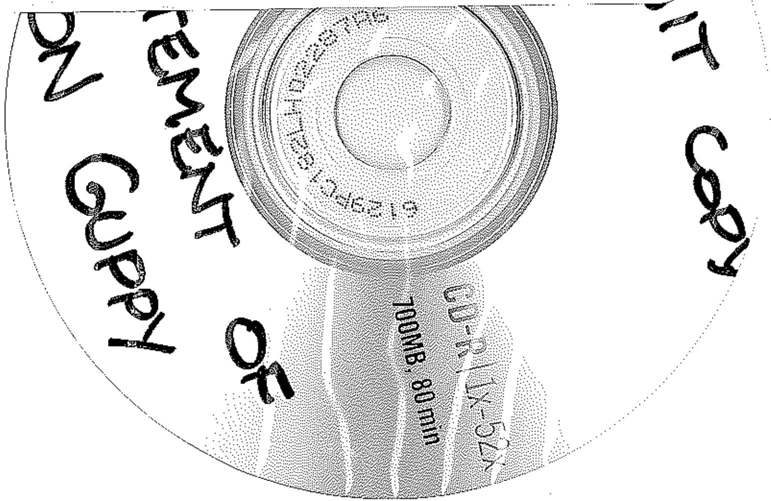
GUPPY

JM

QFCI

Date: 16/05/11

Exhibit Number: 398



QUEENSLAND FLOODS
COMMISSION OF INQUIRY

STATEMENT OF RONALD (RON) KEITH GUPPY

I, **RONALD (RON) KEITH GUPPY**, of c/- 400 George Street Brisbane in the State of Queensland, Project Manager, Department of Environment and Resource Management, state on oath:

Requirement from Queensland Floods Commission of Inquiry

1. I have seen a copy of a letter dated 21 April 2011 from the Commissioner, Queensland Floods Commission of Inquiry to me requiring a sworn statement which is attachment **RKG-01** and which details the topics my statement should cover.

Item 1: A description of my current employment with the Department of Environment and Resource Management, my role, qualifications, training and experience relevant to my work at that Department.

2. I am employed as the Project Manger (Dam Safety) in the Dam Safety work team in the Office of the Water Supply Regulator work unit in the Water and Ecosystem Outcomes division of the Department of Environment and Resource Management. A copy of the Position Description for my current position which details my roles and responsibilities is attachment **RKG-02**. This position is a contract role, however I am a permanent public servant and my substantive role is Principal Engineer, Dam Safety, which is a PO5 position. A copy of my curriculum vitae is attachment **RKG-03**.

3. I hold a Bachelor of Engineering (Civil) from the University of Queensland. I am a Registered Professional Engineer and I undertake training in continuing education requirements to maintain my registration.

4. My immediate supervisor is Peter Allen, Director, Dam Safety. I am aware that Peter Allen has been required to provide a statement to Queensland Floods Commission of Inquiry and I have seen a copy of his statement.

5. I am aware that I am listed as a departmental contact for the Flood Operations Centre however I would expect that the Flood Operations Centre would contact Peter Allen in the first instance. I was on leave during the period of the floods and I did not have any contact with the Flood Operations Centre or involvement in any departmental decision making regarding the operation of the Manuals during the floods.

Item 2: A description of my role in the amendment or revision of the Manual of Operational Procedures for Flood Mitigation at Wivenhoe and Somerset Dams ('the Wivenhoe/Somerset Manual') and the Manual of Operational Procedures for Flood Mitigation at North Pine Dam ('the North Pine Manual')

General

6. I do not have any role in the formal legislative approval of the Manuals as I do not have the delegated responsibility for approval under the *Water Supply (Safety and Reliability) Act 2008* ('Water Supply Act') or previously under the *Water Act 2000* ('Water Act').

7. I was generally aware of the existence of the Manuals prior to 2000 but I had no involvement in their amendment or revision. In around 2000 upon the commencement of the Water Act I became involved in generally assisting with revision. This involvement was always under the supervision of my immediate supervisor, Peter Allen, or someone acting in his position. Prior to John Tibaldi commencing with Seqwater (in about 1998) I was often the initial point of contact. However, subsequent to that time Peter Allen became his initial contact

8. My involvement with the revision of the Manuals involved reading drafts prepared by Queensland Bulk Water Authority *trading as* Seqwater ('Seqwater') reviewing the content, providing comments and attending review meetings. This involvement was under the supervision of my immediate supervisor who was also present at meetings. In addition, I provided recommendations about approval of Revisions 5 and 6 of the Wivenhoe and Somerset Manual and Revision 4 of the North Pine Dam Manual (see Previous Manuals section below).

North Pine Dam (Revision 5)

9. Revision 5 - A draft manual was originally distributed on 12 January 2010 by John Tibaldi (Seqwater) and some preliminary comments were made by me and Khanh (Ken) Nguyen in e-mails dated 13 and 15 January 2010 respectively – see Attachment **RKG-04.**

10. I made comments on the draft Manual on or about 13 and 14 January 2010 – see Attachment **RKG-05.**

11. I believe the one and only meeting with SEQWater was on 11 June 2010 following which a request to approve a submitted manual was received on 16 July 2010. I provided comments on that version of the Manual to Peter Allen – see Attachment **RKG-06**. Following discussions with Peter Allen a request for further changes was made - see Attachments **RKG-07** and **RKG-08**.

12. A further draft Manual (copy of this Manual is not attached) with request for approval was received from Peter Borrows by letter dated 13 August 2010. – see Attachment **RKG-09**. This ultimately became the approved manual.

13. On 24 November 2010 I sent an email to Peter Allen as a prompt for getting approval of the manual –see Attachment **RKG-10.**

14. I subsequently sent an e-mail to John Tibaldi on 17 December 2010 advising him of the approval notice appearing in that day's gazette – see Attachment **RKG-11.**

Item 3: An account, verbatim where possible, of all meetings, conversations or communications I participated in regarding the seventh revision of the Wivenhoe/Somerset Manual in 2009 (including attaching any emails, documents or other material relevant to those meetings, conversations or communications).

15. There were three (3) different episodes in relation to Revision 7 of the Wivenhoe/Somerset Manual (Manual). They were in 2006, 2007 and 2009.

Episode 1 – 2006

16. On 15 March 2006 – the draft 2006 Manual was received from Geoff Hales (consultant working for SEQWater) for comment. The draft 2006 Manual is Attachment **RKG-12**.

17. On 27 March 2006 – comment on draft manual was provided to Geoff Hales. This is Attachment **RKG-13**. The e-mail where the draft 2006 Manual was sent to me is an e-mail in **RKG-12**.

18. 18 April 2006 – response was received from Rob Ayre, senior flood operations engineer, SunWater. The comments included in my email of 27 March 2006 are shown in the attachment to the e-mail in bold italic font. It is stated in the response to my first query that SEQWater were to reconsider the Somerset – Wivenhoe Dams interaction curve which is also included. The e-mail, response and interaction curve are Attachment **RKG-14**.

Episode 2 – 2007

19. On 26 June 2007 – another draft was received from Barton Maher, SEQWater. The draft 2007 Manual is Attachment **RKG-15**.

20. On 13 September 2007 – I sent an e-mail to Peter Allen with my comments on the draft 2007 Manual which is Attachment **RKG-16**. The e-mail where the draft Manual was forwarded to me is an e-mail in Attachment **RKG-15**.

21. Other than the above e-mail of 13 September 2007, I don't recall any action ensuing from receipt of this draft 2007 Manual.

Episode 3 -2009

22. During 2009 contact about the update of the Manual was principally between John Tibaldi (SEQWater) and Peter Allen (DERM). I did not receive meeting requests/documentation from SEQWater and used entries in Peter Allen's Outlook Calendar for viewing the various drafts.

23. To the best of my knowledge the meetings between DERM, SEQWater and the Flood Operations Engineers regarding Revision 7 occurred on 14 August 2009, 14 September 2009, 7 October 2009, 15 October 2009 and 6 November 2009. I did attend most of these meetings at Peter Allen's invitation. At these meetings John Tibaldi, or another SEQWater officer would record the changes to be made to the draft under discussion. I kept no records of the meetings.

24. I prepared some notes for consideration for inclusion in a consolidated DERM response to a particular draft. This is Attachment **RKG-17**. The response sent to SEQWater was included in Peter Allen's e-mail of 13 October 2009 which is Attachments **RKG-18** and **RKG-19**.

25. Revision 7 of the Manual was approved by Peter Allen on 22 December 2009. I obtained approval from Mr John McKenna who at that time was Acting Director, Dam Safety (Water Supply) for the publication of the approval of the Manual (see Attachments **RKG-20** and **RKG-21**). I then arranged for publication of the gazettal notice which occurred on 22 January 2010 (see Attachment **RKG-22**). A draft of the letter from John McKenna to Peter Borrows dated 28 January 2000 (sic) advising of the publication of the gazettal notice is Attachment **RKG-23**.

Previous Manuals

26. I have searched for and located the following: -

Wivenhoe and Somerset Dams

- Revision 4 – draft copy of Manual with various proposed amendments – see Attachment **RKG-24**
- Revision 5 – draft copy of Manual with various proposed amendments and copy of the draft memo of recommendation for approval from me to Peter Allen dated 26 October 2004 – see Attachments **RKG-25** and **RKG-26**.
- Revision 6 - copy of draft memo recommendation for approval from me to Peter Allen dated 24 January 2005 – see Attachment **RKG-27**.

North Pine Dam

- Revision 3 – draft copy of Manual with various proposed amendments – see Attachment **RKG-28**.
- Revision 4 - copy of draft memo of recommendation for approval from me to Peter Allen dated 11 September 2007 – see Attachment **RKG-29**

I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867*.

Signed [redacted]

Ronald (Ron) Keith Guppy

Taken and declared before me, at Brisbane this 4th day of May 2011

[redacted]

Solicitor/~~Barrister/Justice of the Peace/Commissioner for Declarations~~

Our ref: Doc 1587811

21 April 2011

Mr Ron Guppy
Department of Environment and Resource Management
GPO Box 2454
BRISBANE QLD 4001

REQUIREMENT TO PROVIDE STATEMENT TO COMMISSION OF INQUIRY

I, Justice Catherine E Holmes, Commissioner of Inquiry, pursuant to section 5(1)(d) of the *Commissions of Inquiry Act 1950* (Qld), require Mr Ron Guppy to provide a written statement, under oath or affirmation, to the Queensland Floods Commission of Inquiry, in which the said Mr Guppy:

- provides all information in his possession and identifies the source or sources of that information;
- makes commentary and provides opinions he is qualified to give as to the appropriateness of particular actions or decisions and the basis of that commentary or opinion;

in respect of the following:

1. a description of his current employment with the Department of Environment and Resource Management, his role, qualifications, training and experience relevant to his work at that Department;

2. a description of his role in the amendment or revision of the Manual of Operational Procedures for Flood Mitigation at Wivenhoe and Somerset Dams ('the Wivenhoe/Somerset Manual') and the Manual of Operational Procedures for Flood Mitigation at North Pine Dam ('the North Pine Manual'); and

3. an account, verbatim where possible, of all meetings, conversations or communications he participated in regarding the seventh revision of the Wivenhoe/Somerset Manual in 2009 (including attaching any emails, documents or other material relevant to those meetings, conversations or communications).

Mr Guppy may also address other topics relevant to the Terms of Reference of the Commission in the statement, if he wishes.

The statement is to be provided to the Queensland Floods Commission of Inquiry by Wednesday 3 May 2011.

400 George Street Brisbane
GPO Box 1738 Brisbane
Queensland 4001 Australia
Telephone 1300 309 634
Facsimile +61 7 3405 9750
www.floodcommission.qld.gov.au

The statement can be provided by post, email or by arranging delivery to the Commission by emailing info@floodcommission.qld.gov.au.

[redacted]

Commissioner
Justice C E Holmes

Queensland Government
Natural Resources and Water

JAR:	QLD/NRW9664/09
CLOSING DATE:	09/02/2009
MONDAY:	MIDNIGHT

POSITION DESCRIPTION

POSITION TITLE:	Project Manager (Dam Safety)
TYPE OF VACANCY:	Full-Time Contact until 31 March 2011 under Section 122 of the *Public Service Act 2008*
WORK UNIT/REGION:	Dam Safety, Office of the Water Supply Regulator, Water and Catchment Division
LOCATION:	Brisbane
CLASSIFICATION:	SO1
SALARY RANGE:	$109,456 - $114,525 per annum plus Superannuation
SALARY RANGE:	$124,880 - $130,663 total remuneration
CONTACT OFFICER:	Peter Allen, Director, Dam Safety (Water Supply)
CONTACT PHONE:	[redacted]

PURPOSE OF POSITION

The purpose of the position is to manage the dam safety program for major water supply and flood mitigation dams in Queensland. In doing so, the role requires the incumbent to lead or participate in multi-disciplinary teams to support the implementation of a world best practice, dam safety regulation of these dams within the regulatory framework of the *Water Act 2000.*

The position will also participate in departmental and inter-governmental groups developing/implementing State policies, on dam safety as well as the ongoing regulation of dams in Queensland and managing multi-disciplinary projects, teams and consultants involved in (including legislation) in relation to dam of large water supply and flood mitigation.

