Ian Fraser – Statement and attachments dated 31 January 2012

IN THE MATTER OF
THE QUEENSLAND FLOODS COMMISSION OF INQUIRY 2011

A COMMISSION OF INQUIRY UNDER THE COMMISSIONS OF INQUIRY ACT 1950

AND PURSUANT TO THE COMMISSIONS OF INQUIRY ORDER (No. 1) 2011

STATEMENT OF IAN HARLEY FRASER

On the 31st day of January 2012, I, **Ian Harley Fraser**, c/- 240 Margaret Street, Brisbane, state on oath:

1. I am a member of the Board of the Queensland Bulk Water Supply Authority ("**Seqwater**").

2. This statement is provided to the Queensland Floods Commission of Inquiry pursuant to a "Requirement to Provide Statement" issued by the Commission dated 27 January 2012 (the ***Requirement***).

3. I have examined my records to seek to locate notes or other communications falling within the Requirement. To the extent I have been able to find material that may fall within the Requirement, I have annexed it to this statement.

4. My best recollection of the matters the subject of the Requirement is set out below.

5. At no time during the period 6 January 2011 to 2 March 2011 did I have a communication with anyone which, from my understanding, involved the possibility that there had been non-compliance with the Manual.

6. I was well aware of the articles appearing in *The Australian*, and other papers, regarding the operation of Wivenhoe Dam. These articles appeared almost straight after the flood.

7. Mr Borrows sent me an email on 16 January 2011 attaching a draft ministerial briefing. This email and its attachments are annexed to this statement as **Attachment IHF1**.

8. I also received an email from Mr Borrows on 17 January 2011 attaching responses to the issues raised in *The Australian*. That email is annexed to this statement as **Attachment IHF2**.

[redacted] [redacted]

9. We discussed the articles in *The Australian* during several Board meetings. I cannot now recall the specifics of the discussions, but I have a clear recollection that we asked the matters to be considered by Seqwater's technical staff. After this, there was no communication with me that I can recall that suggested to me that there was a possibility of non-compliance with the Manual.

10. As to Mr O'Brien, my recollection is that my fellow Board member, Ms Leeanne Bond received communications from Mr O'Brien. The extent of my knowledge of those communications is set out in the email chain annexed to this statement as **Attachment IHF2**. Ms Bond's communications from Mr O'Brien were also discussed in the Board discussions surrounding the articles in *The Australian*. I cannot remember the specifics of the discussions but we decided that Seqwater should not respond directly to Mr O'Brien.

SWORN by **Ian Harley Fraser** on 31 January 2012 at Brisbane in the presence of:

[redacted]

Deponent

[redacted]

Solicitor

IN THE MATTER OF
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STATEMENT OF IAN HARLEY FRASER

INDEX OF ANNEXURES

Annexure No.	Document	Date
IHF1	Email from Mr Borrows to me attaching draft Ministerial briefing	16 January 2011
IHF2	Email exchange	Various

[redacted]

Toni Lake

From: Peter Borrows
Sent: Sunday, 16 January 2011 4:36 PM
To: Hennessy, Phil A; 'Tom Fenwick'; Leeanne Bond; Leith Boully; Ian Fraser
Cc: Peter Borrows; Toni Lake
Subject: Update - focus on release strategy from Wivenhoe: News tonight - Mt Crosby Interviews with Brett Myatt and Joe Meissner
Attachments: Background Briefing Jan 2011.docx; Brian Cooper - final report.docx; Brian Cooper - final report attachment.xlsx; Record of teleconference 12 January 2011.docx; Mt Crosby.pdf; LetterTurbidityMtCrosby.pdf; SeePage7Figure4.pdf; legislativeprotectionfloodopsFeb2011InfoPack.docx; Cabinet in co nfidence - Ministerial brief outline

This is an update on the event, in the form of the Ministerial briefing. I'll send the final when we receive it.

Section 5 will reference the Brian Cooper report and attachments. This is in the E Mail attached 'Cabinet in confidence.

I have attached 4 documents that relate to a relaxation in WQ parameters (below contract values) that occurred through the event.

The legislative protection document covers flood releases in accordance with the manual.

Regards, Peter.

Peter Borrows
Chief Executive Officer
Queensland Bulk Water Supply Authority *trading as* Seqwater

seqwater
WATER FOR LIFE

Ph [redacted]
Level 3, 240 Margaret St, Brisbane City QLD 4000
PO Box 16146, City East QLD 4002
Website | www.seqwater.com.au

Wivenhoe Dam – Development of Flood Operational Rules

1. Introduction

This briefing note has been prepared to detail the development of the flood operational rules for Wivenhoe and Somerset Dam and the extensive reviews undertaken for the studies.

The flood operational procedures were developed during an extensive hydrological study of the Brisbane and Pine Rivers catchments by the DPI, Water Resources between 1990 and 1994 which was reviewed by an external expert panel. Subsequently, the flood operational rules have been reviewed during the Brisbane Valley Flood Damages Minimisation Study in 2006 and the latest revision to the flood manual in 2009. Both reviews have included expert review panels comprising key stakeholders.

2. History

The Brisbane River Basin is the major water supply source for the City of Brisbane and many of the nearby local authorities. The major floods which are derived from the basin have a history of causing significant damage to the local communities.

Somerset Dam was constructed on the Stanley Rover over the period 1936 to 1954 and was the major regional water supply source up until the late 1970's

During the early 1970's it was identified that both the water supply and flood mitigation of Somerset Dam would need to be augmented. Shortly after the 1974 floods planning for the construction of Wivenhoe Dam began with construction commencing in 1979 and final completion being achieved in 1987.

The main functions of Wivenhoe Dam are to meet the water supply demands of the Moreton Region, provide the lower pool for the 500MW Wivenhoe Pumped Storage Project and provide flood mitigation for the cities of Brisbane and Ipswich.

Changes to the methods used to determine the rainfall for extreme events during the 1980's resulted in significant changes to the design flood for the newly constructed dam.

In 1990, the owners of the Dam, South East Queensland Water Board, undertook a dam safety review of the three dams owned and operated by the Board. A key component of this study was the Brisbane and Pine Rivers Flood Study.

3. Development of the Flood Operations Rules

In August 1990, the South East Queensland Water Board (SEQWB) commissioned the Department of Primary Industries, Water Resources Business Group (DPI,WR) to undertake the Brisbane and Pine Rivers Flood Study. The flood Study was initiated as part of an overall safety review of the Board's dams, Somerset Dam, Wivenhoe Dam and North Pine Dam. The need for the safety review of the dams stemmed from a number of factors including

- the emergence of new techniques for the estimation of probable maximum precipitation and subsequent flooding,
- the development of computer software capable of simulating the hydraulic behaviour of whole river basins and simulating dam failure scenarios,
- advancements in technology associated with real time weather monitoring.

The scope of the flood study was to review the hydrology for each dam and hydraulic aspects associated with the relevant flood studies and to develop real time model programmes for use in flood control operations and forecasting. Key aspects of the study were:

- hydrologic review
- flood operating procedure
- hydraulic analysis, flood studies
- dam break (failure) analysis
- flood inundation.

This study was undertaken from 1990 until 1994 and represented a thorough review of the flooding in the Brisbane and Pine Rivers and the associated role of the dams within the catchment.

i. Brisbane and Pine Rivers Flood Review

The Brisbane and Pine Rivers Flood Study comprise multiple reports, produced at the completion of each stage of the study. The reports were subject to extensive internal review by the Water Resources Group before being reviewed by an independent review panel comprising Professor Colin Apelt, Head of Department, Department of Civil Engineering, University of Queensland and Mr Eric Lesleighter, Principal Hydraulic Engineer and Chief Engineer Water Resources, Snowy Mountains Engineering Corporation.

ii. Real Time Flood Model

The outcome of the Brisbane River and Pine River Flood Studies were used to develop a real time flood model for the three dams. This real time flood model consists of alert stations within the catchment to provide real time rainfall and stream level data, a calibrated run off model to convert rainfall data into flows, a gate operating model to allow decisions on gate openings to be made and a downstream flood model to provide predictions on flood levels.

iii. Flood Operations Manual

The Flood Operation Manual is the key legislative document prepared by the owner of the dam and approved and gazetted by the Qld Dam Safety Regulator. The manual defines flood procedures, roles and responsibilities, staffing and operational requirements.

The manual in its current form was developed in 1992 using the operational procedures developed during the Brisbane and Pine Rivers Flood Study and a manual written in 1968 covering flood operations at Somerset Dam (Wivenhoe Dam was completed in 1984). Six revisions of the Manual have occurred since 1992 to account for updates to the Flood Alert Network and the Real Time Flood Models, the construction of an Auxiliary Spillway at Wivenhoe Dam in 2005 and to account for institutional and legislative changes.

The primary objectives of the procedures contained in the flood manual are, in order of importance:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

To meet the objectives, there are four strategies for Wivenhoe Dam defining the gate operations as a flood event unfolds. The first three strategies are focused on delivering the optimal flood mitigation outcomes based on inflows, downstream flooding and forecast rainfall. Once the water level in Wivenhoe Dam exceeds 7m above the normal operating level, the strategies shift from flood mitigation to ensuring that the dam is not overtopped.

4. Subsequent Reviews of the Flood Operational Procedures

iv. Brisbane Valley Flood Damage Minimisation Study

In 2005 and 2006, Brisbane City Council (BCC) undertook the Brisbane Valley Flood Damage Minimisation Study (BVFDMS) in conjunction with Ipswich City Council and Esk Shire Council. The study provided a flood damage assessment for Brisbane River floods. The study aimed to estimate the potential flood damage in the Brisbane Valley and then assess the flood operation rules for the Wivenhoe Dam flood gates to determine whether the current rules could be modified to reduce flood damage in the valley.

This extensive study involved detailed survey assessment of the flood damages within the Brisbane City and Ipswich City areas. A Project Technical Review Group was formed for the project involving:

- SEQWater Corporation
- The Bureau of Meteorology
- SunWater as the operator of the SEQWater Corporation Flood Control Centre
- NRM&W Dam Safety Regulator
- WRM Consultants

Key outcomes from this study for the Flood Operational Rules were:

- Confirmation of the 4,000m3/s flood adopted in the flood manual as the start of damaging flows in the Brisbane urban areas.
- Confirmation of the effectiveness of the existing flood operating rules as the optimal method of providing flood mitigation to Brisbane.

v. 2009 Review of the Flood Manual

In 2009, after the formation of the Queensland Bulk Water Supply Authority, a comprehensive review of the flood manual was undertaken. This review was focused on re-writing the manual and

refining the operational procedures. As part of this review Seqwater assembled an expert review panel comprising the following organisations.

- The Bureau of Meteorology
- SunWater as the operator of the Flood Control Centre
- DERM Dam Safety Regulator
- Brisbane City Council

Minor changes made to the manual were extensively tested to ensure that the flood mitigation outcomes from the operation of the dam were not compromised.

5. Conclusions

The flood operational procedures for Wivenhoe and Somerset Dam were developed by a comprehensive study undertaken by the DPI Water Resources between 1990 and 1994. These operational rules have been reviewed by independent parties to identify any opportunities to improve the flood mitigation outcomes including the Brisbane City Council.

Barton Maher (RPEQ 6833)
Principal Dams & Weirs Planning
Queensland Bulk Water Supply Authority trading as Seqwater

P.O. Box 205, BELROSE WEST NSW 2085
phone:
mobile
email:
ABN: 56154707619

brian cooper consulting

12 January 2011

Mr. Barry Dennien
CEO, SEQ Water Grid Manager
PO Box 16205
City East QLD 4002

Dear Barry,

This letter report:

- presents my final findings on a review of the operation of Wivenhoe Dam (including controlled releases) for compliance against the Flood Mitigation Manual for the period 12 December 2010 to date (Flood Event), and;
- provides advice on the prudence and appropriateness of the decisions and actions taken during the Flood Event regarding the operation of Wivenhoe Dam in light of the Flood Mitigation Manual's requirements and the circumstances of the Flood Event.

The report follows on from my preliminary report sent to you earlier today. The findings and advice are provided on the basis of information provided by SEQ Water Grid Manager which comprised the Flood Mitigation Manual and Technical Situation Reports. The latter were daily (sometimes twice daily) reports for the subject period. They gave a log of rainfall over the dam catchments and the downstream river (Lockyer Ck. and Bremer R.) catchments; inflows to Somerset and Wivenhoe Dams; storage levels; releases from the dams; details of the operation of gates and other outlets (gate openings/discharges); proposed changes in operating strategies and impacts on the various access crossings downstream of Wivenhoe Dam. In reviewing the Technical Situation Reports, I prepared a spreadsheet (see separate attachment of Excel spreadsheet *Tech Reports – Summary*, summarising the reports so that a timeline of the Flood Event could be seen at a glance. This provided a good overview of the Flood Event as it unfolded and showed what information may or may not have been included in a particular report. The Queensland Director Dam Safety (Water Supply) informed me that the Flood Operation Logs contain much more detailed information including details of the communications that were carried out and some of the more detailed information that is not necessarily included in the Technical Situation Reports. I have been provided with a draft of the "*Protocol for the Communication of Flooding Information for the Brisbane River Catchment – Including Floodwater Releases from Wivenhoe and Somerset Dams*" developed in October/November last year and currently being used. The Technical Situation Reports appear to have been an outcome of that Protocol.

The various requirements and required actions detailed in the Flood Mitigation Manual are summarised in the Table given in Attachment A. The Table also gives my comments (where appropriate) on whether there is evidence from the information presented to me, that there is satisfactory compliance with these requirements and actions.

The main aspects of the Flood Mitigation Manual are the various strategies for operating Wivenhoe Dam and Somerset Dam as well as a number of requirements relating to flood operations personnel, flood preparedness and flood training.

At Wivenhoe Dam there are four main strategies for operating the dam (W1 to W4) and at Dam there are three (S1 to S3). These strategies are hierarchical and are based on a number of flood objectives. These in descending order of importance, are:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;
- Retain the storage at Full Supply Level (FSL) at the conclusion of the Flood Event, and;
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

Normal procedures require a return to FSL within 7 days of the flood event peak passing through the dams so that the potential effects of closely spaced Flood Events can be allowed for.

It is apparent from the Technical Situation Reports that emphasis has been given to communicating changes in flood operations strategies with local authorities and the Bureau of Meteorology (BOM).

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. For a few days at the end of December and for the last day or so before yesterday's big rise, Strategy W2 would be in place (restrain releases from Wivenhoe Dam such that Brisbane River flows are maintained within the upper limit of non-damaging floods at Lowood (3,500 m3/s)). At 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. The operations then moved onto Strategy W4 when the storage in Wivenhoe Dam reached about EL 73.5 (before the W4 trigger level of EL 74) when yesterday's heavy rain came on and it was assessed that there was a chance that the first (central) fuse plug could be triggered. It was then a matter of juggling the radial gate openings in an attempt to circumvent any fuse plug triggering. A graph of storage levels for Wivenhoe and Somerset Dams (from information taken from the Technical Situation Reports) showing the limits for the various Wivenhoe Dam flood strategies is given in Attachment A. It is apparent from this graph, that the appropriate flood operation strategies were adopted. The Technical Situation Reports indicate that proposed changes in strategy were appropriately communicated with appropriate authorities in accordance with the new Communication Protocol.

Summary:

The Technical Situation Reports comply with the requirements of the new Communication Protocol. However, I feel that there could be more consistency in the information presented. There seem to be gaps in information presented such as storage levels (see spreadsheet and graph in Attachment A). It would be useful to specify the minimum information required to be presented in the Technical Situation Reports (storage levels, inflows, recent/current rainfall, forecast rainfall, releases from dams, estimated flows from downstream tributaries, current flood operating strategy for each dam and proposed change in strategy, gate and regulator operations, state of downstream road crossings etc). Most of the minimum information is already given, but not in a consistent manner. As a means of reviewing processes followed during a flood, it would be useful to present a timeline of the flood event showing graphs of storage levels and other data that can be easily presented in a graphical manner.

I am informed by the Queensland Director Dam Safety (Water Supply) that the various requirements of the Flood Mitigation Manual relating to requirements for flood operations personnel, flood preparedness and flood training have been adhered to. There are a number of other requirements however, that I am not able to say whether they were satisfied as I had insufficient information. These requirements (see Table in Attachment A) should be subject to a separate audit.

It appears to me that the decision to implement Strategy W4 was a prudent one. While it would cause some damage in the Brisbane River downstream, its implementation, considering forecast rainfalls and projected flows in Lockyer Ck. And the Bremer River, would allow reduction of the storage level in

Wivenhoe Dam. This reduction in storage level would hopefully provide a sufficient buffer that would minimise the chance of a fuse plug triggering in the auxiliary spillway. Triggering of the first (central) fuse plug would cause a sudden increase of flow of some 2,000m^3/s from Wivenhoe Dam. This increase in flow would cause significantly more flooding in the lower Brisbane River than that caused by early implementation of Strategy W4.

Conclusions:

The strategies as set out in the Flood Mitigation Manual have been followed, allowing for the discretion given to making variations in order to maximise flood mitigation effects. The actions taken and decisions made during the Flood Event appear to have been prudent and appropriate in the context of the available knowledge available to those responsible for flood operations and the way events unfolded.

There are a number of requirements where there was insufficient time given the urgency of this review, to source the necessary information for me to demonstrate compliance. However, satisfaction or otherwise of these requirements would have had little impact on the operation of the two dams during this particular Flood Event. It is intended that they be audited when time permits, after the Flood Event.

There are aspects of the Technical Situation Reports that could be improved and these have been discussed above.

