered when the flooding occurred.[149] The fact that the stock may have in fact been repaired by persons associated with the plaintiff does not diminish the

[144] *Zheng v Cai* at [23].
[145] LAY.ROD.001.0001 at [116(a) to (d)] and [120].
[146] Ibid at [122].
[147] Ibid at [156].
[148] *Powercor* at [25] to [26].
[149] Ibid at [27].

entitlement to recover for that loss.[150] According to *Powercor*, the fact that the stock was repaired by volunteers will only operate to diminish the plaintiff's right to recovery if the proper characterisation of their supply of services is that they were "intended to operate in the interests of the [defendants] and diminish the damages [they] otherwise would be liable to pay"[151] or "whether the benefit received was conferred independently of any right of redress against [the defendants] and not by reference to that right".[152] Thus, as noted in *Powercor*, the Victorian Court of Appeal upheld a finding that the respondent was able to recover the commercial cost of repair work to fixtures, fencing and buildings destroyed by fire undertaken by himself and volunteers.[153] Similarly, in this case there is no basis for suggesting that the "mud army" acted out of anything other than a commendable sense of community and with the particular intention of helping the plaintiff's business be restored for everyone's benefit. It follows that the plaintiff's claim for damage to its chattels, namely its stock, will include the commercial cost of the services that were voluntarily rendered to repair it. The same reasoning is applicable to the costs of cleaning the store after the flooding. I do not understand there to be any dispute over the quantification of these amounts.

Free Storage

78 The plaintiff's claim for the commercial cost of storing the goods at locations for which it was not charged is of a different character. This claim is not in itself an aspect of the diminution in value of a damaged chattel. The claim was not immediately recoverable on the occurrence of damage to the store and its contents being inundated. Instead, at most, it is only a possible claim for consequential loss, specifically a "notional" liability for an expense that is consequential on the damage to the plaintiff's chattels.

79 In *CSR Ltd v Eddy* (2005) 226 CLR 1; [2005] HCA 64 ("CSR v Eddy"), Gleeson CJ, Gummow and Heydon JJ confirmed that a plaintiff who sued for

[150] Ibid at [73].
[151] Ibid at [87], citing *Zheng v Cai* at [18] to [20].
[152] Ibid at [81], citing *Wollington.*
[153] Ibid at [73] and [91].

negligently caused personal injury was "traditionally" only able to recover for three types of loss, being non-pecuniary loss, loss of earning capacity and actual financial loss.[154] Their Honours noted that the third category was not confined to costs incurred prior to trial and could include future expenses, although it was necessary for a court to be satisfied that "they will be incurred".[155] Their Honours referred to the statement of Dixon CJ in *Blundell v Musgrave* (1956) 96 CLR 73 at 79; [1956] HCA 66 to the effect that, for such amounts to be recovered, they must be amounts that will be paid "whether [the plaintiff] obtains the amount from the defendant as damages or not".

80 In this context, I can discern no basis for differentiating between consequential pecuniary loss for personal injury and consequential pecuniary loss for property damage. Unless the plaintiff has in fact paid or incurred a liability for storage costs, or will do so regardless of whether it recovers against the defendants, then it cannot recover them. In these circumstances, no question of the application of the principles concerning the reduction of damages on account of the voluntary provision of services arises. The only potential analogy to this aspect of the plaintiff's claim is to a type of claim for damages arising out of personal injury, namely a *Griffiths v Kerkemeyer*[156] claim, which enables an injured plaintiff to recover for the cost of nursing and home care services even though such services have not been or may never be supplied or had been or only will be supplied gratuitously. In *CSR v Eddy*, Gleeson CJ, Gummow and Heydon JJ described *Griffiths v Kerkemeyer* as "not only exceptional, but anomalous".[157] It follows that any claim that is only analogous to *Griffiths v Kerkemeyer* such as this should be rejected.

Rent Abatement

81 The outcome in relation to the rent abatement is the same as for the claim for voluntarily provided storage. The starting point is that the plaintiff claims consequential loss, being the lost profits of its business, with one component

[154] At [28] to [31].
[155] At [31].
[156] (1977) 139 CLR 161; [1977] HCA 45.
[157] At [31].

of the calculation of those profits being its rental expense (alternatively, it seeks recovery of that "expense" in its own right). If the landlord by granting abatement did not charge rent and disclaimed any entitlement to recover it, then the rent foregone cannot form part of any expense of the business. It is not in any sense an "expense" at all. It follows that the rent that was abated cannot be the subject of recovery.

Free Stock

82 The last item to be addressed under this heading is certain free stock provided by a supplier ("ASICS") to the plaintiff to the value of $9628 in the period immediate prior to the store reopening in May 2011.[158] Mr Rodriguez recalled the ASICS representative stating that it was provided to "help you reopen".[159] As I understand it, the defendants' contention is that the plaintiff's claim for damages, including for damage to its stock, should be reduced by the free or replacement provided stock by ASICS. It follows from the above analysis that this contention should be rejected. It is generally no answer to a claim for the loss or damage caused to an asset that someone provided the injured party with a different asset even though it is of the same kind. Otherwise, there is nothing in Mr Rodriguez's dealings with ASICS to suggest that the provision of the stock was "intended ... to operate in the interest of the [defendants] and to diminish the damages [they] otherwise would be liable to pay".[160] There should be no deduction from the plaintiff's damages for the value of the stock provided by ASICS.

14.2: Proportionate Liability

83 Question 28 of the common questions asks whether, if damages are recoverable against any of the defendants, are "any of the claims … apportionable claims within the meaning of s 28(1) of the *CLA* (Qld) or alternatively s 34(1) of the *CLA* (NSW)?" Assuming the answer is yes,

[158] LAY.ROD.001.0001 at [156]; ROD.504.001.0008.
[159] LAY.ROD.001.0001 at [157].
[160] *Zheng v Cai* at [23].

question 29 asks what is the appropriate amount of any judgment to enter against each defendant?[161]

84 In relation to question 28, both the plaintiff and SunWater contended that the answer was "yes". The State and Seqwater contended that question was not appropriate to answer until after the delivery of the Court's reasons,[162] although both of their defences plead that the claim is apportionable.[163] All of the parties contended that question 29 should not be answered at this stage, a contention that, for the reasons set out below, is accepted. However, it is appropriate to answer question 28 insofar as it concerns the claims that have been upheld because it is interrelated with the issues that arise on the cross-claims.

85 SunWater's submissions relating to question 28 note that there is some doubt as to whether the proportionate liability provisions in the *CLA* (Qld) and the *CLA* (NSW) are substantive or procedural, and thus some doubt as to whether the Court should apply the relevant provisions of the *CLA* (NSW) as the law of the forum or the relevant provisions of the *CLA* (Qld) as the lex loci delicti.[164] SunWater also submitted that it is unlikely to matter as they contain similar provisions.[165] This is generally true, although there is a potentially material difference that is explained below. However, in light of the statement in *John Pfeiffer v Rogerson* that all laws that "bear upon the existence, extent or enforceability of remedies, rights and obligations should be characterised as substantive and not as procedural laws",[166] it seems highly likely that the relevant proportionate liability provisions to apply are those found in Part 2 of Chapter 2 of the *CLA* (Qld), although it is not necessary to decide this at this stage.

86 Section 28(1) of the *CLA* (Qld) defines an "apportionable claim" as including "a claim for economic loss or damage to property in an action for damages

[161] SBM.500.001.0001 at .0014 to .0015.
[162] Ibid at .0014 to .0015.
[163] PLE.020.010.0001 at .0240, [487(a)]; PLE.040.007.0001 at .0134, [317].
[164] SunWater subs at [2897].
[165] Ibid.
[166] At [102].

arising from a breach of a duty of care". There are certain exclusions in s 28(3) and 28(4) but they are not relevant. Similarly, s 34(1) of the *CLA* (NSW) defines an "apportionable claim" as including a "claim for economic loss or damage to property in an action for damages (whether in contract, tort or otherwise) arising from a failure to take reasonable care, but not including any claim arising out of personal injury". The plaintiff's and SunWater's answers to question 28[167] reveal they disagree about whether an action for nuisance falls within these provisions. However, both agreed that the plaintiff's claim in negligence does. Given that this is the only cause of action that has been upheld, their disagreement over the balance does not appear to matter. Accordingly, at this point, I do not perceive any necessity to answer the common question beyond its application to the plaintiff's claim in negligence.

87 In relation to any determination of the amount of the apportionment, s 31(1) of the *CLA* (Qld) provides:

> "(1) In any proceeding involving an apportionable claim—
>
> (a) the liability of a defendant who is a concurrent wrongdoer in relation to the claim is limited to an amount reflecting that proportion of the loss or damage claimed that the court considers *just and equitable having regard to the extent of the defendant's responsibility for the loss or damage*; and
>
> (b) judgment must not be given against the defendant for more than that amount in relation to the claim." (emphasis added)

88 Section 35(1) of the *CLA* (NSW) is in almost identical terms save that, instead of referring to an amount the Court considers "just and equitable", it simply refers to an amount that is "just". For my part I cannot discern any difference between these provisions, although many lawyers react with fevered excitement to the presence of the words "equitable" or "equity". Otherwise I do not propose to embark upon any consideration of the application of these provisions to this matter given the attitude of the parties noted above and the fact that they have not been given the opportunity to consider this judgment before making submissions on those provisions.

[167] SBM.500.001.0001 at .0014 to .0015.

89 Of present relevance to the cross-claims is s 32A of the *CLA* (Qld) which provides:

> **"32A Contribution not recoverable from concurrent wrongdoer**
>
> Subject to this part, a concurrent wrongdoer against whom judgment is given under this part in relation to an apportionable claim—
>
> (a) can not be required to contribute to the damages recovered or recoverable from another concurrent wrongdoer for the apportionable claim, whether or not the damages are recovered or recoverable in the same proceeding in which the judgment is given; and
>
> (b) can not be required to indemnify the other concurrent wrongdoer."

90 Section 36 of the *CLA* (NSW) is in identical terms save that it is not prefaced by the words "[s]ubject to this part". Both provisions clearly operate to exclude the making of any claims for contribution or indemnity between concurrent tortfeasors under the contribution statutes of the respective states.[168] One matter of potential uncertainty is whether the reference to "indemnify" in s 32A(b) of the *CLA* (Qld) (and s 36(b) of the *CLA* (NSW)) excludes the making of a claim for contractual indemnity against a concurrent wrongdoer or whether it is only directed to claims for indemnity under the contribution statutes.[169] The former would be a surprising result and, if it was necessary to decide it, the parties would be afforded an opportunity to address it. In New South Wales, any doubt that is raised about whether or not the possibility that contractual indemnities are excluded may have been removed by s 3A(2) of the *CLA* (NSW), which preserves the rights of parties to a contract to "make express provision for their rights, obligations and liabilities under the contract with respect to any matter to which" the *CLA* (NSW) applies, which would include the proportionate liability provisions. The *CLA* (Qld) has a similar provision but it is not applicable to the proportionate liability provisions (s 7(2)).

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[168] Being s 5 of the *Law Reform (Miscellaneous Provisions) Act 1946* (NSW) and s 6 of the *Law Reform Act 1995* (Qld).

[169] *Law Reform Act 1995* (Qld), s 7; *Law Reform (Miscellaneous Provisions) Act 1946* (NSW), s 5(2).

14.3: Remaining Defences

91 In its defence, Seqwater pleaded contributory negligence on the part of the plaintiff.[170] Shortly after the hearing commenced, Seqwater advised that this aspect of its defence was no longer pressed.

92 As noted in Chapter 5,[171] in its defence and its defence to Seqwater's cross-claim,[172] SunWater pleaded the existence of four common understandings said to have been adhered to by Mr Ayre and SunWater during the January 2011 Flood Event to the knowledge of Seqwater, namely the "2009 Review Intention", the "FSL Common Intention", the "No Precautionary Release Intention" and the "Forecast Rainfall Common Intention". It follows from the finding in Chapter 4[173] and Chapter 5[174] that this aspect of its defence fails at a factual level.

93 SunWater also pleaded reliance on the inherent risk provisions in s 16 of the *CLA* (Qld).[175] This was not the subject of any submissions and need not be considered further.

14.4: Cross-Claims

94 All the defendants filed cross-claims against each other seeking contribution or indemnity under the *Law Reform Act 1995* (Qld).[176] It follows from the above that these claims must be dismissed. SunWater also made a claim for equitable contribution in its cross-claim.[177] The claim is predicated on the other defendants having the same liabilities as SunWater.[178] However, by the operation of the proportionate liability provisions there is no joint liability or same liability for equity to operate upon.

[170] PLE.020.010.0001 at .0238, [486].
[171] At [185].
[172] PLE.030.009.0001 at .0007 to .0008.
[173] At [181].
[174] At [192].
[175] PLE.030.008.0001 at [392].
[176] Or the *Law Reform (Miscellaneous Provisions) Act 1946* (NSW); Seqwater: PLE.020.001.0001; SunWater: PLE.030.003.0001; the State: PLE.040.001.0001.
[177] PLE.030.0003.0001 at .0004; prayer 3.
[178] Ibid at .0006, [8].

Seqwater's Cross-Claim Against SunWater

95 In its cross-claim, Seqwater sought "damages" against SunWater for breaches of the SLA.[179] It pleaded that, in the event the plaintiff was successful against Seqwater, then that would be as a consequence of breaches of two clauses of the SLA by SunWater. The first is clause 3.3 which obliged SunWater to provide services in "a diligent manner" and "to ... the standard of skill and care expected of a contractor experienced in the provision of the Service".[180] The second provision said to have been breached is clause 3.2(a) which obliged SunWater to "provide the Service in accordance with the Service Schedule".[181] As discussed in Chapter 11, the description of the "Service" is such that the performance of the contractual obligation required that flood management services be provided "in accordance with" the Manual.[182] Even though SunWater was contractually obliged to respect the vesting of control over flood operations in the flood engineers under the Manual, it must follow from the findings in this judgment that, to the extent it provided flood engineers under the SLA to Seqwater, the services carried out were not of "the standard of skill and care expected of a contractor experienced in the provision of the Service".

96 In its cross-claim, Seqwater identifies the damages it claims to have suffered as a result of the breaches of the SLA as the amount of any judgment awarded against it in the proceedings, as well as the legal costs incurred by it in defending the plaintiff's claims.[183] In considering this issue, it is necessary to note the finding that was made in Chapter 11 to the effect that the services of Messrs Malone and Tibaldi were not supplied by SunWater under the SLA[184] and the above finding that these are apportionable claims. The result is that Seqwater will only suffer a judgment against it referable to their conduct following an assessment of what is "just and equitable having regard to the extent of [its] responsibility for the [plaintiff and group members'] loss and

[179] PLE.020.001.0001 at .0006, [12] and [14].
[180] SLA: SEQ.001.022.8933 at .8941; Cross-claim – PLE.020.001.0001 at [12(a)]; see Chapter 11 at [139].
[181] SEQ.001.022.8933 at .8941; PLE.020.001.0001 at [12(b)].
[182] Chapter 11 at [146].
[183] PLE.020.001.0001 at 0007, [12(c)].
[184] Chapter 11 at [156].

damage" (*CLA* (Qld); s 31(1)(a)). In those circumstances, it is difficult to envisage how any part of Seqwater's liability to the plaintiff can be attributable to a breach by SunWater of the SLA. The same observation applies to the legal costs incurred by Seqwater in defending these proceedings in that it seems highly likely that the fulsome defence mounted by Seqwater would still have been mounted even if the only claims against it related solely to the conduct of Messrs Malone and Tibaldi.

97 As noted, in its defence to Seqwater's cross-claim, SunWater pleads as estoppels the four common assumptions noted above. In its written submissions, SunWater contended that Mr Ayre was the "relevant mind" of SunWater for these purposes[185] and that Seqwater's "state of mind" was that "of Mr Borrows informed by Messrs Pruss, Drury, Tibaldi and Malone, or alternatively that Seqwater's state of mind was constituted by their collective or individual knowledge and understanding".[186] It follows from the findings in Chapter 4[187] and Chapter 5[188] that this aspect of its defence to the cross-claim must fail at a factual level.

98 However, SunWater also pleaded reliance on clause 9 of the SLA.[189] It provides:[190]

> "**9 Liability**
>
> **9(1) Limitation of Liability**
>
> Subject to clause 9.2 and excluding any liability arising as a result of SunWater's negligent act or omission or breach of this Agreement, SunWater's liability to Seqwater arising out of the performance or non-performance of the Services, whether under the law of contract, tort or otherwise, shall be limited to the Fees. Nothing in this clause shall be read or applied so as to purport to exclude, restrict or modify, or have the effect of excluding, restricting or modifying, the application in relation to the performance of the Services pursuant to this Agreement.

[185] SunWater subs at [2790].
[186] Ibid at [2794].
[187] At [181].
[188] At [192].
[189] PLE.030.009.0001 at .0007, [12(d)].
[190] SEQ.001.022.8933 at .8945.

9(2) Consequential loss excluded

Neither party shall be liable to the other for any indirect or consequential loss, or loss of revenue, profit or anticipated savings or loss, damage or destruction of data.

9(3) Contribution of other party

A party's liability to the other party is reduced to the extent (if any) that the other party causes or contributes to the relevant loss."

99 Subclause 9(1) is directed to limiting SunWater's liability to Seqwater in respect of actions taken under the SLA that are not a breach of the SLA. Subclause 9(3) reinforces the point made above in relation to the proportionate liability provisions. In this case, Seqwater will only bear a liability that is just and equitable having regard to the actions of Messrs Malone and Tibaldi and that will reflect so much of their conduct that caused or contributed to the "relevant loss", namely the apportioned judgment against it in favour of the plaintiff (and group members).[191]

100 In any event, SunWater relied on subclause 9(2). It contended that any judgment entered against Seqwater in favour of the plaintiff or group members was only a form of "indirect or consequential loss" on the part of Seqwater.[192] It contrasted that form of loss or damage with more direct losses that could be occasioned to Seqwater as the owner and occupier of the dam from breaches of the SLA, including damage to Seqwater's equipment and infrastructure.[193]

101 Before addressing clause 9(2), it is necessary to describe the concept of "consequential losses". A number of United Kingdom cases[194] confine the expression "consequential loss" to losses that fall within the second limb of *Hadley v Baxendale* (1854) 9 Exch 341 at 354, namely losses that cannot be "fairly and reasonably be considered … [as] arising naturally [from breach]" but which "may reasonably be supposed to have been in the contemplation of

[191] Cf SeqWater subs at [2583].
[192] SunWater subs at [2873] to [2895].
[193] Ibid at [2881] to [2883].
[194] Eg *Deepak Fertilisers and Petrochemicals Corp v ICI Chemicals & Polymers* [1999] 1 Lloyd's Rep. 493; see Edelman, *McGregor on Damages* (20th edition, 2018, Thomson Reuters) at [3-013]; "McGregor".

both parties, at the time they made the contract, as the probable result of the breach of it".