SELECTION CRITERIA

Applicants will be assessed on how well they meet each of the below selection criteria. In order to apply for the position, applicants will need to provide 1 – 2 pages per criterion. Applicants should refer to all relevant skills, knowledge and experience in addressing the criteria, not just those relating to the duties and responsibilities for the position. The Guide for Applicants http://nrw.qld.gov.au/about/employment/how_to_apply.html provides information about how to respond to selection criteria. More information can also be sought from the contact officer listed above.

Selection Criterion 1 – Proven extensive knowledge of and experience in the design, construction, operation and ongoing management of large water supply and flood mitigation dams, and the causes and effects of dam failures, including emergency measures required in the event of failure. Weighting 35%

Responsibilities relating to this criterion:

- Maintaining an extensive knowledge of dam technology, including the socio-economic issues that determine community acceptance of standards to ensure the safety of the community itself.

- Lead, manage and implement the overall dam safety regulatory program for a number of large referable water dams across the State. This will involve the full complement of regulatory work from initial awareness raising activities through to compliance enforcement activities.
- Leading or participating in the implementation of dam safety policy, guidelines and criteria across Queensland and the development of a high level of competence for all staff and persons involved in departmental dam safety activities by assisting regions to train suitable compliance monitoring staff to implement dam safety regulation and compliance monitoring systems.
- Developing and approving appropriate conditions relating to dam safety to be applied in response to circumstances such as:
  (a) Development permit applications
  (b) Prescribing of dams by regulation
  (c) Changes in techniques for assessing aspects of dam safety
  (d) Changes in conditions or circumstances at individual dams.
- Providing high level strategic advice and recommendations to the Minister, Director-General, Deputy Director-General, General Manager (Office of the Water Supply Regulator) and senior management on dam safety issues.
- Provision of a high level of technical review of dam safety documentation submitted by or on the behalf of dam owners including:
  (a) Design and construction documentation
  (b) Dam safety reviews
  (c) Flood studies including Failure Impact Assessments
  (d) Standing Operating Procedures
  (e) Emergency Action Plans
  (f) Proposals for remedial works and dam upgrades.

Selection Criterion 2 – Proven high level consultation, negotiation and communication (oral and written) skills combined with the ability to professionally represent the department and its interests on dam safety issues and ability to develop effective training and conduct courses and seminars. **Weighting 25%**

Responsibilities relating to this criterion:
- Liaise and negotiate with internal staff, other government agencies, key stakeholders, the community and other interested parties on dam safety issues and acting as the lead agency as the need arises in any consultation process.
- Preparing briefings, responses, submissions and replies with respect to dam safety regulation and compliance monitoring issues.
- Promoting dam safety in Queensland through the development of networks and consulting with peers, industry groups, community groups, departmental staff, State and Federal Government departments and other agencies and representing the interests of the Department and government at State and Federal levels, within industry groups and amongst the consultant service providers.
- Negotiating acceptable dam safety regulatory outcomes with non-cooperative dam owners.
- Providing legally binding advice and direction to dam owners aimed at minimising the risk to human life.

Selection Criterion 3 – Proven ability to lead and manage teams of professional and technical persons (including consultants) engaged in performing, or overseeing the performance of water infrastructure asset management activities. **Weighting 20%**

Responsibilities relating to this criterion:
- Undertaking, or arranging for consultants to undertake, studies to assess a wide variety of aspects affecting (and potentially affecting) the safety of referable (and potentially referable) dams.

- Undertaking works, or arranging for consultants and/or contractors to undertake works associated with appropriate emergency actions to be taken to prevent or minimise the potential impact of dam failure (including decommissioning) of such dams.
- Participate in and promote the professional development and training of staff in head office and regional offices in all aspects of dams and dam safety.
- Lead the coordination, management and implementation of projects within agreed timelines and budgets.

Selection Criterion 4 – Understanding or an ability to rapidly acquire an understanding, of the legislation, policy issues and policy development procedures relevant to the development and management of large water supply and flood mitigation dams including the enforcement of compliance with regulatory requirements. **Weighting 20%**

Responsibilities relating to this criterion:

- Inspecting water dams when dam safety issues arise and, when the situation demands, directing appropriate emergency actions to be taken to prevent or minimise the potential impact of dam failure.
- Development and review of national (through inter-jurisdictional forums) and Queensland standards and regulatory guidelines relevant to dam safety issues associated with large water supply and flood mitigation dams.
- Making regulatory decisions relating to the approval of Failure Impact Assessments and the setting or amending of dam safety conditions
- Monitoring compliance with regulatory requirements and applied conditions relating to dam safety and reporting on the adequacy/appropriateness of dam owner's dam safety management systems and facilitating the development and implementation of such dam safety management systems and, if required, recommending appropriate remedial actions and initiating relevant compliance actions.

MINIMUM QUALIFICATION REQUIREMENT

Possession of tertiary engineering qualifications in a discipline relevant to water infrastructure management and, in particular, dam safety and registration, or the qualifications and experience to gain immediate registration under the *Professional Engineers Act, 2002.*

DELEGATIONS AND ACCOUNTABILITIES

If approved, this position will hold a maximum Financial Delegation of Level 3 from the Director-General under the *Financial Administration and Audit Act 1977.*

The position will also hold delegations under *Water Act 2000* to approve dam failure impact assessments and set and amend dam safety conditions for all referable dams in Queensland.

It is expected the holder of this position will be appointed an Authorised Officer under the *Water Act 2000.*

MANAGEMENT RESPONSIBILITIES

This position has additional responsibilities under the following legislation to ensure a safe, fair and equitable workplace:

- Public Service Act 2008
- Workplace Health and Safety Act 1995
- Industrial Relations Act 1999
- Financial Administration and Audit Act 1977.

Departmental Standards, policies and directives will also provide information and advice to assist managers and supervisors to meet management responsibilities.

REPORTING RELATIONSHIPS

This position reports to Director Dam Safety and supervises 1xPO5, 2xPO4, 1xPO2, 1xPO1 and may supervise other engineers and technical staff in the context of project activities.

ORGANISATIONAL ENVIRONMENT

Managing Queensland's natural resources...for today and tomorrow

How we manage our natural resources today will directly affect the liveability and future prosperity of Queensland.

Now and in the future, Queenslanders will rely on access to well-managed land, water, vegetation, and the preservation of our cultural heritage.

The Department of Natural Resources & Water (NRW) works together with industry, community, landholders and government to ensure that the management of our natural resources is innovative, responsible and balanced.

Our management of the state's valuable resources will support Queensland's future growth—and ensure that future generations are able to share in the benefits.

The Department has a Service Charter which outlines its commitment to excellence in internal and external service delivery and promotes the service principles of solution focus, commitment to clients, choice, consistency, coordination and feedback.

NRW is an equal opportunity employer. We support and recognise the value of a diverse workforce and encourage applicants in all areas of our culturally diverse society to consider a career with us.

NRW staff are expected to work in accordance with NRW's Code of Conduct, Workplace Health and Safety legislation and all other policies, directives and legislation which impact on their position.

Further information on NRW's business and employment conditions is available on our web site http://www.nrw.qld.gov.au/about/index.html.

The Office of the Water Supply Regulator business group (OWSR) has key policy/regulatory roles relevant to the continuity of water supply and sewerage services, including the safety of large water supply dams, in Queensland. It also has a major role in the development and implementation of policies which are aimed at improving the efficiency with which water resources are used in Queensland urban communities.

The Dam Safety section has responsibilities associated with:

- The regulation of referable dams in Queensland through the development, application and periodic review/revision of conditions relevant to dam safety which prescribe the design and construction of individual large water supply/ flood mitigation dams and their operation/maintenance procedures;

- Monitoring of dam owner compliance with these conditions and reporting on the overall performance of the dam safety regulatory program;
- The development and implementation of policies and guidelines (including legislation) prescribing the dam safety regime within which large water supply/flood mitigation dams in Queensland are designed, constructed, operated and maintained;
- Providing coordination and support for the Department's regional dam safety activities;
- Facilitating the involvement of other state and local government bodies in the emergency management planning arrangements for individual dams;
- Providing legally binding directions to dam owners in the event of dam safety emergencies relevant to the operation of individual dams;
- Arranging for, and over sighting, the undertaking of engineering works associated with rectifying safety issues for referable dams in accordance with Court orders or compliance notices issued by the Chief Executive of NRW.

The structure of the Dam Safety unit is relatively flexible with the ability to utilize staff from other organization units of OWSR in accordance with the workload and overall OSWR priorities. Further information on the Dam Safety unit's activities can be found on the OWSR's web site.

OTHER INFORMATION

Possession of a current Queensland motor vehicle driver's licence (Class C) is required.

This position involves intra-state and inter-state travel. The length of time away from Brisbane on any individual trip is unlikely to exceed one week. It may not always be possible to give more than 24 hours notice of the need to travel.

A non-smoking policy is effective in Queensland Government buildings, offices and motor vehicles.

Queensland Government employees are able to salary package.

On appointment to this position, a probationary period may apply in accordance with Section 73 of the *Public Service Act 2008.*

To be eligible for permanent appointment to the Queensland Public Service applicants must be:

- An Australian citizen; or
- A person who resides in Australia and has permission or a right to be granted permission, under Commonwealth law, to remain in Australia indefinitely; or
- A New Zealand citizen who has a special category visa or a right to be granted a special category visa under the *Migration Act 1958.*

To be eligible for temporary appointment the applicant must provide proof that they can legally work in Australia.

Applications may remain current for a period of twelve (12) months for future vacancies.

The personal information collected during the selection process will be used to administer that process under section 78 of the Public *Service Act 2008.* If an appeal is lodged against the recruitment decision, the information may be disclosed to the Office of the Public Service Commissioner and to the parties to that appeal, in accordance with Section 94(2) of the *Public Service Act 2008.*

Your application, CV and other documents are also subject to the *Freedom of Information Act 1992* and unless exempt from release, could be disclosed to an FOI applicant.

HOW TO APPLY

Please note Shared Service Agency do not accept hand delivered applications. You can submit your application to Shared Service Agency online via email or hardcopy application:

If applying online, please follow the steps below:

1. Complete the online application by clicking on the "Apply Online" link at the bottom of the specific job details page (http://www.jobs.qld.gov.au).
2. Upload your application (a maximum of three (3) files) using the online system. Please ensure to click on the "Submit" button once completed.

If applying by electronic mail or hardcopy:

Applications for this position should be sent by e-mail to [redacted] Please ensure that the Application form is attached and include the JAR in the subject line of your email.

Hardcopy applications should be marked "Private and Confidential" and mailed to:

The Applications Officer - NRW
Shared Service Agency
PO Box 610
Spring Hill Qld 4004

For further information on how to apply for this position download the "Guide for Applicants" attached to the Job Advertisement or go to **http://nrw.qld.gov.au/about/employment/how_to_apply.html**.

POSITION NUMBER:	76021391
MOD ID NO.:	
DATE OF REVIEW:	

Curriculum Vitae

Name: Ronald Keith GUPPY

Address: [redacted]

Telephone: [redacted]

Date of Birth: [redacted]

Qualifications

Bachelor of Engineering (Civil) 1977
University of Queensland

Registered Professional Engineer of Queensland
(Registration Number 5119)

Employment History

2009 to present	**Project Manager, Dam Safety** **Department of Environment and Resource Management** **Brisbane, Queensland**

Conduct safety condition audits at dam to assess the dam safety management practices of the dam owner and their regulatory compliance.

Review dam safety aspects of proposals for construction of dams and recommend conditions for the safe construction, operation and maintenance of the dam.

Decide on acceptance of failure impact assessments for determining whether dams are referable

Prepare safety conditions for referable dams

Conduct training courses in dam safety surveillance for dam owners and operators

Act as state representative on the national committee setting the curriculum for national dam safety surveillance operator training

Departmental liaison officer for stages of Ross River Upgrade Project where subsidy of almost $M80 was paid

Represent department on committee preparing guidelines on construction of ponds for use in aquaculture operations.

Contribute to the development of guidelines including for failure impact assessment and dam safety management for use in the regulation of dam safety.