Regards,

Brian Cooper

ATTACHMENT A

Action Requirements extracted from the Flood Mitigation Manual:

Action	Comment
The Flood Mitigation Manual contains the operational procedures for Wivenhoe Dam and Somerset Dam for the purposes of flood mitigation and must be used for the operation of the dams during flood events.	Appears to have been done
Sufficient numbers of suitably qualified personnel are available to operate the dams if a Flood Event occurs.	Director of Dam Safety is satisfied
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.	See Note 1
A regular process of internal audit and management review must be maintained by Seqwater to achieve improvements in the operation of the RTFM.	See Note 1
Seqwater must maintain a log of the performance of the data collection network. The log must include all revised field calibrations and changes to the number, type and locations of gauges. Senior Flood Operations and Flood Operations Engineers are to be notified of all significant changes to the Log.	See Note 1
Seqwater must maintain a log of the performance of the RTFM. Any faults to the computer hardware or software are to be noted and promptly and appropriately attend to.	See Note 1
Seqwater must ensure that all available data and other documentation is appropriately collected and catalogued for future use.	See Note 1
Seqwater must ensure that information relevant to the calibration of its field stations is shared with appropriate agencies.	See Note 1
Seqwater must liaise and consult with these agencies with a view to ensuring all information relative to the flood event is consistent and used in accordance with agreed responsibilities: • Bureau of Meteorology (issue of flood warnings for Brisbane River basin); • Department of Environment and Resource Management (review of flood and discretionary powers); • Somerset Regional Council (flood level information for upstream of Somerset Dam and upstream and downstream of Wivenhoe Dam); • Ipswich City Council (flood level information for Ipswich), and; • Brisbane City Council (flood level information for Brisbane City).	Required also by draft of Communications Protocol. Technical Situation Reports infer compliance
Seqwater must report to the Chief Executive by 30 September each year on the training and state of preparedness of operations personnel.	See Note 1
Seqwater must provide a report to the Chief Executive by 30 September each year on the state of the Flood Monitoring and Forecasting System and Communication Networks.	See Note 1

Action	Comment
After each significant flood event, Seqwater must report to the Chief Executive on the effectiveness of the operational procedures contained in this manual.	It is too early for this action to be implemented. Will be implemented when the Flood Event is finished
Prior to the expiry of the approval period, Seqwater must review the Manual pursuant to provisions of the Act.	It is too early for this action to be implemented
Strategies are changed in response to changing rainfall forecasts and stream flow conditions to maximise the flood mitigation benefits of the dams.	Technical Situation Reports indicate that this is done
When determining dam outflows within all strategies, peak outflow should generally not exceed peak inflow.	Information from Seqwater indicates that the requirement was satisfied
Protocol for use of discretionary powers (i.e. who gets told)	Director of Dam Safety is satisfied – I don't know whether Seqwater CEO or Chairperson approved – See Note 1

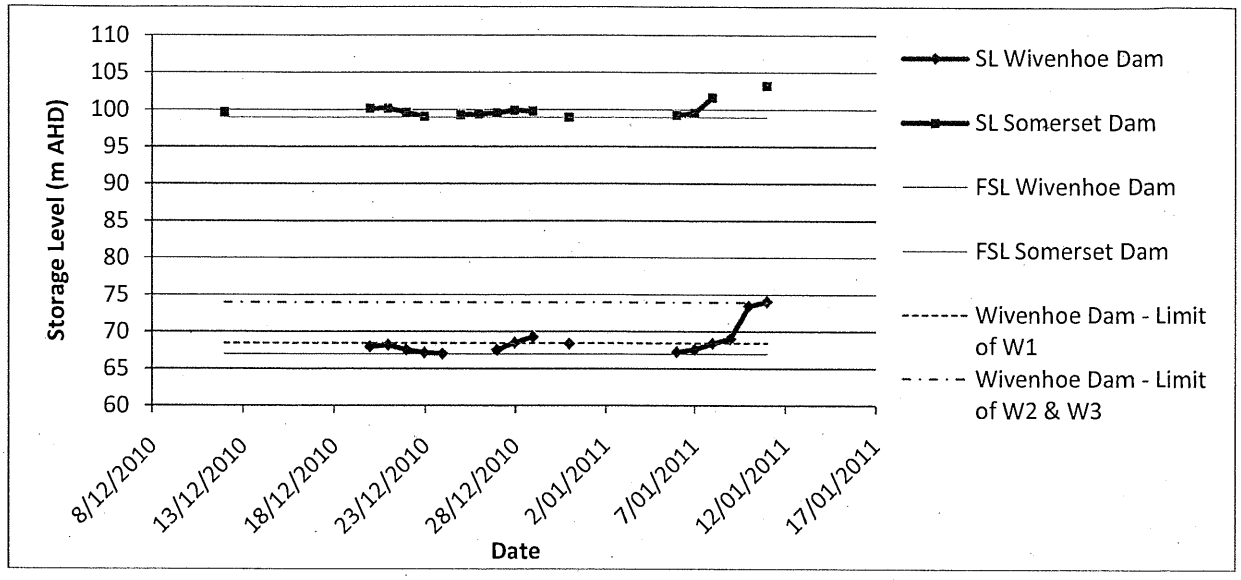
Note1: For a number of the above actions, given the short time frame for the review on compliance of actual flood operations with the Flood Mitigation Manual, it was not possible to source some of the information required to confirm that requirements had been fulfilled. These actions will be audited separately, when time permits.

Action	Comment
Flood Strategies for Wivenhoe Dam:	
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 . For situations where flood rains are occurring on the catchment upstream of Wivenhoe Dam and only minor rainfall is occurring downstream of the dam, releases are to be regulated to limit, as much as appropriate in the circumstances, downstream flooding.	Technical Situation Reports indicate that every attempt was made to keep the specified road crossings open
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:	Technical Situation Reports indicate that Wivenhoe Dam releases were made considering concurrent flows in the Bremer River & Lockyer Ck. To delay damaging floods as long as possible
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.	
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 EL74.0 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. There are no restrictions on gate opening increments or gate operating frequency once the storage level exceeds EL74.0 AHD, as the safety of the dam is of primary concern at these storage levels.	Technical Situation Reports indicate that Wivenhoe Dam releases were such as to delay adopting this strategy as long as possible
Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.	Technical Situation Reports indicate that this requirement was satisfied
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.	Technical Situation Reports indicate that

Action	Comment
	emphasis was given to satisfying this requirement
Flow in the spillway to be as symmetrical as possible with the centre gates opened first.	Technical Situation Reports indicate that this was done
The bottom edge of the radial gates must always be at least 500mm below the release flow surface.	See Note 1 above

Action	Comment
Flood Strategies for Somerset Dam:	
The intent of Strategy S1 (Somerset Dam Level expected to exceed EL 99.0 and Wivenhoe Dam not expected to reach EL 67.0 (FSL) during the course of the Flood Event) is to return the dam to full supply level while minimising the impact on rural life upstream of the dam. Consideration is also given to minimising the downstream environmental impacts from the release.	Technical Situation Reports indicate that this was done
The intent of Strategy S2 (Somerset Dam Level expected to exceed EL 99.0 and Wivenhoe Dam level expected to exceed EL 67.0 (FSL) but not exceed EL 75.5 (fuse plug initiation) during the course of the Flood Event). This to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams. The Flood Mitigation Manual contains a graph that shows the intended interaction of the Wivenhoe Dam and Somerset Dam storage levels.	Technical Situation Reports indicate that this was done – little information on the operation of the radial gates at Somerset Dam. How the graph was followed not really demonstrated
The intent of Strategy S3 (Somerset Dam Level expected to exceed EL 99.0 and Wivenhoe Dam level expected to exceed EL 75.5 (fuse plug initiation) during the course of the Flood Event) is to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams.	Not relevant at this stage
The safety of Somerset Dam is the primary consideration and cannot be compromised and its peak level cannot exceed EL 109.7.	Maximum level only EL103.3

Wivenhoe & Somerset Dams – Storage Level Behaviour (as presented in Technical Situation Reports)



Date	Time	TSR	Wivenhoe Dam Release (m^3/s)				Gate No.	Opening (m)	Storage Level	Rainfall (mm)	Comments	Crossing Closures
			Regulators	Hydro	Gates	Total						
											45,000Ml from Somerset; WL|Somerset to peak at 99.7 on 13/12/2010; 150m^3/s expected through Brisbane; 30,000Ml expected into Wivenhoe from upper Brisbane R.; peak WL in Wivenhoe expected to be 67.6; Releases expected from Wivenhoe on afternoon of 13/12/2010 ramping up to 300m^3/s; Reg. will be closed & Gate 3 opened to 3m to get WL back to 67.25; Incr. release	
12/12/2010	1400	W1									will impact on 3 crossings; Dam Regulator informed	
13/12/2010	1300	W2		10	290	300					138m^3/s from Somerset;	Gate release will impact on 3 crossings
15/12/2010	1800	W3									Releases from Wivenhoe will cease on 16/12/2010; Hydro will continue during fish recovery ops.	
16/12/2010	1600	W4			0						Gate closed 1000	
										Large storms yesterday pm and night;	Decision to commence a release tonight was made this am by Duty Flood Engineers to provide as much notice to impacted	
17/12/2010	1200	W5								20-50 forecast tonight	Councils as possible; 60,000Ml needs to be released from Wivenhoe & Somerset to maintain FSL	
17/12/2010	1800	W6	Closed		Opening Op. Initiated					20-50 forecast o/n	Need to release >60,000Ml from Wivenhoe & Somerset to achieve FSL	
	1830			13	50	63	3	0.5			Releases could increase to 300m^3/s;	Would impact Twin Bridges, Savages Crossing, Colleges Crossing
											100,000Ml to be drained in next 4 days; Q|Brisbane R. to be maintained at 300-350m^3/s;Transfer from Somerset via 2 reg.; Wivenhoe Q incr. to 150m^3/s o/n; Will incr. further to 300m^3/s as Q|Lock.Ck. Subside over next 24 hrs.; Q|Lock.Ck. Currently	
18/12/2010	0700	W7								40-50 since 16/12/2010	130m^3/s	Twin Bridges & Savages Crossing currently closed; Colleges Crossing to be impacted in afternoon
19/12/2010	0700	W8				350 350	3	3.5		20-30 upper Brisbane R.	12,000Ml/day from Somerset; Release expected until 22/12/2010;	Twin Bridges, Savages Crossing, Colleges Crossing currently closed
											Somerset rel. steady (Q|reg.=140m^3/s); Q|Wivenhoe to be maintained at 300m^3/s (Lock.Ck. Permitting) to allow Burtons Bridge to	Twin Bridges, Savages Crossing and Colleges Crossing are closed; closing of Burtons Bridge and Kholo Bridge will be
19/12/2010	1800	W9				300 300	3	3			remain open; WL|Wivenhoe expected to incr. to 67.4 over next 2 days;	considered if more rain or inflows
											Somerset risen to 100.2 - sluice gate releases to be made until am of 22/12/2010 when FSL expected; WL|Wivenhoe at 68 expected this pm; Q|Wivenhoe expected to be >1,200m^3/s - discuss with impacted Cncls.- strategy decision by 10000; Wivenhoe	
20/12/2010	0700	W10									inflows excl. Q|Somerset peak tomorrow at 1800m^3/s	Both Burtons and Kholo bridges likely to be inundated
									68 expected this		Inflow to Somerset to peak today at 700m^3/s; Somerset & Wivenhoe currently storing 140,000Ml above FSL; further inflows	Wivenhoe releases reduced slightly to keep Burtons Bridge open - then incr. releases after Somerset RegnlCncl inform
20/12/2010	0900	W11							afternoon		occurring; releases to be incr. o/n to ~1,200m^3/s; various Cncls. Given heads up; BOM advised	residents affected by Burtons Bridge
20/12/2010	0900	W12									Same as W11	
									peak 68.24 (0400); currently 68.22		410m^3/s from Somerset sluice gates; Somerset peaked @100.43 (1300 on 20/12/2010), currently @ 100.23 (114% of cap.); 110,700Ml Inflow to Somerset,67,500Ml discharged into Wivenhoe; Wivenhoe Inflow (excl. Somerset releases) = 157,900Ml,	
						peak 1,280			(112% cap.) falling slowly		103,000Ml released; Total Inflow to both dams ~310,000Ml; Continued gate operations may be necessary if forecast rainfall	Kholo Bridge is also expected to be inundated by mid-morning ; In accordance with the adopted operational strategy these bridges should be back in service by late Thursday and all bridges (with the possible exception of Twin Bridges)
21/12/2010	0730	W13				(0500)			currently @ 67.61		results in subsequent river rises	should be trafficable for Christmas providing no further rainfall occurs.
									(107% cap.) falling			
22/12/2010	0830	W14							slowly	none since 300 on 20/12/2010	410m^3/s from Somerset sluice gates; Somerset currently @ 99.68 (108% cap.); 121,500Ml inflow to Somerset, 103,000Ml released to Wivenhoe; Gate Ops. @ Wivenhoe; High tides expected to coincide with peak levels in Brisbane R.	Burtons Bridge & Kholo Bridge expected to be back in service by 23-24/12/2010; All bridges expected to be trafficable by Xmas provided no further rain
22/12/2010	1600	W15			Closing sequence				to finish just>FSL		BOM aware of all releases	Gate closing sequence to allow bridges to be accessible
									When gates closed, will be 67.2 (0.2m > FSL) & 50mm <gate opening trigger level		1 sluice open @ Somerset to be closed @ 0900 - WL will be 0.1m> FSL; Est. Inflow to Somerset 135,000ML, majority discharged into Wivenhoe; Gate closure ops @ Wivenhoe in progress; Wivenhoe inflow (excl. Somerset inflow) = 204,000Ml; A total of 324,000Ml has been released; Contd. gate ops may be necessary if forecast rain results in river rises; Gate closure ops sequence to	Projected crossing openings: Burtons Bridge – 18:00 Thursday 23 December 2010. Savages Crossing – 19:00 Thursday 23 December 2010 Kholo Bridge – 21:00 Thursday 23 December 2010 Colleges Crossing – 08:00 Friday 23 December 2010
23/12/2010	0800	W16			All gates expected to be closed by 1500						be reviewed	
										10-30 in CA over last 24 hrs.; further heavy rain expected to start on	Somerset gate ops ceased @ 0900, WL @ 99.1; Gate closure sequence extended to pm of 24/12/2010; Contd. Gate ops may be	Projected crossing openings: Burtons Bridge – 18:00 Thursday 23 December 2010, Kholo Bridge - 21:00
23/12/2010	1430	W17				350	3	3.5	67.23	29/12/2010	necessary if forecast rainfall gives incr. river levels	Thursday 23 December 2010; Other bridges expected to remain closed until Xmas Day
									67.07 expected			Twin Bridges, Savages Crossing and Colleges Crossing are currently closed and should remain so for some
					All gates expected to be				when all gates		Gate ops @ Somerset ceased yesterday, reg. to be opened to bring lake to FSL; Gate ops continuing @ Wivenhoe -1 gate incr.	time due in part to current outflows into the Brisbane River from Lockyer Creek that will peak in excess of 200
24/12/2010	0630	W18			closed by 1300				closed	little or no rainfall	every 5-6 hrs to ensure Brisbane R. Q not incr. due to incr. Lock. Ck. Outflows & maintain Burtons Bridge open;	cumecs late today.
											Flood Centre to monitor o/n & consider options tomorrow am based on inflows & rainfall; further gate ops may be necessary in coming days	
			4,200Ml/day from reg. &		Radial gate ops ceased @						Somerset WL incr. from 99.18 yesterday @ 0600 to 99.33 @ 0730 today; 99.5 tomorrow if no gate ops.; Wivenhoe currently	Twin Bridges, Savages Crossing and Colleges Crossing may still be affected by flows from the Lockyer.
24/12/2010	1330	W19		Hydro	1300		3	zero			4,200Ml through hydro & reg.; 15,00Ml expected just from upper Brisbane R. in next few days; WL cont. to fall in Lock. Ck; Small	Twin Bridges, Savages Crossing and Colleges Crossing remain impacted by Wivenhoe releases and Lockyer and local
25/12/2010	0930	W20								10-20 over last 24 hrs	rises expected in Bremer & Warrill systems; WL in Wivenhoe incr. to 67.28 @ 600	runoff. Burtons and Kholo Bridges would be currently unaffected. Kholo will no doubt still be closed by Council regarding repairs.
												Crossings downstream of the dam are currently impacted primarily by non-controlled river flows only (no RG releases from Wivenhoe). Lockyer Creek outflows into the Brisbane River are currently in the order of
											BOM issued severe weather warning @ 0 445; Somerset WL incr. to 99.46 (0.46m> FSL) - 2 regs. To be opened today (140m^3/s); Wivenhoe WL incr. to 67.37 (0.37m > FSL); RG to be opened later today following discussions with local authorities; further gate	60m^3/s. Twin Bridges, Savages and Colleges Crossings will be inundated but the plan is to release around
26/12/2010	0800	W21								Rel. minor over last 24 hrs.	ops may be necessary if rainfall incr. river levels	300-350m^3/s depending on flows downstream so as to not impact Burtons Bridge.
											BOM continues with severe weather warning & widespread rainfall over dam CA's; 2 regs. @ Somerset giving 139m^3/s release, lake	
											contd. To rise to 99.6 (0.6m> FSL); RG ops @ Wivenhoe commenced yesterday @ 0900, WL contd. To rise to 67.57 (0.57m > FSL);Q|Wivenhoe reduced o/n because of incr. Q|Lockyer to ensure Burtons Bridge remains open; RG @ Wivenhoe wound back as	Twin Bridges, Savages Crossing and Colleges Crossing currently closed; Burtons Bridge is currently open,
											Q|Lockyer incr. > 250m^3/s; Q|Lockyer expected to peak>500m^3/s later today/tomorrow - will innundate Burtons Bridge;When this	but will be closed later today/tomorrow; Kholo Bridge remains unserviceable due to flood damage; No current
27/12/2010	0800	W22								40-50 over dam CA last 24 hrs.	happens, Q|Wivenhoe will be incr. to get WL back to FSL; further gate ops may be necessary in coming days	expectation that either Mt Crosby Weir Bridge or Fernvale Bridge will be impacted by the current event; An
												updated estimate of the time of closure of Burtons Bridge this afternoon will be provided to Council
											Sever weather warning no longer current; Somerset release through regs' ~ 208m^3/s;WL|Somerset incr. to 99.96 (0.96m>FSL) -	RG discharge dropped back to 46m3/s to ensure Burtons Bridge can remain open; Twin Bridges, Savages
					347 (initially) then back to						inflows decreasing; RG opening dependent on Q|Lockyer; Wivenhoe WL currently @ 68.55 (1.55m > FSL); Inflows to Wivenhoe	Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge are currently closed; No current expectation
28/12/2010	0700	W23			46					20-40 over dam CA's ;ast 24 hrs	decr.	that either Mt Crosby Weir Bridge or Fernvale Bridge will be impacted by the current event; Lockyer Creek
												outflows being closely monitored and may come close to impacting upon the Mt Crosby Weir Bridge;
												England Creek access is not impacted yet
									69.26 (@ 0600) - aim is to return to FSL by 2/1/2011		Further 2 sluices opened @ Somerset; WL @ Somerset 99.83 & falling slowly, 2 sluices to be closed @ 1200; Intended to incr.	Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge are currently closed;
29/12/2010	0700	W24							69.33 peak	No/very little in last 24 hrs.	Wivenhoe releases so Q|Wivenhoe+Q|Lockyer maintained @ 1,600m^3/s (similar Q to mid Oct &mid Dec 2010)	no current expectation that Mt Crosby Weir Bridge or Fernvale Bridge will be impacted by current event. At
									yesterday @ 1200			this stage, estimated that the flow at Burtons Bridge will fall below the bridge deck on Sunday morning.
					Wivenhoe+Lockyer =				(2.3m > FSL) 69.07		2 sluices @ Somerset remain open (405m^3/s) - FSL expected by 6/1/2011; RG closing sequence expected to start mid tomorrow-	
30/12/2010	0700	W25			1,600m^3/s				this am	No/very little in last 24 hrs.	RG expected to be closed on 2/1/2011	Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge are currently closed
					Wivenhoe+Lockyer =							Twin Bridges, Savages Crossing, Colleges Crossing, Burtons Bridge and Kholo Bridge are currently closed
31/12/2010	0700	W26 W27			1,600m^3/s				68.4 @ 0500	No/very little in last 24 hrs.	WL @ Somerset 99.01 (falling from peak of 100.0 - 1200 28/12/2010) - currently 2 regs;	due to inundation Not included
												Lockyer Ck peak of about 700m3/s Friday afternoon. This will take out Twin Bridges and nearly inundate
					Commence opening RG @ 1800 & ramp up to					20-30 widespread with up to 50 on dam	Somerset @ 99.34 (0.34m > FSL) & rising slowly; Wivenhoe 67.31 (0.31m > FSL) & rising slowly; Gates will be opened in next 24	Savages Crossing. Colleges Crossing could be taken out by a combined Lockyer and local runoff. Current
6/01/2011	1200	W28			300m^3/s by 2200				67.31 @ 0700	CA's	hrs; Lockyer Ck peak of about 100m3/s Friday afternoon	strategy is to keep Burton Bridge free. Gate release would limit mid-Brisbane Q to 400m^3/s ((Burtons capacity 450m^3/s).
											100-200mm rain forecast for SE Qld next 5 days; Somerset WL @ 99.58 (0.59m > FSL) rising slowly - currently releasing 35m^3/s;	Q|Lockyer may be of sufficient magnitude to inundate Burtons Bridge; Somerset Regional Council, Ipswich City Council and Brisbane City Council have been advised of the potential for gate operations during the next
											Wivenhoe WL @ 67.64 (0.64m > FSL & > gate trigger level) rising slowly; u/s of dam river levels peaked @ Linville and Gregors Ck	24 hours; The relatively high Lockyer flows will adversely impact upon Twin Bridges, Savages Crossing, and
										30-50 with isolated falls up to 75;	gauges; A peak of about 470 cumecs is expected from Lockyer Creek by mid-afternoon; Wivenhoe gate releases will occur after the	Colleges Crossing for several days, may also later impact upon Burtons Bridge & Kholo Bridge; not expected
7/01/2011	0700	W29							67.64 @ 0600	signif. Rain on Lock. Ck.	impact of Lockyer flows on Burtons Bridge has been ascertained and flood levels in the lower Lockyer subside Q|Wivenhoe may be as high as 1,200m^3/s	to be any adverse impacts upon Fernvale Bridge or Mt Crosby Weir Bridge; Councils have been advised of this strategy and are contacting residents
					Release started 1500 to be incr. slowly to ~1,200m^3/s							
7/01/2011	1500	W30			by 1400 tomorrow						Somerset releasing 35m^3/s; 50,000Ml into Somerset; Gate release @ Wivenhoe - strategy to be reviewed tomorrow (dependent on further rainfall)	All of the crossings downstream of Wivenhoe with the exception of Fernvale and Mt Crosby Weir Bridge will be adversely impacted; Councils have been advised of this strategy and are contacting residents
											Somerset WL @100.42 & rising (0500) - 1 open sluice gate; Water temp. held in Wivenhoe - strategy may need to be reviewed	The projected Wivenhoe release of 1,200m3/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
										Widespread rain 20-40 over dam CA's	(depend. On confidence in estimates of Wivenhoe inflows); Intended to ramp Wivenhoe up to 1,200m^3/s by 1200 - likely to be	Colleges Crossing) will be adversely impacted for several days. At this stage Fernvale and Mt Crosby Weir
8/01/2011	0700	W31			~890		All (5) RG's open		68.45 @ 0600 rising steadily	since 0900 yesterday; further high rainfall predicted for next 4 days	incr. next week; since 2/1/2011, ~200,000Ml has flowed into Wivenhoe (incl. Somerset releases), further 180,000Ml expected based on recorded rainfall; ~ 50,000Ml released via reg. & hydro (@50m^3/s)	Bridge are not expected to be affected but they could potentially be affected if the predicted rainfall totals eventuate.
												The current Wivenhoe Dam release 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
									Currently 68.58	For last 12 hrs. av. of 40 for Somerset	Somerset currently @ 100.27 - 60mm rain in last 2 hrs will cause significant inflow later today; 405m^3/s being released into	Colleges Crossing) will be adversely impacted until at least Wednesday 12 January. At this stage Fernvale
9/01/2011	0700	W32				1,343			(falling slowly)	CA & <10 for Wivenhoe CA	Wivenhoe; maintain combined Q of 1,600m^3/s in mid-Brisbane R.	and Mt Crosby Weir Bridge are not expected to be affected, but this may be revised if the predicted rainfall
		W33									Not included	totals eventuate and higher releases from Wivenhoe Dam are considered necessary. Cncls advised of Wivenhoe op. strategy
											Somerset @ 101.68 rising quickly; 5 sluice gates open releasing ~1,100m^3/s; WL expected to reach 103.5 by am 11/1/2011; River	
										Very heavy rainfall -totals for 24 hrs	levels u/s Wivenhoe rising fast; Q|Brisbane R. @ Gregors Ck @ 6,700m^3/s; Wivenhoe expected to reach 73.0 by 11/1/2011 - need	The projected Wivenhoe Dam releases combined with Lockyer flows and local runoff will mean that all
										100 - 300; Severe weather warning for	to incr. Q|Wivenhoe am of 10/1/2011 - crank up to 2,600m^3/s by am 11/1/2011; Attempt to keep combined Q < 3,500m^3/s - <	crossings downstream of Wivenhoe (Twin Bridges, Fernvale, Savages Crossing, Burtons Bridge, Kholo
9/01/2011	2100	W34				1,400			Currently @ 69.1;	heavy rainfall	limit of urban damages in the City	Bridge, Mt Crosby Weir and Colleges Crossing) will be adversely impacted until at least Saturday 15 January
		W35									Not included	in varying degrees; Water levels in the lower Brisbane R will be impacted by the combined flows of Lockyer
		W36									Not included	Ck, Bremer River, local runoff and releases from Wivenhoe Dam
		W37									Not included	
										20-60 last 12 hrs in Lockyer CA; 30 in Bremer R.; Isol. Falls of 125 in upper		The projected Wivenhoe Dam releases combined with Lockyer Creek flows and local runoff will mean that all
										Brisbane R. & widespread falls of 40 -	Somerset WL @ 103.27 & falling slowly ; currently 1,400m^3/s released to Wivenhoe- to be reduced to 500m^3/s later in the day - to	crossings downstream of Wivenhoe (Twin Bridges, Fernvale, Savages Crossing, Burtons Bridge, Kholo
					2,750 since 1930 on		All (5)		73.51 rising @	70 in Somerset CA	ensure flood mitigation of Somerset & Wivenhoe are maximized; BOM provided advice on flash flooding in Lockyer Ck.; WL in	Bridge, Mt Crosby Weir and Colleges Crossing) will be adversely impacted; Water levels in the lower
11/01/2011	0630	W38			10/1/2011		gates		25mm/hr.		Wivenhoe will reach 74 by evening; May need to increase Q further - may result inQ|lower Brisbane R. >5,000m^3/s	Brisbane River will be impacted by the combined flows of Lockyer Creek, Bremer River, local runoff and releases from Wivenhoe Dam.
											Somerset @ 103.3 & rising; Outflows into the Brisbane River from both Lockyer Creek and the Bremer River are also increasing; If	
											no further rain, can hold @ 74.8 - aim is to prevent fuse plug triggering, situation assessed every 3 hrs.; Heavy rainfall continues	
									74.1 (179.5% cap.)		throughout South East Queensland and the situation could deteriorate over the next 24 hours. The flood operation centre will	
11/01/2011	1200	W39				3,970			rising @ 25mm/hr.		continue to monitor the situation and provide situation reports every six hours until the situation stabilizes.	