102 This approach was rejected by the Victorian Court of Appeal in *Environmental Systems Pty Ltd v Peerless Holdings Pty Ltd* [2008] VSCA 26 ("Environmental Systems"). The United Kingdom approach was found to involve a distortion of the ordinary and natural meaning of the phrase "consequential loss".[195] Instead, Nettle JA emphasised,[196] the proposition stated in *Darlington Futures Ltd v Delco Australia Pty Ltd*,[197] that the interpretation of an exclusion clause is to be determined by construing the clause according to its natural and ordinary meaning, read in light of the contract as a whole, giving due weight to the context in which the clause appears, including the nature and object of the contract and, where appropriate, construing the clause *contra proferentem* in cases of ambiguity. Nettle JA concluded that "reasonable business persons would naturally conceive of 'consequential loss' in contract as everything beyond the normal measure of damages, such as profits lost or expenditure incurred through breach".[198] Thus in *Environmental Systems*, which involved the supply of defective equipment, Nettle JA rejected a claim for the cost of labour incurred in attempting to make the defective equipment operate effectively and a claim for the extra cost of gas incurred through using alternative equipment on the basis that both were forms of "consequential loss",[199] the recovery of which was expressly excluded.[200]

103 In *Regional Power Corporation v Pacific Hydro Group Two Pty Ltd (No 2)* (2013) 46 WAR 281, Kenneth Martin J was required to construe a clause that excluded the liability of both parties to each other "for any indirect, consequential, incidental, punitive or exemplary damages or loss of profits".[201] His Honour agreed with Nettle JA's analysis in *Environmental Systems* that the United Kingdom approach should be rejected but did not agree that it

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195 At [91] per Nettle JA, with whom Ashley and Dodds-Streeton JJA agreed.
196 At [92].
197 (1986) 161 CLR 500 at 510; [1996] HCA 82.
198 At [93].
199 At [94].
200 At [5].
201 At [50].

should be replaced by any "touchstone" of the "normal measure of damages".[202] In that case, his Honour concluded that an energy distributor suffered direct losses in the form of costs associated with meeting its replacement energy supply obligations as a result of a breach of a contract for supply by an energy producer.[203]

104 Clause 9(2) of the SLA exempts each party from liability to the other for three types of losses, namely "indirect or consequential loss", "loss of revenue, profit or anticipated savings" or "loss, damage or destruction of data". I interpret the last two categories as neither limiting nor expanding the first. Instead, they represent attempts by the parties to put the position of those two categories of loss or damage beyond doubt. With the first category, the concept of "indirect or consequential loss" has an obvious counterpart with forms of loss that are direct or immediate. The suggested examples of damage to Seqwater's machinery and infrastructure are clearly not covered by clause 9(2). Most such damage clearly would be the direct result of a breach of the SLA and they would not be "consequential" in either a temporal sense or in the sense of requiring further or other steps or circumstances to occur or arise before a loss arose. However, a liability incurred on the part of Seqwater to a downstream property holder is clearly a form of indirect or consequential loss. Whether such a liability will arise is dependent on a number of circumstances after the event that are outside the control of the parties and outside the confines of the SLA. I note that McGregor treats a legal liability to a third party as a form of "consequential pecuniary loss".[204] In light of that conclusion, it is unnecessary to address SunWater's further submission that the *contra proferentem* rule has no application in circumstances where clause 9(2) operates mutually.[205] I consider that the operation of the clause is clear to the extent that liabilities to third parties are clearly consequential losses.

105 It would follow from the above that all cross-claims should be dismissed.

[202] At [96].
[203] At [108].
[204] McGregor at [4-023].
[205] SunWater subs at [2875].

14.5: Limitation Period for group members

106 Section 182 of the *Civil Procedure Act 2005* (NSW) ("CPA") provides that, in representative proceedings, the "running of the limitation period that applies to the claim of a group member to which the proceedings relate is suspended." In this case, it is accepted that the relevant limitation period is fixed by s 10(1)(a) of the *Limitation of Actions Act 1974* (Qld). It relevantly provides that "an action founded on … tort" that does not consist of or include damages for personal injury shall "not be brought after the expiration of 6 years from the date on which the cause of action arose".

107 A question arose in the proceedings as to whether s 182 could operate to suspend the running of a limitation period fixed by Queensland legislation. As noted in Chapter 1, against the contingency that it did not have that effect, the Lynch proceedings were commenced within the six-year period. In the Lynch proceedings all the group members are identified as plaintiffs. The Lynch proceedings were stayed on terms that ensured that the findings in this matter would bind the parties in those proceedings.[206]

108 In the end result it was not necessary to determine any question concerning the interaction between s 182 of the *CPA* (NSW) and s 10(1)(a) of the *Limitation of Actions Act 1974* (Qld). This was so because it was accepted by all the parties[207] that the bringing of these proceedings meant that each group member brought "an action" within the relevant time period for the purposes of s 10(1)(a).[208]

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[206] Order made on 27 March 2017.
[207] See SBM.500.001.0001 at 0017, Q 34.
[208] See *Cameron v National Mutual Life Association of Australasia Ltd (No 2)* [1992] 1 Qd R 133 at 137; *Fostif Pty Ltd v Campbells Cash & Carry Pty Ltd* (2005) 63 NSWLR 203; [2005] NSWCA 83 at [36] to [45].

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CHAPTER 15: COMMON QUESTIONS AND FUTURE DISPOSITION

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CHAPTER 15: COMMON QUESTIONS and FUTURE DISPOSITION

15.1: Common Questions

1 As contemplated by s 157(1)(c) of the *Civil Procedure Act 2005* (NSW) ("CPA") and consistent with the observations in *Scenic Tours Pty Ltd v Moore* [2018] NSWCA 238 at [70], on 14 September 2018 the Court ordered that certain questions that arise in the proceedings be determined separately and in advance of all other issues in the proceedings (the "common questions"). Some of the common questions may only affect some group members, however it was not necessary to establish a sub-group of group members to resolve them.[1]

Full Supply Level

2 The first common question posed by the parties concerned the circumstances, if any, in which releases might be made below FSL for the purposes of flood mitigation. This is addressed in Chapter 5. The question posed and the answer is:

Q.1 In the period 2 January 2011 to 11 January 2011:

a. was Seqwater, SunWater and, or alternatively, their employees and agents prohibited by law from releasing water from Somerset Dam or Wivenhoe Dam below the full supply level for each dam for the purposes of conducting Flood Operations; and

A. No.

b. if the answer to (a) is "no",[2] in what circumstances could such releases be made?

A. Where the exercise of reasonable care in the conduct of flood operations warranted it.

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[1] *CPA*; s 168(2).
[2] Varied to reflect T 10546.

Duty of Care

3 The second common question is directed to the formulation of the risk of harm pleaded by the plaintiff in the 5ASOC at [142A]. I am not convinced that a question directed to that concept was necessary as the formulation of the risk of harm is only a step, albeit an important one, in the process of determining the existence, as well as the scope, of any duty of care and the analysis of breach. Further, the question appears to wrongly assume that there is one single “canonically ‘right’” characterisation of the risk of harm.[3] The answer will reflect that. Otherwise, I note that the analysis in Chapter 11 addresses both the plaintiff and Seqwater’s formulation of the risk of harm.

4 The question posed and the answer is:

Q.2 Were the risks of harm associated with a failure to conduct Flood Operations with reasonable care at Somerset Dam and Wivenhoe Dam those pleaded in paragraph 142A of the 5ASOC (Risks of Harm)?

A. Save for the reference to “a failure properly to conduct Flood Operations at Somerset Dam and Wivenhoe Dam”,[4] ***paragraph 142A of the Fifth Further Amended Statement of Claim is an appropriate formulation of the risk of harm.***

5 The next question is addressed to the existence of a duty of care owed by Seqwater, SunWater and the flood engineers to the plaintiff and the group members. This is also addressed in Chapter 11. The question is posed by reference to whether the duty is owed to a “class comprising the plaintiff and the Group Members”. However, it is sufficient that the question be answered by reference to a class that includes the plaintiff and the Group members. Consistent with the analysis in Chapter 11,[5] the answer in respect of Sunwater is only concerned with its supply of “flood management services” under the SLA with Seqwater.

[3] Cf *Uniting Church in Australia Property Trust (NSW) v Miller; Miller v Lithgow City Council* (2015) 91 NSWLR 752 at [119] per Leeming JA; Chapter 11 at [28] to [30].
[4] See Chapter 11 at [34].
[5] Chapter 11, section 11.4.

6 The question posed and the answer is:

Q.3 Did any of Seqwater, SunWater or any of the Flood Operations Engineers owe a duty or duties of care to a class comprising the plaintiff and the Group Members to exercise reasonable care in the conduct of flood operations at Somerset Dam and Wivenhoe Dam so as to avoid or minimize the Risks of Harm?

A: Each of Seqwater and the Flood Operation Engineers owed such a duty of care to a class that included the plaintiff and group members. SunWater owed such a duty to a class that included the plaintiff and group members but only in respect of the supply of flood management services under the "Service Level Agreement - Flood Management Services" dated 13 October 2009.

7 Question 4 is directed to whether, in determining whether there was a duty of care owed, there is basis for differentiating between a risk of harm to damage to real property on the one hand and personal property on the other as well as a basis for differentiating between locations above and below Lowood and Moggill. The analysis in Chapter 11 accepts that these matters potentially affected the assessment of the degree of control exercised over the risk of harm[6] and the vulnerability of the class to whom the duty was owed[7] but concluded they did not affect the ultimate conclusion as to whether a duty is owed.[8]

8 Accordingly, the questions posed and the answers are:

Q.4 Does the answer to question 3 differ depending:

a. on whether the Risk of Harm was a risk of physical damage to real property?;

[6] Chapter 11 at [26].
[7] Chapter 11 at [54].
[8] Chapter 11 at [26].

A. No

b. on whether the Risk of Harm was a risk of physical damage to personal property?;

A. No

c. on whether the Risk of Harm was a risk of physical damage to real or personal property located near the Brisbane River, between Wivenhoe Dam and Moggill?;

A. No

d. on whether the Risk of Harm was a risk of physical damage to real or personal property located near the Brisbane River, between Moggill and the mouth of the river?;

A. No

e. on whether the Risk of Harm was a risk of physical damage to real or personal property located near the Bremer River?;

A. No

f. on whether the Risk of Harm was a risk of physical damage to real or personal property located near Lockyer Creek?.

A. No.

9 The next question is directed to the standard of care owed by each of Seqwater, SunWater and the flood engineers. As explained in Chapters 11 and 12, the only particulars of negligence concern the conduct of the flood engineers. It was found that the liability of Seqwater, SunWater and the State is only a "true" vicarious liability, that is a liability for the breaches of the duty of care owed by the flood engineers.[9] Accordingly, it is unnecessary to answer the questions in respect of Seqwater and SunWater. In respect of the flood engineers, the standard of care expected of them is addressed in Chapter 11

[9] Chapter 11 at [191].

and Chapter 12. Although s 22 of the *CLA* (Qld) was potentially engaged the defendants failed to discharge their onus of proof under s 22(1).[10]

10 The question posed and the answer is :

Q.5 If the answer to question 3 is yes, what was the applicable standard of care for:

a. Seqwater;

b. SunWater; and

c. each of the Flood Engineers?

A. In respect of Seqwater and Sunwater, unnecessary to answer. In respect of the flood engineers, the standard of care is that of the reasonably competent flood engineer.

Breach of Duty

11 Questions 6 and 7 were addressed to breaches by each of Seqwater and SunWater. The questions refer to breaches "in the manner pleaded" but there were no breaches pleaded against them in their own right, only the flood engineers.Thus, the questions appear to be predicated on the plaintiff establishing that each of Seqwater and SunWater owed a non-delegable duty, which they did not.[11] Accordingly, those questions and their answers are as follows:

Q.6 Did Seqwater breach any duty of care that it is found to have owed in the manner pleaded?

A. On the assumption that this question is directed to a breach of a non-delegable duty, does not arise.

Q.7 Did SunWater breach any duty of care that it is found to have owed in the manner pleaded?

[10] Chapter 11 at [219ff].
[11] Chapter 11 at [140] and [159].

A. ***On the assumption that this question is directed to a breach of a non-delegable duty, does not arise.***

12 Questions 8 to 10 concern whether the flood engineers breached any duty of care they may have owed. This is addressed in Chapter 12. Accordingly, they may be answered as follows:

Q.8 Did Mr Malone and/or Mr Tibaldi breach any duty of care that they are found to have owed in the manner pleaded?

A. Yes, both of them in some respects.

Q.9 Did Mr Ayre breach, in the manner pleaded, any duty of care that he is found to have owed?

A. Yes, in some respects.

Q.10 Did Mr Ruffini breach any duty of care that he is found to have owed in the manner pleaded?

A. Yes, in some respects.

13 Question 11 of the common questions is directed to the application of either s 36(2) of the *CLA* (Qld) or s 43A(3) of the *CLA* (NSW) to Seqwater, SunWater and the flood engineers. The *CLA* (NSW) is irrelevant. As found in Chapter 11, s 36(2) of the *CLA* (Qld) has no application to the conduct of flood operations by the flood engineers.[12] Given that Seqwater and SunWater's liability for the flood engineers is only a vicarious liability, no issue about the application of those provisions arises either.[13] Accordingly, the question and answer are as follows:

Q.11 In carrying out flood operations in the period 2 January 2011 to 11 January 2011 (**the Period**), did Seqwater, SunWater and the Flood Engineers act in a way that was so unreasonable that no authority having the function or power in question could properly consider the

[12] Chapter 11 at [205].
[13] Chapter 11 at [195] to [218].

acts or omissions to be a reasonable exercise of the function or power within the meaning of s 36(2) of the *CLA* or s 43A(3) of the NSW *CLA*?

A. This question does not arise.

14 Question 12 of the common questions is directed to the application of s 22 of the *CLA* (Qld) or s 50 of the *CLA* (NSW) to the conduct of Seqwater, SunWater and the flood engineers. As discussed in Chapter 11, it has no application to either of Seqwater or SunWater.[14] Although it has a potential application to the flood engineers, it fails at a factual level.[15]

15 Accordingly the question and answer are as follows:

Q.12 In carrying out flood operations in the Period did Seqwater, SunWater and each of the Flood Engineers act in a way that was widely accepted by peer professional opinion by a significant number of respected practitioners in the field as competent professional practice within the meaning of s 22 *CLA* or s 50 NSW *CLA*?

A. In respect of Seqwater and SunWater, the question does not arise. In respect of the flood engineers, no.

16 Question 13 is directed to whether, in the circumstances, a reasonable person in the position of the flood engineers would have operated the dams substantially in accordance with any of Dr Christensen's simulations A to J. As explained in Chapter 10, those circumstances must embrace a particular start date for the simulation. Accordingly, the answer is as follows:

Q.13 In the circumstances, would a reasonable person, in the position of the Flood Engineers, have operated the Dams substantially in accordance with any of the simulations A to J of the Response Report?

A. A reasonably competent flood engineer in the position of the flood engineers who inherited the circumstances prevailing as at midnight on 2 January 2011 would have, at

[14] Chapter 11 at [206].
[15] Chapter 11 at [234].

a minimum, made flood releases substantially in accordance with Dr Christensen's Simulation C up to and including 9 January 2011 and made flood releases substantially in accordance with that simulation thereafter.[16]

A reasonably competent flood engineer in the position of the flood engineers who inherited the circumstances prevailing as at midnight on 8 January 2011 would have made flood releases for the balance of the January 2011 Flood Event substantially in accordance with Dr Christensen's Simulation F as varied by Table 18 to Mr Ickert's Response Report dated 30 November 2017.[17]

17 Question 14 was framed by the defendants as follows:

Q.14 In failing to operate the Dams substantially in accordance with any of simulations A to J in Dr Christensen's Response Report:

a. did Seqwater, SunWater or any of the Flood Engineers breach any pleaded duty of care?

b. did Seqwater, SunWater or any of the Flood Engineers act in a way that was so unreasonable that no authority having the function or power in question could properly consider the acts or omissions to be a reasonable exercise of the function or power within the meaning of s 36(2) of the *CLA* or s 43A(3) of the NSW *CLA*?

c. did Seqwater, SunWater or any of the Flood Engineers act in a way that was widely accepted by peer professional opinion by a significant number of respected practitioners in the field as competent professional practice within the meaning of s 22 *CLA* or s 50 NSW *CLA*?

18 These questions are problematic at a number of levels. First, they assume that the breaches pleaded against the individual flood engineers are tied to a failure to act in accordance with the simulations. For the reasons explained in

[16] Chapter 10 at [188].
[17] Chapter 10 at [56].

Chapter 12, they are not.[18] Instead, the findings and reasons made concerning those simulations inform the assessment of whether the pleaded breaches are made out. Second, both of questions 14(b) and 14(c) seek to divorce a consideration of s 36 and s 22 of the *CLA* (Qld) from any consideration of breach of duty in as referred to in question 14(a) whereas if they were applicable, they would form part of that determination.[19] Third, for the reasons explained in Chapter 11, s 36 is not engaged and the application of s 22 has not been established. Accordingly, the appropriate answer to question 14 is:

A. These questions do not arise.

19 The next set of questions concerns the vicarious liability of the defendants for the flood engineers' breaches of duty. It follows from the analysis in Chapter 11[20] that the answers are:

Q.15[21] If Mr Malone and Mr Tibaldi, or one of them, breached their duty of care, is Seqwater vicariously liable for the breach?

A. Yes.

Q.16 If Mr Ayre breached his duty of care, is SunWater vicariously liable for the breach?

A. Yes.

Q.17 If Mr Ruffini breached his duty of care, is SunWater or the State vicariously liable for the breach?

A. The State and not SunWater.

[18] Chapter 12, section 12.2.
[19] Chapter 11 at [223].
[20] Chapter 11, section 11.6.
[21] Note that the version attached to the orders made on 14 September 2018 has a typographical error which identifies this as Question 14. This affected the numbering of the subsequent questions. The numbering of these questions reflects SBM.500.001.0001.

Causation

20 The next set of common questions relates to causation and Dr Altinakar's modelling which is addressed in Chapter 13. As noted in Chapter 13, questions 19 and 20 appear to require an assessment of whether Dr Altinakar's modelling is *determinative* of the level of flooding under the relevant counterfactual, specifically SIM C. In Chapter 13, I rejected that contention.[22] Nevertheless, I found that the modelling was generally reliable[23] and should be considered along with the remainder of the relevant evidence at a particular location to determine the level of flooding under the relevant counterfactual,[24] with such evidence only to be adduced in a manner that is consistent with the findings in this judgment and the forensic choices made by the parties to date.[25]

21 Accordingly the questions posed and the answers are:

Q.18 Did any breach of duty of care that is found to have occurred cause flooding or greater flooding downstream of Wivenhoe Dam than would have occurred otherwise?

A. The breaches of duty of each flood engineer caused greater flooding downstream of Wivenhoe Dam than would have occurred otherwise.

Q.19 Was the measure of that flooding or greater flooding that determined by the modelling of Dr Mustafa Altinakar?

A. Dr Altinakar's modelling is not the determinative measure of that flooding or greater flooding.

Q.20 Does the modelling of [Dr] Altinakar determine what the level of flooding would have been at locations downstream of Wivenhoe Dam if Wivenhoe and Somerset Dams had been operated substantially in accordance with Simulations A to J in Dr Christensen's Response Report?

[22] Chapter 13 at [262].
[23] Chapter 13 at [2] and [254].
[24] Chapter 13 at [262].
[25] See Chapter 13, section 13.4.9.

A. ***Dr Altinakar's modelling is not determinative of that level of flooding.***

Nuisance and Trespass

22 The next set of questions concerns the claims in nuisance and trespass which are addressed in Chapter 11.[26] The questions posed and the answers are:

Q.21 Did the release of water from Wivenhoe Dam onto land in which the Subgroup Members held an interest in the period 9 January 2011 to 19 January 2011 constitute a private nuisance by Seqwater, SunWater and, or alternatively any of the Flood Engineers (Private Nuisance)?

A. No.

Q.22 Did the release of water from Wivenhoe Dam onto land in which the Subgroup Members held an interest in the period 9 January 2011 to 19 January 2011 constitute a trespass by Seqwater, SunWater and, or alternatively any of the Flood Engineers (Trespass)?

A. No.

Q.23 Do the defences of statutory authority and necessity provide a defence to Private Nuisance and Trespass?

A. Not in this case.

Q.24 If Mr Malone and Mr Tibaldi, or one of them, committed the Private Nuisance or Trespass, is Seqwater vicariously liable for that Private Nuisance or Trespass?

A. Does not arise.

Q.25 If Mr Ayre committed the Private Nuisance or Trespass, is SunWater vicariously liable for that Private Nuisance or Trespass?

A. Does not arise.

[26] Chapter 11, section 11.8.

Q.26 If Mr Ruffini committed the Private Nuisance or Trespass, is SunWater or the State vicariously liable for that Private Nuisance or Trespass?