Review and provide recommendations for the update of flood mitigation manuals

Give presentations on referable dam issues such as failure impact assessment, emergency action planning and causes of dam failure to

Investigate and report on dam safety incidents and possible remedial actions

Provide engineering advice to Dam Safety (Farm Dams) group on assessment of the population at risk for farm dams

1998 to 2009	**Principal Engineer, Dam Safety** **Department of Natural Resources and Water** **Brisbane, Queensland** As per above for Project Manager, Department of Environment and Resource Management
1997 to 1998	**Senior Engineer, Dam Safety** **Department of Natural Resources and Water** **Mackay, Queensland** Provide dam safety advice and oversight the regulation of referable dams throughout the northern part of Queensland Advise dam owners on practices to be followed in the management of referable dams Review proposals for the construction of referable dams and negotiate variations with the dam owners and/or engineering consultants so that dam safety requirements are met. Investigate dam safety incidents and recommended remedial actions
1992 to 1997	**Engineer, Dam Safety** **Department of Natural Resources and Water** **Brisbane, Queensland** Conduct comprehensive surveillance inspections of departmental dams including Fred Haigh and Wuruma Dam Undertake dam break analyses for dams, including Ibis Dam at Irvinebank, to determine need for dam safety regulation. Review referable dam proposals and provide recommendations regarding dam safety for the licensing of referable dams, particularly those involving mining operations and hazardous waste containment. Prepare and deliver training courses in dam safety management to dam owners and departmental regulatory staff
1990 to 1992	**Engineer, Surface Water Assessment** **Queensland Water Resources Commission** **Brisbane, Queensland** Undertake hydrologic modelling including flood studies and yield studies for dams.

Undertake hydraulic modelling of floodplain at Rosevale for assessment of flood mitigation proposals.

1989 to 1990 **Engineer, Safety and Technology Branch**
Department of Mines
Cairns, Queensland

Provide recommendations to mining inspectors on all issues concerning construction and operation dams, especially tailings dams, and water and tailings management on mine sites particularly concerning the containment of hazardous substances.

Provide recommendations on rehabilitation works necessary at abandoned mine sites

1983 to 1989 **Engineer, Central Regional**
Queensland Water Resources Commission
Rockhampton, Queensland

Design of works including pump stations, culverts, siphons, flumes and measuring weirs for use in irrigation schemes

Manage the construction and refurbishment of works, including pump stations, culverts, siphons flumes and weirs associated with irrigation schemes

Review the operational performance of the irrigation areas at Theodore.

Act as government representative on Palmgrove, Benleith and Washpool Water Boards

Supervise the construction of the water treatment plant for Theodore

Prepare preliminary designs for water supply schemes for potential Water Board Areas

Provide recommendations on waterworks licensing matters, including dam construction and tailings management

1980 to 1983 **Engineer, Groundwater Branch**
Irrigation and Water Supply Commission
Brisbane, Queensland

Model groundwater behaviour within groundwater use areas to determine the available resource and sustainable yield.

1979 **Engineer, Farm Water Supplies Branch**

Irrigation and Water Supply Commission
Brisbane, Queensland

Investigate and design farm water supply storages and irrigation schemes

1978 **Engineer, Project Planning Branch**
Irrigation and Water Supply Commission
Brisbane, Queensland

Preliminary investigation of proposals for large water supply storages and schemes

[redacted]

[redacted]

From: Nguyen Khanh

Sent: Friday, 15 January 2010 1:57 PM

To: Allen Peter; Guppy Ron

Subject: RE: Revised North Pine Dam Flood Mitigation Manual for your comments

Peter & Ron,

We have not received any AFC information from Seqwater at this stage other than the revised flood hydrology report dated Oct 2007. Our preliminary AFC assessment based on current available revised flood hydrology suggested that:

(1) North Pine Dam can perhaps safety handle an equivalent 1:500,000 AEP flood, which is larger than 75% of the AFC (assumed AFC is the PMP-DF). This based on the assumption of 1 gate is inoperable (20% of gates out of action) as per Fall-back approach. No spillway upgrade is required until 2035.

(2) Due to the low probability of the DCF flood (1:500,000 AEP), adopting RA would probably meeting ANCOLD's tolerability criteria for now. Hence no immediate spillway upgrade is required.

(3) There may be room to modify the current operating rule to contain the PMPDF if necessary. However, unless we have a time to prove that the new operating rules could also improve the flood performance of the Dam for the more frequent flood events (from 1:10 to 1:2,000AEP), then I don't see an immediate benefit to modify the current operating rules.

The following flood routing summary for the 36-hr events are based on the revised flood hydrology May 2007.

(1) With all 5 gates operable, the DCF of the Dam is equivalent to the 1:2,00,000AEP
(2) With all 5 gates operable, the Radial Gate Switch gear level (RL 41.66) is equivalent to the 1:100,000AEP
(3) One gate inoperable: DFC is 1:550,000AEP
(4) Two gates inoperable: DFC is 1:125,000AEP
(5) Three gates inoperable: DFC is 1:25,000AEP
(6) Four gates inoperable: DFC is 1:1,250AEP

Table 10-2: Critical Durations, Outflows and Peak Water Levels – Scenarios 1,2&3

AEP 1 in ...	Normal Operations			One Gate Inoperable			Two Gates Inoperable		
	Critical Duration hr	Peak Outflow m3/s	Peak Water Level m AHD	Critical Duration hr	Peak Outflow m3/s	Peak Water Level m AHD	Critical Duration hr	Peak Outflow m3/s	Peak Water Level m AHD
2	36	390	39.92	72	390	39.91	72	380	39.92
5	36	550	40.01	36	550	40.01	36	550	40.01
10	36	660	40.07	36	660	40.07	36	660	40.07
20	12	830	40.17	12	820	40.16	12	830	40.16
50	12	1,040	40.28	12	1,040	40.28	12	1,040	40.28
100	12	1,200	40.39	12	1,200	40.38	12	1,200	40.38
200	12	1,500	40.51	12	1,500	40.51	12	1,400	40.50
500	18	1,700	40.67	18	1,700	40.66	18	1,700	40.67
1,000	36	2,100	40.85	36	2,100	40.85	36	2,000	40.90
2,000	12	2,200	40.87	12	2,200	40.86	36	2,000	40.92
5,000	36	2,600	41.02	36	2,600	41.01	36	2,200	41.29
10,000	36	3,000	41.14	36	2,800	41.20	36	2,400	41.64
50,000	36	3,600	41.45	36	3,200	41.89	48	2,900	42.71
100,000	36	3,800	41.71	36	3,400	42.29	48	3,200	43.16
200,000	36	4,000	42.06	36	3,700	42.71	36	3,700	43.49
500,000	36	4,300	42.56	36	4,100	43.25	36	4,600	43.73
1,000,000	36	4,700	42.95	36	4,800	43.54	36	5,100	43.89
2,900,000	36	5,400	43.47	36	5,800	43.81	36	6,000	44.13

[illegible]	[illegible]
EL 41.66	Radial Gate Switchgear
[illegible]	[illegible]

Regards

Khanh (Ken) Nguyen
Project Manager - Dam-Safety (Spillway Upgrade)
Office of the Water Supply Regulator
Telephone: [redacted] **Facsimile:** [redacted]
Email: [redacted]
Department of Environment and Resource Management
http://www.derm.qld.gov.au/
Level 3 Mineral House 41 George Street
BRISBANE Q 4000
GPO Box 2454, Brisbane Q 4001

From: Guppy Ron
Sent: Wednesday, 13 January 2010 10:44 AM
To: Nguyen Khanh; Allen Peter
Subject: FW: Revised North Pine Dam Flood Mitigation Manual for your comments

This may cause a bit of a dilemma for us.

The 1991 hydrology which was the most up to date stuff prior to 2007 had for this schedule for gate operation a 'maximum design flood level' of 41.47 and a PMP lake level of 42.38 both below the embankment crest level of 43.28.

The May 2007 hydrology changed that so with the same gate operations the PMP-DF now overtops the embankment for 12 hours by up to 0.19 metres for the all gates operating case.

Do we want to approve a manual with these same gate operations?

Ken, can you do a quick summary of where it sit regards spillway adequacy and any upgrade options they might have in mind.Also does the spillway adequacy

There is no great urgency to get a new manual approved. The current version is valid to September 2012.

As far as the actual manual goes, from first glance there has been a lot of copying from the Wivenhoe Manual some of which shouldn't have happened. e.g.. like having gates out of the water. I will have a more detailed look at it in the future.

Ron Guppy
Principal Engineer (Dam Safety)
Office of the Water Supply Regulator
Telephone [redacted] **Facsimile** [redacted]
Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

From: John Tibaldi [mailto [redacted]
Sent: Tuesday, 12 January 2010 2:42 PM
To: Rob.ayre [redacted] Ruffini John; Allen Peter; Guppy Ron; Terry Malone; Barton Maher; Louw Van Blerk
Cc: Rob Drury; Jim Pruss
Subject: Revised North Pine Dam Flood Mitigation Manual for your comments

All

Attached is a draft of the revised Flood Mitigation Manual for North Pine Dam for your comments prior to formal submission for gazettal. The main changes from the previous version of the manual are:

- Change in relevant legislation to the Water Supply (Safety and Reliability) Act 2008.
- Change in relevant regulatory agency to the Department of Environment and Resource Management.
- Change in dam owner to the Queensland Bulk Water Supply Authority trading as Seqwater.
- Change in Agencies requiring information and holding controlled copies of the Manual in accordance with the Local Government Amalgamations of 2008.
- Change in format to achieve consistency with the Wivenhoe/Somerset Manual.

In my view, none of these changes resulted in any significant change in operational procedure from the previous version of the Manual. I will contact you all individually in the next week or so to determine if a meeting is required to discuss the changes, prior to formal submission to the regulator.

John Tibaldi
Dam Safety Manager

Queensland Bulk Water Supply Authority *trading as* Seqwater

seqwater
WATER FOR LIFE

[redacted]
Unit 1/ 68 Junction Road, Karalee QLD 4306
PO Box 2437, North Ipswich QLD 4305
Website | www.seqwater.com.au

MANUAL

OF

OPERATIONAL PROCEDURES

FOR

FLOOD MITIGATION

Comment [r1]: While it is to be a Flood Mitigation Manual, there is no aim of flood mitigation. Why not go back to Flood Releases.

AT

NORTH PINE DAM

Revision 5
February 2010

Revision No.	Date	Amendment Details
0	10 December 1986	Original Issue
1	6 October 1992	Complete revision and re-issue
2	13 November 1997	Complete revision and re-issue
3	26 July 2002	Complete revision and re-issue
4	5 September 2007	Complete revision and re-issue
5	November 2009	Complete revision and re-issue

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Preface

Given its size and location and rapid catchment response to rainfall, it is imperative that North Pine Dam be operated during flood events in accordance with clearly defined procedures to minimise hazard to life and property. This manual outlines these procedures and is an approved Flood Mitigation Manual under Water Supply Act 2008.

The Manual in its current form was developed in 1992 and the basis of this document was a manual written in 1986 covering flood operations at the dam. Four revisions of the Manual have occurred since 1992 to account for updates to the Flood Alert Network and the Real Time Flood Models and to account for institutional and legislative changes.

Deleted:

The primary objectives of the procedures contained in this Manual are essentially the same as those contained in previous Manual versions. These objectives in order of importance are:

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- 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.

Deleted: populations

In meeting these objectives, the dam must be operated to account for the potential effects of closely spaced Flood Events. Accordingly, normal procedures require stored floodwaters to be emptied from the dam as quickly as possible while meeting all flood mitigation objectives.

1.2 Meaning of Terms

In this manual, save where a contrary definition appears -

"Act" means the *Water Supply (Safety and Reliability) Act 2008*;

"AEP" means annual exceedance probability, the probability of a specified event being exceeded in any year;

"Agency" includes a person, a local government and a department of state government within the meaning of the Acts Interpretation Act 1954;

"AHD" means Australian Height Datum;

"Chairperson" means the Chairperson of Seqwater;

“Chief Executive” means the Director General of the Department of Environment and Resource Management or nominated delegate;

“Controlled Document” means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

“Dam” means the dam to which this manual applies, that is North Pine Dam;

“Dam Supervisor” means the senior on-site officer at North Pine Dam;

“Duty Flood Operations Engineer” means the Senior Flood Operations Engineer or Flood Operations Engineer rostered on duty to be in charge of Flood Operations at the dam;

“EL” means elevation in metres Australian Height Datum;

“Flood Event” is a situation where the Duty Flood Operations Engineer expects the water level at the dam to exceed the Full Supply Level;

“Flood Operations Centre” means the Centre used by Flood Operations Engineers to manage Flood Events;

“Flood Operations Engineer” means a person designated to direct flood operations at the dam in accordance with Section 2.4 of this manual;

“FSL” or “Full Supply Level” means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

“Gauge” when referred to in (m) means river level referenced to AHD, and when referred to in (m^3/s) means flow rate in cubic metres per second;

“Manual” or “Manual of Operational Procedures for Flood Mitigation at North Pine Dam” means the current version of this manual;

“Senior Flood Operations Engineer” means a person designated in accordance with Section 2.3 of this manual under whose general direction the procedures in this manual must be carried out;

“Seqwater” means the Queensland Bulk Water Supply Authority trading as Seqwater.

1.3 Purpose of Manual

The purpose of this manual is to define procedures for the operation of North Pine Dam during flood events. The procedures have been developed on the basis that the structural safety of the dam is to be protected to the maximum extent practical within the limitation of minimise the downstream impacts associated with releasing flood water from the dam.