Record of teleconference 12 January 2011

Key attendees:

Mick Young, Director General, Queensland Health

Dr Jeanette Young, Chief Health Officer, Queensland Health

Sophie Dwyer, Executive Director , Queensland Health

Andrew Wilson, Queensland Health

Arran Hieatt, Senior Environmental Health Scientist, Queensland Health

John Bradley, Director General, Department of Environment and Resource Management

Dr David Cunliffe, SA Department of Health

Dr Dan Deere, WaterFutures

Barry Dennien, CEO, SEQ Water Grid Manager

Dan Spiller, Director Operations, SEQ Water Grid Manager

Jim Pruss, Executive General Manager, Seqwater

Stan Stevenson, Seqwater

Arran Canning, Seqwater

Brett Myatt, Seqwater

Jeff Browne, Linkwater

Summary of outcomes

It was agreed by the Water Grid, Queensland Health and Department of Environment and Resource Management that:

- The primary objective is to maintain supply within the connected area. Production at the Mt Crosby WTP will at least match demand, subject to operational constraints.
- The secondary objective is to maintain drinking water quality, minimising public health risks. However, production will not cease due to treated water quality issues.
- For the duration of the current flood event, the operating rules for the Mt Crosby water treatment plants are:
    - Minimum production of 150 ML/day
    - Achieve and maintain stable operation
    - Shutdown for operational reasons only, not treated water quality

- Target of below 1 NTU in treated water
- Periods of up to 2 NTU in treated water tolerable
- Disinfection residual maintained at standard operating procedure
- Note some discolouration may occur

Queensland Health advised that:

- Based on these operating rules, water supplied from the Mt Crosby water treatment plants is considered to have taken all necessary precautions to minimise the public health risk.
- Further advice should be sought from Queensland Health should there be a prolonged trend to above 1.5 NTU in treated water. Production should not cease while this advice is sought. An evaluation will be made at that time to determine if water of above 2 NTU may still be safe to supply.

Government of South Australia
SA Health

Public Health
Citi Centre Building
11 Hindmarsh Square
Adelaide SA 5000
PO Box 6, Rundle Mall
SA 5000
DX 243
Tel (08) 8226 7100
Fax (08) 8226 7102
www.health.sa.gov.au

13 January 2011

Dr Jeanette Young
Chief Health Officer
Queensland Health
147-163 Charlotte Street
Brisbane
Queensland 4000

Dear Dr Young

Re: Operation of Mt Crosby Water Treatment Plant

Based on the information provided in yesterday's meetings I consider that a target upper turbidity limit of 1NTU combined with existing disinfection procedures at the Mount Crosby Water Treatment Plant should produce safe drinking water. In addition an increase to 2NTU for periods of time can be accepted

This assessment is based on the following:

- Turbidity limits applied to filtered water in Australia are based on USEPA standards. These are intended to ensure a minimum 3 log reduction of *Cryptosporidium.* The turbidity in the source water is currently over 1300NTU and may reach 1700NTU or even higher. Achieving 1-2 NTU in filtered water will provide a 3 log reduction in turbidity indicating effective filtration and substantial removal of *Cryptosporidium.*
- Although recent practice has been to move to turbidity limits of 0.3NTU in filtered water (based on the latest USEPA standards) in previous years turbidity targets of 0.5NTU-1NTU with higher upper limits were commonplace in Australia with no evidence of associated drinking water outbreaks.
- *Giardia* reductions are expected to exceed those of *Cryptosporidium.* Disinfection will also provide a further partial barrier to *Giardia* which is not as resistant to chlorine as *Cryptosporidium*
- The free chlorine concentrations and minimum contact times are sufficient to inactivate enteric viruses and bacteria
- Although there has been reported contamination of the Brisbane River this is likely to have been greatly diluted by the massive volumes of water currently in the River and its tributaries

In summary, the water produced by the plant under the agreed operating conditions should be safe. While turbidity should be kept as low as possible, subject to practical constraints, providing it is maintained with the identified limits public advice to boil the water is not required. This situation should be reviewed if the 1NTU target is consistently exceeded or if the upper limit of 2NTU is exceeded for more than 30-60 minutes.

I hope that this advice is useful. If you need further information or clarification please contact me again.

Yours sincerely

[redacted]

Dr David Cunliffe
Principal Water Quality Adviser
SA Department of Health

Water Futures

Dr Jeanette Young
Chief Health Officer
Queensland Health
147-163 Charlotte Street
Brisbane
Queensland 4000

13th January 2011

Dear Dr Young,

Re: Public health risks associated with the Mt Crosby Water Treatment Plant.

It is my understanding that at the present time the raw water being abstracted into the Mt Crosby Water Treatment Plant is of the order 1,300 NTU and is anticipated to reach 1,700 NTU. I understand that the filtered water turbidity is approaching 1 NTU and may soon reach 2 NTU. I understand that the chlorination process is functioning appropriately and providing a free chlorine dose of over 15 mg•min/L.

In my best professional judgement, the current level of risk to consumers of drinking water supplied by the Mt Crosby Water Treatment Plant is not sufficient to warrant a boil water order for the following reasons. The following set out my reasoning.

All relevant viruses and bacteria will be adequately inactivated by the free chlorine disinfection process. Filtering to below or close to 2 NTU will adequately remove particulates and the disinfection will be effective.

Giardia is relatively rapidly inactivated by natural processes in SEQ summer temperatures and is somewhat susceptive to chlorine and is relatively large and quite well removed by filtration even at 2 NTU.

The only hazard of any potential significance is *Cryptosporidium*.

There are two elevated risk conditions for *Cryptosporidium*:

- The high rainfall causing failure of manure and sewage retention and treatment systems so that elevated *Cryptosporidium* will be released into waterways rather than retained in pondages and sewerage systems.
- The elevated filtered water turbidities implying less than optimal removal of oocysts.

However, all other risk factors are low. For instance:

- *Cryptosporidium* is easier to remove in turbid waters, all other things being equal, since there is more particulate matter to assist in floc formation and oocysts sedimentation. Therefore, dropping turbidity from over 1,000 down to 1 NTU demonstrates extensive particulate removal and much *Cryptosporidium* removal would be achieved. It would be reasonable to expect at least two $\log_{10}$ reduction across the plant under these circumstances and potentially three $\log_{10}$. There is a reasonable correlation between turbidity removal and oocyst removal (see attached paper, noting Figure 4, page 7).
- There are many water filtration plants across Australia that have 1 NTU turbidity as their target and a value up to 2 NTU as their critical limit for operation. Detectable waterborne disease is not seen in these townships.

- The driver for tighter filtered water turbidities, such as 0.3 NTU, is to meet long-term endemic disease burden targets of around 1 in 10,000 infections or 1 in one million DALYs per person per year, not to avoid outbreaks. A 1 NTU target and 2 NTU short-term limit is not uncommon historically in Australia and is commonly practiced in many Australian towns and does seem to be able to prevent short-term outbreaks.
- Dilution factors are high during these very large flood events leading to levels of contamination that would not be at their worst case. The outer catchment with relatively low population densities is probably contributing most of the water. Risks are much lower than a situation in which a flash flood occurs in a small, highly polluted catchment.
- *Cryptosporidium* is appreciably inactivated by natural processes in SEQ summer temperatures and only the last weeks of pathogen shedding would be relevant. Material deposited weeks or months ago would not be relevant.
- Almost all outbreaks of waterborne cryptosporidiosis occur in lower temperature conditions, such as Canada, northern Europe or the northern North American states, and typically in early Spring, e.g. after snow melt during lambing and calving seasons. This is not comparable to the situation in SEQ during mid-summer.
- It is not a mass calving or lambing season so we are not likely to be seeing high numbers of human-infectious strains *Cryptosporidium* (i.e. certain genotypes of *C. parvum*) that are seen in other environments or in early Spring.
- We are probably just prior to the annual swimming pool-related outbreak peak that occurs in humans around February and leads to a peak source concentrations in sewage of around two $\log_{10}$ above normal background, so we are not in the highest risk period for *C. hominis* and human-derived *C. parvum*.

It is plausible that levels of *Cryptosporidium* passing through the filtration plant are higher than those levels required to achieve a 1 in one million DALY disease burden, as per the long term risk targets used for setting normal treatment requirements. However, it is not likely that these levels are high enough to lead to detectable increases in notified cases of cryptosporidiosis. Therefore, issuing a boil order would be unnecessary from a utility and government reputation perspective. Furthermore, from a public health and public convenience perspective, cryptosporidiosis is a self-limiting disease in the Australian context and issuing a boil water order would be a disproportionate response.

In summary, given the above information, my perception is that issuing a boil water order for the Mt Crosby water supply at this time would not be warranted on either public health grounds or in order to protect the reputation or the utility or government at large. I do not foresee a waterborne disease outbreak eventuating under the current circumstances. The situation should be reviewed should turbidities remain consistently elevated above 1 NTU, e.g. for more than several hours, or rise above 2 NTU for more than 1 hour.

Yours sincerely

[redacted]

Dan Deere PhD

Consultant, Water Futures Pty Ltd
Visiting Fellow, Centre for Water Research, University of New South Wales
Member NSW Health *Cryptosporidium* and *Giardia* Testing Independent Expert Panel
Chair NATA *Cryptosporidium* and *Giardia* Proficiency Testing Program Technical Group
Lead Auditor and Technical Professional: Water Quality, Water Licensing and Technical Services Panel, Independent Pricing and Regulatory Tribunal, NSW Government
Lead Auditor, Drinking Water Quality Management Systems: ID 022400, RABQSA

United States
Environmental Protection
Agency

National Risk Management
Research Laboratory
Cincinnati, OH 45268

Research and Development

EPA/600/SR-97/025 July 1997

EPA

Project Summary

Removal of Cryptosporidium and Giardia through Conventional Water Treatment and Direct Filtration

Eva C. Nieminski

Pilot- and full-scale evaluations of Giardia and Cryptosporidium cyst removals through direct filtration and conventional water treatment were conducted by the Utah Department of Environmental Quality. Cysts were seeded continuously in a step dose at a 0.5 gpm pilot plant, and in a spike at a 900 gpm full-scale plant; both plants were operated under conventional treatment and direct filtration regime. The results of 20 pilot-scale cyst seeding trials and 8 full-scale trials indicated that source water quality (turbidity and algal content), as well as treatment effectiveness in removing turbidity, controlled the removal of seeded Giardia and Cryptosporidium. Changes in source water quality influenced removal rates more than the mode of treatment. Higher removal rates were consistently observed for Giardia cysts (3.3-log) than for Cryptosporidium oocysts (3.0-log). A high correlation was found between cyst removal rates and removal of the respective size particles; poorer correlation existed between cysts and turbidity removal, while no significant correlation was established between the removals of cysts and heterotrophic bacteria.

To assure that the best available detection method was used in enumeration of the cysts in raw and treated water, two versions of the immunofluorescence staining method were evaluated for their efficiencies in detecting Giardia cysts and Cryptosporidium oocysts seeded at known concentrations in water: (1) the ASTM method for detection of Giardia cysts and Cryptosporidium oocysts in low-turbidity water and (2) a modified Sauch's procedure employing sampling by 2.0 μm membrane filters, Percoll/Percoll step gradient flotation, and immunofluorescence staining on 2.0 μm porosity polycarbonate membrane filters. The second method was selected, since it was characterized by higher recovery rates in all three types of waters tested: raw surface water, partially treated water from a flocculation basin, and filtered water. Cyst and oocyst recovery efficiencies decreased with increasing water turbidity regardless of the method used. Recoveries of seeded Giardia cysts exceeded those of Cryptosporidium oocysts in all types of water sampled.