A. Does not arise.

Safety and Reliability Act

23 Question 27 concerns the pleaded claim that the State is liable under s 374 of the *Safety and Reliability Act*. This was addressed in Chapter 11 concerning the claim for nuisance.[27] However, that analysis is relevant to all the pleaded causes of action. The question posed and the answer is:

Q.27 Is the State liable, and if so to what extent, by operation of s 374 of the *Water Supply (Safety and Reliability) Act 2008* (Qld) (as it then stood)?

A. No.

Apportionment of Liability

24 Questions 28 and 29 concern the application of the proportionate liability provisions of the *CLA* (Qld) and the *CLA* (NSW). Their application is addressed in Chapter 14.[28] The questions and answers are:

Q.28 If damages are recoverable against any of the defendants, are any of the claims 'apportionable claims' within the meaning of s 28(1) *CLA* or alternatively s 34(1) NSW *CLA*?

A. The plaintiff's claim in negligence is an "apportionable claim" within the meaning of both s 28(1) of the **CLA (Qld)** ***and s 34(1) of the*** **CLA (NSW)*****, depending on which is applicable. Otherwise unnecessary to answer.***

Q.29 If yes to question 28, what is the appropriate amount of any judgment against any defendant, having regard to s 31 *CLA* or alternatively s 36(1) NSW *CLA*?

A. Not appropriate to answer at this point.

[27] Chapter 11 at [256].
[28] Section 14.2.

Cross-Claims

25 Question 30 is directed to the respective rights of the defendants under their cross-claims. All of the parties requested that it not be answered pending their consideration of this judgment,[29] although it follows from the findings in Chapter 14 that all the cross-claims should be dismissed.[30] Accordingly, the question posed and the answer is:

Q.30 What are the respective rights and liabilities as between the defendants in the event that one or more of them is liable to the plaintiff or one or more Group Members?

A. Not appropriate to answer at this point.

QRAA Payments

26 Question 31 concerns the treatment of grants payable under the *Rural and Regional Adjustment Act 1994* (Qld). The treatment of payments under one of the schemes created by a regulation made under that Act is addressed in Chapter 14.[31] The question and answer are as follows:

Q.31 Should money received by the plaintiff and Group Members from the Queensland Rural Adjustment Authority (QRAA) as the Queensland Government's administrator of schemes of governmental support established by the *Rural and Regional Adjustment Act 1994* (Qld), be taken into account in the assessment of any damages, and if so, in what way?

A. In respect of the plaintiff:

(i) to the extent that the plaintiff's claim for damages includes the cost of replacing and repairing store equipment then an amount of up to $4598.95 should be deducted from its damages but not otherwise and such deduction is to occur before any apportionment

[29] SBM.500.001.0001 at .0015, A30.
[30] Chapter 14 at [105].
[31] Chapter 14 at [43] to [72].

of the amount of damages to be paid by each defendant to the plaintiff;

(ii) ***to the extent that the plaintiff's claim for damages includes the cost of replacing or repairing store equipment then an amount of up to $2937.93 should be deducted from its damages but not otherwise and such deduction is to occur before any apportionment of the amount of damages to be paid by each defendant to the plaintiff; and***

(iii) ***to the extent that the plaintiff's claim for damages includes the cost of replacing lost or damaged stock then an amount of up to $17,463.22 should be deducted from its damages but not otherwise and such deduction is to occur before any apportionment of the amount of damages to be paid by each defendant to the plaintiff.***

In respect of group members who received grants from the QRAA under the scheme created by Part 29 of the Rural and Regional Adjustment Regulation 2000 (the "Regulation") for no more than $5000, then to the extent that they can otherwise recover in these proceedings costs of the kind referred to in subclause 288(2) of the Regulation the grant should be deducted from their damages but not otherwise and such deduction is to occur before any apportionment of the amount of damages to be paid by each defendant to that group member.

In respect of group members who received grants from the QRAA under the scheme created by Part 29 of the Regulation of more than $5000, then to the extent that they can otherwise recover in these proceedings the costs the subject of the material provided to comply with clause 291 of the Regulation, then the grants should be deducted from their damages but not otherwise and such deduction is to occur before any apportionment of the amount of damages to be paid by each defendant to that group member.

In respect of group members who received grants under the Rural and Regional Adjustment Act but not under the scheme created by Part 29 of the Regulation, unnecessary to answer.

Damages for Own Labour and Volunteer Labour

27 The next two questions concern so much of the plaintiff's and group members' claims for damages in respect of their own labour and volunteer labour undertaken in "carrying out rectification and repairs" which I understand to

relate to their own property. This was addressed in Chapter 14.[32] The questions posed and the answers are:

Q.32 Are the plaintiff and Group Members entitled to damages for their own labour and/or the labour of volunteers in carrying out rectification and repairs?

A. In respect of the plaintiff, yes. In respect of the group members and assuming that the question relates to rectifications and repairs to real or personal property that is owned or leased by them, yes. Otherwise unnecessary to answer.

Q.33 If yes, is the entitlement to damages based on the reasonable commercial cost of those services or some other measure?

A. The quantification of the loss is based on the reasonable commercial cost of those services.

Limitation Period

28 The next two questions concern the application of the limitation period specified in s 10(1)(a) of the *Limitation of Actions Act 1974* (Qld) to these proceedings. This is also addressed in Chapter 14.[33] The questions posed and the answers are:

Q.34 Does the commencement or maintenance of these proceedings mean that group members have "brought" an "action … founded … on tort" within six years from the date on which their cause of action arose within the meaning of s 10(1)(a) of the *Limitation of Actions Act 1974* (Qld)?

A. Yes.

Q.35 If the answer to 34 is "no" in respect of any or all group members, does s 182 of the *Civil Procedure Act 2005* (NSW) (or any equivalent provision) operate to suspend the limitation period applicable to group

[32] Chapter 14 at [77].
[33] Section 14.5.

members' claim in *Rodriguez & Sons Pty Ltd v Queensland Bulk Water Supply Authority t/as Seqwater & Ors* (NSW Supreme Court No 2014/200854)?

A. Does not arise.

Binding Effect

29 The last question posed concerns the binding effect of the findings made in this judgment. Two of the parties submitted that the findings were binding on all group members and two submitted that it was premature to answer.[34] It would appear to follow from s 179(b) of the *CPA* that all the findings are binding. They are clearly binding on the plaintiff, the sample group members and the defendants. I will defer answering the entirety of the group members to enable any further consideration as may be necessary. Accordingly, the question posed and the answer is:

Q.36 For the purposes of formulating a judgment conforming to s 179(a) of the *Civil Procedure Act 2005* (NSW), which answers to each question above, alternatively which findings made for the purposes of answering each or any question above, bind:

(a) the plaintiff?

(b) any and if so which Sample Group Members?

(c) any and if so which Group Members?

(d) all Group Members?

A. The plaintiff, the sample group members and the defendants are bound by the above answers and all the findings in this judgment. In respect of the remaining group members, not necessary to answer at this stage.

15.2 Future Disposition

[34] SBM.500.001.0001 at .0018.

30 In view of the length of this judgment I will give the parties time to consider it and direct them to confer concerning the next steps to be taken in the proceedings. At the very least they would appear to include the quantification of the plaintiff's damages, the application of the apportionment provisions, the determination of the balance of the group members' claims, the disposition of the cross-claims and costs at first instance. The only orders that will be made at this point will be to stand the proceedings over for directions on 21 February 2020 at 9.30am and direct the parties to confer by no later 7 February 2020 as to the next steps to be taken in the proceedings.

31 Accordingly, the Court orders that:

(1) The proceedings stand over to 9.30am on 21 February 2020 for directions; and

(2) By no later than 7 February 2020 the parties are to confer as to the further progress of the proceedings.

****

APPENDIX A - Defined Terms and Terminology

Term	Meaning
Abutment	Ancillary concrete structures that buttress the dam wall and provide structural support by diffusing lateral tension.
ACCESS Forecasts	Various forecasts generated via the BoM's Australian Community Climate Earth-System Simulator (ACCESS) model.
AMTD	The adopted middle thread distance (AMTD) is the length of a watercourse as measured by along midpoint of the width of that watercourse.
Annual Exceedance Probability ("AEP")	The probability of a specified event (such as a certain water level) being reached or exceeded in any given year. This is expressed as a ratio (ie, 1 in X) or as a percentage.
Antecedent Precipitation Index ("API")	A BoM developed index used to calibrate modelled loss rates at the start of a flood event. The API takes the average loss rate of past historical events (with no consideration of the actual conditions that preceded the flood event).
Appendix A Model Runs	Model runs that were constructed by Mr Malone during the drafting of the January FER using preserved RTFM data from the January 2011 Flood Event.
Assimilation	The process of transposing and combining the FEWS system modelled results with observed rainfall and meteorological data to improve the system's output.
Attenuation	In river hydraulics, attenuation occurs when the water level of the watercourse rises above its banks and spreads across the flood plain. The flow of the water on the flood plain slows dramatically but it may eventually re-join the watercourse downstream (creating difficulties in accurately capturing and modelling discharge rates).

Aurecon URBS Model	A hydrological model of the Brisbane River catchment system developed as part of the BRCFS through a recalibration of Seqwater's URBS model (which itself was created after the January 2011 Flood Event).
Australian Height Datum ("AHD")	The official national vertical datum for Australia.
Average Recurrence Interval ("ARI")	ARI indicates an event's rarity by estimating the amount of time intervening between two successive occurrences of the event in question. Ie, an ARI of 25 indicates the event will occur in cycles of 25 years (and has a 4% chance of occurring in any given year).
Base Time	The time at which the data for a forecast product commences. This is not to be confused with the **issue time** of a forecast, which refers to the time that the forecast product became available. Ie, a one-day 00UTC PME has a base time of 10.00am, but has an issue time of 6.00pm. See [126] – [134] of Chapter 2 for more detail.
Baseflow	The portion of dam inflows that is the product of the slow seepage of water from within the ground (ie, not surface runoff).
Basin Authority	The Murray-Darling Basin Authority.
Bathymetry	The study of the topography and terrain underneath the surface of a watercourse.
BCC	Brisbane City Council.
BoM	The Australian Government Bureau of Meteorology.
BRCFS	The Brisbane River Catchment Flood Study, a comprehensive hydraulic and hydrological study of the lower Brisbane catchment systems undertaken after the QFCI.

"Can Release" Modelling	Selection of a flood event strategy based on predicted Wivenhoe and Somerset lake levels that are modelled *with* the inclusion of releases of water that are predicted to be made.
Catchment	A defined basin where rainfall is captured and measured. If a catchment is referred to as **dry** or **wet**, this speaks to the amount of rainfall that has been experienced up to that point and the surface's level of saturation (the former indicates little rain and the latter indicates substantial rain).
Category One/Two Simulations	Dr Christensen's simulations can be divided into two categories: Category One simulations don't take Wivenhoe Dam above EL 74.0m AHD; Category Two simulations take Wivenhoe Dam above EL 74.0m AHD.
Chief Executive	The Director General of DERM or a nominated delegate.
***CLA* (Qld)**	The *Civil Liability Act 2003* (Qld), as current from 1 January 2011 to 31 August 2012.
Computational Mesh	See "Digital Elevation Model (DEM)".
Cone Valve	See "Regulator Cone Dispersion Valve".
Connell Wagner Paper	Discussion Paper – Change in Operation of Wivenhoe Dam (Draft, Revision 2, Dec. 2006). [Document code: ROD.901.001.1115]
Continuing Loss Rate (CL)	The continuing loss rate is the depth of rainfall in a catchment, falling over a specified time period, that must be exceeded before runoff is experienced for that time period. It is normally expressed in terms of mm/hour (ie, CL = 2.5mm/hour = for runoff to be experienced over this hour long period, more than 2.5mm of rain must fall).
Crest Gates (AKA Radial Gates, Spillway	A cylindrically curved flood gate (with the curved segment facing the reservoir) which is supported by beams

Gates)	connected to a shared trunnion pivot. Raising the crest gate will increase releases of water from the Dam.
Crest Level	The highest point of impoundment at either dam (Wivenhoe = EL 79.10m AHD; Somerset = EL 107.46m AHD). Any increase in the water level above this point will cause overtopping and water spillage below (and potentially dam failure). NB: the crest level at Somerset Dam rises above EL 107.46m AHD depending on how high the crest gates are open (see [126] in Chapter 8).
Curve Method	A curvilinear method of calculating runoff based on a given rainfall depth and the catchment's curve number.
Curve Number	A number between 1 and 100 which represents the relative runoff producing conditions of a catchment. This number is used in the Curve Method of runoff calculation.
Cut-Off Low	An atmospheric phenomenon wherein a small pool of cold polar air in the Antarctic breaks off from the larger polar vortex and tracks north. This low pressure system interacts with warmer air systems on the Australian mainland and causes extreme weather events.
Dam Supervisor	The senior on-site officer at Wivenhoe or Somerset Dam.
DERM	The Queensland Government Department of Environment and Resource Management, the governmental department that was responsible for management of Queensland's water resources at the time of the January 2011 Flood Event.
Digital Elevation Model (DEM)	The suite of geospatial data concerning the topography and terrain of the Brisbane River catchment that was input as the "computational mesh" (ie, a subdivided geometric grid superimposed via computer) into Dr Altinakar's hydraulic modelling in order to accurately determine processes of flow.

Drafts 1 - 7	Draft revisions of Version 6 of the Manual made from time to time between 30 July 2009 and 26 November 2009.
Drain Down Sequence (AKA Draw Down Sequence)	After inflows into the Dam have peaked, the drain down phase of flood operations commences. This is the process of steadily making releases until the storage level sits at FSL once again. Section 3.2 of the Manual provided for a 7-day drain down sequence as a general target for the flood engineers.
DSS-WISE	A two-dimensional hydraulic modelling software system used by Dr Altinakar to re-construct and estimate the patterns of flow across the topography of the Brisbane River catchment.
Duty Flood Operations Engineer ("DFOE")	The Senior Flood Operations Engineer (SFOE) or Flood Operations Engineer (FOE) rostered on duty to be in charge of Flood Operations at the dam.
Early-December Flood Event	The flood event declared on 1 December 2010.
El Niño	A weather phenomenon wherein a reduction in the strength of equatorial trade winds causes cooler-than-average ocean currents to pool off the north-east coast of Australia, resulting in sustained periods of drought. This is the inverse of the La Niña phenomenon.
Elevation Level ("EL")	Elevation in metres in Australian Height Datum (AHD).
Embankment Level	The level of the earthen embankments that abut either side of the dam wall, which (at Wivenhoe Dam) aligns with the highest point of the dam structure itself.
Event Log	A running log of flood operations and communications undertaken by the FOE's during the January 2011 Flood Event as made and updated by data collectors working in the FOC. [Document code: QLD.002.001.8660]

Excess Rainfall	For the purposes of Mr Malone's affidavit [Document code: LAY.SEQ.007.0001], 'excess rainfall' is synonymous with 'runoff'.
FEWS System	A Seqwater developed flood modelling system wherein ACCESS data is fed into the FEWS system at different times per day, merged, downscaled and gridded to create forecast images.
Fish Recovery	The rescue of fish and other aquatic animals from the spillway that are left stranded once the crest gates are fully closed. The recovered fish are then returned to the reservoir.
Flood Engineers (AKA Floods Operations Engineers)	At all relevant times during the January 2011 Flood Event, the flood engineers were Mr Terry Malone, Mr Robert Ayre, Mr John Tibaldi and Mr John Ruffini.
Flood Event	The situation where the Duty Flood Operations Engineer expects the water level in either Somerset or Wivenhoe Dam to exceed the Full Supply Level.
Flood Objectives (AKA Flood Mitigation Objectives)	See Section 1.1 of the Manual or [6] of Chapter 3.
Flood Operations (AKA Gate Operations)	The decision to increase, decrease or maintain gate openings made by flood engineers to manage flood events.
Flood Operations Centre ("FOC")	The centre used during Flood Operations to manage flood events.
Flood Plain	All physical areas that may be potentially flooded by water from a watercourse.
Flood Pool	In USACE terminology, the flood pool is the allotment of water from which releases can be validly made.
Flood Procedure Manual ("FPM")	A document prepared by Seqwater in January 2010 internally assigning responsibilities and obligations on

	Seqwater personnel for flood preparation, flood mobilisation and flood operations. [Document code: SEQ.004.028.0001]
Full Supply Level ("FSL")	The level of the lake's water surface when the reservoir is at maximum operating level (excluding periods affected by flood) and the Dam is functioning at peak capacity. For Wivenhoe Dam FSL is EL 67.0m AHD and for Somerset Dam FSL is EL 99.0m AHD.
Fuse Plug Initiation	The situation where the water level in the Wivenhoe reservoir exceeds a certain trigger level and precipitates the disintegration of a collapsible earthen dam, thereby opening an auxiliary spillway and increasing flows downstream (by 200m^3/s) in order to create more flood storage capacity (see Sections 3.1 and 8.4 of the Manual).
Gate Closing Sequence	See "Shutdown Procedure" below.
Gate Directive (AKA Flood Directive)	A facsimile sent from the DFOE to the FOC during a flood event directing them to make certain gate operations at specified times.
Gate Operations	See "Flood Operations" above.
Georeferencing	The process of assigning and overlaying real-world geographic characteristics and co-ordinates to forecast maps, thus allowing for a more accurate interpretation.
Greater Flooding	Greater flooding downstream of Wivenhoe Dam than would have occurred had the flood engineers not committed one or more of the flood engineers' breaches (see 5ASOC at [346(b)(i) and (ii)]).
Gross Rain	The total amount of rainfall that lands in the catchment area (ie, before loss and runoff occurs).

Group Members	All persons or entities that satisfy both limbs of the group member qualification test set out at [17] in Chapter 1. Within this cohort, four persons were selected to represent a sample (along with the plaintiff) in the running of the case: Mr John and Mrs Betty Keller, Ms Lynette Lynch, Ms Sharon Visser and Ms Lynette Harrison (the "**sample group members**").
Historic Release	The highest rate of releases made from Wivenhoe Dam since its establishment.
Hydraulic Effect	The equalisation of time taken for runoff from the upper and lower reaches of a dam's reservoir to reach the dam wall. This effect causes a 'traffic jam' of runoff flows and generates increases in observed inflow rates.
Hydraulic Model	A two-dimensional model of specific water flow regimes and conditions generated by the solution of mathematical equations expressing principles of engineering that operate to reflect the physical process of water flow.
Hydrograph	A graphical representation of the rate of flow through a watercourse over time. The **upwards limb** represents the situation where flow rates are *increasing* over time, whereas the **downwards limb** represents the situation where flow rates are *decreasing* over time.
Hydrological Model	A mathematical model of rainfall, runoff and stream flow within a catchment network, providing a conceptual approximation of flows. Also known as a "**Hydrologic Model**".
Hydrology	The study of the movement, properties and flow of water.
ICOLD	International Committee on Large Dams.
Incised Channel	A channel that is manually or naturally deepened and/or widened by displacement of the riverbed, leading to higher

	rates of flow through the incised part of the channel.
Increment	The discrete distance (1 increment = 0.5m) that is used as the standard unit of measurement for gate operations.
Induced Surcharge Operations	In USACE terminology, induced surcharge operations are the prescribed forms of flood operations that are mandated once the dam level exceeds the flood pool.
Infiltration	The seepage of water into the soil of a catchment.
Initial Loss Rate (IL)	The initial loss rate is the depth of rainfall required to fall in the catchment at the start of a rainfall event before any runoff is generated. It is expressed in mm (ie, IL = 40mm = 40mm of rain must fall before the catchment generates runoff).
January 2011 Flood Event	The flood event declared on 6 January 2011 (but taken to have commenced on 2 January 2011), being the subject of this legal proceeding.
January FER	The Flood Event Report for the January 2011 Flood Event. [Document code: SUN.016.001.0280]
La Niña	A weather phenomenon where increases in equatorial trade winds cause warmer-than-average ocean currents to pool off the north-east coast of Australia, triggering warm air circulation and, as a result, intense and sustained bouts of rainfall.
Late-December Flood Event	The flood event declared on 24 December 2010.
Loss Rates	Loss rates are the rates at which water infiltrates the earth's surface (instead of becoming runoff). They can be divided into two components for modelling purposes: **Initial losses** and **continuing losses** (see above).