Comment [r2]: structural safety gets mentioned a lot. In some instances we could be more specific and use overtopping

Comment [r3]: This should be reworded

1.4 Legal Authority

This manual has been prepared as a Flood Mitigation Manual in accordance with Chapter 4 Part 2 of the Act.

1.5 Application and Effect

The procedures in this manual apply to the operation of North Pine Dam for the purpose of flood mitigation, and operation in accordance with the manual shall give the protection from liability provided by Section 374 of the Act.

Comment [r4]: I know it is a flood mitigation manual but how about flood management in this instance

1.6 Date of Effect

The procedures in this manual shall have effect on and from the date on which this version of the manual is approved by gazette notice.

The manual shall remain in force for the period of approval as determined by the Chief Executive. This approval may be for a period of up to five years.

Before the approval of the manual expires, Seqwater must review and if necessary update the manual and submit a copy to the chief executive for approval.

1.7 Observance of Manual

This manual contains the operational procedures for North Pine Dam for the purposes of flood mitigation and must be used for the operation of the dam during flood events.

Formatted: Highlight

Deleted: s

1.8 Provision to Variation of Manual

If Seqwater is of the opinion that this manual should be amended, altered or varied, it must submit for approval as soon as practical, an appropriate request to the Chief Executive, setting out the circumstances and the exact nature of the amendment, alteration or variation sought. The Chief Executive may accept, reject or modify the request prior to approval.

1.9 Distribution of Manual

Seqwater must regard the manual as a Controlled Document and ensure that only controlled manuals are used in the direction of flood mitigation activities. Agencies having copies of controlled hardcopies of the manual are listed in Appendix A. Seqwater must maintain a Register of contact persons for issued controlled hardcopies of the manual and must ensure that each issued document is updated whenever amendments or changes are approved.

2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

Pursuant to the provisions of the Act, Seqwater is responsible for operating and maintaining the dam in accordance with this manual in order to retain the protection from liability afforded by the Act. Operators, employees, agents, and contractors working for Seqwater must also comply with this manual to obtain the protection of the Act.

2.2 Operational Arrangements

For the purposes of operation of the dam during Flood Events, Seqwater must ensure that:

- Sufficient numbers of suitably qualified personnel are available to operate the dam if a Flood Event occurs.
- Sufficient numbers of suitably qualified personnel are available to operate the Flood Operations Centre if a Flood Event occurs
- A Duty Flood Operations Engineer is on call at all times. The Duty Flood Operations Engineer may be either a Senior Flood Operations Engineer or a Flood Operations Engineer. The Duty Flood Operations Engineer must constantly review weather forecasts and catchment rainfall and must declare a Flood Event if the water level at North Pine Dam is expected to exceed Full Supply Level as a result of prevailing or predicted weather conditions.
- A Senior Flood Operations Engineer is designated to be in the charge of Flood Operations at all times during a Flood Event.
- Release of water at the dam during Flood Events is carried out under the direction of the Duty Flood Operations Engineer.
- All practical attempts are made to liaise with the Chairperson and the Chief Executive if the release of water from the Dams during a Flood Event is likely to endanger life or property.

2.3 Designation and Responsibilities of Senior Flood Operations Engineer

Seqwater must nominate one or more suitably qualified and experienced persons to undertake the role of Senior Flood Operations Engineer. If approved by the Chief Executive, these persons can be authorised in the Schedule of Authorities (see Section 2.6). When rostered on duty during a Flood Event, the responsibilities of the Senior Flood Engineer are as follows:

- Set the overall strategy for management of the Flood Event in accordance with the objectives of this manual.

- Provide instructions to site staff to make releases of water from the dam during Flood Events that are in accordance with this manual.
- Apply reasonable discretion in managing a Flood Event as described in Section 2.8.

Seqwater must ensure that an adequate number of Senior Flood Operations Engineers are available to manage all Flood Events.

2.4 Designation and Responsibilities of Flood Operations Engineer

Seqwater must nominate one or more suitably qualified and experienced persons to undertake the role of Flood Operations Engineer. If approved by the Chief Executive, these persons can be authorised in the Schedule of Authorities (see Section 2.6). When rostered on duty during a Flood Event, the responsibilities of the Flood Operations Engineer are as follows:

- Direct the operation of the dam during a flood event in accordance with the general strategy determined by the Senior Flood Operations Engineer.
- Follow any direction from the Senior Flood Operations Engineer in relation to applying reasonable discretion in managing a Flood Event as described in Section 2.8. Unless otherwise directed, a Flood Operations Engineer is to follow this manual in managing Flood Events and is not to apply reasonable discretion unless directed by the Senior Flood Operations Engineer or the Chief Executive.
- Provide instructions to site staff to make releases of water from the dam during Flood Events that are in accordance with this manual.

Seqwater must ensure that an adequate number of Flood Operations Engineers are available to manage all Flood Events. Seqwater must also ensure that an adequate number of suitably qualified and experienced persons are available to assist the Flood Operations Engineers during all Floods Events.

2.5 Qualification and Experience of Engineers

Qualifications

All engineers referred to in Sections 2.3 and 2.4 must hold a Certificate of Registration as a Registered Professional Engineer of Queensland and must hold appropriate engineering qualifications to the satisfaction of the Chief Executive.

Experience

All engineers referred to in Sections 2.3 and 2.4 must, to the satisfaction of the Chief Executive, have:

1. Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and

2. At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:

    - Investigation, design or construction of major dams;
    - Operation and maintenance of major dams;
    - Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;
    - Applied hydrology with particular reference to flood forecasting and/or flood forecasting systems.

2.6 Schedule of Authorities

Seqwater must maintain a Schedule of Authorities containing a list of the Senior Flood Operations Engineers and Flood Operations Engineers approved by the Chief Executive to direct flood operations at the dams during floods. A copy of the Schedule of Authority must be provided to the Chief Executive by 30 September of each year.

Seqwater shall nominate suitably qualified and experienced engineers for registration in the Schedule of Authorities as the need arises. Each new nomination must include a validated statement of qualifications and experience as required by the Chief Executive. Seqwater must obtain the approval for all nominations from the Chief Executive prior to their inclusion in the Schedule of Authorities.

If, in the event of unforseen and emergency situations, no Senior Flood Operations Engineer or no Flood Operations Engineer is available from the Schedule of Authorities to manage a Flood Event, Seqwater must temporarily appoint a suitable person or persons and immediately seek ratification from the Chief Executive.

2.7 Training

Seqwater must ensure that operational personnel required for flood operations activities receive adequate training in the various activities involved in flood control operation as required by the Chief Executive.

2.8 Reasonable Discretion

If in the opinion of the Senior Flood Operations Engineer, it is necessary to depart from the procedures set out in this manual to meet the flood mitigation objectives set out in Section 3, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary subject to the following:

- Before exercising discretion under this Section of the manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must make a reasonable attempt to consult with both the Chairperson and Chief Executive.
- The Chief Executive would normally authorise any departures from the manual. However if the Chief Executive cannot be contacted within a reasonable time, departures from the Manual can be authorised by the Chairperson.
- If both the Chairperson and the Chief Executive cannot be contacted within a reasonable time, the Senior Flood Operations Engineer may proceed with the procedures considered necessary and report such action at the earliest opportunity to the Chairperson and Chief Executive.

2.9 Report

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.

3 FLOOD MITIGATION OBJECTIVES

3.1 General

To meet the purpose of the flood operation procedures in this manual, the flood release objectives, listed in descending order of importance, are as follows:

- Ensure the structural safety of the dam;
- Minimise disruption to populations in areas downstream of the dam;
- 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.

3.2 Structural Safety of Dam

The structural safety of North Pine Dam must be the first consideration in flood release operations. Failure could have catastrophic consequences due to the magnitude of flood damage that would be caused downstream, and also due to the loss of a water supply source.

The most likely cause of damage is overtopping. North Pine Dam consists of a mass concrete section, and earthen embankment sections. Concrete sections can withstand limited overtopping without damage. Embankment sections on the other hand will washout rapidly if overtopped and cause failure of the dam, resulting in severe flooding downstream. The prevention of overtopping is thus of paramount importance.

The safety of the dam therefore depends primarily on the proper operation of the spillway gates, which are used to control maximum flood levels. Such operation in turn relies on the proper functioning of the mechanical hoist mechanisms and their electric power supply and controls. This equipment is located within the dam structure above full supply level and can become inundated if flood releases are not initiated in a timely manner. The critical levels for the operation of the dam and the consequence of their exceedance are as follows:

Critical Levels for North Pine Dam

Description	AHD (m)	Possible Consequence
Full supply level.	39.60	-
Radial Gate Control Gear.	41.66	Electric motors submerged, use of backup systems required to operate radial gates.
Embankment Crest.	43.28	Breach of embankment by erosion

Extreme Floods and Closely Spaced Large Floods

As indicated in the previous section, techniques for estimating extreme floods show that floods are possible which would overtop the dam. Such an overtopping would most likely result in the destruction of the dam. Such events however require several days of intense rainfall to produce the necessary runoff.

Comment [r5]: this paragraph fits in the previous section

Comment [r6]: Is this really several days.

Historical records show that there is a significant probability of two or more flood producing storms occurring in the Pine River system within a short time of each other. Therefore, unless determined otherwise by the Senior Flood Operations Engineer in accordance with Section 2.8, the aim during a Flood Event should be to empty stored floodwaters as quickly as possible while meeting all flood mitigation objectives.

Pre-release of storage at flood producing levels could reduce the risk of overtopping but this may result in discharges exceeding inflows. Such a measure should be taken only after careful consideration of the reliability of precipitation forecasts and of perceived antecedent conditions.

Comment [r7]: Should really think if pre-release is an option

3.3 Minimise disruption to Downstream Populations

Comment [r8]: Replace populations with community

While North Pine Dam provides only limited flood mitigation benefits in terms retaining flood water above Full Supply Level, flood releases can result in the submergence of bridges and public areas. Accordingly, the operation of the dam should not prolong this inundation unnecessarily.

Deleted: s

3.4 Retain the Storage at Full Supply Level at the Conclusion of the Flood Event

As North Pine Dam is a primary urban water supply for South East Queensland, it is important that all opportunities to fill the dam are taken. There should be no reason why the dams should not be full following a Flood Event.

3.5 Minimising Impacts to Riparian Flora and Fauna

During the drain down phase, consideration is to be given to minimising the impacts on riparian flora and fauna. In particular, strategies aimed at reducing fish deaths in the vicinity of the dam walls are to be instigated, provided such procedures do not adversely impact on other flood mitigation objectives.

Additionally, when determining the time interval between successive gate closures, consideration should also be given to reducing potential bank slumping. Rapid draw down of stream levels where banks are saturated should be avoided if this can be managed within the other flood mitigation objectives.

4 FLOOD CLASSIFICATION

For the reference purposes of this manual, four magnitudes of flooding are classified as follows:

1. Minor Flooding

Causes inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.

2. Moderate Flooding

In addition to the impacts experienced during Minor Flooding, the evacuation of some houses may be required. Main traffic routes may be impacted. The area of inundation is substantial in rural areas requiring the removal of stock.

3. Major Flooding

In addition to the impacts experienced during Moderate Flooding, extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required. The 1974 flood that impacted on the Ipswich and Brisbane areas is classified as a major flood.

4. Extreme Flooding

This causes flooding impacts equal to or in excess of levels previously experienced. In addition to the impacts experienced during Major Floods, the general evacuation of people from significant populated areas is likely to be required.

It should be noted that a flood may not cause the same category of flooding along its entire length and the relevant agencies shall have regard to this when flooding is predicted. The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia.

5 FLOOD MONITORING AND FORECASTING SYSTEM

5.1 General

A real time flood monitoring and forecasting system has been established in the dam catchment. This system employs radio telemetry to collect, transmit and receive rainfall and stream flow information. The system consists of 30 field stations that automatically record rainfall and/or river heights at selected locations in the dam catchments. Some of the 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 potential rainfall in the dam catchments. The RTFM is a suite of hydrologic and hydraulic computer programs that utilise the real time data to assist in the operation of the dams during flood events. Seqwater is responsible for providing and maintaining the RTFM and for ensuring that sufficient data is available to allow proper operation of the RTFM during a Flood Event.

5.2 Operation

The Senior Flood Operations and Flood Operations Engineers use the RTFM for flood monitoring and forecasting during flood events to operate the dams in accordance with this manual. This is done by optimising releases of water from the dams to minimise the impacts of flooding in accordance with the objectives and procedures contained in this manual.

Seqwater is responsible for improving the operation of the RTFM over time by using the following processes:

- Implementing improvements based on Flood Event audits and reviews.
- Improving RTFM calibration as further data becomes available.
- Updating software in line with modern day standards.
- Improving the coverage and reliability of the data collection network to optimise data availability during Flood Events.
- Recommendations by Senior Flood Operations Engineers.