This Project Summary was developed by EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at the back).

Introduction

Problem Statement and Study Objectives

The Surface Water Treatment Rule requires all public water system treating surface water to effectively remove enteric viruses and Giardia cysts. The removal of microbial contaminants by filtration is being re-evaluated by the U.S. Environmental Protection Agency in conjunction with

the publication of the proposed Interim Enhanced Surface Water Treatment Rule. While the removal requirements for Giardia may be increased depending on cyst concentration in raw water, additional, more stringent regulations may be developed to control Cryptosporidium in response to health concerns surrounding this pathogen. As new rules are being developed, allowable filtration credits should be revisited and possibly revised. Also, as the analytical methods for detection of Giardia and Cryptosporidium cysts in water are being improved and new methods developed, surrogate water quality parameters should be established to allow for an accurate, economical, and practical evaluation of cyst removal effectiveness through treatment.

The project objectives were designed to address some of the questions associated with the development of the new regulations. The specific tasks were to examine the most critical relationships in removal of Giardia and Cryptosporidium by comparing the effectiveness of Giardia and Cryptosporidium removal through conventional treatment with that resulting from direct filtration, the effectiveness of Giardia removal with Cryptosporidium removal, and the effectiveness of Giardia and Cryptosporidium removals with the removals of turbidity, cyst-size particles, and heterotrophic bacteria.

To enable accurate evaluation of Giardia and Cryptosporidium removal efficiency in water treatment processes, a reliable method for measuring the concentration of these pathogens in water must be used.

Therefore, another objective of this project was to select an analytical method capable of measuring the concentration of Giardia cysts and Cryptosporidium oocysts that would be accurate, reliable, flexible, and verifiable, and could be applied to measuring the cyst/oocyst removal performance of water treatment processes.

Procedure

Evaluation of Analytical Methods

Two methods for finding Giardia cysts and Cryptosporidium oocysts in water were compared. Both methods follow flotation steps and immunofluorescence staining. These methods were 1) The American Society for Testing and Materials (ASTM) method and 2) another immunofluorescence antibody (IFA) method, referred to as the alternate method, and applied principally by Ongerth and Stibbs. The objective was to evaluate the two IFA methods using three factors as criteria for comparison. First, the applicability to cyst seeding experiments in full- or pilot-scale water treatment plant was evaluated. Second, the applicability of the methods to cyst detection in environmental water samples of varying water quality was assessed. The third criterion was the economics associated with the two methods. The superior method was then used in the cyst seeding experiments in the pilot- and in the full-scale treatment plant.

The ASTM method involves sampling 100 L or more of water through a 1.0 µm porosity polypropylene yarn cartridge filter, extracting the particulates from the cartridge filter, and concentrating the extracted particulates by centrifugation. The concentrated particulates are then processed to selectively concentrate cysts and oocysts by flotation in 50 mL tubes on a Percoll/sucrose gradient. The particulates recovered at the interface of the Percoll/sucrose are stained with fluorescent-tagged antibodies on 25 mm diameter, 0.2 µm pore size cellulose acetate filters. After mounting on slides, the membrane filters are scanned using a UV epifluorescent microscope for objects of the right size, shape, and fluorescence characteristic as Giardia cysts and Cryptosporidium oocysts. On finding such objects the microscope optics are switched to phase contrast to look for internal characteristics of the organisms.

The alternate method involves filtration of the water sample through either a 293 or 142 mm diameter, 2.0 µm pore-size polycarbonate membrane filter; recovery of particles from the filter by rinsing and scraping them from the surface; and concentration of the particulates by centrifugation. The cysts and oocysts are then selectively concentrated from other particulates by flotation in 15 mL tubes on a two-step Percoll/Percoll gradient, followed by IFA staining on 13 mm diameter, 2.0 µm pore-size polycarbonate membrane filters. After mounting on slides, the membrane filters are scanned using an UV epifluorescent microscope for objects of the right size, shape, and fluorescence as Giardia cysts and Cryptosporidium oocysts. Confirmation of internal structures is not performed in this method.

Cyst Seeding and Sampling Procedures

Monitoring of raw and filtered water quality was conducted throughout the seeding trials. In addition to monitoring the major water quality parameters, particle counting in four size ranges (2-4 µm, 4-7 µm, 7-14 µm, and 14-25 µm), was performed during the seeding trials. Raw water sources were sampled and analyzed for background count of Giardia and Cryptosporidium, naturally occurring in the two watersheds.

Inactivated, formalin-fixed Giardia lamblia cysts and Cryptosporidium parvum oocysts were used in seeding experiments in a pilot- and a full-scale treatment plant. A total of 20 trials were conducted in the pilot plant, and 8 trials in the full-scale plant, alternating between conventional treatment and direct filtration.

The first site for testing was a pilot plant residing at the 180 MGD Jordan Valley Water Treatment Plant in Bluffdale, UT. The pilot plant simulated the actual, conventional treatment plant, treating Provo River water downstream from Deer Creek Reservoir. Water flow rate was maintained at 0.5 gpm. Alum was used as a coagulant, at dosages established through jar testing. After each seeding trial using the conventional treatment train, the water was re-routed through the direct filtration train for seeding trials the following day. Alternating between the conventional treatment and direct filtration allowed for a comparison of treatment effectiveness of the water of comparable quality.

The second site was a 900 gpm Huntington Water Treatment Plant, situated near Price, UT. The plant was operated at 600 gpm for cyst seeding experiments. Polyaluminum chloride was used as a coagulant. The Huntington Plant was operated by conventional treatment during the first four seeding trials. After converting the plant to direct filtration mode, another four seeding trials were performed.

Detection of Giardia and Cryptosporidium Cysts

The alternate IFA method for sampling, processing, and detection of Giardia and Cryptosporidium cysts was chosen for the seeding trials, based on results of the method comparison. Samples were collected by membrane filtration through 2.0 µm porosity, 293 mm diameter polycarbonate membrane filters, processed on Percoll/Percoll step gradient in 15 mL centrifuge tubes, stained on 2.0 µm porosity, 13 mm diameter polycarbonate membrane filters, and enumerated under an epifluorescent microscope.

In calculations of cyst removal through treatment, a direct ratio of the difference between the cysts seeded and the cysts detected was calculated for each run in the pilot plant. Two cyst removal rates were determined based on two different

initial cyst concentrations: concentration in the seeding solution prior to being pumped into the raw influent, and concentration in the seeded influent already mixed with the raw influent. The cyst removal rates, achieved in the full-scale plant, were also calculated as relative differences between the influent and effluent concentrations, but the influent concentrations were adjusted for dilution of cysts in respective basins.

Three conservative assumptions were made for data interpretation in calculations of the removal rates, both in the pilot- and full-scale plant. First, the removals based on the cyst concentrations found in the seeded influent were used in data analysis. Otherwise, the higher cyst concentrations found in the seeding solutions would result in higher removal rates reported. Secondly, cyst removal rates were calculated only for trials in which cysts were detected in both influent and effluent samples. Otherwise, calculations of removals during trials when cysts were not detected in the effluent would be based on very low detection limits, and therefore would result in higher removal rates. Finally, no adjustments were made for the differences in cyst recovery efficiencies in turbid raw influent samples versus clean filtered effluent samples. Adjusting for low recovery rates in influent samples would also result in higher removal rates being calculated.

Results and Discussion

Evaluation of Two IFA Methods for Detection of Giardia and Cryptosporidium

The effectiveness of cyst recovery from spiked water samples was impacted primarily by the number of analytical steps involved in the cyst detection. Both IFA methods were characterized by low recovery efficiency, when seeded raw water samples were filtered, then concentrated, transferred to gradients, stained, and enumerated. Higher recovery rates were observed in detecting Giardia cysts when the alternate method was employed (Figure 1). In spiked raw water samples, an average 12% of the seeded Giardia cysts were detected by the ASTM method, while the alternate method was characterized by an average 49% Giardia cysts recovery efficiency. Recovery rates for Cryptosporidium oocysts in spiked raw water averaged 8% detected by the ASTM method and 9% detected by the alternate IFA method. The recovery rates in filtered water were 14% and 52% for Giardia and 12% and 12% for Cryptosporidium, using the ASTM, and the alternate method, respectively. In flocculated water samples, an average 22% of Giardia cysts were detected using the ASTM method and 40% using the alternate method. The recoveries of Cryptosporidium in flocculated water were 7% with the ASTM method and 1% with the alternate method.

Losses were demonstrated to occur due to incomplete yarn cartridge filtration. In sampling raw water, 5% Giardia cysts and 6% Cryptosporidium oocysts were captured from the yarn cartridge filtrate by passing it through a 293 mm diameter 2.0 µm pore size Nuclepore membrane filter. An average 7% of Giardia and 8% of Cryptosporidium were recovered from membrane filters after cartridge filtration.

The sampling step resulted in a high loss of seeded Giardia cysts and Cryptosporidium oocysts. When the sampling step was eliminated and cysts were seeded directly onto flotation gradients, the resulting recovery rates increased dramatically (Figure 2). An average 53% of Giardia cysts and 27% of Cryptosporidium oocysts was detected from seeded Percoll/sucrose gradients used in the ASTM method. The alternate method employing Percoll/Percoll flotation, yielded recoveries of 82% for seeded Giardia cysts and 69% for Cryptosporidium oocysts.

The highest cyst recovery rates were reported when both sampling and flotation steps were avoided and spiked with Giardia cysts and Cryptosporidium oocysts samples were stained directly onto the membrane filters used for IFA assay. The ASTM method resulted in recoveries of 72% and 56% for Giardia cysts and Crypto-

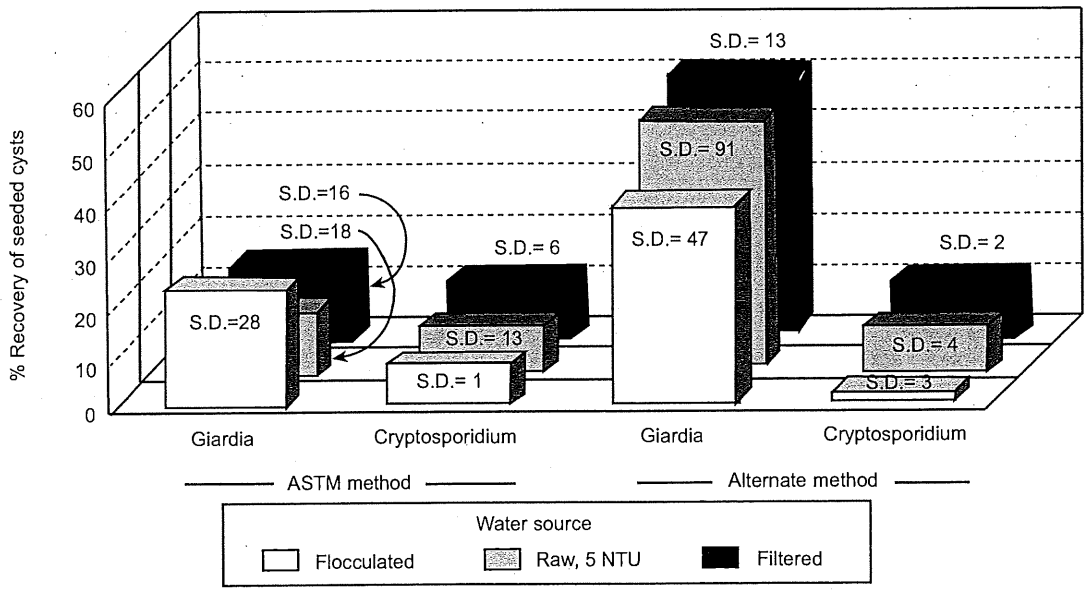


Figure 1. Water quality vs. recovery of cysts seeded into water.

sporidium oocysts, respectively. The alternate method was characterized by an average recovery of 86% for Giardia cysts and 78% for Cryptosporidium oocysts.

Testing of cyst recovery efficiencies from raw, flocculated, and filtered water indicated that any increase in water turbidity, whether due to presence of algae or to that of chemical floc, resulted in a significant decrease in parasite recoveries. The results also indicate both methods were more effective in detecting seeded Giardia cysts than Cryptosporidium oocysts.

The results of testing the processing and detection methods indicated that recoveries of cysts were substantially and consistently higher with the alternate method, employing Percoll/Percoll step gradient combined with IFA on 13 mm polycarbonate filters, than with the ASTM method, in all three types of water. Consequently, the alternate method was selected as the method of choice for seeding experiments. Added support for this choice was provided by a comparison of the qualitative advantages and disadvantages of the two methods. In summary, the main advantage of the ASTM method was its ability to confirm presumptive cysts and oocysts. The most serious disadvantages of this method were its relatively high cost and the amount of time required to complete it. The alternate method, on the other hand, was found to be less expensive and required less time to complete than the ASTM method. Attractive features of the membrane filter sampling method include relatively small sample volumes, flexibility, and compatibility with frequent seeded controls. The major limitation of the alternate method was its lack of a confirmation step.

Experience with detecting Giardia cysts and Cryptosporidium oocysts in the waters tested during this study and the results generated during this part of the study, indicate that the alternate method be recommended to evaluate water treatment processes that use high concentrations of seeded parasites in which algae, occurring in concentrations much lower than the seeded parasites, are not of concern. The alternate method can be considered for analysis of environmental samples, particularly for low-turbidity waters. When high water turbidity requires higher-volume samples to be collected and examined, and when cross-reacting algae should be differentiated from the organisms of interest, the ASTM method should be used with environmental samples.

The results of this stage of the study have indicated Giardia cysts and especially, Cryptosporidium oocysts are lost during the gradient flotation steps of both methods. Therefore, it is recommended that the flotation step should be avoided, whenever possible when processing treated (filtered) water samples.

A hybrid method, combining the most efficient steps from the two methods, should be investigated. Such a hybrid method should include sampling by membrane filtration only for low-turbidity waters. High-turbidity waters should be sampled by the ASTM cartridge sampling method. Since the Percoll/Percoll step gradient in 15 mL tubes is more economical and had higher cyst recovery than the Percoll/sucrose gradient, it should be used. Staining on cellulose acetate membranes, as opposed to polycarbonate membranes, allows the demonstration of the internal morphological characteristics of the organisms. Consequently, staining on cellulose acetate membranes should be incorporated into a hybrid method. Elvanol mounting medium should not be incorporated into a hybrid method. As a water-based medium, it is not compatible with the dehydrated cellulose acetate membrane and does not allow the membrane to be cleared so that the cyst's internal structure can be visualized by contrast microscopy.

Removal of Giardia and Cryptosporidium through Conventional Water Treatment and Direct Filtration

A general observation about removal of seeded Giardia and Cryptosporidium was made that was valid in both pilot- and full-scale plant throughout the entire seeding studies. Consistent removal rates of Giardia and Cryptosporidium were achieved, when the treatment plant was producing water of consistently low turbidity (0.1-0.2

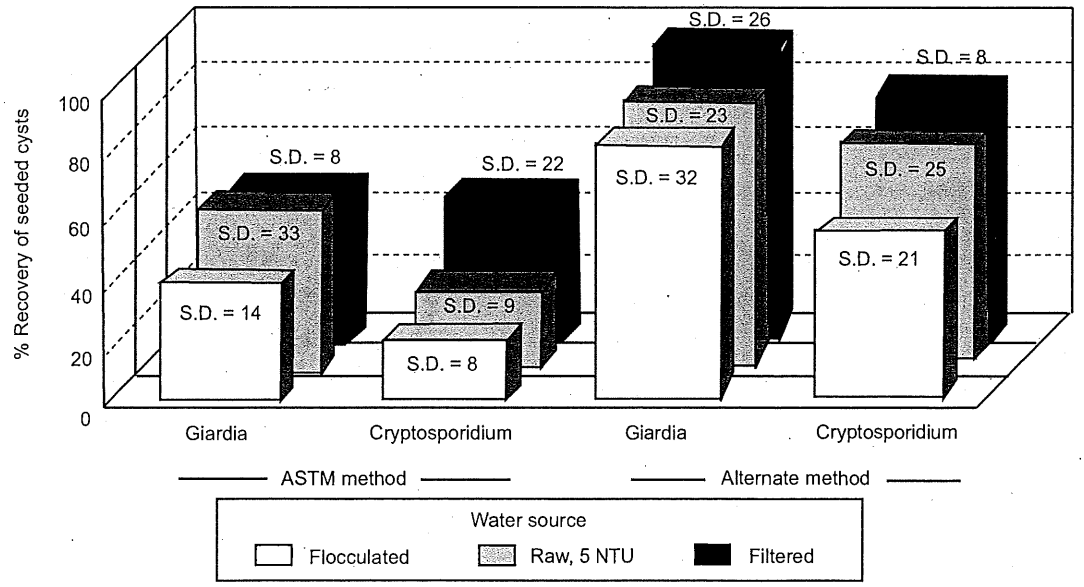


Figure 2. Water quality vs. recovery of cysts seeded into flotation gradients.

NTU). As soon as the plant's performance changed, and resulting filtered water turbidity fluctuated, a high variability in cyst concentrations was detected in collected samples.

Removal of Cryptosporidium was compared with removal of Giardia by both methods of treatment, conventional and direct filtration, at both the full-scale plant, and the pilot plant. Trials at the full-scale plant were impacted by the change in seasonal water temperature and algal content. Because of the need for a construction to bypass the sedimentation basin, the first four trials by conventional treatment were conducted from June through September, while the four trials using direct filtration were conducted in November and December. Greater flexibility of the pilot plant allowed trials by both treatment methods to be conducted within one day of each other and enhanced not only the comparison between removal of Cryptosporidium with Giardia removal, but also the comparison between conventional treatment and direct filtration, as well as the comparison of cyst removal with removal of other water quality indicators.

Removal of Seeded Giardia and Cryptosporidium During Pilot-Scale Seeding Trials

Table 1 summarizes cyst removal rates calculated based on cyst concentration in seeded influent (after mixing the cysts with the incoming raw water). These removal rates, based on seeded influent concentration, were consistently lower than the removal rates based on cyst concentrations in seeding solution (indicating 99.99% or 4 log removal for both Giardia and Cryptosporidium regardless of the treatment mode). Calculations of cyst removals, observed during seeding experiments, can also be highly impacted by measurements of cyst concentration in filter effluent samples. When cysts were not detected in filter effluent samples, their concentration could be estimated based on analytical detection limits, determined for each sample batch. Such estimates lead to underestimation of cyst concentration in finished water samples and in turn, result in overestimation of calculated cyst removal rates.