Manual	The Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam (Revision 7, Nov. 2009). [Document code: QLD.001.001.0146].
March 2010 Flood Event	The flood event declared on 1 March 2010 which saw the flood engineers make releases from Somerset Dam prior to the lake level reaching FSL during the flood event.
Market Rules	The set of rules designed by the Minister for the operation of a wholesale market for the exchange of water and water services in Queensland (see Chapter 5 at [75] – [79]).
May 2009 Flood Event	The flood event declared on 20 May 2009 which saw the flood engineers make pre-releases from Somerset Dam to below FSL before the event was declared and releases from Somerset to below FSL during the event.
MDBA	Murray-Darling Basin Agreement
Method A, B, or C Reservoir	In the context of US dam engineering, the nature of flood operations in a dam is contingent on their classification. Method A reservoirs apply a methodology that protects against minor and moderate flooding until it is no longer tenable. Method B reservoirs always apply a methodology that protects against high-level flooding. Method C reservoirs are a combination of Methods A and B.
Mid-December Flood Event	The flood event declared on 16 December 2010.
Minimum Interval for Gate Operations	The minimum rate of time in which radial gates must be opened in certain increments to increase dam outflows (thus stabilising the effects of releases on the river system downstream).
Model Run	A single permutation of the RTFM at a given point in time. An RTFM model run may be based exclusively on rain on

	the ground data (an "**ROG run**") or may include rainfall forecast data in addition to the ROG inputs (a "**with forecast run**").
Moreton ROP	The Moreton Resource Operations Plan (commenced 7 December 2009). This implemented the Moreton WRP.
Moreton WRP	The *Water Resource (Moreton) Plan 2007 (Qld)*, as current from 18 December 2009 to 23 November 2011.
MRMS	The Missouri River Mainstem System
Natural Flow (AKA Naturally Occurring Flow)	The flow that would have been recorded through a certain place at a certain point in time without combining with any releases from Wivenhoe or Somerset Dam.
"No Release" Modelling	Selection of a flood event strategy based on predicted Wivenhoe and Somerset lake levels that are modelled *without* factoring in any likely future releases of water.
Numerical Weather Prediction ("NWP")	A method of weather forecasting that uses mathematical equations and models in addition to current weather conditions to forecast future weather outcomes. The NWP method is used in the calculation of the QPF forecast.
October Flood Event	The flood event declared on 6 October 2010.
Operations Target Line (AKA Operating Target Line)	An optimised function in section 9.3 of the Manual that provides the flood engineers with a target for storage levels in order to equalise the risk of dam failure.
Orographic Rainfall	The process of maritime airstreams being forced upwards ('orographic lift') by a mountain range thereby reaching warm enough temperatures to generate rainfall.
Over the Floor Flooding	The level of flooding that results in the inundation of a person's house or other premises on their property.
Overtopping	Where the water level of the Wivenhoe or Somerset reservoir exceeds the highest point of the dam (ie, the

	crest level), potentially causing dam failure.
Precautionary Releases (AKA Pre-emptive Releases; AKA Pre-releases)	Releases of water made in anticipation of a certain amount of forecast rain before it has fallen (where the dam may be sitting above or below FSL).
Probability Matched Ensemble (AKA Poor Man's Ensemble) ("PME")	A Bureau of Meteorology (BoM) precipitation forecast report (drawing from an ensemble of seven independent numerical weather prediction sources) offering national maps that chart probabilities of daily rainfall, as well as four and eight-day accumulation forecasts.
Probability of Exceedance Forecast ("POE")	POE forecasts are estimations of the probability that a rainfall event will exceed a certain amount of predicted rainfall. It is developed from the constituent models of the PME.
Probable Maximum Flood ("PMF")	An estimated maximum possible flood load (AEP > 1,000,000) used to test whether under normal spillway gate operations at Somerset Dam the procedures defined in the Manual ensure that the flood event can be managed without Dam failure.
Q (ie $Q_{Wivenhoe}$)	Volumetric flow rate at a certain point of the river (in m^3/sec).
QFCI	The Queensland Floods Commission of Inquiry.
Quantitative Precipitation Forecast ("QPF")	A BoM developed report of the range (ie a lower and upper bound) of expected rainfall. The QPFs in issue were a rainfall forecast delivered twice-daily for the Wivenhoe, Somerset and North Pine catchment areas within a 24 hour timeframe.
QWC	Queensland Water Commission

Radial Gates	See "Crest Gates" above.
Rain on the Ground Modelling (ROG)	The collection of data from rain gauges that is used to estimate the amount of rainfall that has fallen on a specific catchment region (ie not a precipitation *forecast*).
Rainband	An extended cell of precipitation-carrying clouds that generates substantial amounts of rainfall.
Rainfall Depth	The quantity of rainfall that falls during a given period (usually expressed as mm/day).
Rated Flow	The fixed relationship between the height of a stream and the rate of flow at a particular location along a watercourse.
Real Time Flood Model ("RTFM")	A suite of hydrological and hydraulic computer programs that utilise real time rainfall and river height data to determine likely inflows and assist in the operation of dams during flood events. The RTFM consisted of three components: rainfall data collection (**FLOODCOL**), a rainfall and runoff flood simulation model (**FLOODOPS**), and a Microsoft Excel spreadsheet containing past and predicted gate operations relative to dam inflows (both recorded and modelled) (**Gate Operations Spreadsheets** or "**GOS**").
Regulator Cone Dispersion Valve (AKA Cone Valve; AKA Regulator)	A valve at Somerset Dam through which smaller releases of water are made that don't damage the surrounding environs, as the valve's hollow, conical shape disperses water efficiently.
Restructuring Act	*South East Queensland Water (Restructuring) Act 2007* (Qld), as current from 1 July 2010 to 3 April 2011.

Reverse Routing	When the RTFM was not able to accurately model lake levels, the process of reverse routing was undertaken. This process involves calculating back from increases in observed lake levels and outflows to determine the rate of inflows.
ROL	A resource operations licence, as defined in s 107A(1) of the *Water Act* (see Chapter 5 at [7], [21] – [23]).
Runoff	Water that doesn't infiltrate the earth's surface and runs across the top layer of the ground until it reaches a watercourse or is absorbed by the soil.
Runoff Response Curve	A generally applicable curve that displays the relationship between runoff, infiltration and rainfall (ie, increased rainfall = decreased infiltration = increased runoff). An example of this curve can be found in Chapter 2 at [94].
Safety and Reliability Act	*Water Supply (Safety and Reliability) Act 2008* (Qld), as current from 1 January 2011 to 3 April 2011.
Senior Flood Operations Engineer ("SFOE")	A person designated in accordance with Section 2.3 of the Manual under whose general direction the procedures of the Manual must be carried out.
Seqwater	The Queensland Bulk Water Supply Authority (t/a Seqwater).
SEQWC	The South East Queensland Water Corporation (the predecessor to Seqwater).
Shutdown Procedure (AKA Gate Closing Sequence)	The process of steadily closing gates at the conclusion of a flood event.
SILO Meteograms	A BoM developed mid-range (72-hour to seven-day) weather forecasting product which provides information on air temperature, mean sea level pressure, wind, precipitation, cloud cover, relative humidity and evapotranspiration for a particular Australian region.

Simulation Analysis	A document entitled "Extended Simulations A-J", released with Dr Christensen's Response Report, which sets out the water level, release patterns and gate operations adopted by Dr Christensen in his simulations, with remarks on his reasoning process. [Document Code: EXP.ROD.015.0461].
Situation Report	A detailed update on current and future weather conditions, dam levels and inflows, current and future operational strategy, and downstream impacts that was distributed by the DFOE via email to the FOE's, Seqwater and Sunwater staff, and various government officials.
Skill	The ability of a weather forecasting product to predict weather patterns to a rate of accuracy that is statistically more significant than a random guess.
SLA	Service Level Agreement (see Chapter 11 at [142]).
Sluice Gate	A vertical floodgate at Somerset Dam which is raised or lowered to manipulate releases of water for gate operations.
Somerset 2010 Report	Report entitled Somerset Dam: Five Year Comprehensive Dam Safety Report (September 2010). [Document code: SEQ.001.001.6895]
Spillway	The sloped structure which funnels the release of flows from the dam into the watercourse downstream.
Stochastic Modelling	A form of statistical analysis that involves the repeated removal of key inputs from a multivariate system to test their relative significance to the final output of that system.
Storage Level	The level of water in the reservoir.
Straight Line Method	A calculation of the volume of runoff based on the linear relationship between runoff inflows and rainfall depth. The

	percentage of runoff to rain from the preceding flood event combined with this calculation provides an estimate of likely future runoff and loss rates.
SunWater	A statutorily created Queensland Government-owned corporation that holds and manages bulk water infrastructure assets.
Supply Pool (AKA Conservation Pool)	In USACE terminology, the supply pool is the allotment of water beneath the flood pool that exists for water supply, environmental and hydropower purposes.
Target Level Approach	The approach adopted by Dr Christensen in his general methodology for the simulation of flood operations. This approach consisted of setting a target reservoir level to meet via future planned releases after calculating the predicted level of inflows into Wivenhoe Dam (as discerned by the 4-day PME rainfall estimate). For more detail, see Chapter 8 at [52] – [61].
Technical Situation Report	A brief update on Seqwater dam conditions, the status of inflows and current operational strategy that was distributed by the Dam Operations Manager (Mr Drury) via email to Seqwater staff and DERM during flood events.
Trigger Level	The point at which the Manual allows dam releases to be made (eg, the trigger level for releases through the spillway gate from Wivenhoe Dam is EL 67.25m AHD).
Uncontrolled Spillage (AKA Ungated Releases)	Releases from Somerset Dam that occur as a result of water uncontrollably spilling over the crest of the radial gates. This occurs at a height of EL 100.45m AHD at a minimum (depending on how far open the radial gates are).
USACE	The United States Army Corps of Engineers.
UTC	Coordinated Universal Time. Brisbane's GMT time zone is

	ten hours ahead of UTC (ie, 10.00am = 00UTC).
Version(s) 1 - 7	The successive versions of the Manual that were drafted from time to time between 1992 and 2009.
Water Act	The *Water Act 2000* (Qld), as current from 10 December 2010 to 7 April 2011.
Water Supply Act ("WSA")	The *Water Supply (Safety and Reliability) Act 2008* (Qld), as current from 1 January 2011 to 3 April 2011.
1995 Safety Report	Safety Review by the South East Queensland Water Board into Somerset Dam (September 1995). [Document code: SEQ.006.002.0001]
2001 Pre-Release Report	Report entitled "Feasibility of Making Pre-Releases from SEQWC Reservoirs" (September 2001). [Document code: SUN.001.002.6314]
2006 BoM Report	Report entitled "Rainfall Forecasting for the Wivenhoe Dam Catchment" (July 2006). [Document code: SEQ.001.018.9373]
2009 FER	The Flood Event Report for the flood event in May 2009. [Document code: SEQ.084.003.0365]
2010 FER	The Flood Event Report for the flood events in October and December 2010. [Document code: ROD.650.003.6506]
5ASOC	Fifth Amended Statement of Claim. [Document Code: PLE.010.001.0001]

APPENDIX B - *Dramatis Personae*

Name	Organisation and Role
Neville Ablitt	Seqwater employee: Principal Tenure Advisor, Data Collector and Technical Officer during the January 2011 Flood Event.
Peter Allen	DERM employee: Director of Dam Safety (Water Supply) during the January 2011 Flood Event.
Dr Mustafa Altinakar	Plaintiff expert witness: mathematical flood simulation and hydraulic modelling.
Robert Ayre	SunWater employee: Senior Flood Operations Engineer in the Flood Operations Centre during the January 2011 Flood Event.
Mark Babister	Seqwater expert witness: Numerical floodplain modelling and hydraulic investigations of Australian floods. (Not read.)
Peter Baddiley	BoM employee: Regional Hydrology Manager for Queensland – Climate & Water Division.
Mike Bergin	BoM employee: Manager of Weather Services.
Debra-Lee (Debbie) Best	DERM employee: Acting Director-General of DERM from 25 December 2010 – 10 January 2011.
Brad Bird	State of Qld lay-witness: Senior Regional Engineer for Civil Works, Engineering and Construction Division, USACE.
Wes Birdwell	SunWater expert witness: Dam operations and flood control. (Not read.)
Anna Bligh AC	Premier of Queensland at the time of the January 2011 Flood Event.
Peter Borrows	Seqwater witness: CEO/Managing Director during the January 2011 Flood Event.

Gary Burgess	DERM employee: Acting General Manager, Water Allocation and Planning in December 2010.
Martin Cairns	Plaintiff expert witness: Forensic accounting and damage assessment.
James Charalambous	Senior Engineer in the Flood Management Section of the Brisbane City Council (BCC) from June 2009. Worked in the BCC's Flood Information Centre (FIC) as a controller during the January 2011 Flood Event.
Dr Ronald Christensen	Plaintiff expert witness: Simulated dam operations and flood control.
Neil Collins	State of Qld expert witness: Hydraulic and Water Resources Engineer.
Brian Cooper	Seqwater witness: Dam engineer retained by the SEQ Water Grid Manager to prepare a report on the operation of Wivenhoe Dam immediately at the conclusion of the January 2011 Flood Event.
Arran Corbett	Seqwater witness: Performed acoustic Doppler tests to determine accurate streamflow measurements.
Tom Crothers	DERM employee: General Manager, Water Allocation and Planning during February 2010.
David Curtis	State of Qld expert witness: Meteorology and flood forecasting and modelling. Neither of his two reports were tendered.
Anthony (Agg) Dagan	Seqwater employee: Somerset Dam operator from 2000 – 2016 (including during the January 2011 Flood Event).
Christopher Peter Dann	Seqwater expert witness: Geotechnical and structural dam engineering.
Todd Davis	Plaintiff expert witness: Vice-President of Animations at 21st Century Animations retained by the plaintiff to create an

	animated model to digitally represent the flooding of the Brisbane River Catchment and the characteristics of the terrain.
Barry Dennien	Seqwater employee: CEO - SEQ Water Grid Manager at the time of the January 2011 Flood Event.
Dianne Douglas	DERM employee: involved with revision of the Manual in 2009.
Alan Dreverman	Seqwater lay-witness: Executive Director of River Management for the Murray-Darling Basin Authority (MDBA) since 2003.
Robert (Rob) Drury	Seqwater employee: Dam Operations Manager during the January 2011 Flood Event.
Kevin Fagot	State of Qld expert witness: Dam operations, hydraulic and hydrological engineering projects and water control manual review.
Alex Fisher	Seqwater employee: Executive General Manager, Asset Delivery during August 2010.
Martin Giles	State of Qld expert witness: Loss rates, modelling and operational spreadsheets.
Ron Guppy	DERM employee: Principal Engineer, Dam Safety from (at least) 2006 - 2011.
Lynette Harrison	Plaintiff lay-witness: Personal property sample group member.
Glenister (Glenn) Hobbs	Seqwater expert witness: Mechanical engineering and the operation of control structures in bulk water supply.
Andrew Ickert	SunWater expert witness: Hydrology, hydraulics and flood forecasting.
Michael Kane	Plaintiff expert witness: Flood forecasting and hydro-meteorology.

Graham Keegan	Seqwater employee: Engineering officer and Dam Operator during the January 2011 Flood Event.
John and Betty Keller	Plaintiff lay-witness: Lockyer Creek sample group member.
Lynette Lynch	Plaintiff lay-witness: Upstream Moggill sample group member.
Barton Maher	Seqwater employee: Project Director, Dams and Weirs from November 2007 to January 2011.
Terry Malone	SeqWater employee: Flood Operations Engineer in the Flood Operations Centre during the January 2011 Flood Event. Employed from 2009 – 2015 as a senior hydrologist at Seqwater (now holds the role of expert hydrologist).
Michael Manton	Seqwater expert witness: Meteorology, atmospheric science and mathematics, and weather prediction modelling.
Dr Sharmil Markar	SunWater expert witness: Hydraulic modelling and the study of stormwater drainage.
David Pokarier	Seqwater expert witness: Currently the Senior Engineer in the Flood Services team within Seqwater. Expertise in flood forecasting and modelling. Worked for SunWater in a data collection role in the FOC during the January 2011 Flood Event.
Terence Michael Potter	Seqwater expert witness: Forensic accounting and the valuation of damage/economic loss.
Jim Pruss	Seqwater employee: Executive General Manager of Water Delivery during the January 2011 Flood Event.
Bob Reilly	DERM employee: Office of the Water Supply Regulator, General Manager from (at least) 2010 to the January 2011 Flood Event.

The Hon. Stephen Robertson MP	Minister for Natural Resources, Mines and Energy from March 2009 – February 2011.
Vincente Rodriguez	Lead plaintiff: Sole director of Rodriguez & Sons Pty Ltd.
Leanne Rudd	Plaintiff lay-witness: part owner and manager of High Powered Floor Restoration Pty Ltd, a commercial restoration and cleaning company that serviced many flood affected properties in the wake of the January 2011 Flood Event.
John Ruffini	Qld. Government employee: Duty Flood Operations Engineer from 1996 until after the January 2011 Flood Event. Was a Flood Operations Engineer in the Flood Operations Centre during the January 2011 Flood Event.
Ben (R) Russo	Consulting Engineer – Dam Surveillance Consulting Services. Provided consultation on Somerset Dam in 1996.
Professor Anton Schleiss	Plaintiff expert witness: Overseas dam system practices.
Daniel (Dan) Spiller	Employee of the SEQ Water Grid Manager: Director of Operations, Acting CEO from 25 December 2010 to 8 January 2011.
Alissa Starkey	Plaintiff expert witness: Geo-spatial data and remote sensing specialist retained to model the boundaries of the peak flooding in the January 2011 Flood Event.
Andre Stuart	Plaintiff expert witness: CEO of 21st Century Animations, retained by the plaintiff to create an animated model to digitally represent the flooding of the Brisbane River Catchment and the characteristics of the terrain.
Robert Swain	Seqwater expert witness: Overseas dam system practices and flood modelling.

Claire Thorstensen	Seqwater employee: Principal Commercial Advisor from (at least) 2009 – 2010.
John Tibaldi	SeqWater employee: Principal Engineer (Dam Safety) since 2008. Was a Flood Operations Engineer in the Flood Operations Centre during the January 2011 Flood Event.
Sharon Visser	Plaintiff lay-witness: Bremer River sample group member
Professor Kevin Walsh	Plaintiff expert witness: Meteorology, forecasting and rainfall modelling.

APPENDIX C - Expert Witness and Flood Engineer Biographies*

1. Mr Robert Ayre

Mr Ayre is a civil engineer with 33 years' experience in water engineering projects related to Queensland's surface water resources.[1] He is currently employed as the Technical Director of Water Services at the Aurecon Group.[2] From July 2004 to October 2011, Mr Ayre was employed as Headworks Design Manager in the Infrastructure Development Business Unit at SunWater.[3] In addition to his primary employment, between 2002 and 2011, Mr Ayre was the Senior Flood Operations Engineer for Wivenhoe, Somerset and North Pine Dams.[4] This role was secondary to his core responsibilities at the time – except during a flood event.[5] The role required him to manage the Dams during flood events, in addition to providing advice and conducting flood operations services on behalf of SunWater.[6] Mr Ayre was one of four engineers responsible for the direction of flood operations during flood events, including the January 2011 Flood Event.[7]

Mr Ayre obtained a Bachelor of Engineering (Civil) from the Queensland Institute of Technology in 1983, followed by a Post-Graduate Certificate in Hydrology from the University of New South Wales in 1986.[8] In 1983, he joined the Queensland Water Resource Commission as a Graduate Engineer and remained there until 1989.[9] From 1989 to 1990, he worked in water engineering at KBR Pty Ltd.[10] From 1990 to 1997, he was a Senior Engineer at the Department of Natural Resources.[11] He returned to KBR to work in the water engineering section in 1997. Mr Ayre has a number of professional affiliations, including acting as a Fellow of the Institution of

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*Biographies are current as at the time the particular expert witness signed their affidavit(s). All information to be taken as such unless otherwise expressly stated.