A regular process of internal audit and management review must be maintained by Seqwater to achieve these improvements.

Seqwater must also 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.

Seqwater must also 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.

5.3 Storage of Documentation

The performance of any flood monitoring and forecasting system is reliant on accurate historical data over a long period of time. Seqwater must ensure that all available data and other documentation is appropriately collected and catalogued for future use.

5.4 Key Reference Gauges

Key field station locations have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to relocate field stations from these locations or vary flood classification levels, agreement must first be obtained between Seqwater, Bureau of Meteorology and the Local Government within whose boundaries the locations are situated.

Gauge boards that can be read manually must be maintained by Seqwater as part of the equipment of each key field station. Where possible and practical during Flood events, Seqwater is to have procedures in place for manual reading of these gauge boards in the event of failure of field stations.

5.5 Reference Gauge Values

Other agencies such as the Bureau of Meteorology, the Moreton Bay Regional Council and the Brisbane City Council have direct access to the information from field stations for flood assessment purposes. The consultation between agencies is a very important part of the assessment and prediction of flood flows and heights.

Seqwater must ensure that information relevant to the calibration of its field stations is shared with these agencies.

6 COMMUNICATIONS

6.1 Communications between Staff

Seqwater is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Seqwater Flood Operations Centre and site staff at North Pine Dam.

6.2 Dissemination of Information

Agencies other than Seqwater have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public associated with Flood Events. Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public. Agency information requirements are generally as shown in the table below.

The Senior Flood Operations and Flood Operations Engineers must supply information to each of these agencies during Flood Events. The contact information for these Agencies and communication procedures is contained in the Emergency Action Plans for the dam and each agency is to receive updated controlled copies of these documents.

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.

AGENCY INFORMATION REQUIREMENTS

Agency	Activity	Information Required from Flood Operations Centre	Trigger
Bureau of Meteorology	Issue of flood warnings for Brisbane River basin	Actual and predicted lake levels and discharges	Initial gate operations and thereafter at intervals to suit forecasting requirements
Department of Environment and Resource Management	Review of flood operations and discretionary powers	Actual and predicted lake levels and discharges	Initial gate operations
Moreton Bay Regional Council	Flood level information downstream of North Pine Dam	Actual and predicted lake levels and discharges	Initial gate operations
Brisbane City Council	Flood level information for Brisbane City area	Nil (information obtained from BOM)	

6.3 Release of Information to the Public

Seqwater is responsible for the issue of information regarding storage conditions and current and proposed releases from the dam to the public and the media.

The Bureau of Meteorology has responsibility for issuing flood warnings.

The Emergency Services Response Authorities, under the Disaster Management Act 2003, have responsibility for the preparation of a local counter disaster plan and the interpretation of flood forecast information for inclusion in their local flood warnings prepared under the flood sub plan of the counter disaster plan.

7 REVIEW

7.1 Introduction

With the passage of time, neither the technical assumptions nor the physical conditions on which this manual is based may remain unchanged. It is also recognised that the relevance of the manual may change with changing circumstances. It is important therefore, that the manual contain operational procedures which cause the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

This process must involve all personnel involved in the management of Flood Events, to ensure that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based. Variations to the manual may be made in accordance with provisions in Section 1.8.

7.2 Personal Training

Seqwater must report to the Chief Executive by 30 September each year on the training and state of preparedness of operations personnel.

7.3 Monitoring and Forecasting System and Communication Networks

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. The report must assess following in terms of hardware, software and personnel:

- Adequacy of the communication and data gathering facilities
- Reliability of the system over the previous period
- Reliability of the system under prolonged flood conditions
- Accuracy of forecasting flood flows and heights
- The overall state of preparedness of the system

Seqwater must take any action considered necessary for the proper functioning and improvement of this system.

7.4 Operational Review

After each significant flood event, Seqwater must report to the Chief Executive on the effectiveness of the operational procedures contained in this manual. This report must be submitted within six weeks of any flood event that requires mobilisation of the Flood Operations Centre.

7.5 Five Yearly Review

Prior to the expiry of the approval period, Seqwater must review the manual pursuant to provisions of the Act. The review is to take into account the continued suitability of the communication network and the flood monitoring and forecasting system, as well as hydrological and hydraulic engineering assessments of the operational procedures.

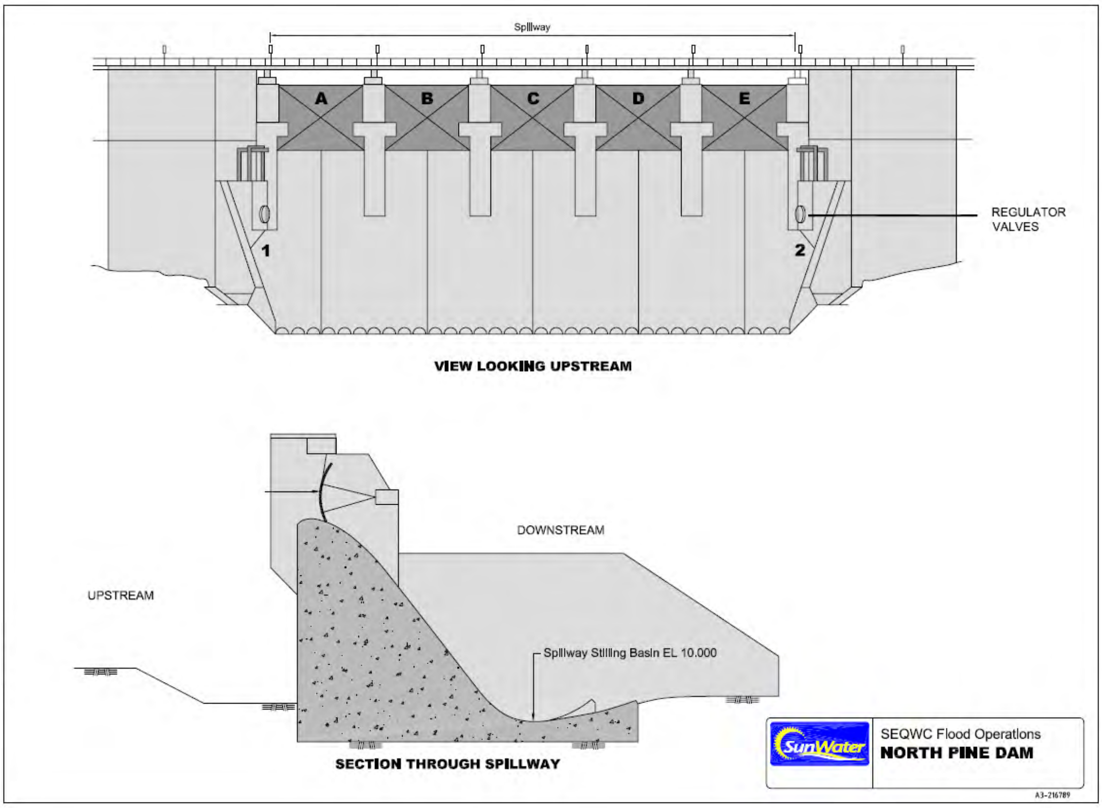
8 FLOOD RELEASE OPERATION

8.1 Introduction

North Pine dam is a water supply dam with only a small flood storage compartment above full supply level. It effectively has no significant provision for flood mitigation and once the dam is full, floods will pass through the reservoir with little mitigation. The peak inflow from critical storms may occur approximately two to four hours after the commencement of heavy rain.

8.2 Flood Release Infrastructure

Radial Gates are the primary infrastructure used to release water during flood events at North Pine Dam. The arrangement of the Radial Gates is shown in the diagram below:



8.3 Initial Action

Once a Flood Event is declared, an assessment is to be made of the magnitude of the Flood Event, including:

- A prediction of the maximum storage levels in the dam.
- A prediction of the peak outflow rate from the dam.

Unless a decision has been made to commence a pre-release of flood water to control the risk of dam overtopping, releases from the radial gates should not commence until the lake level exceeds FSL by 50 millimetres (39.65 m AHD).

Prior to releases from the radial gates commencing the Flood Operations Engineer must ensure that the Grant Street causeway is closed and the Moreton Bay Regional Council has been advised of the impact of the proposed flood releases on Youngs Crossing.

8.4 Flood Operations Strategies

The flood release objectives for North Pine Dam, listed in descending order of importance, are as follows:

- Ensure the structural safety of the dam;
- Minimise disruption to populations in areas downstream of the dam;
- 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.

North Pine Dam effectively has no significant provision for flood mitigation and once the dam is full ensuring the structural safety of the dam is paramount. Accordingly the flood operation strategy is to pass the flood through the reservoir, while ensuring that peak outflow generally does not exceed peak inflow while aiming to empty stored floodwaters as quickly as possible. To achieve this strategy, the radial gate opening settings shown in Appendix C are normally used to determine flood releases.

Departures from the tables shown in Appendix C are allowed in the following circumstances:

- Pre-release of water is allowed to reduce the risk of dam overtopping.
- Reduction in release rate is allowed once the flood peak has passed to either minimise disruption to populations in areas downstream of the dam or to minimise impacts to riparian flora and fauna.
- At the end of a flood event, additional gate openings may be used to reduce the duration of gate operation and resulting adverse downstream impacts.

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a gate by the immediate opening of a regulator valve (or the reverse operation). This allows for greater control of low flows.

Comment [r9]: Isn't the catchment response so rapid that predicting maximums and peak is a pipedream.

Comment [r10]: predictions?

Comment [r11]: what about inflows?

Comment [r12]: pre-release to control the risk of overtopping.

Comment [r13]: Is this a Flood Operations Engineer job

Comment [r14]: Use 'the community' rather than 'populations'

Comment [r15]: We have this as an objective but we have no information on what are the critical levels or flows at which disruption occurs.

Comment [r16]: I would like to have this given more emphasis

Comment [r17]: These release rules are very rigid, is that required

Comment [r18]: This just isn't going to happen.

Comment [r19]: During initial opening?

8.5 Gate Closing Strategies

Comment [r20]: What about a Gate Opening Strategy

In general, gate closing commences when the level in North Pine Dam begins to fall and the closing sequence is generally to occur in the reverse order to opening. The final gate closure should occur when the lake level has returned to Full Supply Level. The following requirements must be considered when determining gate closure sequences:

- Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.
- The maximum discharge from the dam during closure should generally be less than the peak inflow into North Pine Dam experienced during the event.
- The aim should always be to empty stored floodwaters stored above EL 39.65m as quickly as possible after the flood peak has passed through the dam. However, provided a favourable weather outlook is available, this requirement can be relaxed for the volume between EL 39.65m and EL 39.75m, to minimise downstream .
- To minimise the stranding of fish downstream of the dam, final closure sequences should consider Seqwater policies relating to fish protection at the dam.

Comment [r21]: words missing – maybe disruption

There may be a need to take into account base flow when determining final gate closure. This may mean that the lake level temporarily falls below Full Supply Level to provide for a full dam at the end of the Flood Event.

8.6 Gate Operation Sequences

Rapid opening of the radial gates at North Pine dam can cause undesirable rapid rises in downstream river levels. Accordingly, the aim in opening radial gates is to operate the gates one at a time at intervals that will minimise adverse impacts on the river system. The table below shows the target minimum interval for gate operations. This target interval can be reduced if the gates are at risk of being overtopped or the safety of the dam is at risk and operations are generally not allowed to fall more than three openings behind the gate opening settings contained in Appendix C.

TARGET MINIMUM INTERVALS FOR RADIAL GATE OPENING

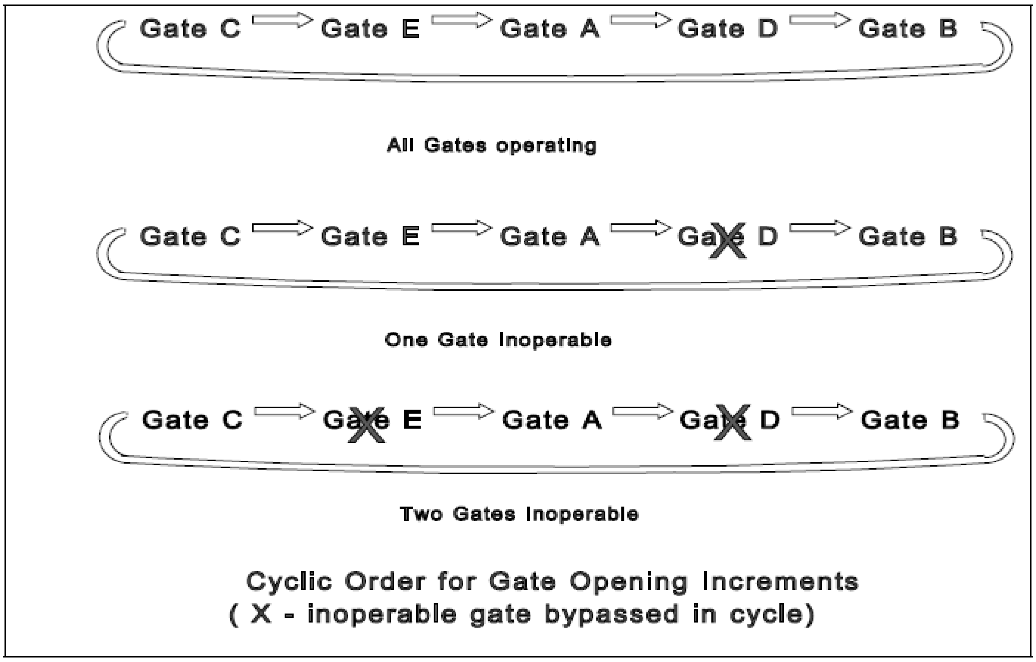
Lake Level	Opening Interval	Closing Interval
Below EL 39.9m	15 min	15 min
EL 39.9m to 40.5m	10 min	10 min
Above EL 40.5m	5 min	5 min

Rapid closure of radial gates is also permissible when there is a requirement to preserve storage or to reduce downstream flooding. When determining gate closure sequences, consideration should also be given to following the calculated natural recession of the flood in the river to aim to ensure that the recession impacts are not greater than those that would have been experienced had the dam not been constructed.