Table 1. Removal of Giardia and Cryptosporidium Through Conventional Treatment and Direct Filtration at Jordan Valley

		Giardia removal		Cryptosporidium removal	
Trial No.	Date	Percent removal	Log removal	Percent removal	Log removal
Conventional treatment					
1-C	4/27/93	ND	ND	99.65	2.81
2-C	5/11/93	99.16	2.20	98.66	1.94
3-C	5/25/93	ND	ND	99.87	2.94
4-C	6/8/93	99.98	3.90	99.95	3.98
5-C	6/22/93	ND	ND	ND	ND
6-C	7/6/93	99.95	3.69	99.88	2.94
7-C	7/20/93	99.95	3.69	99.45	2.64
8-C	8/4/93	ND	ND	ND	ND
9-C	8/17/93	99.91	3.03	99.69	2.84
10-C	8/31/93	99.98	3.90	99.96	3.78
Average log removal			3.40		2.98
Standard deviation			0.67		0.64
Direct Filtration					
1-D	4/29/93	ND	ND	99.95	3.60
2-D	5/13/93	ND	ND	ND	ND
3-D	5/28/93	99.78	2.90	92.06	1.31
4-D	6/15/93	ND	ND	99.96	3.78
5-D	6/23/93	ND	ND	ND	ND
6-D	7/8/93	ND	ND	ND	ND
7-D	7/22/93	99.90	3.00	99.80	2.90
8-D	8/5/93	ND	ND	ND	ND
9-D	8/19/93	ND	ND	99.92	3.31
10-D	9/2/93	99.99	4.00	99.84	2.93
Average log removal			3.30		2.97
Standard deviation			0.77		0.89

ND indicates that cysts were not detected in filter effluent.

Removal of Seeded Giardia and Cryptosporidium During Full-Scale Seeding Trials

Table 2 presents a summary of results and removal rates calculated only from the trials where cysts were detected both in influent and effluent in the full-scale plant. Similar to the pilot-scale experiments, the removal of Giardia and Cryptosporidium can be overestimated when calculations are based on estimated effluent concentrations. Removal rates based on cyst concentrations detected and enumerated both in influent and effluent can be considered conservative.

Several factors impacted the results of the full-scale seeding trials, which made the comparison between conventional treatment and direct filtration more dependent on uncontrolled variables. Changes in raw water quality, observed from the time the plant was in operation by the conventional mode, compared to raw water quality during operation by the direct filtration mode, influenced removal rates more than the mode of treatment. The water was treated in the conventional plant during summer, when treatability was more difficult, while direct filtration was used in late fall, when the water was easier to treat. The presence of prolific algal blooms in samples collected during the first four trials, and the lack of algal content in samples from the last four trials, was another variable making the comparison of removal data problematic.

The results of the pilot-plant experiments indicate that Giardia cysts were removed more effectively than were Cryptosporidium oocysts. This observation was valid regardless of the treatment mode. The difference between log removals of Giardia and Cryptosporidium ranged from 0.1

Table 2. Removal of Giardia and Cryptosporidium Through Conventional Treatment and Direct Filtration at Huntington

		Giardia removal		Cryptosporidium removal	
Trial No.	Date	Percent removal	Log removal	Percent removal	Log removal
Conventional treatment					
1-C	6/11/92	99.95	3.7	99.60	2.78
2-C	7/7/92	ND	ND	99.05	2.07
3-C	8/5/92	ND	ND	97.87	1.89
4-C	10/6/92	99.66	2.82	ND	ND
Average log removal			3.26		2.25
Standard deviation			0.67		0.47
Direct Filtration					
1-D	11/10/92	99.97	3.87	99.75	2.88
2-D	11/20/92	ND	ND	99.82	2.92
3-D	12/8/92	99.97	3.87	99.37	2.57
4-D	12/22/92	ND	ND	ND	ND
Average log removal			3.87		2.79
Standard deviation			0.00		0.19

ND indicates that cysts were not detected in filter effluent.

to 1.1 log and averaged 0.3 log, as calculated across all seeding runs. The difference between cysts and oocysts removals were even more pronounced in the full-scale plant than those observed in the pilot plant.

Among the seeding trials, where the cysts were detected both in influent and effluent, the following average removals were calculated for the pilot plant runs:

- average removal of Giardia through conventional treatment: 3.40 log; S.D. = 0.67
- average removal of Cryptosporidium in conventional treatment: 2.98 log; S.D. = 0.64
- average removal of Giardia through direct filtration: 3.30 log; S.D. = 0.77
- average removal of Cryptosporidium through direct filtration: 2.97 log; S.D. = 0.89

Similarly, the following average removals were reported from the full-scale seeding trials:

- average removal of Giardia through conventional treatment: 3.26 log; S.D. = 0.67
- average removal of Cryptosporidium in conventional treatment: 2.25 log; S.D. = 0.47
- average removal of Giardia through direct filtration; 3.87 log
- average removal of Cryptosporidium through direct filtration: 2.79 log; S.D. = 0.19

Taking into consideration that the reported removal rates of Giardia and Cryptosporidium were calculated very conservatively, the values presented above can be interpreted as expected removals, resulting from a consistent performance and steady operation of the treatment plants.

Surrogate Parameters for Evaluation of Giardia and Cryptosporidium Removal

Both surface water sources treated in the treatment plants were characterized by a high quality water, with low levels of inorganic, organic, and microbial contamination. Both sources, however, were tested positive for both Giardia and Cryptosporidium cysts, confirming previous hypothesis and observations about these pathogens being ubiquitous in surface waters.

Both effectiveness and consistency of removal of seeded Giardia and Cryptosporidium cysts depended on the effectiveness and consistency of the removal of turbidity. When raw water turbidity was high and it could not be removed by direct filtration, resulting removals of seeded cysts were low and inconsistent. On the other hand, if treatment by direct filtration consistently produced low turbidity effluent, resulting cyst removals were comparable to those achieved from conventional treatment.

The results of seeded cyst removals, generated throughout the study regardless of treatment mode, were compared with the respective results from particle counting, turbidity measurements, and heterotrophic bacteria counts. Correlation between Giardia and Cryptosporidium cyst removal and removal of these potential surrogates are presented in Figures 3 through 5.

The analysis of correlation between cyst removal and particle removal was performed separately for Giardia cyst and cyst-size particles, and for Cryptosporidium oocysts and oocyst-size particles (Figure 3). High correlation was reported between both sets of data. A correlation coefficient of 0.82 was calculated ($p<0.1$) for the relationship between Giardia cyst removal and removal of particles ranging between 7 μm and 11 μm. Similarly, a correlation coefficient for the relationship between Cryptosporidium oocyst removal and removal of 4 μm to 7 μm particles was 0.79.

The results indicated that particle counting could serve as a reliable indicator of cysts and oocysts removal. Particle counters, even though capital intensive, are cheap to operate and are more sensitive than the assays used in Giardia and Cryptosporidium analyses.

Much lower correlation was established between removals of Giardia and Cryptosporidium and removal of turbidity (correlation coefficients of 0.64 and 0.55, respectively). As presented in Figure 4, log removal of turbidity can be used as an indicator of cyst and oocyst removals, but with lower accuracy than particle counting. The most pronounced differences between removal of Giardia and Cryptosporidium and the expected removals of turbidity were observed, when very high cysts removals (4-log) were reported.

Heterotrophic plate count was not shown to be a surrogate in evaluation of cyst removals (Figure 5). No correlation was found between log removal of seeded cyst and log removal of HPC. Despite the fact that the filters in both pilot- and full-scale plants were backwashed with chlorinated water, a growth of heterotrophic bacteria was reported in the filters during the seeding experiment and plant run.

Plant performance evaluation using particle counting and turbidity measurement can be an effective tool in evaluating expected removals of Giardia and Cryptosporidium. The search for a biological surrogate for Giardia and Cryptosporidium should continue and result in identification of a parameter that defines both occurrence and removal of Giardia and Cryptosporidium. The results of the study coincide with previously reported relationships between cysts and particulates. Effective removal of Giardia and Cryptosporidium from the water would, however, require treatment plants to consistently produce very low turbidity (0.1-0.2 NTU)—much lower than the levels currently required.

Conclusions and Recommendations

Analytical Procedures for Detection of Cysts in Water

Based on the results generated during the evaluation of the effectiveness of the IFA methods in enumeration of Giardia cysts and Cryptosporidium oocysts, it was concluded that the alternate IFA method was more suitable for meeting the project objectives. This method employed sam-

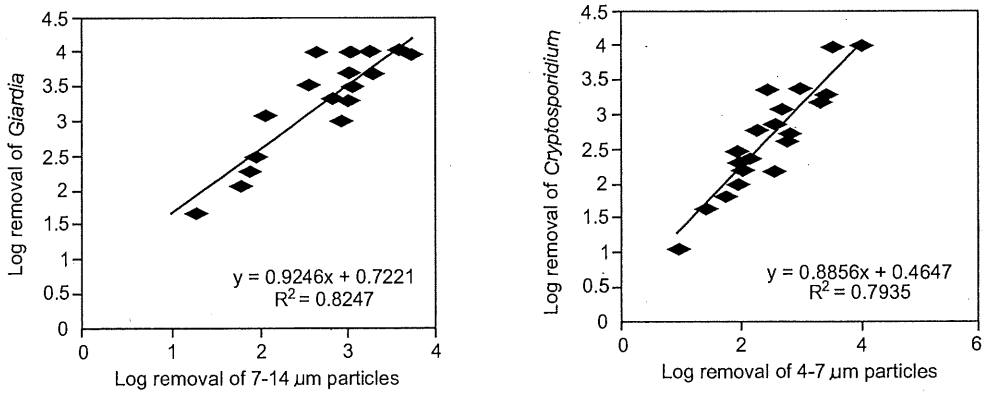


Figure 3. Relationship between removal of cysts and particles.

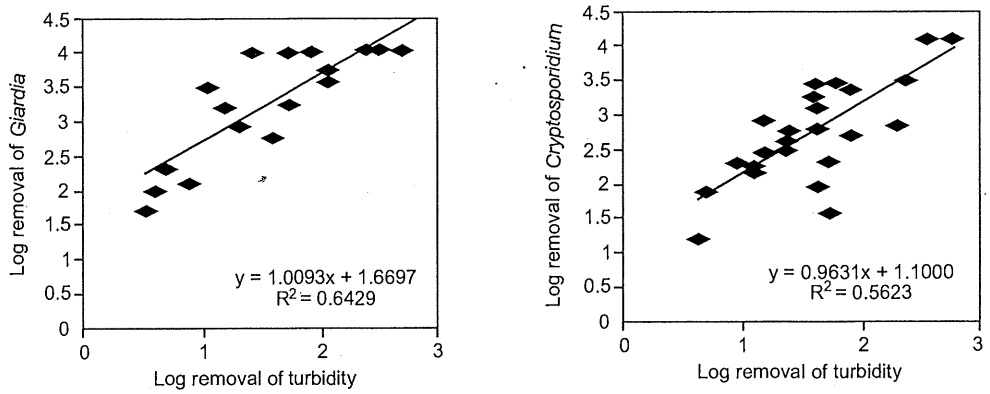


Figure 4. Relationship between removal of cysts and turbidity.

pling through a 2.0 µm polycarbonate membrane filter, centrifugation in 15 mL tubes, flotation on a two-step Percoll/ Percoll gradient, IFA staining on 13 mm diameter, 2.0 µm pore-size polycarbonate membrane filters, and enumeration under an UV epifluorescent microscope. The following conclusions were formed:

- The membrane filtration for low turbidity samples outperformed the polypropylene yarn sampling method in terms of recovery efficiency of seeded organisms.
- The Percoll/Percoll step gradient had better recoveries of seeded organisms then the Percoll/sucrose gradient. Since 15 mL tubes were used in place of 50 mL tubes, the procedure of the step gradient flotation was more economical.
- The alternate method has proven more effective in recovering seeded cysts, and therefore, was considered more suitable in parasite seeding experiments, where evaluation of water treatment process efficiencies was conducted using high concentrations of seeded cysts.

The ASTM method, employing staining on cellulose acetate membranes, had the advantage since the gradients could be cleared and the internal structure of the organisms could be visualized under the phase- or differential-interference contrast microscopy. The ASTM method, due to its ability to confirm presumptive cysts and distinguish between algal cells and the cysts by contrast microscopy, was found very applicable in testing of the environmental water samples.

Based on the above results, it is recommended that the alternate method should be used in evaluating water treatment process efficiencies using high concentrations of seeded parasites. The ASTM method is recommended in analyses of environmental samples where the confirmation step is essential.

A hybrid method, combining the most efficient steps from the two methods, should be investigated. The membrane filtration for low turbidity samples, which far outperformed the polypropylene yam sampling method in terms of recovery efficiency of seeded organisms, shows promise in sample collection. Similarly, Percoll/Percoll step gradient, used in the alternate method, had better recoveries of seeded organisms then the Percoll/sucrose gradient. Since 15 mL tubes were used in place of 50 mL tubes used in the ASTM method, the procedure of the step gradient flotation was more economical. On the other hand, staining on cellulose acetate membranes used in the ASTM method, had the advantage since the gradients could be cleared and the internal structure of the organisms could be visualized under the phase- or differential- interference contrast microscopy.

The results of the testing of IFA method effectiveness have indicated that Giardia cysts and especially Cryptosporidium oocysts are lost during the gradient flotation steps of both methods. Recovery efficiencies increased dramatically in samples, did not contain much debris, and could be processed without the flotation steps and stained directly on membranes. Therefore, it is recommended that the flotation step should be avoided when processing treated (filtered) water samples whenever possible.

Removal of Giardia and Cryptosporidium through Conventional Treatment and Direct Filtration

The following conclusions were formed from the pilot- and full-scale study on Giardia and Cryptosporidium cysts removal through conventional treatment and direct filtration:

- In a properly operated treatment plant effectively removing turbidity to 0.1-0.2 NTU, either conventional treatment or direct filtration can result in a 3-log removal of Giardia.
- Cryptosporidium oocysts are more difficult to remove than Giardia cysts,

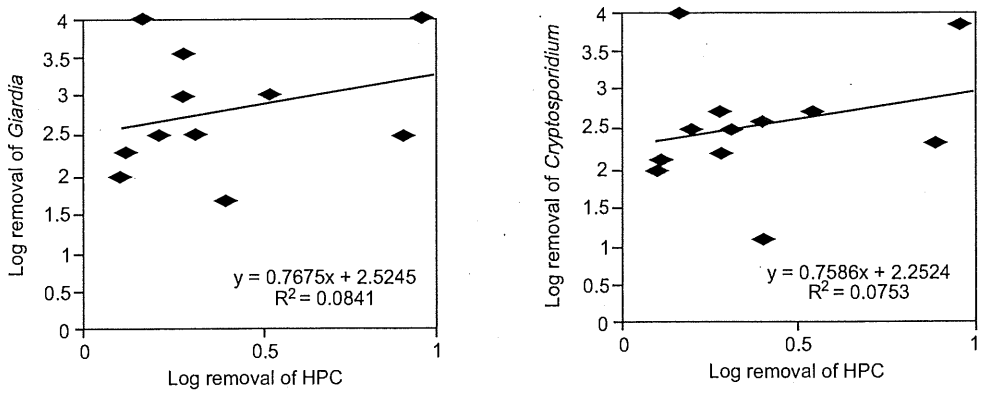


Figure 5. Relationship between removal of cysts and heterotrophic bacteria.

both in a conventional plant and through direct filtration (up to 1.0-log difference).

- Removals of cyst-size particles and removal of turbidity can be used as indicators of cyst removal effectiveness.

A general observation about removal of seeded Giardia and Cryptosporidium cysts was made that was valid in both pilot- and full-scale plant throughout the entire seeding studies. Both effectiveness and consistency of removal of seeded Giardia and Cryptosporidium cysts depended primarily on the effectiveness and consistency of the removal of turbidity. When treatment by direct filtration consistently produced low turbidity effluent (0.1-0.2 NTU), the resulting Giardia and Cryptosporidium cyst removals were consistent and comparable to these achieved from conventional treatment. As soon as the plant's performance changed, and resulting filtered water turbidity fluctuated, a high variability in cyst concentrations was detected in collected samples. When raw water turbidity was high, and it could not be removed by direct filtration, resulting removals of seeded cysts were low and inconsistent.

A high correlation coefficient was calculated for the relationship between Giardia cyst removal and removal of particles ranging between 7 μm and 14 μm, and similarly, for the relationship between Cryptosporidium oocyst removal and removal of particles of 4 μm to 7 μm in size. Much lower correlation was established between removals of Giardia and Cryptosporidium and removal of turbidity. Heterotrophic plate count was not shown to be a surrogate in evaluation of cyst removals, with no correlation found between log removal of seeded cyst and log removal of HPC.

A combination of particle counting and turbidity measurement was shown to be an effective tool in water treatment plant performance evaluation in terms of predicting removals of Giardia and Cryptosporidium. Effective removal of Giardia and Cryptosporidium from the water would, however, require treatment plants to consistently produce very low turbidity (0.1-0.2 NTU)—much lower than the levels currently required. The results of the study indicate that the removal of particulates, measured through particle counting and turbidity monitoring, should be a critical factor used in the evaluation of plant performance in Giardia and Cryptosporidium removal. Continuous and consistent removal of particulates should be monitored by continuous particle counting and turbidity monitoring.

The results of the project imply that the credits given for Giardia cyst removal in direct filtration plants, may be similar to credits obtained in conventional treatment plants, and also may be higher than the credits applicable under the current regulations. Since Cryptosporidium is more difficult to remove than Giardia, and it is also more resistant to disinfection than Giardia, new requirements need to be developed to control this pathogen. Finally, due to the need of further defining the credits given to treatment plants for physical removal of Giardia and Cryptosporidium, a study on evaluation of removal of these pathogens through pre-sedimentation should be conducted.

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Eva C. Nieminski is with the Utah Department of Environmental Quality, Salt Lake City, UT 84114.
Kim Fox is the EPA Project Officer (see below).
The complete report, entitled "Removal of Cryptosporidium and Giardia through Conventional Water Treatment and Direct Filtration," (Order No. PB97-162507; Cost: $35.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

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LEGISLATIVE PROTECTION FOR FLOOD MITIGATION ACTIVITIES

Seqwater's flood mitigation manuals for Wivenhoe/Somerset Dams and North Pine Dam have been approved by the Chief Executive under the *Water (Safety & Reliability) Act*.

That legislation provides the following protection to the dam owner/operator in undertaking flood operations –

374 Protection from liability for complying with flood mitigation manual

(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; or
(b) a director of the owner or operator of the dam; or
(c) an employee of the owner or operator of the dam; or
(d) an agent of the owner or operator of the dam.