1 Affidavit of Robert Arnold Ayre - affirmed 6 June 2016, LAY.SUN.001.0001 at [23].
2 Ibid at [22].
3 Ibid at [18].
4 Ibid at [39].
5 Ibid at [40].
6 Ibid at [41] - [42].
7 Ibid at [43].
8 Ibid at [4].
9 Ibid at [9].
10 Ibid at [7].
11 Ibid at [8].

Engineers, Australia, as a Chartered Professional Engineer and as an Associate Member of the Australian National Committee on Large Dams.[12]

2. Mr John Tibaldi

Mr Tibaldi is a civil engineer with considerable experience in flood hydrology. He is employed by Seqwater as the Principal Engineer in Dam Safety and Flood Operations. This role involves, among other things, ensuring compliance with the requirements of the Queensland Dam Safety Regulator, managing the Flood Operations Centre, managing flood mitigation activities and undertaking duties as a Senior Flood Operations Engineer during flood events at Wivenhoe, Somerset and North Pine Dams.[13] He has held this position since 2008, with the responsibilities for managing the Flood Operations Centre and Seqwater's flood operations activities added towards the end of 2011.[14] Mr Tibaldi was one of two Flood Operations Engineers who managed the December 2010 and January 2011 Flood Events under the direction of a Senior Flood Operations Engineer (Mr Ayre).[15]

Mr Tibaldi obtained a Bachelor of Engineering (Hons) (Civil) from James Cook University in 1983 followed by a Bachelor of Business from the University of Southern Queensland in 1990.[16] He has also obtained a Graduate Diploma in Commercial Computing, a Postgraduate Diploma in Environmental Impact Assessment, a Graduate Diploma in Maintenance Management and a Graduate Certificate in Electrical and Electronic Engineering from various educational institutions.[17] From 1983 to 1990, Mr Tibaldi was employed as a Civil Engineer with the Water Resources Commission.[18] In 1990, he went on to manage in-stream works approvals across the Brisbane District at the Queensland Water Resources Commission.[19] From 1993 to 1994, he was the Senior Policy Officer, Water Industry

[12] Ibid at [5].
[13] Affidavit of John Victor Tibaldi – affirmed 31 May 2016, LAY.SEQ.004.0001 at [1].
[14] Ibid at [2].
[15] Ibid at [3].
[16] Ibid at [17].
[17] Ibid.
[18] Ibid at [6].
[19] Ibid at [7].

Strategy Unit at the Department of Primary Industries.[20] In 1995, he became an Operations Manager at SunWater.[21]

3. Dr Mustafa Altinakar

Dr Altinakar is the Director and Research Professor at the National Center for Computation Hydroscience and Engineering at the University of Mississippi.[22] His areas of speciality include numerical flood simulation and GIS-based decision support systems for flood protection and management.[23] Prior to becoming Director in 2010, Dr Altinakar was a Research Professor (2003 – 2005) and an Associate Director (2005 – 2010) at the Center. He has published a number of journal papers, conference papers, articles and textbooks in the areas of hydraulics and flood simulation, mapping and management.

Dr Altinakar obtained a Bachelor of Civil Engineering (1978) and a Master of Civil Engineering (1980) from the Middle East Technical University in Turkey.[24] In 1988, he obtained his Ph.D. in Hydraulics at the Hydraulic Research Laboratory at École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. He also has a Masters in Applied Mathematics (1987) from EPFL. Dr Altinakar was employed as a Senior Design Engineer and Project Manager in the Hydraulics division of Bonnard and Gardel Consulting Engineering Ltd from 1989 to 1997. From 1998 to 2002, he was engaged as an independent consultant with various civil engineering companies. He was a tenured Research Associate and Head of Fluvial Hydraulics at EPFL from 1998 to 2000, before his appointment as Acting Director of EPFL from 2001 to 2002.

4. Dr Rory Nathan

Dr Nathan is an Associate Professor of Hydrology and Water Resources in the Department of Infrastructure at the University of Melbourne.[25] He is also currently employed as Technical Director at Jacobs Engineering. His research interests include characterisation of hydrological extremes, regionalisation, hydrological model

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[20] Ibid at [9].
[21] Ibid at [10].
[22] Mustafa Altinakar, Ph.D. – Curriculum Vitae, EXP.ROD.005.0004 at 4.
[23] Ibid at 2.
[24] Ibid.
[25] Affidavit of Roderic John Nathan – affirmed 2 June 2016, EXP.SEQ.001.0001 at [1].

development and application, stochastic hydrology and sustainable use of water resources.[26] Dr Nathan is a Fellow of the Institution of Engineers, Australia, and is the Australian representative on the Floods Committee of the International Committee on Large Dams (ICOLD). He has published over 150 research papers on engineering and environmental hydrology in refereed journals, books and conference proceedings.

Dr Nathan obtained a Bachelor of Engineering (Agri) from the University of Melbourne in 1980. He also holds a Master of Science (1984) from the University of London and a Ph.D. in Hydrological Regionalisation (1990) from the University of Melbourne. From 1982 to 1984, Dr Nathan worked as an Engineer at Cementation International. In 1985, he was a hydrologist at GHD Engineering before commencing as a Research Fellow at the Department of Civil and Environmental Engineering at the University of Melbourne in 1987. From 1990 to 1995, he was an Engineering Hydrologist at the Rural Water Commission. In the period from 1995 to 2014, he worked variously as a Principal Hydrologist, the General Manager of Technology and Practice, and Director at Sinclair Knight Merz.[27]

5. Mr Andrew Ickert

Mr Ickert is a registered professional engineer with over 15 years' experience in hydrological and hydraulic modelling.[28] He has been employed by Halff Associates Inc. since 2001, during which time he has advanced from Project Manager to a Water Resources Team Leader to his current position as Fort Worth Office Manager. His work has involved undertaking a range of hydrologic, hydraulic and reservoir operations projects, including the development of hydrological models and the calibration of hydrological parameters, including loss rates, unit hydrograph and routing parameters.[29] Mr Ickert is registered as a licenced professional engineer in Texas, Arizona and Arkansas, in addition to being a Certified Floodplain Manager with the Texas Floodplain Management Association.

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[26] Ibid at 5.
[27] Ibid at 5.
[28] Affidavit of Andrew Ickert - Sworn 2 March 2017, EXP.SUN.003.0001, at [1].
[29] Ibid at .0016.

Mr Ickert obtained a Bachelor of Science from Texas Tech University in 2000, followed by a Master of Engineering in Civil Engineering from Cornell University in 2001.[30] He has authored a number of technical papers and presentations.

6. Dr Ronald Christensen

Dr Christensen is a civil and environmental engineer with 32 years of extensive experience in hydrology, hydraulics, dams, reservoir water supply and flood operations, flood control and analysis, and hydraulic modelling.[31] He has been the owner and consultant civil engineer of Water and Environmental Services, LLC, in Highland, Utah, since April 2000. In this role, he provides expert witness analysis in relation to his areas of expertise, in addition to undertaking flood control projects and hydrological modelling and design. Previous projects include providing expert witness services for flood and spillway operations of a hydroelectric dam on the Tallapoosa River, Alabama, and levee overtopping on the Missouri River, Missouri. Dr Christensen has also published a number of reports, papers and publications arising from his areas of expertise, such as flood control and management. He is registered as a professional engineer in Utah and Alabama.[32]

Dr Christensen obtained a Bachelor of Science (Watershed Science) from Utah State University College of Natural Resources in 1978, followed by a Master of Science (Civil Engineering) from Utah State University in 1980.[33] He was awarded a Ph.D. in Civil and Environmental Engineering from Utah State University in 1996.[34] From 1980 to 1985, Dr Christensen was a Civil/Water Resources Engineer at Rollins, Brown and Gunnell, Inc. In 1985, he commenced as a Staff Civil/Water Resources Engineer at the Central Utah Water Conservancy District. From 1990 to 2000, he was a Supervising Civil/Water Engineer at Parsons Engineering Science, Inc. He also worked as an Adjunct Professor in the Civil and Environmental Engineering Department at Utah State University from 1998 to 2002. He was an Adjunct Instructor in Hydrology at Utah Valley State College in the Fall Semester of

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[30] Ibid.
[31] Ronald Christensen – Curriculum Vitae, EXP.ROD.001.0006 at .0006.
[32] Ibid.
[33] Ibid.
[34] Ibid.

2007. Dr Christensen's other credentials include qualification as an Attorney at Law at the Utah State Bar and Washington State Bar.[35]

7. Professor Anton Schleiss

Professor Schleiss is a civil engineer and professor. He has been a full professor and the Director of the Laboratory of Hydraulic Constructions at EPFL since October 1997.[36] His fields of specialisation include hydraulic and hydro-mechanical analysis of hydraulic structures, supervision and interpretation of hydraulic model tests, and planning and design of river flood protection measures.[37] Since 2000, he has supervised more than 190 applied research projects on physical and numerical modelling of hydraulic structures at EPFL. His professional experience includes expert consulting and design of hydraulic structures. He has also published a large number of works arising from his areas of expertise. Since 2015, Professor Schleiss has been the President of the International Committee on Large Dams (ICOLD).

Professor Schleiss obtained qualifications equivalent to a Master of Science (Civil Engineering) from the Swiss Federal Institute of Technology in 1978. In 1986, he was awarded a Ph.D. in Technical Sciences from the Laboratory of Hydraulics, Hydrology and Glaciology at the Swiss Federal Institute of Technology.[38] From 1979 to 1985, he worked as a Research Associate and Senior Assistant at the Laboratory of Hydraulics, Hydrology and Glaciology. In 1986, he was the Head of the Hydraulic Structures Section in the Hydropower Plants and Water Management Department, Electrowatt Engineering Ltd before commencing at EPFL in 1997. He also served as Head of the Civil Engineering Department at EPFL between 2006 and 2012.[39]

8. Mr Michael Kane

Mr Kane is a Senior Water Resources Engineer and the Director of Fort Collins Operations at RTI International.[40] In this role, he is responsible for the overall operation and performance of technical staff within the Fort Collins office. He has 33

[35] Ibid at .0007.
[36] Curriculum Vitae of Prof. Dr. Anton J Schleiss, EXP.ROD.012.0006 at .0007.
[37] Ibid at .0008-0009.
[38] Ibid at .0007.
[39] Ibid.
[40] Curriculum Vitae of Michael D. Kane, P.E., C.F.M, EXP.ROD.011.0006 at .0006.

years of professional experience, specialising in the development and implementation of real-time river forecasting and decision support for water resources systems.[41] Other experience includes the development and application of hydrological models and use of hydrological computer models. Mr Kane is a registered professional engineer and certified floodplain manager in Colorado. He is also a member of the American Society of Civil Engineers. He has authored six publications and presentations in the area of flood forecasting.[42]

Mr Kane obtained a Bachelor of Science (Civil Engineering/Hydrology) in 1983 followed by a Master of Science (Civil Engineering/Water Resources) in 1988 from the University of Maryland.[43] From 1984 to 1986, he worked at Dewberry and Davis Engineering. Following this, he was employed at the Remote Sensing Laboratory at the University of Maryland (1986-1987), at the Hydrologic Research Laboratory at the National Weather Service (1988-1990) and at Tampa Bay Water (1991-1993). He commenced at RTI International in 1994.[44]

9. Mr Martin Cairns

Mr Cairns is a Chartered Accountant (within the Institute of Chartered Accountants in England and Wales) specialising in forensic accounting.[45] He is a Director of Sapere Research Group Limited and works within its Forensic Accounting and Valuation Group. He has worked in the Australian forensic market for over three years, during which time he has been involved in matters regarding the assessment of damages, valuations, breach of contract, post-acquisition disputes and class actions.[46] In addition, Mr Cairns has over 15 years' experience in the London forensic accounting market, specialising in the preparation of expert accountant reports, the assessment of damages, and investigations.

Mr Cairns holds a Master's degree in Science from the University of London. From 1997 to 2005, he was Senior Manager at Lee & Allen Consulting Limited before

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[41] Ibid.
[42] Ibid at .0010.
[43] Ibid at .0006.
[44] Ibid.
[45] Martin Cairns (MSci FAC) - Curriculum Vitae, EXP.ROD.008.0006 at .0007.
[46] Ibid.

commencing as a Director at AlixPartners LLC in 2005.[47] From May 2011 to August 2011, he was employed at Clifford Chance LLP. He commenced at Sapere Forensics in September 2011.

10. Professor Kevin Walsh

Professor Walsh is a Professor of Meteorology at the School of Earth Sciences within the University of Melbourne.[48] In this role, he undertakes and supervises research in fields of meteorology such as Australian forecasting and rainfall modelling, tropical cyclones and other extreme weather events, and climate variability.[49] He also provides consulting services to corporate and government bodies.[50] In addition, Professor Walsh has served as Vice-President (2004-2005) and President (2006-2008) of the Australian Meteorological and Oceanographic Society.[51] He has authored a large number of peer-reviewed publications, research reports, conference papers and seminars.[52]

Professor Walsh obtained a Bachelor of Arts majoring in Physics from Harvard University in 1980.[53] In 1983, he was awarded a Master of Science (Meteorology) from the Massachusetts Institute of Technology. This was followed by a Ph.D. (Meteorology) from the University of Melbourne in 1994. From 1981 to 1983, Professor Walsh was a Research Assistant at the Massachusetts Institute of Technology.[54] He then commenced in 1983 as scientist at Meteorological and Environmental Planning Ltd in Ontario, Canada. From 1994, he occupied various positions as a scientist at CSIRO Atmospheric Research in Australia, including his current appointment as a Visiting Scientist, which he has held since 2002. Professor Walsh was a Senior Lecturer at the University of Melbourne's School of Earth Sciences (2002-2004) before becoming an Associate Professor and Reader (2005-2016) and finally a full Professor in 2017.

[47] Ibid at .0012.
[48] Curriculum Vitae – Professor Kevin Walsh, EXP.ROD.014.0004 at .0004.
[49] Kevin Walsh – December 2016 Report, EXP.ROD.014.0034 at .0035.
[50] Ibid; see also Curriculum Vitae – Professor Kevin Walsh, EXP.ROD.014.0004 at .0007.
[51] Curriculum Vitae – Professor Kevin Walsh, EXP.ROD.014.0004 at .0005.
[52] Ibid at .0007 – .0033.
[53] Ibid at .0004.
[54] Ibid.

11. Mr Peter Borrows

Mr Borrows is currently a Director of Murrumbidgee Irrigation Limited and Kedron Consulting Pty Ltd.[55] From December 2010 to January 2011 he was the Chief Executive Officer of Seqwater.[56] As CEO, he was responsible for the management of all of Seqwater's operations and reported to the Seqwater Board.[57] In December 2010, Seqwater owned, operated and managed approximately 25 dams and 47 weirs, including Wivenhoe and Somerset Dams.[58] Mr Borrows is also a Fellow of the Australian Institute of Company Directors, the Australian Institute of Management and the Institution of Engineers, Australia.[59]

Mr Borrows holds a Bachelor of Engineering (Civil) from the University of Queensland (1973) and a Graduate Diploma in Business Administration from the Queensland Institute of Technology (1981).[60] From March 2002 to November 2007, he was CEO of South East Queensland Water Corporation Pty Limited (one of Seqwater's predecessors).[61] Mr Borrows then held the position of CEO of Seqwater from the time that Seqwater was established in November 2007 until December 2012.

12. Mr Alan Dreverman

Mr Dreverman is the former Executive Director of River Management for the Murray-Darling Basin Authority.[62] He retired in August 2017.[63] As part of this role, Mr Dreverman and his team directed daily operations of the River Murray System, including flood operations at Dartmouth and Hume Dams and Yarrawonga Weir.[64] Other functions included the preparation of water resource assessments for the states and overseeing the investigation, design, construction, operation and maintenance of the River Murray Operations assets such as the major storages and

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[55] Affidavit of Peter Clark Borrows – sworn 31 May 2016, LAY.SEQ.005.0001_OBJ, at .0003, [1].
[56] Ibid at [4].
[57] Ibid at .0004, [7].
[58] Ibid at [11].
[59] Ibid at .0003, [6].
[60] Ibid at [5].
[61] Ibid at [4].
[62] Affidavit of Alan David Dreverman – affirmed 14 July 2017, LAY.SEQ.012.0001 at .0002, [1].
[63] T 4109.43 (Dreverman).
[64] Affidavit of Alan David Dreverman - affirmed 14 July 2017, LAY.SEQ.012.0001 at .0002, [3] - [4].

weirs. Mr Dreverman has 42 years' experience in large dam and hydropower projects, both in Australia and overseas.[65] He has worked in the consulting engineering industry with the Snowy Mountains Engineering Corporation (SMEC), the Hydro-Electric Commission of Tasmania and Australian Power & Water. Mr Dreverman joined the Murray-Darling Basin Commission in 2000 as Manager Assets.[66] He was appointed General Manager River Murray Water in 2003. He then transferred to the Authority in 2008 when the Authority subsumed the function of the Commission.

13. Mr Jim Pruss

Mr Pruss is the former General Manager Water Supply Strategy and Policy at Seqwater.[67] He held that position from 1 May 2013 until leaving Seqwater.[68] During the December 2010 and January 2011 Flood Events, however, Mr Pruss was the Executive General Manager – Water Delivery at Seqwater.[69] This role meant he was responsible for overseeing the day-to-day management and performance of the assets in Seqwater's portfolio, including ensuring that operational protocols were followed and regulatory requirements met. He oversaw the day-to-day operation of approximately 25 dams (including Wivenhoe and Somerset Dams) in addition to having overall responsibility for operational staff matters, financial management, people management and interaction with relevant Government regulators such as DERM.[70] Mr Pruss was one of two General Managers with general responsibility for the management of Seqwater's assets during December 2010 and January 2011.[71] He reported to the CEO of Seqwater at the time, Peter Borrows.[72] Moreover, six managers reported to Mr Pruss, including Robert Drury who was the manager responsible for dam operations.[73]

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[65] Ibid at .0003, [7].
[66] Ibid at .0002, [2].
[67] Affidavit of James Andrew Pruss – sworn 1 June 2016, LAY.SEQ.003.0001_OBJ at .0002, [1].
[68] T 4209.26 (Pruss).
[69] Affidavit of James Andrew Pruss – sworn 1 June 2016, LAY.SEQ.003.0001_OBJ at .0003, [6].
[70] Ibid at [7].
[71] Ibid at [8].
[72] Ibid at .0004, [9].
[73] Ibid at [10].