8.7 Protection of the Spillway

To minimise potential damage to the dissipator and the river-bed and banks downstream, the gates must be opened incrementally in accordance with the cyclic sequences shown below.

Gate Operation Sequence



8.8 Gate Failure or Malfunction Procedures

Where one or more gates are inoperable, the sequencing outlined in section 8.7 (above) still applies, except that the inoperable gates must be ignored in the cycle and their increments passed on to the next gate in the sequence. The cumulative number of increments taken by all gates at any particular lake level thus remains unaltered save that the total number of available gate increments has been reduced by inoperable gates. Appendix C contains tables of gate position settings against lake levels for the situations where all gates are operating and where one gate is inoperable.

8.9 Radial Gate Turbulence Considerations

Unless in the process of lifting the gates clear of the flow, the bottom edge of the radial gates must always be at least 500 millimetres below the release flow surface. Having the bottom edge of the gates closer to the release flow surface than 500 millimetres may cause unusual turbulence that could adversely impact on the gates. This procedure has never been undertaken in practice and should be observed closely when being undertaken. Variations to the procedure are allowed to protect the structural safety of the dam.

Comment [r22]: The bottom of a fully open gate is EL38.045 (this manual) or EL38.405 (previous manual) which is over a metre below full supply level. So getting gates out of the water is never going to be a consideration.

8.10 Lowering Radial Gates that have been lifted Clear of the Release Flow

Comment [r23]: same comment as previous section

When lowering radial gates that have been lifted clear of the release flow, the bottom edge of the gates must be lowered at least 500 millimetres into the flow. Lowering gates into the release flow less than this amount may cause unusual turbulence that could adversely impact on the gates. This procedure has never been undertaken in practice and should be observed closely when being undertaken. Variations to the procedure are allowed to protect the structural safety of the dam.

9 EMERGENCY

9.1 Introduction

While every care has been exercised in the design and construction of the dam, there still remains a low risk that the dam may develop an emergency condition either through flood events or other causes. Experience elsewhere in the world suggests that vigilance is required to recognise emergency flood conditions such as:

- Occurrence of a much larger flood than discharge capacity of the dam;
- Occurrence of a series of large storms in a short period;
- Failure of one or more gates during a flood;
- Development of a piping failure through the embankment;
- Damage to the dam by earthquake;
- Damage to the dam as an act of war or terrorism; and
- Other rarer mechanisms.

Responses to these and other conditions are included in the North Pine Dam - Emergency Action Plans.

9.2 Overtopping of Dam

Whatever the circumstances, every endeavour must be made to prevent overtopping of North Pine Dam by the progressive opening of operative spillway gates. Overtopping of the dam is likely to result in a dam failure.

9.3 Communications Failure

If communications are lost between the Flood Operations Centre and the dam, the officers in charge at the dam are to adopt the procedures set out below. The Dam Supervisor at North Pine Dam is to assume responsibility for flood releases from the Dam. Once it has been established that communications have been lost, the Dam Supervisor at North Pine Dam is to:-

- Take all practicable measures to restore communications and periodically check the lines of communication for any change;
- Follow the procedures set out below to determine the relevant magnitude and duration of releases from North Pine Dam;
- Log all actions in the Event Log;
- Ensure the dam is at full supply level at the end of the event;
- Remain in the general vicinity of the dam while on duty.

The radial gate opening sequence to be used is as set out in Appendix C. The table below shows the target minimum interval for gate operations. This target interval can be reduced if the gates are at risk of being overtopped or the safety of the dam is at risk and operations are not allowed to fall more than three openings behind the gate opening settings contained in Appendix C.

TARGET MINIMUM INTERVALS FOR RADIAL GATE OPENING

Lake Level	Opening Interval	Closing Interval
Below EL 39.9m	15 min	15 min
EL 39.9m to 40.5m	10 min	10 min
Above EL 40.5m	5 min	5 min

In the event of one or more radial gates becoming jammed, the remaining gates are to be operated to provide the same total opening for a particular storage level, as shown Appendix C. In these circumstances, gates are generally operated in the order of C, E, A, D, B moving through the sequence shown in the tables.

In a loss of communication scenario, the bulkhead gate is not to be used. At the end of the event, the full supply level of the storage is to be achieved.

APPENDIX A
AGENCIES HOLDING CONTROLLED COPIES OF THIS MANUAL

Agency	Responsible Person	Location
Seqwater	Dam Safety and Source Operations Manager	Brisbane
Seqwater	Principal Engineer Dam Safety	Ipswich
Seqwater	Storage Supervisor	North Pine Dam
Seqwater	Operations Coordinator	North Coast
Seqwater	Senior Flood Operations Engineer	Flood Operations Centre, Brisbane
Department of Environment and Natural Resources	Director Dam Safety	Brisbane
Department of Emergency Services	Duty Officer – Disaster Management Service	Brisbane
Moreton Bay Regional Council	Local Disaster Response Coordinator	Caboolture
Brisbane City Council	Local Disaster Response Coordinator	Brisbane
Emergency Management Queensland	Regional Director, Brisbane District	Brisbane

APPENDIX B
KEY REFERENCE GAUGES

Pine Rivers Shire

Gauge	Flood Classification			
	Minor	**Moderate**	**Major**	**1974 Flood**
Grant Street, Whiteside	Any release from dam	-	-	-
Railway Bridge, Wyllie Park, Petrie	4.0m	5.0m	6.0m	5.1m
Railway Bridge, South Pine River, Bald Hills	-	3.5m	6.0m	5.18m

Note: Values are in metres AHD

APPENDIX C
RADIAL GATE SETTINGS

Gate Setting	Gate Opening (m)	Top of Gate (EL)	Gate Setting	Gate Opening (m)	Top of Gate (EL)
1	0.152	40.362	13	3.810	41.885
2	0.457	40.547	14	4.115	41.940
3	0.762	40.720	15	4.420	41.984
4	1.067	40.886	16	4.724	42.016
5	1.372	41.041	17	5.029	42.037
6	1.676	41.185	18	5.334	42.047
7	1.981	41.316	19	5.639	42.047
8	2.286	41.349	20	5.944	42.047
9	2.591	41.549	21	6.248	42.047
10	2.896	41.650	22	6.553	42.047
11	3.200	41.740	23	6.858	42.047
12	3.505	41.817			

RADIAL GATE SETTINGS

All Gates Operational						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
39.600	closed	closed	closed	closed	closed	0
39.650	closed	closed	1	closed	closed	16
39.700	closed	closed	1	closed	1	32
39.715	1	closed	1	closed	1	48
39.730	1	closed	1	1	1	64
39.745	1	1	1	1	1	80
39.760	1	1	2	1	1	104
39.775	1	1	2	1	2	129
39.790	2	1	2	1	2	153
39.805	2	1	2	2	2	177
39.820	2	2	2	2	2	201
39.835	2	2	3	2	2	228
39.850	2	2	3	2	3	254
39.865	3	2	3	2	3	281
39.880	3	2	3	3	3	307
39.895	3	3	3	3	3	334
39.910	3	3	4	3	3	362
39.925	3	3	4	3	4	390
39.940	4	3	4	3	4	417
39.955	4	3	4	4	4	445
39.970	4	4	4	4	4	473
39.985	4	4	5	4	4	500
40.000	4	4	5	4	5	527
40.015	5	4	5	4	5	554
40.030	5	4	5	5	5	581
40.045	5	5	5	5	5	608
40.060	5	5	6	5	5	636
40.075	5	5	6	5	6	664
40.090	6	5	6	5	6	692
40.105	6	5	6	6	6	720
40.120	6	6	6	6	6	748
40.135	6	6	7	6	6	776
40.150	6	6	7	6	7	804
40.165	7	6	7	6	7	832
40.180	7	6	7	7	7	860
40.195	7	7	7	7	7	888
40.210	7	7	8	7	7	916
40.225	7	7	8	7	8	943
40.240	8	7	8	7	8	970
40.255	8	7	8	8	8	998
40.270	8	8	8	8	8	1025
40.285	8	8	9	8	8	1052
40.300	8	8	9	8	9	1079
40.315	9	8	9	8	9	1106
40.330	9	8	9	9	9	1133
40.345	9	9	9	9	9	1160

All Gates Operational						
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Discharge (m^3/sec)
40.360	9	9	10	9	9	1187
40.375	9	9	10	9	10	1213
40.390	10	9	10	9	10	1240
40.405	10	9	10	10	10	1266
40.420	10	10	10	10	10	1293
40.435	10	10	11	10	10	1320
40.450	10	10	11	10	11	1347
40.465	11	10	11	10	11	1374
40.480	11	10	11	11	11	1401
40.495	11	11	11	11	11	1428
40.510	11	11	12	11	11	1455
40.525	11	11	12	11	12	1482
40.540	12	11	12	11	12	1510
40.555	12	11	12	12	12	1537
40.570	12	12	12	12	12	1564
40.585	12	12	13	12	12	1593
40.600	12	12	13	12	13	1621
40.615	13	12	13	12	13	1650
40.630	13	12	13	13	13	1678
40.645	13	13	13	13	13	1707
40.660	13	13	14	13	13	1736
40.675	13	13	14	13	14	1765
40.690	14	13	14	13	14	1794
40.705	14	13	14	14	14	1823
40.720	14	14	14	14	14	1852
40.735	14	14	15	14	14	1883
40.750	14	14	15	14	15	1914
40.765	15	14	15	14	15	1946
40.780	15	14	15	15	15	1978
40.795	15	15	15	15	15	2009
40.810	15	15	16	15	15	2044
40.825	15	15	16	15	16	2079
40.840	16	15	16	15	16	2114
40.855	16	15	16	16	16	2148
40.870	16	16	16	16	16	2183
40.885	16	16	17	16	16	2222
40.900	16	16	17	16	17	2260
40.915	17	16	17	16	17	2299
40.930	17	16	17	17	17	2337
40.945	17	17	17	17	17	2376
40.960	17	17	18	17	17	2415
40.975	17	17	18	17	18	2453
40.990	18	17	18	17	18	2491
41.005	18	17	18	18	18	2530
41.020	18	18	18	18	18	2568
41.035	18	18	19	18	18	2601
41.050	18	18	19	18	19	2635

All Gates Operational						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
41.065	19	18	19	18	19	2668
41.080	19	18	19	19	19	2701
41.095	19	19	19	19	19	2734
41.110	19	19	20	19	19	2773
41.125	19	19	20	19	20	2806
41.140	20	19	20	19	20	2842
41.155	20	19	20	20	20	2878
41.170	20	20	20	20	20	2913
41.185	20	20	21	20	20	3026
41.200	20	20	21	20	21	3142
41.215	21	20	21	20	21	3260
41.230	21	20	21	21	21	3382
41.245	21	21	21	21	21	3506
41.260	21	21	22	21	21	3515
41.275	21	21	22	21	22	3524
41.290	22	21	22	21	22	3532
41.305	22	21	22	22	22	3541
41.320	22	22	22	22	22	3550
41.335	22	22	23	22	22	3559
41.350	22	22	23	22	23	3567
41.365	23	22	23	22	23	3576
41.380	23	22	23	23	23	3585
41.395	23	23	23	23	23	3594