Toni Lake

From: Peter Borrows
Sent: Sunday, 16 January 2011 4:28 PM
To: 'bob.reill[redacted] Rob Drury; Duty Seq; 'john.bradley[redacted]; 'barry.dennien[redacted] 'daniel.spiller[redacted]
Cc: 'michael.lyons[redacted] Mike Foster; 'Elaina Smouha'; 'peter.allen[redacted]
Subject: Cabinet in co nfidence - Ministerial brief outline
Attachments: Ministerial brief - contents outline.docx; Ministerial Briefing Note January 17 2011 Final Draft for distribution:doc; Jan 2011 Flood Event_Ver 1_draft for distribution.docx

Please see attached draft with attachment.

In relation to the draft contents outline sent yesterday, the following is a cross reference FYI.

The attached Ministerial Briefing Note addresses the questions contained in the Ministerial Information Request as follows:

1) Design of Dam – Storages/Spillway upgrade

Refer Section 1

2) "The Flood Event" – Q&A

a. Chronology - High level time step of events and significant decision making/changes – more detailed time step information for Tuesday afternoon (i.e. what was the BOM forecast at the time, narrow peak etc.)

Refer Section 2.5

b. How does Wivenhoe Dam work as a flood mitigator?

Refer Sections 2.1, 2.3 and 3.1

c. What are the factors being balanced when making decisions about the amount of dam releases? To what extent does information from the Bureau of Meteorology/rain gauges influence decisions? How reliable is this information?

Refer Sections 3.1 and 3.2

d. Statistics on how much did Wivenhoe Dam knock off the flood peak.

Refer Section 2.1

e. What would have happened if Wivenhoe Dam had not been built and we only had Somerset Dam? What damage would have been caused compared to what has currently been experienced (damage statistics)?

Refer Sections 2.1 and 2.2

f. If we have undertaken pre-emptive dam releases to bring Wivenhoe Dam's full supply level down to lower than what we had maintained (i.e. 60%), what would have been the river height for the period that this flood event occurred?

Refer Section 2.4

g. If pre-emptive dam releases would not have made a difference, why? (i.e. why did we not release earlier?)

Refer Section 2.4

h. Why was Wivenhoe Dam only allowed to rise up to 191% and not 230%?

Refer Section 2.2

i. What is the fuse plug and why did it need to be maintained?

Refer Section 2.3

j. What damage or town isolation occurred during the Wivenhoe Dam releases that occurred since October 2010?

Refer Section 2.4

k. Did Seqwater have time to reduce the dam level between the 5 events? If so, would it have made a difference to this flood event?

Refer Section 2.4

3) The Flood Mitigation Manual

Refer Section 3.1

a. Describe the decision making framework - Four strategies

Refer Section 3.2

b. How is the Manual designed to work?

Refer Section 3.2

c. History of Flood Mitigation Manual updates and peer review – who was on the panels, studies that fed into previous versions of the Manual and who was involved in these studies?

Refer Section 3.1

4) Regulatory context - *Water Supply (Safety and Reliability) Act 2008* (Information provider: Peter Allen - DERM)

Refer Section 4

Regards, Peter.

Peter Borrows
Chief Executive Officer
Queensland Bulk Water Supply Authority *trading as* Seqwater

seqwater
WATER FOR LIFE

Ph [redacted]
Level 3, 240 Margaret St, Brisbane City QLD 4000
PO Box 16146, City East QLD 4002
Website | www.seqwater.com.au

From: Elaina Smouha[redacted]
Sent: Saturday, 15 January 2011 5:03 PM
To: Mike Foster; peter.allen[redacted] bob.reilly[redacted] Peter Borrows; Rob Drury; Duty Seq
Cc: john.bradley[redacted] barry.dennier[redacted] daniel.spille[redacted]
michael.lyons[redacted] Elaina Smouha
Subject: Cabinet in confidence - Ministerial brief outline

Dear All

To assist, attached is a Ministerial brief outline as per our recent teleconference, for Monday's Emergency Cabinet meeting. It also records those who will be providing information for the Background and Flood Mitigation Manual report process.

As discussed, the brief needs to be provided to Minister Robertson tomorrow (Sunday, 16 January 2011).

Regards

Elaina

Elaina Smouha
Director, Governance and Regulatory Compliance
SEQ Water Grid Manager
Phone[redacted]
Email: [redacted]
Visit: Level 15, 53 Albert Street Brisbane
Post: PO Box 16205, City East QLD 4002
ABN: 14783 317 630

Ministerial brief outline

What is the objective?

a) Ensuring public transparency
b) To answer the State's questions on the performance of Wivenhoe Dam operations
c) Preparation for a public inquiry
d) Normal and logical course of conduct after the occurrence of a major flood event – Review requirement under the Flood Mitigation Manual

Background (focus on Brisbane River flooding issues)

1) Design of Dam – Storages/Spillway upgrade (*Information provider:* ***Seqwater and Peter Allen*** *- DERM*) [1/3 to ½ a page]

2) "The Flood Event" – Q&A (*Information provider:* ***Seqwater***) [2 ½ pages]

    a. Chronology - High level time step of events and significant decision making/changes – more detailed time step information for Tuesday afternoon (i.e. what was the BOM forecast at the time, narrow peak etc.)
    b. How does Wivenhoe Dam work as a flood mitigator?
    c. What are the factors being balanced when making decisions about the amount of dam releases? To what extent does information from the Bureau of Meteorology/rain gauges influence decisions? How reliable is this information?
    d. Statistics on how much did Wivenhoe Dam knock off the flood peak.
    e. What would have happened if Wivenhoe Dam had not been built and we only had Somerset Dam? What damage would have been caused compared to what has currently been experienced (damage statistics)?
    f. If we have undertaken pre-emptive dam releases to bring Wivenhoe Dam's full supply level down to lower than what we had maintained (i.e. 60%), what would have been the river height for the period that this flood event occurred?
    g. If pre-emptive dam releases would not have made a difference, why? (i.e. why did we not release earlier?)
    h. Why was Wivenhoe Dam only allowed to rise up to 191% and not 230%?
    i. What is the fuse plug and why did it need to be maintained?
    j. What damage or town isolation occurred during the Wivenhoe Dam releases that occurred since October 2010?
    k. Did Seqwater have time to reduce the dam level between the 5 events? If so, would it have made a difference to this flood event?

3) The Flood Mitigation Manual (*Information Provider:* ***Seqwater/DERM***) [½ to 1 page]

    a. Describe the decision making framework - Four strategies
    b. How is the Manual designed to work?
    c. History of Flood Mitigation Manual updates and peer review – who was on the panels, studies that fed into previous versions of the Manual and who was involved in these studies?
    d. **Attach** Minister Robertson's request for advice on pre-emptive release and our response (*Information provider:* ***SEQ Water Grid Manager***)

4) Regulatory context - *Water Supply (Safety and Reliability) Act 2008* (*Information provider:* ***Peter Allen - DERM***)

    a. Flood Mitigation Manual approval
    b. Formal reporting process under the Flood Mitigation Manual – **attach** report resulting from the February 1999 flood event
    c. Decision making process under the Flood Mitigation Manual –
        i. Who makes the flood release decisions under the Manual?
        ii. who is informed/consulted?
        iii. effect of the recent Flood Communication Protocol?

5) Brian Cooper Flood Mitigation Manual compliance review (*Responsible:* ***SEQ Water Grid Manager***)

Seqwater report

(*Information provider:* ***Seqwater, Peter Allen and Bob Reilly***)

Seqwater, in consultation with Peter Allen and Bob Reilly, to set out how Seqwater's Flood Mitigation Manual Report to the Chief Executive on the effectiveness of the operational procedures will be undertaken.

- **Attach** table of contents of the 1999 Flood Mitigation Manual report
- Reflect Brian Cooper's compliance review
- Peer review – establishment of an expert panel – who will be on it? Peter Allen and Bob Reilly may provide some input.
- Communication Protocol and incorporation into the Flood Mitigation Manual (revisit in the next fortnight?)

Timeframes on the development of the report – consider urgency due to anticipated further rainfall during this summer.

Ministerial Briefing Note

17 January 2010

Flood Event January 2011

1 BACKGROUND INFORMATION ON WIVENHOE DAM

Wivenhoe Dam was completed in 1984 and has two main functions;

- A 1,165,000 ML storage providing an urban water supply for Brisbane;
- Flood mitigation in the Brisbane River by providing a dedicated flood storage volume of 1,450,000 ML (this flood storage was increased in 2005 to 1,966,000 ML with the dam at the point of failure).

In accordance with the Queensland Regulatory program for dam spillway upgrades, a further upgrade of Wivenhoe Dam is scheduled to occur prior to 2035.

Wivenhoe Dam is in excellent condition with four Comprehensive Dam Safety reviews undertaken in the last 14 years, the latest in 2010.

2 WIVENHOE DAM FLOOD MITIGATION AND FLOOD OPERATIONS

2.1 What were the benefits provided by Wivenhoe Dam during the current event?

The following graphs demonstrate the significant benefits of Wivenhoe Dam in mitigating the current flood event, with reductions in flood peak of up to 2.5 metres in the City area and up to 5.5 metres in the Moggill area further upstream.

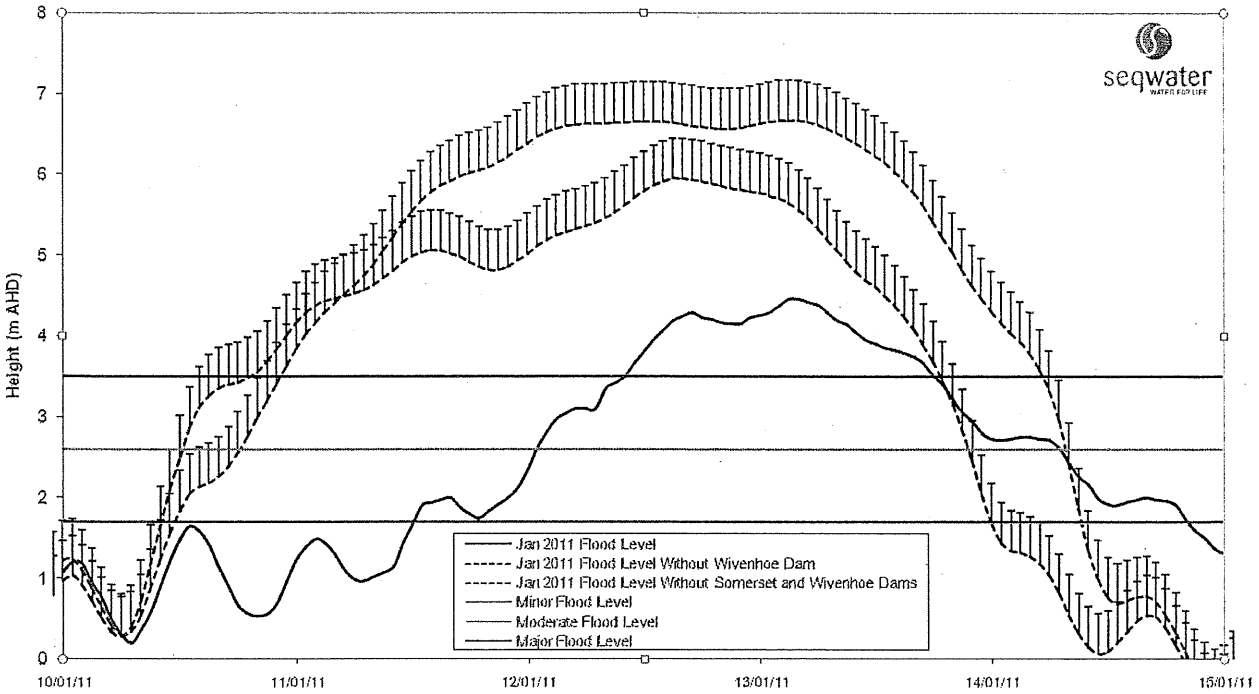
This equates to significant reduction in the potential for loss of life as well as saving in damages in the order of up to $1.6 billion based on current damage curves. Up to 13,000 more properties would have been impacted by the event without the Dam. (Source: Flood Damage Tables provided to Seqwater by the Brisbane City Council).

The time at which flood levels remained elevated above major levels has also been reduced by up to 3 days by the dam. This has significant benefits to impact on the population of the city, property damage and the recovery operation.

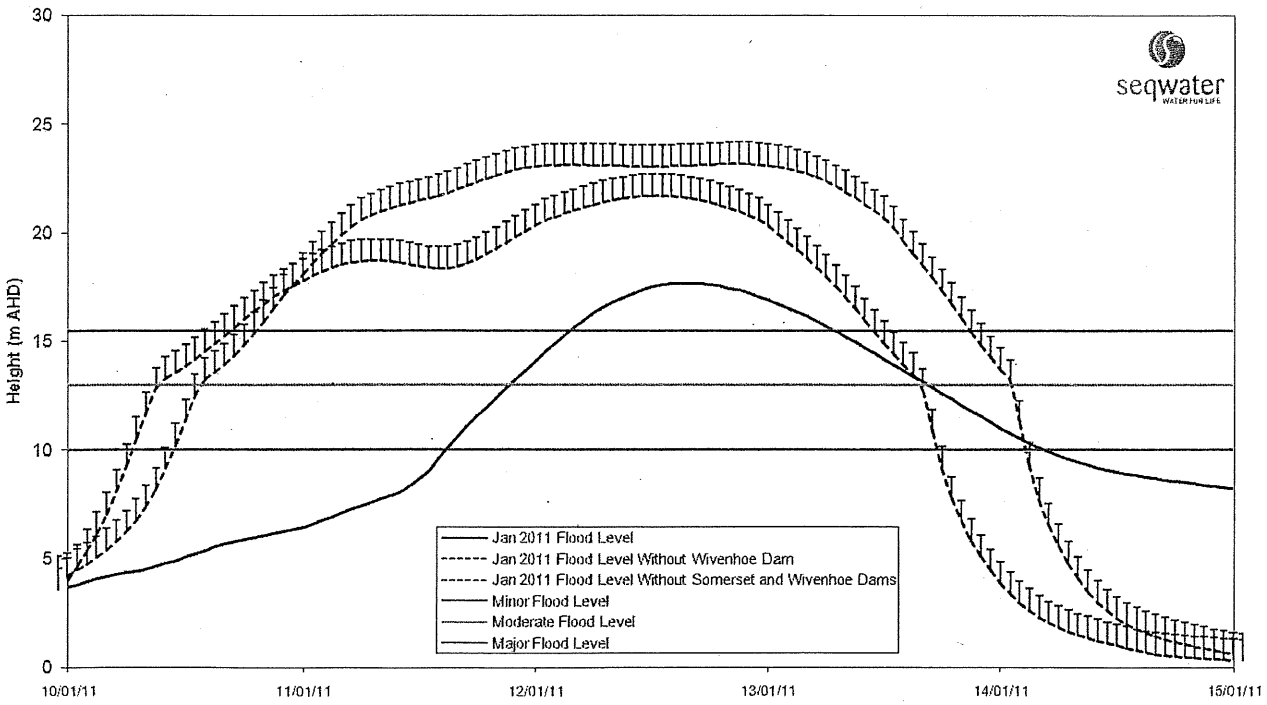
Depending on the nature of the event, the presence of Wivenhoe Dam could also potentially increase flood warning times to impacted areas. How these times may have been increased during the current event is presently difficult to quantify, but discussions will be held with BOM on this issue at a later date.

In addition, the strategy adopted to quickly close off releases once the peak in the dam had been reached and rain stopped falling certainly reduced the predicted flood peak by at least one metre in the lower Brisbane River area.

JANUARY 2011 BRISBANE FLOOD
Assessment of Flood Levels at Brisbane City



JANUARY 2011 BRISBANE FLOOD
Assessment of Flood Levels at Moggill



2.2 Why was Wivenhoe Dam only allowed to rise up to 191% and not 230%?

Wivenhoe Dam mitigates downstream flooding by storing incoming flood water during a rainfall event and releasing these waters at a reduced flow rate downstream to reduce flood impacts. The timing of the releases is also manipulated so that the aim is for outflows from the dams to impact on downstream areas only after the peak inflows from the downstream major tributaries have passed. However this aim cannot always be achieved in practice. This is because some large floods, such as the one currently being experienced, have the potential to overflow the dam's flood storage compartment. **Should this occur, the dam would fail and the resulting damage and loss of life would be at least 100 to 1000 times greater than that currently being experienced.**

Therefore the basis of all flood operation decision making is to ensure the dam never fails. This is the reason that the dam's flood storage compartment would never be intentionally fully filled as any additional inflows after this point would result in a dam failure. At any one time, there will always be uncertainty about what rain is going to occur. Hence, we cannot use all of the flood capacity as we would not be able to release sufficient water to cater for large inflows.

2.3 What is the role of the erodible fuse plug embankments?

Another factor that impacts on flood release decision making in large events are the levels at which the erodible fuse plugs are triggered. The fuse plugs act as a safety valve to rapidly increase dam outflows if the structural safety of the dam is in danger. Loss of one or more fuse plugs severely limits the ability of the dam to mitigate the effects of future flood events that may occur prior to the fuse plug or plugs being reinstated. Reinstatement of a fuse plug following an event would take a minimum of 4 to 6 months and would require an extended period of relatively dry weather.

2.4 Why weren't pre-emptive releases undertaken prior to the start of the flood event?

In the 25 days leading up to the current event, three flood events impacting on Wivenhoe Dam were experienced, with gate releases being made on all but five of those days. The total outflow from these events was around 700,000ML.

During these events, requests were received from Councils and residents impacted by bridge closures downstream of the dam to curtail releases as soon and as quickly as possible. Additionally the 2 January end date of the flood event prior to the current event 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 750,000ML 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 (as defined by BOM and BCC) in the lower Brisbane River.

Regardless, significant drain down prior to the current event would have had little impact on the peak level in Wivenhoe Dam as shown in the table below. The reason for this is that this total event inflow volume of 2,600,000 ML is well in excess of the useable flood storage combined with the available water supply storages shown in the table.

The specific impact on the Lower Brisbane River of these reduced dam levels requires the use of a complex hydraulic model. The results of this modelling would still contain a degree of uncertainty as illustrated by the difficulties in estimating the final flood peak in Brisbane during the event. This is because the rapid closure of the gates after peak inflow was achieved resulted in significant water level reductions downstream and this is difficult to model accurately.

JANUARY 2011 FLOOD			
Starting Level		Peak Height	Capacity
%	m AHD	m AHD	%
100	67.0	74.97	191
95	66.5	74.93	191
90	65.8	74.88	190
75	64.0	74.63	187
50	60.0	74.11	180

It should be noted that the possible reductions shown above are based up a unique dual peaked flood hydrograph with a volume of about 2,600,000 ML which occurred during this event. A hydrograph with the same volume but a different distribution could result in a significantly lower reduction in peak water levels.
Flood operations at the dam are also highly dependent upon the flood inflow volume and a slight variation in the flood volume could significantly reduce the benefits associated with draining down the dam prior to a flood event.

2.5 Is there a detailed record of the events associated with the current flood?

A preliminary report has been prepared and is attached to this briefing.