Mr Pruss graduated with a Bachelor of Science from Macquarie University in 1984.[74] In 1995, he obtained a Master of Commerce with Distinction from the University of Western Sydney. He became a member of the Australian Institute of Company Directors in 2008. Following this, he completed a Post-Graduate Diploma in Environmental Engineering (Management) at the University of Technology Sydney in 2016.[75] From September 1990 to June 2005, Mr Pruss was employed by Sydney Water in a number of technical and managerial roles.[76] In June 2005, he was the General Manager of Redland Water at Redland City Council.[77] He commenced at Seqwater in January 2008 as General Manager, Strategic Water and Asset Delivery. In October 2009, he became Executive General Manager – Water Delivery, before his appointment as General Manager Water Supply Strategy and Policy on 1 May 2013.[78] During his time at Seqwater, he was a member of the Executive Leadership Team (previously known as the Executive Management Team).[79]

14. Mr Rob Drury

Mr Drury is a Manager of Water Source Services at Seqwater.[80] During the December 2010 and January 2011 Flood Events, Mr Drury was the Dam Operations Manager at Seqwater.[81] In this role, he was responsible for approximately 26 dams and 51 weirs within Southeast Queensland.[82] His role included overseeing the ordinary operations, maintenance and the release of water from the dams, weirs and irrigation schemes in addition to managing budgets and expenditure, managing staff and resource allocations, co-ordinating and reporting on Seqwater's compliance with regulatory requirements, and overall responsibility for dam safety.[83] Mr Drury's role did not include making any decisions regarding releases of water during the period

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[74] Ibid at [13].
[75] Ibid at [14].
[76] Ibid at [12].
[77] Ibid at [11].
[78] Ibid at [6].
[79] Ibid at [1].
[80] Affidavit of Robert John Drury – sworn 1 June 2016, LAY.SEQ.006.0001 at .0003, [1].
[81] Ibid at [5].
[82] Ibid at .0004, [6].
[83] Ibid at [7].

when the Flood Operations Centre was mobilised.[84] He reported to Jim Pruss, who was Executive General Manager for Water Delivery at Seqwater at the time.[85]

Mr Drury holds a Bachelor of Civil Engineering and a Masters of Engineering Science from the University of Queensland.[86] He worked in various positions at what was then called the Department of Natural Resources and Mines before commencing at SEQwater Corporation (a predecessor of Seqwater) to manage the operations of North Pine, Somerset and Wivenhoe Dams in December 2004.[87] He became Dam Operations Manager for Seqwater in October 2007. From 27 July 2013 to 30 June 2015, he was appointed as Manager, Water Source, Operations and Management.[88] This was followed by his current position as Manager, Water Source Services at Seqwater.

15. Mr David Pokarier

Mr Pokarier is a Senior Hydrologist at Seqwater.[89] During the December 2010 and January 2011 Flood Events, however, he was employed by SunWater Limited as a Data Collector in the Flood Operations Centre.[90] This meant that during the January 2011 Flood Event he undertook administrative tasks such as maintaining the Event Log, taking phone calls and validating data. In his current position as a Senior Hydrologist, he is responsible for the training and assessment of Flood Operations Centre staff, the development and continual improvement of the Flood Forecasting System and the processes and procedures of the Flood Operations Centre.[91] Mr Pokarier was taught to operate a dam under the Manual by Messrs John Tibaldi, Terry Malone and Robert Ayre.[92]

Mr Pokarier obtained a Bachelor of Engineering (Environmental) from the University of Southern Queensland in 2005.[93] Since 2012, he was been a Registered

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[84] Ibid at .0005, [11].
[85] Ibid at .0004, [8].
[86] Ibid at .0005, [15].
[87] Ibid at [13] - [14].
[88] Ibid at .0003, [4] - [5].
[89] Affidavit of David James Pokarier – affirmed 30 November 2017, EXP.SEQ.016.0001 at .0002, [1].
[90] Ibid at .0215, [577].
[91] Ibid at [574].
[92] T 6737.8 (Pokarier).
[93] Affidavit of David James Pokarier – affirmed 30 November 2017, EXP.SEQ.016.0001, at .0215.

Professional Engineer (Civil) of Queensland and a Chartered Professional Engineer (Civil). He is also a member of Engineers Australia. From April 2006 to May 2011, Mr Pokarier held various roles at SunWater involving hydrological and hydraulic modelling, including his position as Data Collector in the Flood Operations Centre.[94] He was then employed by Seqwater as a Hydrologist in May 2011. In March 2016, he was appointed Senior Hydrologist in the Flood Services Team.[95]

16. Mr Christopher Dann

Mr Dann is a civil and geotechnical engineer with 30 years' experience in the design management of a range of large dam engineering projects.[96] He is the Technical Director, Dam Engineering at AECOM Services Pty Ltd (AECOM).[97] He has been responsible for the management of a range of heavy civil engineering projects, including dam safety upgrade projects for major water supply dams (such as the Hinze Dam), the design of new water storage dams, dam safety assessments, water supply schemes, and geotechnical engineering including slope stability, basement and retention design.

Mr Dann obtained a Bachelor of Engineering (Civil) from the University of Queensland in 1985.[98] He is a Fellow of the Institution of Engineers, Australia. In 2009, Mr Dann was awarded the Engineers Australia Sir John Holland Civil Engineer of the Year Award.

17. Mr Robert Swain

Mr Swain is a consulting engineer with approximately 40 years' experience in managing, planning, directing, reviewing and conducting hydrological and hydraulic investigations.[99] In his current role, he conducts technical and independent reviews of hydrological projects and drafts guidelines.[100] Mr Swain is a member of the American Society of Civil Engineers and the Hydraulics Committee of the

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[94] Ibid at [577].
[95] Ibid at [574] - [575].
[96] Affidavit of Christopher Peter Dann – affirmed 2 June 2016, EXP.SEQ.003.0001_OBJ at .0002, [1].
[97] Ibid at .0005.
[98] Ibid.
[99] Affidavit of Robert Elmore Swain – affirmed 6 May 2016, EXP.SEQ.008.0001_OBJ at .0005.
[100] Ibid at .0005 - .0006.

International Commission on Large Dams (ICOLD).[101] He is a licensed professional engineer in Colorado.[102] He has also published a number of works in the areas of hydrology and flood modelling.[103]

Mr Swain has a Bachelor of Science in Civil and Environmental Engineering from the University of Wisconsin and a Master's of Science in Civil Engineering from Stanford University.[104] In 1975, he was a Civil Engineer at the Engineering and Research Center with the Bureau of Reclamation.[105] From 1975 to 1976, he worked as a Teaching Assistant in Fluid Mechanics at Stanford University. This was followed by employment at the Bureau of Reclamation in the Lower Missouri Region as a Hydraulic Engineer (1976 to 1981) and Chief of the Water Resources Branch (1981 to 1985).[106] Mr Swain then worked as Project Manager at Morrison-Kundsen Engineers Inc. from 1985 to 1988. From 1988, he occupied various roles at the Technical Service Center of the Bureau of Reclamation, these being Principal Hydraulic Engineer (1988 to 1992), Head of the Flood Section (1992 to 1994) and Flood Hydrology Technical Specialist (1994 to 2008).[107] In 2008, he commenced as a Consulting Engineer.[108]

18. Mr Neil Collins

Mr Collins is the Principal Hydraulic and Water Resources Engineer at BMT WBM Pty Ltd.[109] He has over 35 years' experience in the areas of flooding, water quality and coastal processes. In his current role, he is part of the Expert Services team and provides expert witness services in flooding, floodplain risk and emergency management, stormwater, quality control and coastal engineering. He has appeared in the Planning and Environment Court (QLD), the Land Court (QLD), the Administrative Appeals Tribunal (Commonwealth) and the Commission of Inquiry

[101] Ibid at .0013.
[102] Ibid at .0005.
[103] Ibid at .0013 - .0015.
[104] Ibid at .0005.
[105] Ibid at .0012.
[106] Ibid at .0010 - .0011.
[107] Ibid at .0006 - .0010.
[108] Ibid at .0005.
[109] Technical Report on the January 2011 Floods in the Brisbane River, Lockyer Creek and Bremer River Catchments - Neil Collins (June 2016), EXP.QLD.001.0881 at .1170.

into the Queensland Floods.[110] Mr Collins has also authored a number of papers, publications and presentations in his areas of expertise.[111]

Mr Collins holds a Bachelor of Engineering (Civil) and a Master of Science Engineering from the University of Queensland.[112] From 1981 to 1993, he was an Associate Director at Connell Wagner. Following this, he was a Director (1993 to 2004) and the Queensland Manager (2004 to 2007) at Lawson Treloar. From 2007 to 2010, he was the Principal Hydraulic and Water Resources Engineer at Gilbert and Sutherland Pty Ltd. He then commenced his current position at BMT WBM in 2010.

19. Mr Martin Giles

Mr Giles is a Team Leader (Expert Services) at BMT WBM Pty Ltd with over 28 years' experience specialising in hydraulic and environmental investigations.[113] His areas of expertise include hydraulics, hydrology and water resources, urban flood mitigation, stormwater management and water quality, and flood risk management. He has undertaken modelling work of complex floodplain systems and the application of dynamic modelling to urban stormwater drainage design to allow the development of cost effective relief drainage solutions for brownfield sites and existing flood-prone areas. He also provides expert witness services.[114] Mr Giles is registered with the Board of Professional Engineers Queensland. He is also a member of the Institution of Engineers, Australia.

Mr Giles obtained a Bachelor of Engineering (Civil, Hons 1st) from the University of Queensland in 1987.[115] This was followed by a Master of Engineering Studies from the University of Queensland in 1996. From 1997 to 2015, Mr Giles held a number of positions at Cardno including Senior Hydraulic and Environmental Engineer (1997 to 1998), Principal (1998 to 2004) and Senior Principal (2007 to 2015). He commenced his current position as Team Leader in November 2015.

[110] Ibid at .1171.
[111] Ibid at .1175 - .1176.
[112] Ibid at .1170.
[113] Technical Report on Loss Rates, Modelling and Operational Spreadsheets – Martin Giles (June 2016), EXP.QLD.001.0611 at .0810.
[114] Ibid at .0811.
[115] Ibid at .0810.

20. Mr Kevin Fagot

Mr Fagot is a Project Manager at WEST Consultants.[116] In this role, he undertakes reservoir operations modelling and hydrological and hydraulic engineering projects in addition to updating and reviewing water control manuals. Mr Fagot is a licensed professional engineer in the states of Colorado and Washington.[117] He is also a member of the American Academy of Water Resources Engineers and the Association of State Floodplain Managers. He is Assistant Treasurer of the Society of American Military Engineers.

Mr Fagot obtained a Bachelor of Science (Civil Engineering) in December 1993 followed by a Master of Science (Civil Engineering) in December 1997 from the University of New Orleans.[118] From 1993 to 1998, he was a Hydraulic Engineer at the United States Army Corps of Engineers (USACE) in the New Orleans District.[119] He then worked as a Hydraulic Engineer at the Bureau of Reclamation in the Lower Colorado region from 1998 to 2003. In 2003, he again became a Hydraulic Engineer with the Corps of Engineers in the Little Rock District. He then commenced his current position at WEST Consultants in 2010.

21. Professor Michael Manton

Professor Manton is an Emeritus Professor within the School of Earth, Atmosphere and Environment at Monash University and a research scientist with almost 50 years of experience in the fields of mathematics and atmospheric science.[120] From 1984 to 2005, he was the Chief of the BoM Research Centre.[121] This role saw Professor Manton assist in the development of numerical prediction systems used in BoM operations and forecast products, such as the PME.[122] Other roles (that were performed concurrently) saw Professor Manton lead research analyses of rainfall

[116] Wivenhoe and Somerset Dam Operations during the Brisbane River Flood of December 2010 and January 2011 Queensland Australia – Kevin Fagot (June 2016), EXP.QLD.001.0232 at .0455.
[117] Ibid at .0457.
[118] Ibid at .0455.
[119] Ibid at .0456.
[120] Report of Emeritus Professor Michael Manton (January 2011), EXP.SEQ.004.0131 at .0134; Affidavit of Emeritus Professor Michael Manton - affirmed 17 May 2016, EXP.SEQ.004.0001 at .0005.
[121] Report of Emeritus Professor Michael Manton (January 2011), EXP.SEQ.004.0131 at .0134.
[122] Ibid.

events in SE Asia, the Pacific and SE Queensland.[123] He also collaborated on evaluation projects of satellite rainfall data and BoM rainfall forecast products.[124]

Professor Manton obtained a Bachelor of Engineering (First Class Honours) and a Master of Science in Engineering from the University of Sydney in 1966 and 1968 respectively.[125] He completed his PhD in oceanography at the University of British Columbia (UBC) in 1970.[126] From 1970 to 1975 he held various academic research roles at the University of Sydney, Monash University, UBC and Colorado State University.[127] From 1975 to 1984 he worked as a scientist at the CSIRO Division of Cloud Physics, before moving to the BoM as a research scientist until 2005 (as explained above).[128] From 2005 until 2013 he was a part-time Professor at Monash University.[129] From 1979 until the present day he has acted as a consultant and independent expert for a variety of Australian and international organisations, including the Australian Academy of Technological Sciences (ATSE), the European Centre for Medium-Range Weather Forecasts, Imperial College London, Snowy Hydro Ltd, the Murray Darling Basin Authority, SGS Economics and Planning and Southern Innovation.[130] In 2001 he was made a fellow of the ATSE and from 2009 until 2012 he served as the director of the Academy.[131]

Professor Manton has held numerous positions on policy, project and research committees, including (but not limited to) membership of the: NASA TRMM Science Team, NASDA Working Group on Hydrology Datasets, WMO Commission for Atmospheric Science, ATSE Urban Water and Infrastructure Project, Queensland Cloud Seeding Research Program, National Committee for Atmospheric Science and the GEWEX Working Group on Precipitation Measurements at High Latitudes.[132]

22. Mr Michael Potter (AKA Terence Michael Potter)

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[123] Ibid.
[124] Ibid.
[125] Affidavit of Emeritus Professor Michael Manton - affirmed 17 May 2016, EXP.SEQ.004.0001 at .0005.
[126] Ibid.
[127] Ibid.
[128] Ibid.
[129] Ibid.
[130] Ibid.
[131] Report of Emeritus Professor Michael Manton (January 2011), EXP.SEQ.004.0131 at .0134.
[132] Ibid at .0137 - .0141.

Mr Potter is a Chartered Accountant and the founding director of Axiom Forensics Pty Ltd.[133] For the past seventeen years, he has specialised in the provision of forensic accounting services in respect of a number of businesses and industries, acting as in independent expert in a many litigious matters.[134] As a result, Mr Potter has considerable experience in the quantification of damages, valuation and economic loss in a variety of matters (such as contract disputes and breaches of warranty).[135] He has undertaken financial investigations for both corporates and regulators and possesses particular expertise in asset tracing, reviews of transactions, reconstruction of accounting records, franchisee revenue reporting, and insurance claims.[136]

Mr Potter worked for two years as a trainee accountant in Perth before obtaining a Bachelor of Commerce from the University of Western Australia.[137] He then spent three years as a graduate accountant in Perth before becoming a Chartered Accountant in 1990, a position he has held until the present day.[138] Mr Potter has approximately thirteen years' worth of experience in insolvency and reconstruction accountancy specialisation and approximately seventeen years' worth of experience in forensic accounting.[139] He is a designated as an Institute of Chartered Accounts in Australia (ICAA) Business Valuation Speciality, he is an associate member of the Certified Practising Accountants in Australia (CPA), he is an associate member of the Australian Restructuring Insolvency and Turnaround Association (ARITA) and he possesses a Cert IV in Fraud Control.[140]

23. Andre Stuart

Mr Stuart is the CEO of 21st Century Animations, a firm that specialises in the generation of visual animations for use in litigation and accident investigations.[141] In

[133] Affidavit of Terence Michael Potter – sworn 1 June 2016, EXP.SEQ.007.0001 at .0002, [1].
[134] Ibid at .0005.
[135] Ibid.
[136] Ibid at .0006.
[137] Report of Michael Potter (1 June 2016), EXP.SEQ.007.0154 at .0162, [1.14].
[138] Ibid; see also affidavit of Terence Michael Potter – sworn 1 June 2016, EXP.SEQ.007.0001 at .0005.
[139] Report of Michael Potter (1 June 2016), EXP.SEQ.007.0154 at .0162, [1.14].
[140] Affidavit of Terence Michael Potter – sworn 1 June 2016, EXP.SEQ.007.0001 at .0005.
[141] Affidavit of Andre Stuart - affirmed 8 October 2015, LAY.ROD.004.0001, [2] – [3].

order to accurately replicate the observable features of the real world, 21st Century Animations uses various image capture and measurement technologies (e.g. LiDAR, close range photogrammetry, total station surveys, terrestrial laser scan data, Global Position Systems (GPS) and Global Navigation Satellite Systems (GNSS)). This data is then processed and converted into visual animations.

Mr Stuart has over 26 years' experience in the field of forensic animations. Over this time he has extensively utilised GPS and GNSS land surveying equipment for terrain measurement and has conducted hundreds of surveys using laser scanner devices to obtain 3D measurement for animated object reconstruction.[142] He has attended and presented at numerous international conferences and panels regarding forensic metrology, LiDAR mapping, and 3D measurement and mapping technologies.[143] Mr Stuart holds professional associations with the National Association of Professional Accident Reconstructions Specialists, the Texas Association of Accident Reconstruction Specialists, the Association of Computing Machinery's Special Interest Group on Computer Graphics and Interactive Techniques and the International Association of Forensic and Security Metrology.[144] Mr Stuart has undergraduate qualifications in Biochemistry and a Bachelor of Business Administration (Finance).

24. Mr Todd Davis

Mr Davis is the Vice President of Animations at 21st Century Animations. He has been employed at the firm since 2000 and is responsible for generating forensic computer animations, gathering data, and modelling and rendering the animated output.[145]

Mr Davis has broad experience in gathering and processing data for 3D model generation. He possesses an Associate of Science degree in Computer Animation and Film and Video Production. He has undertaken training courses in laser scanning and animation software technologies and regularly attends industry conferences and conventions, such as the Special Interest Group on Computer

[142] Ibid at [12], [15] – [16].
[143] Ibid at [18] – [21].
[144] Ibid at [17].
[145] Affidavit of Todd Davis – affirmed 8 October 2015, LAY.ROD.005.0001 at [1] – [2].

Graphics and Interactive Techniques.[146] Mr Davis is proficient in the use of technical software, including 3ds Max, Adobe Photoshop and AutoCAD, and has extensive experience in photogrammetry. He has held professional registrations with the Association for Computing Machinery, SPAR Point Group and the International Association of Forensic & Security Metrology.[147]

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[146] Ibid at [10] – [17].
[147] Ibid at [17] – [19].

APPENDIX D – Comparison of Wivenhoe and Somerset Catchment Loss Rates used by Flood Engineers and Dr Christensen[1]

Wivenhoe and Somerset Catchment Loss Rates							
		Initial Loss (mm)			Continuing Loss Rates (mm/hr)		
		Loss Used by Flood Engineers	Christensen No Rain Loss	Christensen 4- and 8-day Forecast Loss	Rates Used by Flood Engineers	Christensen No Rain Rates	Christensen 4- and 8-day Forecast Loss Rates
2 Jan	CRE	none	0	0	none	0.8	0.12
	COO	none	0	0	none	0.5	0.12
	LIN	none	0	0	none	0.5	0.12
	EMU	none	0	0	none	0.5	0.12
	GRE	none	0	0	none	0.5	0.12
	SDI	none	0	0	none	0.5	0.10
	WDI	none	0	0	none	0.8	0.10
3 Jan	CRE	none	0	10	none	0.8	0.12
	COO	none	0	10	none	0.5	0.12
	LIN	none	0	10	none	0.5	0.12
	EMU	none	0	10	none	0.5	0.12
	GRE	none	0	10	none	0.5	0.12
	SDI	none	0	10	none	0.5	0.10
	WDI	none	0	10	none	0.8	0.10
4 Jan	CRE	none	0	10	none	0.8	0.1
	COO	none	0	10	none	0.5	0.1
	LIN	none	0	10	none	0.5	0.1
	EMU	none	0	10	none	0.5	0.1
	GRE	none	0	10	none	0.5	0.1
	SDI	none	0	10	none	0.5	0.05
	WDI	none	0	10	none	0.8	0.05
5 Jan	CRE	none	10	2.1	none	0.8	0.1
	COO	none	10	2.1	none	0.5	0.1
	LIN	none	10	2.1	none	0.5	0.1
	EMU	none	10	2.1	none	0.5	0.1
	GRE	none	10	2.1	none	0.5	0.1
	SDI	none	10	1.0	none	0.5	0.05
	WDI	none	10	1.0	none	0.8	0.05
6 Jan	CRE	0 & 10	10	0	2.5	0.8	0.1
	COO	10 & 25	10	0	2.5	0.5	0.1
	LIN	10 & 15	10	0	2.5	0.5	0.1
	EMU	10 & 25	10	0	2.5	0.5	0.1
	GRE	0 & 10	10	0	2.5	0.5	0.1
	SDI	0	10	0	2.5	0.5	0.05
	WDI	0 & 10	10	0	2.5	0.8	0.05
7 Jan	CRE	10	10	0	2.5	0.8	0.09
	COO	10	10	0	2.5	0.5	0.09
	LIN	15	15	0	2.5	0.5	0.09
	EMU	30	30	0	2.5	0.5	0.09
	GRE	10	10	0	2.5	0.5	0.09
	SDI	0	0	0	2.5	0.5	0.07
	WDI	0	0	0	2.5	0.8	0.07
8 Jan	CRE	10	10	0	2.5	0.8	0.2
	COO	10 & 30	30	0	0.5	0.5	0.2
	LIN	15 & 30	30	0	0.5	0.5	0.2
	EMU	30	30	0	0.5	0.5	0.2

[1] See Chapter 8 at [74].