Gate A Stuck or Inoperable						
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Discharge (m^3/sec)
39.600	closed	closed	closed	closed	closed	0
39.650	closed	closed	1	closed	closed	16
39.700	closed	closed	1	closed	1	32
39.715	closed	closed	1	1	1	48
39.730	closed	1	1	1	1	64
39.745	closed	1	2	1	1	88
39.760	closed	1	2	1	2	112
39.775	closed	1	2	2	2	137
39.790	closed	2	2	2	2	161
39.805	closed	2	3	2	2	187
39.820	closed	2	3	2	3	213
39.835	closed	2	3	3	3	240
39.850	closed	3	3	3	3	266
39.865	closed	3	4	3	3	294
39.880	closed	3	4	3	4	322
39.895	closed	3	4	4	4	349
39.910	closed	4	4	4	4	377
39.925	closed	4	5	4	4	404
39.940	closed	4	5	4	5	430
39.955	closed	4	5	5	5	457
39.970	closed	5	5	5	5	484
39.985	closed	5	6	5	5	512
40.000	closed	5	6	5	6	539
40.015	closed	5	6	6	6	567
40.030	closed	6	6	6	6	595
40.045	closed	6	7	6	6	623
40.060	closed	6	7	6	7	650
40.075	closed	6	7	7	7	678
40.090	closed	7	7	7	7	706
40.105	closed	7	8	7	7	732
40.120	closed	7	8	7	8	759
40.135	closed	7	8	8	8	786
40.150	closed	8	8	8	8	812
40.165	closed	8	9	8	8	839
40.180	closed	8	9	8	9	866
40.195	closed	8	9	9	9	893
40.210	closed	9	9	9	9	920
40.225	closed	9	10	9	9	946
40.240	closed	9	10	9	10	972
40.255	closed	9	10	10	10	998
40.270	closed	10	10	10	10	1024
40.285	closed	10	11	10	10	1050
40.300	closed	10	11	10	11	1077
40.315	closed	10	11	11	11	1103
40.330	closed	11	11	11	11	1130
40.345	closed	11	12	11	11	1156

Gate A Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
40.360	closed	11	12	11	12	1183
40.375	closed	11	12	12	12	1210
40.390	closed	12	12	12	12	1237
40.405	closed	12	13	12	12	1264
40.420	closed	12	13	12	13	1292
40.435	closed	12	13	13	13	1320
40.450	closed	13	13	13	13	1348
40.465	closed	13	14	13	13	1377
40.480	closed	13	14	13	14	1405
40.495	closed	13	14	14	14	1433
40.510	closed	14	14	14	14	1462
40.525	closed	14	15	14	14	1492
40.540	closed	14	15	14	15	1523
40.555	closed	14	15	15	15	1554
40.570	closed	15	15	15	15	1585
40.585	closed	15	16	15	15	1619
40.600	closed	15	16	15	16	1653
40.615	closed	15	16	16	16	1687
40.630	closed	16	16	16	16	1721
40.645	closed	16	17	16	16	1759
40.660	closed	16	17	16	17	1797
40.675	closed	16	17	17	17	1834
40.690	closed	17	17	17	17	1872
40.705	closed	17	18	17	17	1911
40.720	closed	17	18	17	18	1949
40.735	closed	17	18	18	18	1988
40.750	closed	18	18	18	18	2026
40.765	closed	18	19	18	18	2060
40.780	closed	18	19	18	19	2094
40.795	closed	18	19	19	19	2127
40.810	closed	19	19	19	19	2161
40.825	closed	19	20	19	19	2277
40.840	closed	19	20	19	20	2395
40.855	closed	19	20	20	20	2516
40.870	closed	20	20	20	20	2639
40.885	closed	20	21	20	20	2645
40.900	closed	20	21	20	21	2650
40.915	closed	20	21	21	21	2655
40.930	closed	21	21	21	21	2660
40.945	closed	21	22	21	21	2667
40.960	closed	21	22	21	22	2674
40.975	closed	21	22	22	22	2680
40.990	closed	22	22	22	22	2687
41.005	closed	22	23	22	22	2694
41.020	closed	22	23	22	23	2701
41.035	closed	22	23	23	23	2708
41.050	closed	23	23	23	23	2715

Gate A Stuck or Inoperable						
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Discharge (m^3/sec)
41.065	closed	23	23	23	23	2722
41.080	closed	23	23	23	23	2729
41.095	closed	23	23	23	23	2736
41.110	closed	23	23	23	23	2742
41.125	closed	23	23	23	23	2749
41.140	closed	23	23	23	23	2756
41.155	closed	23	23	23	23	2763
41.170	closed	23	23	23	23	2770
41.185	closed	23	23	23	23	2777
41.200	closed	23	23	23	23	2784
41.215	closed	23	23	23	23	2791
41.230	closed	23	23	23	23	2798
41.245	closed	23	23	23	23	2805
41.260	closed	23	23	23	23	2812
41.275	closed	23	23	23	23	2819
41.290	closed	23	23	23	23	2826
41.305	closed	23	23	23	23	2833
41.320	closed	23	23	23	23	2840
41.335	closed	23	23	23	23	2847
41.350	closed	23	23	23	23	2854
41.365	closed	23	23	23	23	2861
41.380	closed	23	23	23	23	2868
41.395	closed	23	23	23	23	2875

Gate B Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
39.600	closed	closed	closed	closed	closed	0
39.650	closed	closed	1	closed	closed	16
39.700	closed	closed	1	closed	1	32
39.715	1	closed	1	closed	1	48
39.730	1	closed	1	1	1	64
39.745	1	closed	2	1	1	88
39.760	1	closed	2	1	2	112
39.775	2	closed	2	1	2	137
39.790	2	closed	2	2	2	161
39.805	2	closed	3	2	2	187
39.820	2	closed	3	2	3	213
39.835	3	closed	3	2	3	240
39.850	3	closed	3	3	3	266
39.865	3	closed	4	3	3	294
39.880	3	closed	4	3	4	322
39.895	4	closed	4	3	4	349
39.910	4	closed	4	4	4	377
39.925	4	closed	5	4	4	404
39.940	4	closed	5	4	5	430
39.955	5	closed	5	4	5	457
39.970	5	closed	5	5	5	484
39.985	5	closed	6	5	5	512
40.000	5	closed	6	5	6	539
40.015	6	closed	6	5	6	567
40.030	6	closed	6	6	6	595
40.045	6	closed	7	6	6	623
40.060	6	closed	7	6	7	650
40.075	7	closed	7	6	7	678
40.090	7	closed	7	7	7	706
40.105	7	closed	8	7	7	732
40.120	7	closed	8	7	8	759
40.135	8	closed	8	7	8	786
40.150	8	closed	8	8	8	812
40.165	8	closed	9	8	8	839
40.180	8	closed	9	8	9	866
40.195	9	closed	9	8	9	893
40.210	9	closed	9	9	9	920
40.225	9	closed	10	9	9	946
40.240	9	closed	10	9	10	972
40.255	10	closed	10	9	10	998
40.270	10	closed	10	10	10	1024
40.285	10	closed	11	10	10	1050
40.300	10	closed	11	10	11	1077
40.315	11	closed	11	10	11	1103
40.330	11	closed	11	11	11	1130
40.345	11	closed	12	11	11	1156

Gate B Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
40.360	11	closed	12	11	12	1183
40.375	12	closed	12	11	12	1210
40.390	12	closed	12	12	12	1237
40.405	12	closed	13	12	12	1264
40.420	12	closed	13	12	13	1292
40.435	13	closed	13	12	13	1320
40.450	13	closed	13	13	13	1348
40.465	13	closed	14	13	13	1377
40.480	13	closed	14	13	14	1405
40.495	14	closed	14	13	14	1433
40.510	14	closed	14	14	14	1462
40.525	14	closed	15	14	14	1492
40.540	14	closed	15	14	15	1523
40.555	15	closed	15	14	15	1554
40.570	15	closed	15	15	15	1585
40.585	15	closed	16	15	15	1619
40.600	15	closed	16	15	16	1653
40.615	16	closed	16	15	16	1687
40.630	16	closed	16	16	16	1721
40.645	16	closed	17	16	16	1759
40.660	16	closed	17	16	17	1797
40.675	17	closed	17	16	17	1834
40.690	17	closed	17	17	17	1872
40.705	17	closed	18	17	17	1911
40.720	17	closed	18	17	18	1949
40.735	18	closed	18	17	18	1988
40.750	18	closed	18	18	18	2026
40.765	18	closed	19	18	18	2060
40.780	18	closed	19	18	19	2094
40.795	19	closed	19	18	19	2127
40.810	19	closed	19	19	19	2161
40.825	19	closed	20	19	19	2277
40.840	19	closed	20	19	20	2395
40.855	20	closed	20	19	20	2516
40.870	20	closed	20	20	20	2639
40.885	20	closed	21	20	20	2645
40.900	20	closed	21	20	21	2650
40.915	21	closed	21	20	21	2655
40.930	21	closed	21	21	21	2660
40.945	21	closed	22	21	21	2667
40.960	21	closed	22	21	22	2674
40.975	22	closed	22	21	22	2680
40.990	22	closed	22	22	22	2687
41.005	22	closed	23	22	22	2694
41.020	22	closed	23	22	23	2701
41.035	23	closed	23	22	23	2708
41.050	23	closed	23	23	23	2715

Gate B Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
41.065	23	closed	23	23	23	2722
41.080	23	closed	23	23	23	2729
41.095	23	closed	23	23	23	2736
41.110	23	closed	23	23	23	2742
41.125	23	closed	23	23	23	2749
41.140	23	closed	23	23	23	2756
41.155	23	closed	23	23	23	2763
41.170	23	closed	23	23	23	2770
41.185	23	closed	23	23	23	2777
41.200	23	closed	23	23	23	2784
41.215	23	closed	23	23	23	2791
41.230	23	closed	23	23	23	2798
41.245	23	closed	23	23	23	2805
41.260	23	closed	23	23	23	2812
41.275	23	closed	23	23	23	2819
41.290	23	closed	23	23	23	2826
41.305	23	closed	23	23	23	2833
41.320	23	closed	23	23	23	2840
41.335	23	closed	23	23	23	2847
41.350	23	closed	23	23	23	2854
41.365	23	closed	23	23	23	2861
41.380	23	closed	23	23	23	2868
41.395	23	closed	23	23	23	2875

Gate C Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
39.600	closed	closed	closed	closed	closed	0
39.650	closed	closed	closed	closed	1	16
39.700	1	closed	closed	closed	1	32
39.715	1	closed	closed	1	1	48
39.730	1	1	closed	1	1	64
39.745	1	1	closed	1	2	88
39.760	2	1	closed	1	2	112
39.775	2	1	closed	2	2	137
39.790	2	2	closed	2	2	161
39.805	2	2	closed	2	3	187
39.820	3	2	closed	2	3	213
39.835	3	2	closed	3	3	240
39.850	3	3	closed	3	3	266
39.865	3	3	closed	3	4	294
39.880	4	3	closed	3	4	322
39.895	4	3	closed	4	4	349
39.910	4	4	closed	4	4	377
39.925	4	4	closed	4	5	404
39.940	5	4	closed	4	5	430
39.955	5	4	closed	5	5	457
39.970	5	5	closed	5	5	484
39.985	5	5	closed	5	6	512
40.000	6	5	closed	5	6	539
40.015	6	5	closed	6	6	567
40.030	6	6	closed	6	6	595
40.045	6	6	closed	6	7	623
40.060	7	6	closed	6	7	650
40.075	7	6	closed	7	7	678
40.090	7	7	closed	7	7	706
40.105	7	7	closed	7	8	732
40.120	8	7	closed	7	8	759
40.135	8	7	closed	8	8	786
40.150	8	8	closed	8	8	812
40.165	8	8	closed	8	9	839
40.180	9	8	closed	8	9	866
40.195	9	8	closed	9	9	893
40.210	9	9	closed	9	9	920
40.225	9	9	closed	9	10	946
40.240	10	9	closed	9	10	972
40.255	10	9	closed	10	10	998
40.270	10	10	closed	10	10	1024
40.285	10	10	closed	10	11	1050
40.300	11	10	closed	10	11	1077
40.315	11	10	closed	11	11	1103
40.330	11	11	closed	11	11	1130
40.345	11	11	closed	11	12	1156

Gate C Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
40.360	12	11	closed	11	12	1183
40.375	12	11	closed	12	12	1210
40.390	12	12	closed	12	12	1237
40.405	12	12	closed	12	13	1264
40.420	13	12	closed	12	13	1292
40.435	13	12	closed	13	13	1320
40.450	13	13	closed	13	13	1348
40.465	13	13	closed	13	14	1377
40.480	14	13	closed	13	14	1405
40.495	14	13	closed	14	14	1433
40.510	14	14	closed	14	14	1462
40.525	14	14	closed	14	15	1492
40.540	15	14	closed	14	15	1523
40.555	15	14	closed	15	15	1554
40.570	15	15	closed	15	15	1585
40.585	15	15	closed	15	16	1619
40.600	16	15	closed	15	16	1653
40.615	16	15	closed	16	16	1687
40.630	16	16	closed	16	16	1721
40.645	16	16	closed	16	17	1759
40.660	17	16	closed	16	17	1797
40.675	17	16	closed	17	17	1834
40.690	17	17	closed	17	17	1872
40.705	17	17	closed	17	18	1911
40.720	18	17	closed	17	18	1949
40.735	18	17	closed	18	18	1988
40.750	18	18	closed	18	18	2026
40.765	18	18	closed	18	19	2060
40.780	19	18	closed	18	19	2094
40.795	19	18	closed	19	19	2127
40.810	19	19	closed	19	19	2161
40.825	19	19	closed	19	20	2277
40.840	20	19	closed	19	20	2395
40.855	20	19	closed	20	20	2516
40.870	20	20	closed	20	20	2639
40.885	20	20	closed	20	21	2645
40.900	21	20	closed	20	21	2650
40.915	21	20	closed	21	21	2655
40.930	21	21	closed	21	21	2660
40.945	21	21	closed	21	22	2667
40.960	22	21	closed	21	22	2674
40.975	22	21	closed	22	22	2680
40.990	22	22	closed	22	22	2687
41.005	22	22	closed	22	23	2694
41.020	23	22	closed	22	23	2701
41.035	23	22	closed	23	23	2708
41.050	23	23	closed	23	23	2715