3 THE MANUAL OF FLOOD MITIGATION AT WIVENHOE DAM AND SOMERSET DAM

3.1 What is the Manual of Flood Mitigation and how was it developed?

The Manual of Flood Mitigation for Wivenhoe and Somerset dams in its current form was developed in 1992 during an extensive hydrological study of the Brisbane and Pine Rivers catchments by DPI, Water Resources. The final reports were subject to extensive internal review by the Water Resources Group before being reviewed by an independent review panel comprising Professor Colin Apelt, Head of Department, Department of Civil Engineering, University of Queensland and Mr Eric Lesleighter, Principal Hydraulic Engineer and Chief Engineer Water Resources, Snowy Mountains Engineering Corporation. Subsequently, the Manual was extensively reviewed during the Brisbane Valley Flood Damages Minimisation Study in 2006, with the latest comprehensive review of the Manual undertaken in 2009. Both of these reviews have included expert review panels comprising key stakeholders, with the most recent review involving representatives from DERM, BOM, BCC and SunWater.

The Manual of Flood Mitigation is prepared by Seqwater as the owner of the dam and approved and gazetted by the Chief Executive of DERM in accordance with the Water Supply Act 2008. The manual defines flood objectives procedures; roles and responsibilities; and staffing and operational requirements for flood events impacting on Wivenhoe and Somerset dams.

3.2 What is contained in the Manual?

The primary objectives of the procedures contained in the Manual are, in order of importance:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers primarily, this involves minimising inundation of the seven bridges below the dam upstream of Moggill);
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.

- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

During an event, the operation of the dam transitions between the following four operating strategies depending of the circumstances at the time. These procedures associated with these strategies are explained in detail in the Manual.

- **Strategy W1** – Primary consideration is given to Minimising Disruption to Downstream Rural Life.
- **Strategy W2** – Transition Phase moving from Minimising Disruption to Protecting Downstream Urban Areas.
- **Strategy W3** – Primary consideration is to Protect of Urban Areas from Inundation.
- **Strategy W4** – Primary consideration is to protecting the structural safety of the Dam.

In addition to these strategies, 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. Accordingly for each flood event, the aim is always to empty stored floodwaters within seven days after the flood peak has passed through the dams.

4 REGULATORY CONTEXT (Provided by Peter Allen and unedited)

These are contained in the Flood Mitigation Manual (manual) approved under sections 370 to 374 of the *Water Supply (Safety and Reliability) Act 2008.* The Chief Executive Officer (CEO) of DERM (or his delegate) approves the manual, and the approval is notified in the Queensland Government Gazette. Approval can be for a period of up to five years, after which the approval needs to be renewed. There are no decision-making criteria specified in the Act for the CEO to take into account when approving the manual.

The manual for the dams requires, amongst other matters:

1. Flood operations to be conducted in accordance with manual's provisions. (There is an approval process specified in the manual, if Seqwater considers a different flood release strategy is desirable to deal with a particular flood event. This was not used in the January 2011 flood event)
2. Flood operations to be under the control of CEO-approved engineers (who are highly qualified and experienced)
3. Annual reporting on the preparedness and status of the flood control system for flood operations, and the training of the personnel who manage the flood events.
4. Reporting on the flood operations during flood events.
5. Reviews after flood events such as the January 2011 event. For this flood event, the Queensland Government engaged Mr Brian Cooper, an independent consulting engineer, to review compliance with the manual. Mr Cooper concluded (Attachment??): "...The strategies in the Flood Mitigation Manual have been followed, allowing for the discretion given to make variations in order to maximise flood mitigation effects. The actions taken and decisions made during the Flood Event appear to have been prudent and appropriate in the context of the available knowledge available to these responsible for flood operations and the way events unfolded..." (p.3 of the final report or other appropriate reference??)

The manual is separate from a draft communication protocol (Insert name) between the Local, State and Commonwealth government agencies that are affected by the dams' flood operations. This protocol is not binding on the parties to it is not subject to regulatory approval/review.

Some DERM staff, because of their specialist skills, work in the Flood Operations Centre that Seqwater activates to manage such events. None of them are involved in any of the regulatory decisions concerning the dams or are members of the work unit (Office of the Water Supply Regulator) which undertakes the CEO's regulatory functions.

5 COMPLIANCE WITH THE MANUAL

(To be provided)

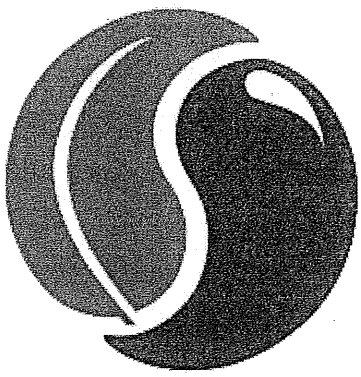
6 SEQWATER REPORT

It is recommended that the process and content for reports required for this event be:

- In the short term, utilise this report attached to this briefing note as the basis for communications and discussion.
- Prepare any Interim Reports as agreed to provide information and input as required.
- Seqwater prepare a Comprehensive Report as per the existing regulatory requirements of the Act and the gazetted manual and any requirements of the Dam Safety Regulator. This would be done within 6 weeks of the closure of the current event as per the manual. This timeframe is subject to any new mobilisation of the Flood Operations Centre. The Table of Contents would include:
    - Introduction
    - Flood Event Summary
    - Mobilisation and Staffing
    - Event Rainfall
    - Inflow and Release Details
    - Data Collection System Performance
    - Data Analysis Performance
    - Communication
    - Flood Management Strategies and Manual Compliance
    - Improvements in data collection systems, practices and processes.
    - improvements by interacting agencies
    - Review of factors impacting on the protection of urban areas
    - Recommendations & Conclusions
- The report would then be reviewed by the Dam Safety Regulator in conjunction with any peer review they require. The review should cover:
    - Were the provisions of the manual complied with?
    - What improvements to either facilities e.g. stream gauges, or work practices, are desirable to improve Sewater's ability to predict inflows into the dams.
    - Are improvements to either Seqwater's facilities or work practices desirable to improve Seqwater's ability to manage events? For example, investigations to raise the dam to improve its flood storage capacity, If so, what are they and their implications

- Are changes to the facilities or work practices of other organisations desirable to improve Seqwater's abilities to manage these events? If so, what are they and their implications? (For example, would it be worth funding Brisbane River crossing upgrades so that floodwater could be released faster, while not adversely affecting access to properties--or maybe alternative strategies e.g. resupply operations could be put in place to achieve similar outcomes?)
- Given the manual's order of priorities i.e. protection of the dam etc, are any changes in the flood release strategies for either dam desirable? If so, what are they, and their implications

- Based on this review, a review of the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam would occur utilising an expert panel of review including representatives of DERM, Seqwater, BoM, affected Local Governments and other stakeholders as necessary.



seqwater

WATER FOR LIFE

JANUARY 2011 FLOOD EVENT

TABLE OF CONTENTS

1 INTRODUCTION

Wivenhoe Dam was constructed by the Queensland Government between 1977 and 1984. The dam is a 56 m AHD high and 2.3 kilometre long earth and rock embankment separated into two parts by a concrete gravity spillway. The spillway is controlled by 5 radial gates, each 12.0 metres wide by 16.0 m AHD high. Two saddle dam embankments are located on the left side of the reservoir.

The dam spillway capacity was upgraded in 2005. This was done primarily through the construction of a 164 metre wide secondary spillway through the right abutment of the existing dam. This spillway contains three erodible earth fill fuse plug embankments that are initiated at different dam levels in excess of EL 75.6.

The dam has two main functions by providing:

- A 1,165,000 ML storage at full supply level (FSL EL 67.0) providing an urban water supply for Brisbane and surrounding areas;

- Flood mitigation in the Brisbane River by providing a dedicated flood storage volume of 1,450,000 ML up to EL77 (this flood level was increased as part the 2005 upgrade to allow a water level of EL80m and a temporary flood storage volume of 1,966,000 ML with all fuse plugs initiated and the dam at the point of failure).

The dam has an EXTREME hazard classification under ANCOLD guidelines because of the significant development downstream in the Brisbane and Ipswich metropolitan areas, with the population at risk in the event of a dam failure numbering in the hundreds of thousands.

In accordance with the Queensland Regulatory program for dam spillway upgrades, a further upgrade of Wivenhoe Dam is scheduled to occur prior to 2035 to enable the dam to safely pass the Probable Maximum Flood. This work will involve the reconstruction of Saddle Dam 2 as a fuse plug spillway.

Wivenhoe Dam is in excellent condition. Comprehensive Dam Safety reviews undertaken in accordance with ANCOLD guidelines have been undertaken in 1997 (Gutteridge, Haskins & Davey Pty Ltd), 2003 (Wivenhoe Alliance), 2006 (NSW Department of Commerce), 2009 (GHD) and September 2010 (Seqwater). The reports concluded that the design of the dam is in accordance with modern day standards and that there are no significant outstanding design or construction issues that require investigation.

2 WIVENHOE DAM FLOOD MITIGATION AND FLOOD OPERATIONS

2.1 Flood Mitigation

The Brisbane River catchment covers an area of approximately 14,000 square kilometres of which about half is below Wivenhoe Dam. Maximum overall flood mitigation effect is achieved by operating Wivenhoe Dam in conjunction with Somerset Dam. Although Somerset and Wivenhoe Dam reduce flooding in Brisbane City, major flooding can still occur. The Lockyer-Laidley Valley drains into the Brisbane River through Lockyer Creek that enters the Brisbane River just downstream of Wivenhoe Dam near Lowood. Another major tributary, the Bremer River, flows into the Brisbane River at Moggill. Wivenhoe Dam has no control over inflows into the Brisbane River from both these major tributaries.

Wivenhoe Dam mitigates downstream flooding by storing incoming flood water during a rainfall event and releasing these waters at a reduced flow rate downstream to minimise flood impacts. The timing of the releases is also manipulated so that the aim is for outflows from the dams to impact on downstream areas only after the peak inflows from the downstream major tributaries have passed. However, this aim cannot always be achieved in practice. This is because some large floods, such as the one currently being experienced, have the potential to overflow the dam's flood storage compartment. **Should this occur, the dam would fail and the resulting damage and loss of life would be at least 100 to 1000 times greater than that currently being experienced.**

Therefore the basis of all flood operation decision making is to ensure the dam never fails. This is the reason that the dam's flood storage compartment would never be intentionally fully filled as additional inflows after this point would result in a dam failure. Similarly, there will be uncertainty on future rainfall that could occur which could not be releases if there was insufficient flood storage which could not be stored or released.

Another factor that impacts on flood release decision making in large events are the levels at which the erodible fuse plugs are triggered. Loss of one or more fuse plugs severely limits the ability of the dam to mitigate the effects of future flood events that may occur prior to the fuse plug or plugs being reinstated. Reinstatement of a fuse plug following an event would take a minimum of 4 to 6 months and would require an extended period of relatively dry weather.

2.2 Flood Operations

A real time flood monitoring and forecasting system has been established in the Wivenhoe and Somerset Dam catchments. This system employs radio telemetry to collect, transmit and receive rainfall and stream flow information. The system consists of around 230 field stations that automatically record rainfall and/or river heights at selected locations in the dam catchments. Most of these field stations are owned by Seqwater with the remainder belonging to other agencies.

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 recorded rainfall in the dam catchments. The RTFM is a suite of hydrologic computer programs that utilise the real time data to assist in the operation of the dams during flood events.

Seqwater engineers use the RTFM for flood monitoring and forecasting during flood events to operate the dams in accordance with a Manual of Flood Mitigation (the origin of and objectives and procedures contained in the Manual of Flood Mitigation are explained in the following section of this document). Releases of water from the dams are optimised to minimise the impacts of flooding in accordance with the objectives and procedures contained in a Manual of Flood Mitigation.

The RTFM and data collection network performed well During the January 2011 event, with no failures experienced that compromised the ability of Seqwater to operate the dam.

3 MANUAL OF FLOOD MITIGATION FOR WIVENHOE AND SOMERSET DAMS

The Manual of Flood Mitigation for Wivenhoe and Somerset Dams, in its current form, was developed in 1992 during an extensive hydrological study of the Brisbane and Pine Rivers catchments by DPI, Water Resources. The final reports were subject to extensive internal review by the Water Resources Group before being reviewed by an independent review panel comprising Professor Colin Apelt, Head of Department, Department of Civil Engineering, University of Queensland and Mr Eric Lesleighter, Principal Hydraulic Engineer and Chief Engineer Water Resources, Snowy Mountains Engineering Corporation.

Subsequently, the Manual was extensively reviewed during the Brisbane Valley Flood Damages Minimisation Study in 2006, with the latest comprehensive review of the Manual undertaken in 2009. Both of these reviews have included expert review panels comprising key stakeholders, with the most recent review involving representatives from DERM, BOM, BCC and SunWater.

The Manual of Flood Mitigation is prepared by Seqwater as the owner of the dam and approved and gazetted by the Chief Executive of DERM in accordance with the Water Supply Act 2008. The manual defines flood objectives procedures; roles and responsibilities; and staffing and operational requirements for flood events impacting on Wivenhoe and Somerset dams.

The primary objectives of the procedures contained in the flood manual are, in order of importance:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers primarily, this involves minimising inundation of the seven bridges below the dam upstream of Moggill);
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

During an event, the operation of the dam transitions between the following four operating strategies depending of the circumstances at the time. These procedures associated with these strategies are explained in detail in the Manual.

- **Strategy W1** – Primary consideration is given to Minimising Disruption to Downstream Rural Life. Under this strategy, the predicted water level is below 68.50 m AHD and the maximum release is 1,900m3/s.

- **Strategy W2** – Transition Phase moving from Minimising Disruption to Protecting Downstream Urban Areas. Under this strategy, the water level is predicted to be between 68.5 and 74.0 m AHD and the maximum release is less than 3,500m3/s.

- **Strategy W3** – Primary consideration is to Protect of Urban Areas from Inundation. Under this strategy, the water level is predicted to be between 68.5 and 74.0 m AHD but the maximum release is less than 4,000m3/s.

- **Strategy W4** – Primary consideration is to protecting the structural safety of the Dam. Under this strategy, the water level is predicted to exceed 74.0 m AHD and there is no limit to the maximum release. Consideration is given to managing flood releases to avoid fuse plug initiation if at all possible as this would compromise flood mitigation capacity in the short to medium term.

In addition to these strategies, 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. Accordingly for each flood event, the aim is always to empty stored floodwaters within seven days after the flood peak has passed through the dams.

4 JANUARY 2011 FLOOD EVENT

4.1 Background

In the 25 days leading up to the current event, three flood events impacting on Wivenhoe Dam were experienced, with gate releases being made on all but five of those days. The total outflow from these events was around 700,000ML. The details of these events are as follows:

EVENT	EVENT START DATE	EVENT END DATE	VOLUME RELEASED (ML)
1	13/12/2010	16/12/2010	70,000
2	17/12/2010	24/12/2010	150,000
3	26/12/2010	02/01/2010	470,000

During these events, requests were received from Councils and residents impacted by bridge closures downstream of the dam to curtail releases as soon and as quickly as possible. Additionally the 2 January end date of the flood event prior to the current event 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 750,000ML 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 (as defined by BOM and BCC) in the lower Brisbane River.

Regardless, significant drain down prior to the current event would have had little impact on the peak level in Wivenhoe Dam as shown in the table below. The reason for this is that this total event inflow volume of 2,600,000 ML is well in excess of the useable flood storage combined with the available water supply storages shown in the table.

The specific impact on the Lower Brisbane River of these reduced dam levels requires the use of a complex hydraulic model. The results of this modelling would still contain a degree of uncertainty as illustrated by the difficulties in estimating the final flood peak in Brisbane during the event. This is because the rapid closure of the gates after peak inflow was achieved resulted in significant water level reductions downstream and this is difficult to model accurately.

JANUARY 2011 FLOOD			
Starting Level		Peak Height	Capacity
%	m AHD	m AHD	%
100	67.0	74.97	191
95	66.5	74.93	191
90	65.8	74.88	190
75	64.0	74.63	187
50	60.0	74.11	180

It should be noted that the possible reductions shown above are based up a unique dual peaked flood hydrograph with a volume of about 2,600,000 ML which occurred during this event. A hydrograph with the same volume but a different distribution could result in a significantly lower reduction in peak water levels.
Flood operations at the dam are also highly dependent upon the flood inflow volume and a slight variation in the flood volume could significantly reduce the benefits associated with draining down the dam prior to a flood event.