	GRE	10 & 40	40	0	0.5	0.5	0.2
	SDI	0 & 15	15	0	0.5	0.5	0.18
	WDI	0	0	0	2.5	0.8	0.18
9 Jan	CRE	10	10	0	2.5	0.8	0.25
	COO	30	30	0	0.5	0.5	0.25
	LIN	30	30	0	0.5	0.5	0.25
	EMU	30	30	0	0.5	0.5	0.25
	GRE	40	40	10	0.5	0.5	0.25
	SDI	15	15	0	0.5	0.5	0.23
	WDI	0	0	0	2.5	0.8	0.23
10 Jan	CRE	10	10	0	2.5	0.8	0.25
	COO	30	30	0	0.5	0.5	0.25
	LIN	30	30	0	0.5	0.5	0.25
	EMU	30	30	0	0.5	0.5	0.25
	GRE	40	40	0	0.5	0.5	0.25
	SDI	15	15	0	0.5	0.5	0.23
	WDI	0	0	0	2.5	0.8	0.23
11 Jan	CRE	10	10	0	2.5	0.8	0.20
	COO	30	30	0	0.5	0.5	0.20
	LIN	30	30	0	0.5	0.5	0.20
	EMU	30	30	0	0.5	0.5	0.20
	GRE	40	40	0	0.5	0.5	0.20
	SDI	15	15	0	0.5	0.5	0.18
	WDI	0	0	0	2.5	0.8	0.18
12 Jan	CRE	10	10	0	2.5	0.8	0.12
	COO	30	30	0	0.5	0.5	0.12
	LIN	30	30	0	0.5	0.5	0.12
	EMU	30	30	0	0.5	0.5	0.12
	GRE	40	40	0	0.5	0.5	0.12
	SDI	15	15	0	0.5	0.5	0.10
	WDI	0	0	0	2.5	0.8	0.10

APPENDIX E – SIM F AND SIM H PROJECTED HEIGHTS[1]

SIM F/H – Wivenhoe Dam

Date/Time/ Height	4 day PME (RC) (ML)[2]	Projected Height ("PH")[3] (m AHD)	4 day PME (LDE corrected Giles)[4]	PH	4 day PME (Giles depth – flood engineers' loss rates[5]	PH	One day QPF (RC)[6]	PH	One day QPF (corrected by Mr Pokarier for QPF error)[7]	PH[8]	One day (Giles loss rates)[9]	PH[10]
7 Jan 17:00 68.09									324,839	70.73	286,000	70.43
8 Jan 00 68.32	1,048,000	75.82[11]	934,954	75.09[12]	468,000[13]	71.99						
8 Jan 11:00 68.23							383000	71.29	319471	70.81	288,000	70.57
8 Jan 17:00 67.92							399000	71.14	307425	70.45	265,000	70.11

[1] Chapter 10 at [7].
[2] Table 9-6; Chapter 9 at [235].
[3] No Release; Pokarier, EXP.SEQ.016.0012 at .0175.
[4] See Table 9-6; Chapter 9 at [235].
[5] Giles, EXP.QLD.001.1359 at .1378; Table 9-6.
[6] Set out in Giles, EXP.QLD.001.1359 at .1378; Pokarier, EXP.SEQ.016.0012 at .0150; Chapter 9 at [286]; Table 9-8.
[7] Pokarier, EXP.SEQ.016.0012 at .0150; Chapter 9 at [286]; Table 9-8.
[8] Parties' Joint Response to trial judge's request dated 23 April 2019.
[9] Giles, EXP.QLD.002.0093, Table 4-1. Corrected document provided 30 April 2019.
[10] Note, these are not taken from Table 4-3 of EXP.QLD.002.0093 because Mr Giles' start levels are the actual levels not Sim F/H levels.
[11] = 75.15m AHD if 30,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
[12] = 74.91m AHD if 30,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
[13] Mr Giles also recalculated Dr Christensen's PME depths as at midnight on 8 January 2011 using flood engineers' loss rates and obtained a volume of 612,000ML which yields a projected height of EL 72.99m AHD: EXP.QLD.001.1395 at .1417; Table 4-4.

9 Jan 00 67.54	886000	74.17[14]	782,000	73.54[15]	622,000	72.44						
9 Jan 11:00 66.67							443000	70.43	418881	70.25	355,000	69.58
9 Jan 17:00 66.59							888000	73.56	836748	73.22	678,000	72.04
10 Jan 00 67.52	1288000	76.71	1,192,000	>76	988,000	74.87						
10 Jan 11:00 69.69							1160000	77.40	854498	75.62	810,000[16]	75.35
10 Jan 17:00 70.61							1007000	77.20	563496	74.54	518,000	73.82
11 Jan 00 71.15	683000	75.82	639,840	75.46	447,000	74.25						
11 Jan 11:00 72.51							1230000	79.78	1073450	78.97	972,000	78.44
11 Jan 17:00 73.73							1332000	81.13	1001806	79.52	911,000	79.06
12 Jan 00 74.56	421000											
12 Jan 11:00 75.05							335000	77.04	182068	76.16		

[14] = 74.11m AHD if 17,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
[15] = 73.43m AHD if 17,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
[16] Corrected document provided 30 April 2019.

12 Jan 17:00 75.09							322000	77.01	125031	75.86		

APPENDIX F – SIM C PROJECTED HEIGHTS[1]

Date/ Time/ Height	4 day PME (RC)[1] (ML)	Projected Height ("PH")[2] (m)	4 day PME (LDE corrected (Giles)[3] (ML)	PH	4 day PME (Giles Depth - Flood Engineers' ROG loss rates)[4]	PH	One day QPF (RC)[5]	PH	One day QPF (corrected by David Pokarier for QPF error)[6]	PH	One day (Giles – diff loss rates)[7]	PH	SIM C Wivenhoe Dam Release Rate[8] (m3/s)	SIM C Somerset Dam Release Rate[9] (m3/s)
2 Jan 00:00 67.15	33,000	67.45	30,000	67.42	20,000	67.33							395	69
2 Jan 11:00 67.08							51000	67.54[10] (W1A)	45,537	67.49[11] (W1A)	18,500[12]	67.25[13]	472	201
2 Jan 17:00 67.05							53000	67.53[14] (W1A)	45324	67.46[15] (W1A)	8,300[16] (16,854)	67.13[17] (67.20)	471	201
3 Jan 00:00 67.02	361000	70.09[18]	328,000	69.84[19]	175,000	68.57[20]							470	200
3 Jan 11:00 66.92							42000	67.31[21] (W1A)	36,674	67.26[22] (W1A)	13,200[23] (12,535)[24]	67.04[25] (67.04)	468	34
3 Jan 17:00 66.88							99000	67.78[26] (W1B)	91,437	67.71[27] (W1B)	36,700 (39,697)[28]	67.23[29] (67.16)	327	68
4 Jan 00:00 66.85	517000	71.14[30]	501,000	71.02[31]	250,000	69.05[32]							326	68

[1] Chapter 10 at [58].

Date/ Time/ Height	4 day PME (RC)[1] (ML)	Projected Height ("PH")[2] (m)	4 day PME (LDE corrected (Giles)[3] (ML)	PH	4 day PME (Giles Depth - Flood Engineers' ROG loss rates)[4]	PH	One day QPF (RC)[5]	PH	One day QPF (corrected by David Pokarier for QPF error)[6]	PH	One day (Giles – diff loss rates)[7]	PH	SIM C Wivenhoe Dam Release Rate[8] (m3/s)	SIM C Somerset Dam Release Rate[9] (m3/s)
4 Jan 11:00 66.77							89000	67.58[33] (W1B)	84246	67.54[34] (W1B)	52,300[35]	67.25[36]	325	68
4 Jan 17:00 66.73							66000	67.34[37] (W1A)	59018	67.28[38] (W1A)	30,448 (32,084)[39]	67.02[40] (67.03)	324	68
5 Jan 00:00 66.67	364000	69.82[41]	330,000	69.55[42]	111,000	67.71[43]							323	34
5 Jan 11:00 66.57							112000	67.60[44] (W1B)	106762	67.56[45] (W1B)	96,400[46] (95,845)	67.46[47] (67.46)	321	102
5 Jan 17:00 66.53							238000	68.66[48] (W3)	230752	68.61[49] (W3)	210,000	68.43[50]	368	136
6 Jan 00:00 66.47	460000	70.40[51]	414,500	70.05[52]	138,000	67.74[53]							1379	535
6 Jan 11:00 66.23							338000	69.24[54] (W3)	326730	69.15[55] (W3)	206,900	68.13[56]	1380	531
6 Jan 17:00 66.04							330000	69.01[57] (W3)	301671	68.78[58] (W3)	216,900	68.05[59]	2136	529
7 Jan 00:00	608000	70.94[60]	547,000	70.47[61]	203,000	67.62[62]							2429	526

Date/ Time/ Height	4 day PME (RC)[1] (ML)	Projected Height ("PH")[2] (m)	4 day PME (LDE corrected (Giles)[3] (ML)	PH	4 day PME (Giles Depth - Flood Engineers' ROG loss rates)[4]	PH	One day QPF (RC)[5]	PH	One day QPF (corrected by David Pokarier for QPF error)[6]	PH	One day (Giles – diff loss rates)[7]	PH	SIM C Wivenhoe Dam Release Rate[8] (m3/s)	SIM C Somerset Dam Release Rate[9] (m3/s)
65.69														
7 Jan 11:00 65.38							340000	68.56[63] (W3)	274866	68.00[64] (W1C)	219000	67.5[65]	2521	456
7 Jan 17:00 65.20							433000	69.20[66] (W3)	324839	68.28[67] (W1E)	286000	67.95[68]	2490	391
8 Jan 00:00 64.91	1048000	73.53[69]	935,000	72.76[70]	468,000	69.26[71]							2575	393
8 Jan 11:00 64.59							383000	68.30[72] (W1E)	319471	67.75[73] (W1B)	288,000	67.47[74]	2454	393
8 Jan 17:00 64.42							399000	68.31[75] (W1E)	307425	67.51[76] (W1B)	265000	67.12[77]	1888	392
9 Jan 00:00 64.21	886000	71.99[78]	782,000	71.23[79]	622,000	70.0[80]							1855	391
9 Jan 11:00 63.81							443000	68.24[81] (W1D)	418881	68.03[82] (W1D)	355,000	67.46[83]	1868	392
9 Jan 17:00 64.00							888000	71.87[84] (W3)	836748	71.5[85] (W3)	678,000	70.30[86]	1886	401

Date/ Time/ Height	4 day PME (RC)[1] (ML)	Projected Height ("PH")[2] (m)	4 day PME (LDE corrected (Giles)[3] (ML)	PH	4 day PME (Giles Depth - Flood Engineers' ROG loss rates)[4]	PH	One day QPF (RC)[5]	PH	One day QPF (corrected by David Pokarier for QPF error)[6]	PH	One day (Giles – diff loss rates)[7]	PH	SIM C Wivenhoe Dam Release Rate[8] (m3/s)	SIM C Somerset Dam Release Rate[9] (m3/s)
10 Jan 00:00 65.20	1288000	75.25[87]	1,192,000	74.65[88]	988,000	73.31[89]							1841	434
10 Jan 11:00 67.55							1160000	75.94[90] (W4B)	854498	74.03[91] (W4A)	810,000[92]	73.74[93]	1805	715
10 Jan 17:00 68.51							1007000	75.68[94] (W4B)	563496	72.81[95] (W3)	518,000	72.5[96]	1523	889
11 Jan 00:00 69.03	683000	74.02[97]	640,000	73.74[98]	447,000	72.43[99]							1860	965
11 Jan 11:00 70.46							1230000	78.32[100] (W4B)	1073450	77.47[101] (W4B)	972,000	76.90[102]	1487	1110
11 Jan 17:00 71.86							1332000	79.82[103] (W4B)	1,001,806	78.11[104] (W4B)	911,000	77.61[105]	1051	948
12 Jan 00:00 72.85	421000	75.58[106]											1091	1177
12 Jan 11:00 73.55							335000	75.68 (W4B)	182068	74.73 (W4A)			1118	1225
12 Jan 17:00							322000	75.78	125031	74.55			1250	1151

Date/ Time/ Height	4 day PME (RC)[1] (ML)	Projected Height ("PH")[2] (m)	4 day PME (LDE corrected (Giles)[3] (ML)	PH	4 day PME (Giles Depth - Flood Engineers' ROG loss rates)[4]	PH	One day QPF (RC)[5]	PH	One day QPF (corrected by David Pokarier for QPF error)[6]	PH	One day (Giles – diff loss rates)[7]	PH	SIM C Wivenhoe Dam Release Rate[8] (m3/s)	SIM C Somerset Dam Release Rate[9] (m3/s)
73.74								(W4B)		(W4A)				

[1] Set out in Giles, EXP.QLD.001.1359 at .1378; Table 9-6; Chapter 9 at [235].
[2] No release rise.
[3] See Table 9-6.
[4] Giles, EXP.QLD.001.1359 at .1378; Table 9-6.
[5] Set out in Giles, EXP.QLD.001.1359 at .1378 and Pokarier, EXP.SEQ.016.0012 at .0150; Table 9-8; Chapter at [286].
[6] Pokarier, EXP.SEQ.016.0012 at .0150.
[7] Giles, EXP.QLD.002.0040 at .0063; corrected at T 8931; see SBM.040.007.0001.
[8] EXP.ROD.015.0461 at .0627.
[9] EXP.ROD.015.0461 at .0635.
[10] Allowing for the inflow error = 67.55m AHD; see SBM.020.021.0001 at .0004; Chapter 10 at [70] to [71].
[11] Allowing for the inflow error = 67.5m AHD.
[12] T 8931; Plaintiff's version in brackets.
[13] Allowing for the inflow error = 67.26m AHD.
[14] Allowing for the inflow error = 67.53m AHD.
[15] Allowing for the inflow error = 67.45m AHD.
[16] Plaintiff's version of Giles figures, SBM.010.018.0001 at .0003.
[17] Allowing for the inflow error = 67.12m AHD.
[18] Allowing for the inflow error = 70.07m AHD.
[19] Allowing for the inflow error = 69.82m AHD.
[20] Allowing for the inflow error = 68.55m AHD.
[21] Allowing for the inflow error = 67.27m AHD.
[22] Allowing for the inflow error = 67.22m AHD.
[23] T 8931.
[24] Allowing for the inflow error = 66.97m AHD.
[25] Allowing for the inflow error = 67.00m AHD.
[26] Allowing for the inflow error = 67.73m AHD.
[27] Allowing for the inflow error = 67.66m AHD.
[28] Allowing for the inflow error = 67.18m AHD.
[29] Allowing for the inflow error = 67.18m AHD.
[30] Allowing for the inflow error = 71.09m AHD.
[31] Allowing for the inflow error = 70.97m AHD.

32 Allowing for the inflow error = 68.99m AHD.
33 Allowing for the inflow error = 67.51m AHD.
34 Allowing for the inflow error = 67.47m AHD.
35 T 8931.
36 Allowing for the inflow error = 67.18m AHD.
37 Allowing for the inflow error = 67.24m AHD.
38 Allowing for the inflow error = 67.21m AHD.
39 Allowing for the inflow error = 66.96m AHD.
40 Allowing for the inflow error = 66.95m AHD.
41 Allowing for the inflow error = 69.77m AHD.
42 Allowing for the inflow error = 69.49m AHD.
43 Allowing for the inflow error = 67.65m AHD.
44 Allowing for the inflow error = 67.55m AHD.
45 Allowing for the inflow error = 67.51m AHD.
46 Corrected at T 8931; Plaintiff's version in brackets.
47 Allowing for the inflow error = 67.41m AHD; Plaintiff's version in brackets.
48 Allowing for the inflow error = 68.60m AHD.
49 Allowing for the inflow error = 68.55m AHD.
50 Allowing for the inflow error = 68.37m AHD.
51 Allowing for the inflow error = 70.34m AHD.
52 Allowing for the inflow error = 69.99m AHD.
53 Allowing for the inflow error = 67.67m AHD.
54 Allowing for the inflow error = 69.14m AHD.
55 Allowing for the inflow error = 69.05m AHD.
56 Allowing for the inflow error = 68.03m AHD.
57 Allowing for the inflow error = 68.91m AHD.
58 Allowing for the inflow error = 68.68m AHD.
59 Allowing for the inflow error = 67.95m AHD.
60 Allowing for the inflow error = 70.86m AHD; Height = 70.65m AHD if 28,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
61 Allowing for the inflow error = 70.38m AHD; Height = 70.16m AHD if 28,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
62 Allowing for the inflow error = 67.52m AHD.
63 Allowing for the inflow error = 68.47m AHD.
64 Allowing for the inflow error = 67.91m AHD.
65 Allowing for the inflow error = 67.41m AHD.
66 Allowing for the inflow error = 69.12m AHD.
67 Allowing for the inflow error = 68.2m AHD.
68 Allowing for the inflow error = 67.86m AHD.
69 Allowing for the inflow error = 73.47m AHD; Height = 73.27m AHD if 30,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
70 Allowing for the inflow error = 72.7m AHD; Height = 72.49m AHD if 30,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
71 Allowing for the inflow error = 69.18m AHD.
72 Allowing for the inflow error = 68.23m AHD.
73 Allowing for the inflow error = 67.68m AHD.

[74] Allowing for the inflow error = 67.4m AHD.
[75] Allowing for the inflow error = 68.25m AHD.
[76] Allowing for the inflow error = 67.44m AHD.
[77] Allowing for the inflow error = 67.05m AHD.
[78] Allowing for the inflow error = 71.94m AHD; Height = 71.82m AHD if 17,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
[79] Allowing for the inflow error = 71.18m AHD; Height = 71.05m AHD if 17,000ML less used as per flood engineers' rain on ground estimate: Chapter 9 at [284].
[80] Allowing for the inflow error = 69.94m AHD.
[81] Allowing for the inflow error = 68.19m AHD.
[82] Allowing for the inflow error = 67.98m AHD.
[83] Allowing for the inflow error = 67.40m AHD.
[84] Allowing for the inflow error = 71.83m AHD.
[85] Allowing for the inflow error = 71.45m AHD.
[86] Allowing for the inflow error = 70.25m AHD.
[87] Allowing for the inflow error = 75.21m AHD.
[88] Allowing for the inflow error = 74.61m AHD.
[89] Allowing for the inflow error = 73.27m AHD.
[90] Allowing for the inflow error = 75.90m AHD.
[91] Allowing for the inflow error = 73.99m AHD.
[92] Corrected figure provided on 30 April 2019.
[93] Allowing for the inflow error = 73.70m AHD.
[94] Allowing for the inflow error = 75.64m AHD.
[95] Allowing for the inflow error = 72.77m AHD.
[96] Allowing for the inflow error = 72.46m AHD.
[97] Allowing for the inflow error = 74.48m AHD.
[98] Allowing for the inflow error = 73.70m AHD.
[99] Allowing for the inflow error = 72.39m AHD.
[100] Allowing for the inflow error = 78.28m AHD.
[101] Allowing for the inflow error = 77.43m AHD.
[102] Allowing for the inflow error = 76.86m AHD.
[103] Allowing for the inflow error = 79.79m AHD.
[104] Allowing for the inflow error = 78.07m AHD.
[105] Allowing for the inflow error = 77.57m AHD.
[106] Allowing for the inflow error = 75.54m AHD.