4.2 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 dependent of 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)	Moderate to heavy rain periods forecast until Tuesday, but both Wivenhoe and Somerset dam levels were falling slowly, with Somerset at 1.27 m AHD above FSL and Wivenhoe 1.58 m AHD above FSL.
15:30 09/01/2011 (Sunday)	Following significant rain during the day a meeting of 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 m AHD above FSL in Somerset and 5.5 m AHD above FSL in Wivenhoe. However, by 19:00 it was apparent that both Fernvale Bridge and Mt Crosby Weir Bridge would be inundated by the combined dam releases and Lockyer Creek flows 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 strategy to W4.
08:00 11/01/2011 (Tuesday)	Rainfall continued during the night with isolated heavy falls in the Wivenhoe Dam catchment area and based on rainfall on the ground it was apparent the operational strategy would soon progress to W4 with Wivenhoe Dam exceeding 8.00 m AHD above FSL. The objective now was to limit outflows and subsequent flood damage to urban areas, while ensuring the structural safety of the dam.
11:00 11/01/2011 (Tuesday)	Rapid inflows were experienced in Wivenhoe Dam, with the dam rising almost a metre in eight hours. Releases were increased until the dam level stabilised in accordance with Strategy W4. Computer models were not reflecting actual dam inflows due to intense point rainfalls in the immediate catchment around the dam. Falls are estimated to be similar to those experienced at both Toowoomba and Upper Lockyer the previous day and are falling outside and between existing rain gauges.
21:00 11/01/2011 (Tuesday)	Wivenhoe Dam peaked. Peak release of 7450 cumecs with a level of 0.7 metres below fuse plug trigger.
22:00 11/01/2011	Wivenhoe Dam releases were closed off as quickly as possible over the

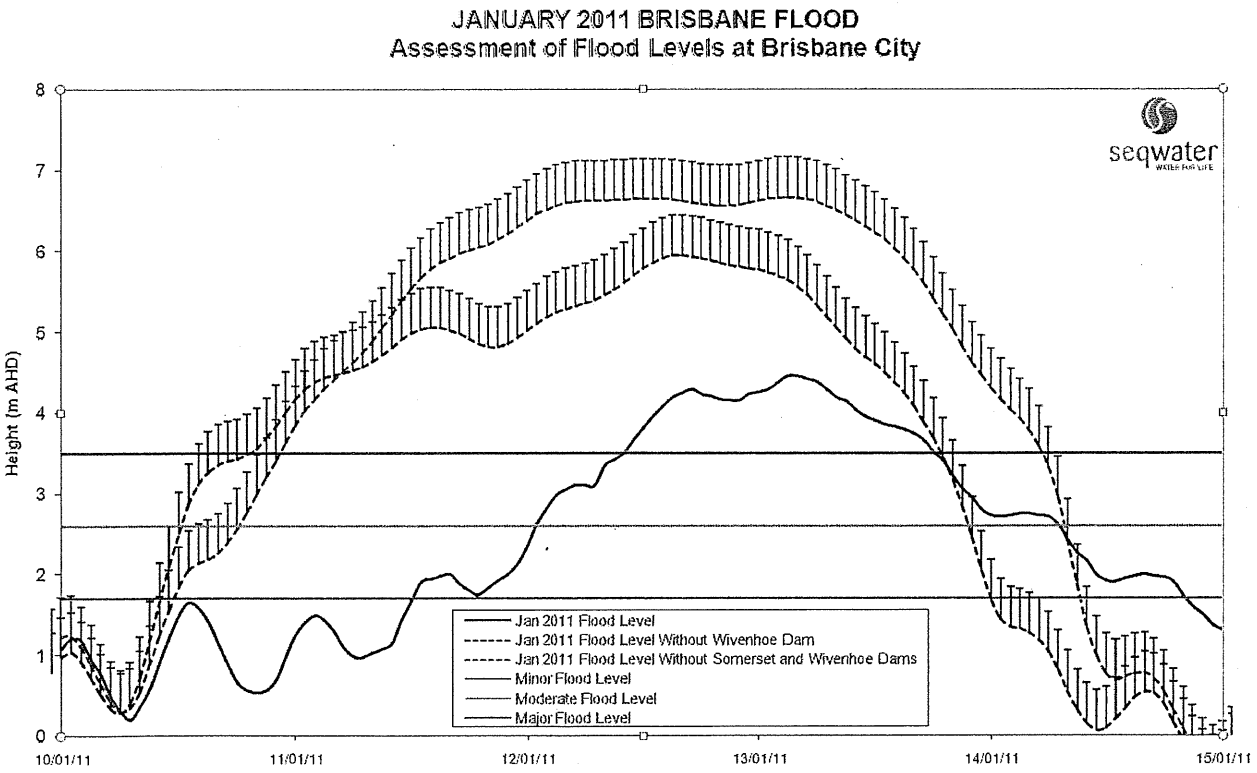
(Tuesday)	next 11 hours, while ensuring water levels in the dam did not rise further and initiate a fuse plug embankment.
08:00 12/01/2011 (Wednesday)	Minimum possible release level reached, with inflows matching outflows. Further reductions in release rate would likely cause the dam level to rise.
21:00 13/01/2011 (Thursday)	The 7 day dam drain down is commenced as Lockyer Creek and Bremer River peaks pass the Lower Brisbane area. Maximum release target is the limit of damaging floods in Brisbane being 3500 cumecs.
09:00 17/01/2011 (Monday)	Drain down continues, with released expected to cease on Wednesday 19 January 2011 unless further rainfall is experienced.

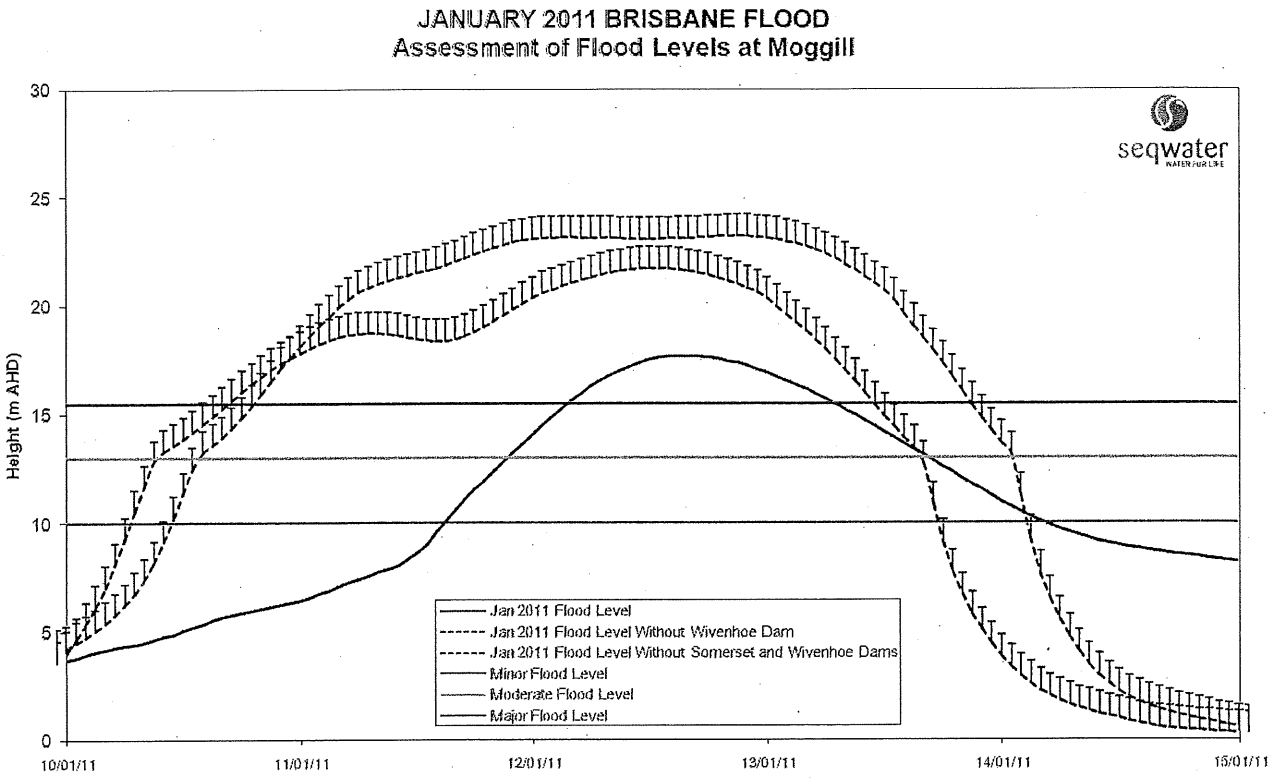
4.3 Flood Mitigation Benefits of Wivenhoe Dam

The following graphs demonstrate the significant benefits of Wivenhoe Dam in mitigating the current flood event, with reductions in flood peak of up to 2.5 metres in the City area and up to 5.5 metres in the Moggill area further upstream.

This equates to significant reduction in the potential for loss of life as well as saving in damages in the order of up to $1.6 billion based on current damage curves. Up to 13,000 more properties would have been impacted by the event without the Dam.

The time at which flood levels remained elevated above major levels has also been reduced by up to 3 days by the dam. This has significant benefits to impact on the population of the city, property damage and the recovery operation.





The strategy adopted to quickly close off releases once the peak in the dam had been reached and rain stopped falling certainly reduced the predicted flood peak by at least one metre in the lower Brisbane River area. This notion is supported by BOM.

5 EVENT REVIEW

Under the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam that are approved and gazetted by the Department of Environment and Resource Management, there is a regulatory requirement that a report must be prepared as per the below wording:

"Seqwater must prepare a report after each Flood Event. The report must contain details of the procedures used, the reasons therefore and other pertinent information. Seqwater must forward the report to the Chief Executive within six weeks of the completion of the Flood Event."

Such a report was prepared for the flood events of February and March 2010 and copies are available. A copy of the Table of Contents of that report is included as Appendix 1. For this event, the report would be a comprehensive summary of all procedures, actions, outcomes and processes during the event.

It is recommended that the process and content for reports required for this event be:

- In the short term, utilise this report attached to this briefing note as the basis for communications and discussion.
- Prepare any Interim Reports as agreed to provide information and input as required.
- Seqwater prepare a Comprehensive Report as per the existing regulatory requirements of the Act and the gazetted manual and any requirements of the Dam Safety Regulator. This would be done within 6 weeks of the closure of the current event as per the manual. This timeframe is subject to any new mobilisation of the Flood Operations Centre. The Table of Contents would include:
    - Introduction
    - Flood Event Summary
    - Mobilisation and Staffing
    - Event Rainfall
    - Inflow and Release Details
    - Data Collection System Performance
    - Data Analysis Performance
    - Communication
    - Flood Management Strategies and Manual Compliance
    - Improvements in data collection systems, practices and processes.
    - improvements by interacting agencies

- Review of factors impacting on the protection of urban areas
- Recommendations & Conclusions

- The report would then be reviewed by the Dam Safety Regulator in conjunction with any peer review they require. The review should cover:
  - Were the provisions of the manual complied with?
  - What improvements to either facilities e.g. stream gauges, or work practices, are desirable to improve Sewater's ability to predict inflows into the dams.
  - Are improvements to either Seqwater's facilities or work practices desirable to improve Seqwater's ability to manage events? For example, investigations to raise the dam to improve its flood storage capacity, If so, what are they and their implications.
  - Are changes to the facilities or work practices of other organisations desirable to improve Seqwater's abilities to manage these events? If so, what are they and their implications? (For example, would it be worth funding Brisbane River crossing upgrades so that floodwater could be released faster, while not adversely affecting access to properties--or maybe alternative strategies e.g. resupply operations could be put in place to achieve similar outcomes?)
  - Given the manual's order of priorities i.e. protection of the dam etc, are any changes in the flood release strategies for either dam desirable? If so, what are they, and their implications
- Based on this review, a review of the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam would occur utilising an expert panel of review including representatives of DERM, Seqwater, BoM, affected Local Governments and other stakeholders as necessary.

Appendix A

FINAL REPORT – FLOOD EVENTS AT WIVENHOE, SOMERSET AND NORTH PINE DAMS FOR FEBRUARY AND MARCH 2010

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

"IHF-2"

Ian Fraser

[redacted]

From: Leeanne Bond [redacted]
Sent: Tuesday, 18 January 2011 2:22 PM
To: Ian Fraser
Cc: Peter Borrows; Hennessy, Phil A; <lboully [redacted]; Tom Fenwick
Subject: Re: Australian Questions 17-Jan & Mr O'Brien

Hi Ian - I also endorse

The 'report' was sent to me by a former colleague on Thursday night. I sent it to Phil & Peter when i opened it on Friday. I tried to defuse it but he went to the paper on Sunday. It was a one page word document. I rang Mick on Monday to get the version he sent to the paper and he also provided his spreadsheets etc.

I tried not to engage in debate but was unable to defuse his concerns. I am very sorry that this stance has been taken by a friend. I'll avoid further contact with him unless asked to get involved.

Sent from Leeanne Bond's iPhone

On 18/01/2011, at 14:11, "Ian Fraser" <[redacted] wrote:

> Peter
>
> Thank you very much for all the information.
>
> I endorse Tom's earlier comments. It must be very challenging for you and your people to read the media articles in recent days but particularly The Australian – a more positive perspective in today's Courier Mail on page 7 though. Who was the SEQWater director who was sent Mr O'Brien's report – yesterday's Australian ?
>
> Regards, Ian
>
> **From:** Peter Borrows [redacted]
> **Sent:** Monday, 17 January 2011 5:31 PM
> **To:** Hennessy, Phil A; lbond [redacted] lboully [redacted] Tom Fenwick; Ian Fraser
> **Cc:** Peter Borrows
> **Subject:** FW: Australian Questions 17-Jan & Mr O'Brien
>
> FYI – Confidential at this stage.
>
> These have now been held pending legal advice given the announcement of the Royal Commission.
>
> I have also added some comments from Bob Reilly that will be incorporated in the answers – we want them packaged for when they are necessary. Bob's message is that we used almost

all of the flood compartment and the dam was rising at between 4.5% and 5% per hour at the time – good indicators that the operations of the dam was appropriate given the circumstances.

There will also be some amendment to the comment about agreement with BoM, not because they disagree, rather, they only talk in river levels and not flows.

Regards, Peter.

Peter Borrows

Chief Executive Officer

Queensland Bulk Water Supply Authority *trading as* Seqwater

<image001.png>

Ph [redacted]

Level 3, 240 Margaret St, Brisbane City QLD 4000
PO Box 16146, City East QLD 4002

Website | www.seqwater.com.au

<image002.jpg>

From: Peter Borrows
Sent: Monday, 17 January 2011 2:46 PM
To: 'barry.dennien [redacted] 'bob.reilly [redacted] 'peter.allen [redacted]
Cc: 'daniel.spiller [redacted]
Rob Drury; John Tibaldi; Jim Pruss
Subject: FW: Australian Questions 17-Jan & Mr O'Brien

Barry.

First 4 questions are answers to Mr O'Brien.

The rest are the Australian.

Regards, Peter.

Peter Borrows

Chief Executive Officer

Queensland Bulk Water Supply Authority *trading as* Seqwater

<image001.png>

Ph [redacted]

Level 3, 240 Margaret St, Brisbane City QLD 4000
PO Box 16146, City East QLD 4002

Website | www.seqwater.com.au

<image002.jpg>

From: John Tibaldi
Sent: Monday, 17 January 2011 2:36 PM
To: Peter Borrows
Cc: Arnou Pruden
Subject: Australian Questions 17-Jan (subject to BOM confirmation on one number)

JANUARY 2011 FLOOD EVENT
QUESTIONS AND ANSWERS

Why did Seqwater not allow the total available flood storage capacity of Wivenhoe to be utilised during this period?

- Wivenhoe Dam is not designed to overtop. If it did, the dam would fail and the resulting damage and loss of life would be at least 100 to 1,000 times greater than that currently being experienced.
- To ensure that this never occurs, the dam has been designed with fuse plugs that automatically open when it reaches more than 200% of full supply volume.
- Once triggered, the rate of release through these plugs cannot be varied.
- The plugs continue to release water at this rate until the dam reaches full supply level.
- The fuse plugs would take four to six months of dry weather to repair, and severely restrict the capability to manage further flood events during this period.
- Flood operations were managed to ensure a buffer below 200% to allow for possibilities of further extensive inflows to ensure that the dam does not fail.

What justification was there for the substantial increase in discharge from Wivenhoe to 645,000ML/d when a release rate of 215,000ML/d has been demonstrably sufficient to stop the levels in Wivenhoe rising and while there remained substantial capacity in Wivenhoe for additional flood storage?

At the peak of the event a discharge rate of 215,000ML/d would not have been sufficient to stop the levels in Wivenhoe rising.

The reasons why the remaining flood storage capacity in Wivenhoe Dam was not used at the peak of the event are contained in the answer to the previous question.

Was this increase to 645,000ML/d the sole reason for the significant flooding in Brisbane?

The Bureau of Meteorology has stated that, even at their peak, outflows from Wivenhoe Dam contributed slightly more than half the flood arriving in Brisbane (Courier Mail, 14 January). Seqwater agrees with this assessment.

Based on the fact that the current event was one meter lower than the 1974 event, BOM and Seqwater have agreed that the flow in the Lower Brisbane River at the peak of the event was in the order of 690,000ML/d. Accordingly outflows from Wivenhoe Dam contributed around 350,000ML/d to the total flow at this time. The difference between this flow and the peak outflow from Wivenhoe Dam during the event is due to attenuation effects along the length of the river as would be expected in such an event.

Why did it initially take SEQWater 6 days to respond to the gradually increasing water levels in Wivenhoe which reduced its flood control capacity?

Seqwater responded immediately to increases in storage level by commencing releases from Wivenhoe Dam at the commencement of the flood event. When managing a flood event using Wivenhoe Dam, the primary objectives in order of importance are:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers. Primarily this involves minimising inundation of the seven bridges below the dam upstream of Moggill.

The most recent four flood events (commencing October 2011), demonstrate the importance of following these objective to minimise overall downstream flood impacts.

Why did Seqwater permit the flood storage capacity to build up so much over the weekend?

Seqwater commenced releases from Wivenhoe Dam at the start of the flood event on 7 January 2011. When managing a flood event using Wivenhoe Dam, the primary objectives in order of importance are:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers. Primarily this involves minimising inundation of the seven bridges below the dam upstream of Moggill.

The most recent four flood events (commencing October 2011), demonstrate the importance of following these objective to minimise overall downstream flood impacts.

Why did Seqwater not release significantly greater volumes on Friday, Saturday and Sunday, prior to the freak rainfall event on Monday over the Toowoomba escarpment?

No agency or person was able to forecast the freak rainfall event on Monday over the Toowoomba escarpment prior to it occurring. Therefore it was not possible to ramp up releases to cater for this freak event before it actually occurred.

What does Seqwater say to the suggestion that its strategy to limit the releases on the weekend meant its storage buffer was limited, necessitating a massive outflow on Tuesday of 645,000 megalitres?

The peak outflow that occurred for three hours of 645,000 ML/d (total volume of 80,625 megalitres) does not reflect the impact at Brisbane due to the attenuation effects of the river. The Bureau of Meteorology has stated that, even at their peak, outflows from Wivenhoe Dam contributed slightly more than half the flood arriving in Brisbane (Courier Mail, 14 January). Seqwater agrees with this assessment.

Based on the fact that the current event was one meter lower than the 1974 event, BOM and Seqwater have agreed that the flow in the Lower Brisbane River at the peak of the event was in the order of 690,000ML/d. Accordingly outflows from Wivenhoe Dam contributed around 350,000ML/d to the total flow at this time. The difference between this flow and the peak outflow from Wivenhoe Dam during the event is due to attenuation effects along the length of the river as would be expected in such an event.

What does Seqwater say to the suggestion that this 645,000 megalitres release was responsible for more than 80 per cent of the peak flow rate (which you advised me last Friday was about 9000 cubic metres per second in Brisbane)?

The Bureau of Meteorology has stated that, even at their peak, outflows from Wivenhoe Dam contributed slightly more than half the flood arriving in Brisbane (Courier Mail, 14 January). Seqwater agrees with this assessment.

Based on the fact that the current event was one meter lower than the 1974 event, BOM and Seqwater have agreed that the flow in the Lower Brisbane River at the peak of the event was in the order of 690,000ML/d. Accordingly outflows from Wivenhoe Dam contributed around 350,000ML/d to the total flow at this time. The difference between this flow and the peak outflow from Wivenhoe Dam during the event is due to attenuation effects along the length of the river as would be expected in such an event.

What does Seqwater say to the suggestion that its delay in responding to the increasing water levels at Wivenhoe forced its management to take rash action on Tuesday, which produced the flood in Brisbane?

No rash action was taken at any time during the flood event in managing releases from Wivenhoe Dam. Wivenhoe dam reduced flood levels in Brisbane by up to 2.5 metres in Brisbane city and a metre from the BOM peak flood level forecast. This was achieved by following carefully considered objectives and procedures.

Seqwater commenced releases from Wivenhoe Dam at the start of the flood event on 7 January 2011. When managing a flood event using Wivenhoe Dam, the primary objectives in order of importance are:

- Ensure the structural safety of the dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers. Primarily this involves minimising inundation of the seven bridges below the dam upstream of Moggill.

The most recent four flood events (commencing October 2011), demonstrate the importance of following these objective to minimise overall downstream flood impacts.