APPENDIX G

Deciding to Inundate Remaining Bridges at Midnight on 7/1/11 in SIM C[1]

Date/time	Sim C release (m^3/s)[2]	Limit to maintain bridges open	Difference (m^3/s)	Hourly Volume Difference (MLx10^3)	Cumulative Volume Difference (MLx10^3)
6 January					
10:00	1361				
11:00	1360				
12:00	1484	1400	84	0.30	0.30
13:00	1684	1400	284	1.02	1.32
14:00	1766	1400	366	1.32	2.64
15:00	1919	1400	519	1.87	4.51
16:00	1992	1400	592	2.13	6.64
17:00	2136	1400	736	2.65	9.29
18:00	2131	1400	731	2.63	11.92
19:00	2124	1400	724	2.61	14.53
20:00	2295	1400	895	3.22	17.75
21:00	2287	1400	887	3.19	20.94
22:00	2449	1400	1049	3.77	24.71
23:00	2439	1400	1039	3.92	28.63
7 January					
00:00	2429	1400	1029	3.71	32.34
01:00	2422	1484[3]	938	3.38	35.72
02:00	2415	1648[4]	767	2.76	38.48
03:00	2407	1766[5]	641	2.31	40.79

[1] See Chapter 10 at [157].
[2] EXP.ROD.015.0461 at .0627 to .0628.
[3] Based on releases increased from gate openings in SIM F: EXP.ROD.015.0461 at .0846.
[4] Gate opening by three increments as per 6 January 2011 at 12.00pm in SIM C: ibid. Note release rate would be higher given revised water levels.
[5] Gate opening by six increments as per 6 January 2011 at 1.00pm in SIM C: ibid. Note release rate would be higher given revised water levels.

04:00	2400	1919[6]	476	1.71	42.5
05:00	2395	2136[7]	259	0.93	43.43
06:00	2390	2295[8]	141	0.51	43.94
07:00	2385	2449[9]	-	-	-
08:00	2385	[10]	-		

[6] Gate opening by three increments as per 6 January 2011 at 2.00pm in SIM C: ibid. Note release rate would be higher given revised water levels.
[7] Gate opening by four increments as per 3.00pm on 6 January 2011 in SIM C: ibid. Note release rate would be higher given revised water levels.
[8] Gate opening by four increments as per 5.00pm on 6 January 2011 in SIM C: ibid. Note release rate would be higher given revised water levels.
[9] Gate opening by five increments as per 8.00pm on 6 January 2011 in SIM C: ibid. Note release rate would be higher given revised water levels.
[10] Gate openings of five increments at 10.00pm on 6 January 2011 in SIMC: ibid. Note release rate would be higher given revised water level.

APPENDIX H

Comparison of SIM C and SIM F Releases – 8 & 9 January[1]

Date/Time	SIM C Release[2]	SIM F Release[3]	Difference	Hourly Volume Difference (MLx10^3)	Cumulative Volume Difference (MLx10^3)
8 January					
09:00	2477	2482			
10:00	2464	2691	227	.817	.817
11:00	2454	2770	316	1.14	1.96
12:00	2351	2764	413	1.49	3.45
13:00	2203	2756	553	1.99	5.43
14:00	2137	2747	610	2.20	7.64
15:00	2046	2740	694	2.50	10.14
16:00	1983	2734	751	2.70	12.84
17:00	1888	2726	838	3.02	15.86
18:00	1884	2717	833	3.00	18.86
19:00	1880	2708	828	2.98	21.84
20:00	1875	2780	905	3.26	25.10
21:00	1871	2770	899	3.24	28.34
22:00	1866	2760	894	3.22	31.56
23:00	1862	2750	888	2.66	34.22
9 January					
00:00	1855	2778	923	3.32	37.54
01:00	1849	2843	994	3.55	41.09
02:00	1842	2830	988	3.56	44.65
03:00	1865	2817	952	3.43	48.08

[1] See Chapter 10 at [164].
[2] EXP.ROD.015.0461 at .0629.
[3] EXP.ROD.015.0461 at .0846.

04:00	1859	2805	946	3.28	51.36
05:00	1853	2868	1015	3.65	55.01
06:00	1846	2854	1008	3.63	58.64
07:00	1839	2840	1001	3.60	62.24
08:00	1833	2827	994	3.58	65.82
09:00	1882	2848	966	3.58	69.4
10:00	1874	2833	959	3.48	72.88
11:00	1868	2820	952	3.43	76.31
12:00	1864	2808	944	3.40	79.71
13:00	1862	2799	937	3.37	83.08
14:00	1861	2755	894	3.22	86.03
15:00	1864	2678	814	2.93	89.23
16:00	1874	2608	734	2.64	91.87
17:00	1886	2575	689	2.48	94.35
18:00	1843	2500	657	2.37	96.72
19:00	1861	2405	544	1.96	98.68
20:00	1883	2227	344	1.24	99.92
21:00	1881	2044	163	0.587	100.51
22:00	1849	1936	87	0.313	100.82
23:00	1879	1871	-		
10 January					
00:00	1841	1844	-		

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APPENDIX I

Comparison of SIM C and lesser of SIM F releases and discharge limits on 8 & 9 January if 33000ML extra retained in Wivenhoe Dam in SIM C as at 11.00am on 8 January 2011[1]

Date/Time	SIM C Release[2] (m^3/s)	SIM C Height (m AHD) /Volume(ML)	Revised SIM C Volume (ML)	Min of SIM F Release or downstream threshold[3] (m^3/s)	Difference between discharge limit/SIM F Release and SIM C Release (m^3/s)	Hourly Volume Difference ($MLx10^3$)	Cumulative Volume Difference ($MLx10^3$)[4]
8 January							
11:00	2454	64.59/ 927,743	960,743[5]	2450[6]	-	-	-
12:00	2351	64.55/ 924,177	957,177[7]	2450	99	.36	.36
13:00	2203	64.51/ 920,927	953,567[8]	2450	247	.89	1.25
14:00	2137	64.49/ 919,033	950,783[9]	2450	313	1.13	2.38
15:00	2046	64.47/ 917,511	948,131[10]	2450	404	1.45	3.83
16:00	1983	64.45/ 915,582	944,752[11]	2450	467	1.68	5.51
17:00	1888	64.42/ 913,299	940,789[12]	2450	562	2.02	7.53

[1] See Chapter 10 at [167].
[2] EXP.ROD.015.0461 at .0629.
[3] This figure represents the lesser of: the rate of release taken from either SIM F (Simulation Analysis, EXP.ROD.015.0461 at .0846) or the maximum discharge limit (Manual at .0203) for SIM C allowing for the extra volume retained if the downstream bridges were kept closed until midnight on 7 January 2011 (33,000) and the extra amount released as per the last two columns. It has (conservatively) been assumed that the lower bound of any given set of figures in Appendix C is the applicable discharge limit for the corresponding storage level.
[4] Rounded to two decimal figures.
[5] 927,743 + 33,000.
[6] The spillway discharge limit when Wivenhoe Dam Height is between EL 64.5m AHD and EL 65.0m AHD (or between a volume of 920,000ML and 965,000ML is 2,450m^3/s (Manual at p 53).
[7] 924,177 + 33,000.
[8] 920,927 + 33,000 - 360.
[9] 919,033 + 33,000 – 1,250.
[10] 917,511 + 33,000 – 2,380.
[11] 915,582 + 33,000 – 3,830.
[12] 913,299 + 33,000 – 5,510.

18:00	1884	64.39/ 910,900	936,370[13]	2450	570	2.05	9.58
19:00	1880	64.37/ 908,567	931,987[14]	2450	570	2.05	11.63
20:00	1875	64.34/ 906,249	927,619[15]	2450	575	2.07	13.70
21:00	1871	64.31/ 903,998	923,298[16]	2450	579	2.08	15.78
22:00	1866	64.28/ 901,648	918,868[17]	2195[18]	329	1.18	16.96
23:00	1862	64.25/ 898,265	914,305[19]	2195	333	1.20	18.16
9 January							
00:00	1855	64.21/ 894,785	909,735[20]	2195	340	1.22	19.38
01:00	1849	64.17/ 891,374	904,994[21]	2195	346	1.25	20.53
02:00	1842	64.13/ 888,017	900,487[22]	2195	353	1.27	21.80
03:00	1865	64.09/ 885,107	896,307[23]	2195	330	1.19	22.99
04:00	1859	64.09/ 882,106	892,116[24]	2195	336	1.21	24.20
05:00	1853	64.02/ 878,648	887,448[25]	2195	342	1.23	25.43
06:00	1846	63.98/ 875,242	882,812[26]	2195	349	1.26	26.69
07:00	1839	63.94/	878,611[27]	2195	356	1.28	27.97

[13] 910,900 + 33,000 – 7,530.
[14] 908,567 + 33,000 – 9,580.
[15] 906,249 + 33,000 – 11,630.
[16] 903,998 + 33,000 – 13,700.
[17] 901,648 + 33,000 – 15,780.
[18] The spillway discharge limit when Wivenhoe Dam Height is between EL 64.00 and EL 64.5m AHD (or between a volume of 877,000ML and 920,000ML) is 2195m^3/s (Manual at p 53).
[19] 898,265 + 33,000 – 16,960.
[20] 898,265 + 33,000 – 18,160.
[21] 891,374 + 33,000 – 19,380.
[22] 888,017 + 33,000 – 20,530.
[23] 885,107 + 33,000 – 21,800.
[24] 882,106 + 33,000 – 22,990.
[25] 878,648 + 33,000 – 24,200.
[26] 875,242 + 33,000 – 25,430.

		872,301					
08:00	1833	63.90/ 868,889	873,917[28]	1950[29]	117	.42	28.39
09:00	1882	63.86/ 865,276	869,886[30]	1950	68	.24	28.63
10:00	1874	63.83/ 862,592	866,962[31]	1950	76	.27	28.90
11:00	1868	63.81/ 860,768	864,868[32]	1950	82	.30	29.20
12:00	1864	63.80/ 859,941	863,741[33]	1950	86	.31	29.51
13:00	1862	63.79/ 859,488	862,978[34]	1950	86	.31	29.82
14:00	1861	63.81/ 860,758	863,938[35]	1950	89	.32	30.14
15:00	1864	63.86/ 865,395	868,255[36]	1950	92	.33	30.47
16:00	1874	63.93/ 870,879	873,409[37]	1950	76	.27	30.74
17:00	1886	64.00/ 877,301	879,561[38]	2195[39]	309	1.11	31.85
18:00	1843	64.11/ 886,379	887,529[40]	2195	309	1.27	33.12

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[27] 872,301 + 33,000 – 26,690.
[28] 868,889 + 33,000 – 27,970.
[29] The spillway discharge limit when Wivenhoe Dam height is below EL 64.0m AHD or a volume of 877,000ML is 1950m^3/s (Manual at p 53).
[30] 865,276 + 33,000 – 28,390.
[31] 862,592 + 33,000 – 28,630.
[32] 860,768 + 33,000 – 28,900.
[33] 859,941 + 33,000 – 29,200.
[34] 859,488 + 33,000 – 29,570.
[35] 860,758 + 33,000 – 29,820.
[36] 865,395 + 33,000 – 30,140.
[37] 870,879 + 33,000 – 30,470.
[38] 877,301 + 33,000 – 30,740.
[39] The spillway discharge limit when Wivenhoe Dam height is between EL 64.00 and EL 64.5m AHD (or between a volume of 877,000ML and 920,000ML) is 2195m^3/s (Manual at p 53).
[40] 886,379 + 33,000 – 31,850.

Appendix J – SIM F commencing at 7.00pm on 7 January 2011[1]

A Time	B Actual Outflow	C Increments[2]	D SIM F	E SIM F gate increments	F Volume difference between SIM F and Actual	G SIM F time adjusted outflow	H SIM F adjusted	I Volume difference between adjusted SIM F and actual outflow
19:00	255	3	---				3	-
20:00	303	4	---			456	7	0.55
21:00	351	5	---			509	10	0.57
22:00	403	6	-----			814	16	1.23
23:00	456	7	----			1124	22	2.40
00:00	509	10	502	10	0	1125	22	2.22
01:00	561	11	814	16	0.92	1126	22	2.03
02:00	614	12	1124	22	1.84	1422	28	2.91
03:00	667	13	1125	22	1.65	1713	34	3.77
04:00	719	14	1126	22	1.47	1992	40	4.58
05:00	773	15	1422	28	2.33	2265	46	5.37
06:00	825	16	1713	34	3.19	2482	51	5.97
07:00	879	17	1992	40	4.01 Total = 15,410ML	2691	56	6.52 Total = 38,120ML
08:00			2265	46		2770	58	
09:00			2482	51		2764	58	
10:00			2691	56		2756	58	
11:00			2770	58		2747	58	
12:00			2764	58		2740	58	
13:00			2756	58				
14:00			2747	58				
15:00			2740	58				

[1] See Chapter 13 at [332]
[2] Jan FER at .0450.

Appendix K – Volume differential due to Mr Ruffini's breaches on evening of 9 January 2011[1]

A 9 Jan 2011	B Actual Out flows	C SIM F outflows	D Flow Differe nce	E Extra Volume Released	F Increase in outflows as per breach finding	G Flow Differ ence	H Extra Volume released
19:00	1398	2405	1007	3.63	1600	202	0.73
20:00	1404	2247	823	2.96	1800	396	1.43
21:00	1411	2044	633	2.28	2000	589	2.12
22:00	1419	1936	517	1.86	2200	781	2.81
23:00	1428	1817	389	1.4	2400	972	3.50
0:00	1440	1844	404	1.45	2600	1160	4.18
				13,580ML			14,770ML

[1] Chapter 13 at [334].

APPENDIX L:[1]

SIM C vs. Actual Levels: 10 January 2011 – 12 January 2011

Date and Time	Actual Level (m AHD)	Actual Volume (ML)	Actual Outflows (m^3/s)	SIM Level (m AHD)	SIM Volume (ML)	SIM Outflows (m^3/s)	Height Difference (m) (Actual – SIM)	Volume Difference (ML) (Actual – SIM)
1/10/2011 7:00	71.16	1668426	1875	66.72	1135864	1841	4.44	532562
1/10/2011 8:00	71.36	1695406	1944	66.96	1160890	1865	4.40	534516
1/10/2011 9:00	71.56	1722624	2015	67.20	1186621	1847	4.36	536003
1/10/2011 10:00	71.78	1752854	2031	67.39	1207443	1786	4.39	545411
1/10/2011 11:00	71.95	1776448	2044	67.55	1225381	1805	4.40	551067
1/10/2011 12:00	72.07	1793215	2053	67.74	1246533	1779	4.33	546682
1/10/2011 13:00	72.26	1819906	2067	67.92	1266510	1797	4.34	553396
1/10/2011 14:00	72.41	1841210	2077	68.07	1284444	1768	4.34	556766
1/10/2011 15:00	72.54	1859739	2087	68.25	1304307	1782	4.29	555432
1/10/2011 16:00	72.70	1882728	2155	68.40	1322102	1655	4.30	560626
1/10/2011 17:00	72.84	1902994	2277	68.51	1334487	1523	4.33	568507
1/10/2011 18:00	72.92	1914623	2399	68.60	1345113	1381	4.32	569510

[1] See Chapter 13 at [338]

1/10/2011 19:00	72.99	1924798	2517	68.69	1355731	1387	4.30	569067
1/10/2011 20:00	73.06	1935072	2695	68.77	1365451	1544	4.29	569621
1/10/2011 21:00	73.11	1942421	2699	68.84	1374630	1796	4.27	567791
1/10/2011 22:00	73.17	1951241	2705	68.91	1382541	1849	4.26	568700
1/10/2011 23:00	73.22	1958590	2709	68.97	1389584	1855	4.25	569006
1/11/2011 0:00	73.26	1964486	2713	69.03	1396956	1860	4.23	567530
1/11/2011 1:00	73.31	1971917	2717	69.09	1403727	1817	4.22	568190
1/11/2011 2:00	73.35	1977862	2721	69.13	1408709	1822	4.22	569153
1/11/2011 3:00	73.38	1982321	2724	69.17	1414112	1825	4.21	568209
1/11/2011 4:00	73.40	1985294	2726	69.24	1422041	1829	4.16	563253
1/11/2011 5:00	73.46	1994211	2731	69.33	1433050	1834	4.13	561161
1/11/2011 6:00	73.51	2001658	2736	69.45	1448167	1842	4.06	553491
1/11/2011 7:00	73.61	2016681	2745	69.59	1465752	1852	4.02	550929
1/11/2011 8:00	73.70	2030202	2753	69.76	1486608	1709	3.94	543594
1/11/2011 9:00	73.81	2046825	2991	69.97	1513012	1566	3.84	533813
1/11/2011 10:00	73.95	2068085	3347	70.21	1544390	1472	3.74	523695
1/11/2011 11:00	74.10	2091030	3533	70.46	1576673	1487	3.64	514357
1/11/2011 12:00	74.27	2117163	3667	70.71	1608518	1446	3.56	508645

1/11/2011 13:00	74.39	2135795	4250	70.98	1643899	1460	3.41	491896
1/11/2011 14:00	74.57	2163861	4562	71.23	1678407	1311	3.34	485454
1/11/2011 15:00	74.71	2185835	5167	71.45	1708157	1150	3.26	477678
1/11/2011 16:00	74.81	2201636	5786	71.66	1736567	1043	3.15	465069
1/11/2011 17:00	74.89	2214333	6432	71.86	1763614	1051	3.03	450719
1/11/2011 18:00	74.95	2223855	6774	72.03	1787362	1058	2.92	436493
1/11/2011 19:00	74.97	2227030	7464	72.18	1808697	1065	2.79	418333
1/11/2011 20:00	74.97	2227030	7464	72.33	1829864	1070	2.64	397166
1/11/2011 21:00	74.95	2223855	7458	72.48	1850867	1076	2.47	372988
1/11/2011 22:00	74.95	2223855	7111	72.61	1870357	1081	2.34	353498
1/11/2011 23:00	74.92	2219094	7103	72.74	1888336	1086	2.18	330758
1/12/2011 0:00	74.91	2217507	6118	72.85	1904173	1091	2.06	313334
1/12/2011 1:00	74.87	2211158	6109	72.94	1917810	1094	1.93	293348
1/12/2011 2:00	74.86	2209571	5492	73.02	1929725	1098	1.84	279846
1/12/2011 3:00	74.81	2201636	5483	73.10	1941422	1101	1.71	260214
1/12/2011 4:00	74.80	2200049	4888	73.18	1953280	1103	1.62	246769
1/12/2011 5:00	74.77	2195287	4304	73.26	1964131	1106	1.51	231156
1/12/2011 6:00	74.77	2195287	3727	73.33	1974603	1109	1.44	220684

1/12/2011 7:00	74.76	2193700	3143	73.39	1984366	1111	1.37	209334
1/12/2011 8:00	74.78	2196874	2547	73.44	1991402	1114	1.34	205472
1/12/2011 9:00	74.78	2196874	2547	73.47	1996303	1115	1.31	200571
1/12/2011 10:00	74.78	2196874	2547	73.51	2001793	1117	1.27	195081
1/12/2011 11:00	74.78	2196874	2547	73.55	2007277	1118	1.23	189597
1/12/2011 12:00	74.79	2198461	2547	73.58	2012758	1119	1.21	185703
1/12/2011 13:00	74.79	2198461	2547	73.62	2018908	1120	1.17	179553
1/12/2011 14:00	74.81	2201636	2549	73.66	2023494	1122	1.15	178142
1/12/2011 15:00	74.81	2201636	2549	73.68	2027704	1123	1.13	173932
1/12/2011 16:00	74.80	2200049	2548	73.71	2032360	1249	1.09	167689
1/12/2011 17:00	74.82	2203223	2550	73.74	2036078	1250	1.08	167145
1/12/2011 18:00	74.80	2200049	2548	73.77	2040935	1251	1.03	159114