Gate C Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
41.065	23	23	closed	23	23	2722
41.080	23	23	closed	23	23	2729
41.095	23	23	closed	23	23	2736
41.110	23	23	closed	23	23	2742
41.125	23	23	closed	23	23	2749
41.140	23	23	closed	23	23	2756
41.155	23	23	closed	23	23	2763
41.170	23	23	closed	23	23	2770
41.185	23	23	closed	23	23	2777
41.200	23	23	closed	23	23	2784
41.215	23	23	closed	23	23	2791
41.230	23	23	closed	23	23	2798
41.245	23	23	closed	23	23	2805
41.260	23	23	closed	23	23	2812
41.275	23	23	closed	23	23	2819
41.290	23	23	closed	23	23	2826
41.305	23	23	closed	23	23	2833
41.320	23	23	closed	23	23	2840
41.335	23	23	closed	23	23	2847
41.350	23	23	closed	23	23	2854
41.365	23	23	closed	23	23	2861
41.380	23	23	closed	23	23	2868
41.395	23	23	closed	23	23	2875

Gate D Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
39.600	closed	closed	closed	closed	closed	0
39.650	closed	closed	1	closed	closed	16
39.700	closed	closed	1	closed	1	32
39.715	1	closed	1	closed	1	48
39.730	1	1	1	closed	1	64
39.745	1	1	2	closed	1	88
39.760	1	1	2	closed	2	112
39.775	2	1	2	closed	2	137
39.790	2	2	2	closed	2	161
39.805	2	2	3	closed	2	187
39.820	2	2	3	closed	3	213
39.835	3	2	3	closed	3	240
39.850	3	3	3	closed	3	266
39.865	3	3	4	closed	3	294
39.880	3	3	4	closed	4	322
39.895	4	3	4	closed	4	349
39.910	4	4	4	closed	4	377
39.925	4	4	5	closed	4	404
39.940	4	4	5	closed	5	430
39.955	5	4	5	closed	5	457
39.970	5	5	5	closed	5	484
39.985	5	5	6	closed	5	512
40.000	5	5	6	closed	6	539
40.015	6	5	6	closed	6	567
40.030	6	6	6	closed	6	595
40.045	6	6	7	closed	6	623
40.060	6	6	7	closed	7	650
40.075	7	6	7	closed	7	678
40.090	7	7	7	closed	7	706
40.105	7	7	8	closed	7	732
40.120	7	7	8	closed	8	759
40.135	8	7	8	closed	8	786
40.150	8	8	8	closed	8	812
40.165	8	8	9	closed	8	839
40.180	8	8	9	closed	9	866
40.195	9	8	9	closed	9	893
40.210	9	9	9	closed	9	920
40.225	9	9	10	closed	9	946
40.240	9	9	10	closed	10	972
40.255	10	9	10	closed	10	998
40.270	10	10	10	closed	10	1024
40.285	10	10	11	closed	10	1050
40.300	10	10	11	closed	11	1077
40.315	11	10	11	closed	11	1103
40.330	11	11	11	closed	11	1130
40.345	11	11	12	closed	11	1156

Gate D Stuck or Inoperable						
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Discharge (m^3/sec)
40.360	11	11	12	closed	12	1183
40.375	12	11	12	closed	12	1210
40.390	12	12	12	closed	12	1237
40.405	12	12	13	closed	12	1264
40.420	12	12	13	closed	13	1292
40.435	13	12	13	closed	13	1320
40.450	13	13	13	closed	13	1348
40.465	13	13	14	closed	13	1377
40.480	13	13	14	closed	14	1405
40.495	14	13	14	closed	14	1433
40.510	14	14	14	closed	14	1462
40.525	14	14	15	closed	14	1492
40.540	14	14	15	closed	15	1523
40.555	15	14	15	closed	15	1554
40.570	15	15	15	closed	15	1585
40.585	15	15	16	closed	15	1619
40.600	15	15	16	closed	16	1653
40.615	16	15	16	closed	16	1687
40.630	16	16	16	closed	16	1721
40.645	16	16	17	closed	16	1759
40.660	16	16	17	closed	17	1797
40.675	17	16	17	closed	17	1834
40.690	17	17	17	closed	17	1872
40.705	17	17	18	closed	17	1911
40.720	17	17	18	closed	18	1949
40.735	18	17	18	closed	18	1988
40.750	18	18	18	closed	18	2026
40.765	18	18	19	closed	18	2060
40.780	18	18	19	closed	19	2094
40.795	19	18	19	closed	19	2127
40.810	19	19	19	closed	19	2161
40.825	19	19	20	closed	19	2277
40.840	19	19	20	closed	20	2395
40.855	20	19	20	closed	20	2516
40.870	20	20	20	closed	20	2639
40.885	20	20	21	closed	20	2645
40.900	20	20	21	closed	21	2650
40.915	21	20	21	closed	21	2655
40.930	21	21	21	closed	21	2660
40.945	21	21	22	closed	21	2667
40.960	21	21	22	closed	22	2674
40.975	22	21	22	closed	22	2680
40.990	22	22	22	closed	22	2687
41.005	22	22	23	closed	22	2694
41.020	22	22	23	closed	23	2701
41.035	23	22	23	closed	23	2708
41.050	23	23	23	closed	23	2715

Gate D Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
41.065	23	23	23	closed	23	2722
41.080	23	23	23	closed	23	2729
41.095	23	23	23	closed	23	2736
41.110	23	23	23	closed	23	2742
41.125	23	23	23	closed	23	2749
41.140	23	23	23	closed	23	2756
41.155	23	23	23	closed	23	2763
41.170	23	23	23	closed	23	2770
41.185	23	23	23	closed	23	2777
41.200	23	23	23	closed	23	2784
41.215	23	23	23	closed	23	2791
41.230	23	23	23	closed	23	2798
41.245	23	23	23	closed	23	2805
41.260	23	23	23	closed	23	2812
41.275	23	23	23	closed	23	2819
41.290	23	23	23	closed	23	2826
41.305	23	23	23	closed	23	2833
41.320	23	23	23	closed	23	2840
41.335	23	23	23	closed	23	2847
41.350	23	23	23	closed	23	2854
41.365	23	23	23	closed	23	2861
41.380	23	23	23	closed	23	2868
41.395	23	23	23	closed	23	2875

Gate E Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
39.600	closed	closed	closed	closed	closed	0
39.650	closed	closed	1	closed	closed	16
39.700	1	closed	1	closed	closed	32
39.715	1	closed	1	1	closed	48
39.730	1	1	1	1	closed	64
39.745	1	1	2	1	closed	88
39.760	2	1	2	1	closed	112
39.775	2	1	2	2	closed	137
39.790	2	2	2	2	closed	161
39.805	2	2	3	2	closed	187
39.820	3	2	3	2	closed	213
39.835	3	2	3	3	closed	240
39.850	3	3	3	3	closed	266
39.865	3	3	4	3	closed	294
39.880	4	3	4	3	closed	322
39.895	4	3	4	4	closed	349
39.910	4	4	4	4	closed	377
39.925	4	4	5	4	closed	404
39.940	5	4	5	4	closed	430
39.955	5	4	5	5	closed	457
39.970	5	5	5	5	closed	484
39.985	5	5	6	5	closed	512
40.000	6	5	6	5	closed	539
40.015	6	5	6	6	closed	567
40.030	6	6	6	6	closed	595
40.045	6	6	7	6	closed	623
40.060	7	6	7	6	closed	650
40.075	7	6	7	7	closed	678
40.090	7	7	7	7	closed	706
40.105	7	7	8	7	closed	732
40.120	8	7	8	7	closed	759
40.135	8	7	8	8	closed	786
40.150	8	8	8	8	closed	812
40.165	8	8	9	8	closed	839
40.180	9	8	9	8	closed	866
40.195	9	8	9	9	closed	893
40.210	9	9	9	9	closed	920
40.225	9	9	10	9	closed	946
40.240	10	9	10	9	closed	972
40.255	10	9	10	10	closed	998
40.270	10	10	10	10	closed	1024
40.285	10	10	11	10	closed	1050
40.300	11	10	11	10	closed	1077
40.315	11	10	11	11	closed	1103
40.330	11	11	11	11	closed	1130
40.345	11	11	12	11	closed	1156

Gate E Stuck or Inoperable						
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Discharge (m^3/sec)
40.360	12	11	12	11	closed	1183
40.375	12	11	12	12	closed	1210
40.390	12	12	12	12	closed	1237
40.405	12	12	13	12	closed	1264
40.420	13	12	13	12	closed	1292
40.435	13	12	13	13	closed	1320
40.450	13	13	13	13	closed	1348
40.465	13	13	14	13	closed	1377
40.480	14	13	14	13	closed	1405
40.495	14	13	14	14	closed	1433
40.510	14	14	14	14	closed	1462
40.525	14	14	15	14	closed	1492
40.540	15	14	15	14	closed	1523
40.555	15	14	15	15	closed	1554
40.570	15	15	15	15	closed	1585
40.585	15	15	16	15	closed	1619
40.600	16	15	16	15	closed	1653
40.615	16	15	16	16	closed	1687
40.630	16	16	16	16	closed	1721
40.645	16	16	17	16	closed	1759
40.660	17	16	17	16	closed	1797
40.675	17	16	17	17	closed	1834
40.690	17	17	17	17	closed	1872
40.705	17	17	18	17	closed	1911
40.720	18	17	18	17	closed	1949
40.735	18	17	18	18	closed	1988
40.750	18	18	18	18	closed	2026
40.765	18	18	19	18	closed	2060
40.780	19	18	19	18	closed	2094
40.795	19	18	19	19	closed	2127
40.810	19	19	19	19	closed	2161
40.825	19	19	20	19	closed	2277
40.840	20	19	20	19	closed	2395
40.855	20	19	20	20	closed	2516
40.870	20	20	20	20	closed	2639
40.885	20	20	21	20	closed	2645
40.900	21	20	21	20	closed	2650
40.915	21	20	21	21	closed	2655
40.930	21	21	21	21	closed	2660
40.945	21	21	22	21	closed	2667
40.960	22	21	22	21	closed	2674
40.975	22	21	22	22	closed	2680
40.990	22	22	22	22	closed	2687
41.005	22	22	23	22	closed	2694
41.020	23	22	23	22	closed	2701
41.035	23	22	23	23	closed	2708
41.050	23	23	23	23	closed	2715

Gate E Stuck or Inoperable						
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Discharge (m^3/sec)**
41.065	23	23	23	23	closed	2722
41.080	23	23	23	23	closed	2729
41.095	23	23	23	23	closed	2736
41.110	23	23	23	23	closed	2742
41.125	23	23	23	23	closed	2749
41.140	23	23	23	23	closed	2756
41.155	23	23	23	23	closed	2763
41.170	23	23	23	23	closed	2770
41.185	23	23	23	23	closed	2777
41.200	23	23	23	23	closed	2784
41.215	23	23	23	23	closed	2791
41.230	23	23	23	23	closed	2798
41.245	23	23	23	23	closed	2805
41.260	23	23	23	23	closed	2812
41.275	23	23	23	23	closed	2819
41.290	23	23	23	23	closed	2826
41.305	23	23	23	23	closed	2833
41.320	23	23	23	23	closed	2840
41.335	23	23	23	23	closed	2847
41.350	23	23	23	23	closed	2854
41.365	23	23	23	23	closed	2861
41.380	23	23	23	23	closed	2868
41.395	23	23	23	23	closed	2875

APPENDIX E
NORTH PINE DAM AUXILIARY EQUIPMENT

The spillway gates at North Pine Dam are raised and lowered using electric motor driven winches. These motors are normally powered from the mains electric supply. In the event of a failure of the mains supply, a standby diesel generator (located on level 2 of the dam) automatically cuts in to maintain electric supply.

Review of the North Pine Dam hydrology has shown that extreme events can submerge the five radial gate electric winch motors that are located on platforms beneath the bridge deck forming the dam crest. During such an event the electric winch motors would not operate and the winches would not be accessible to enable operation using the compressed air system.

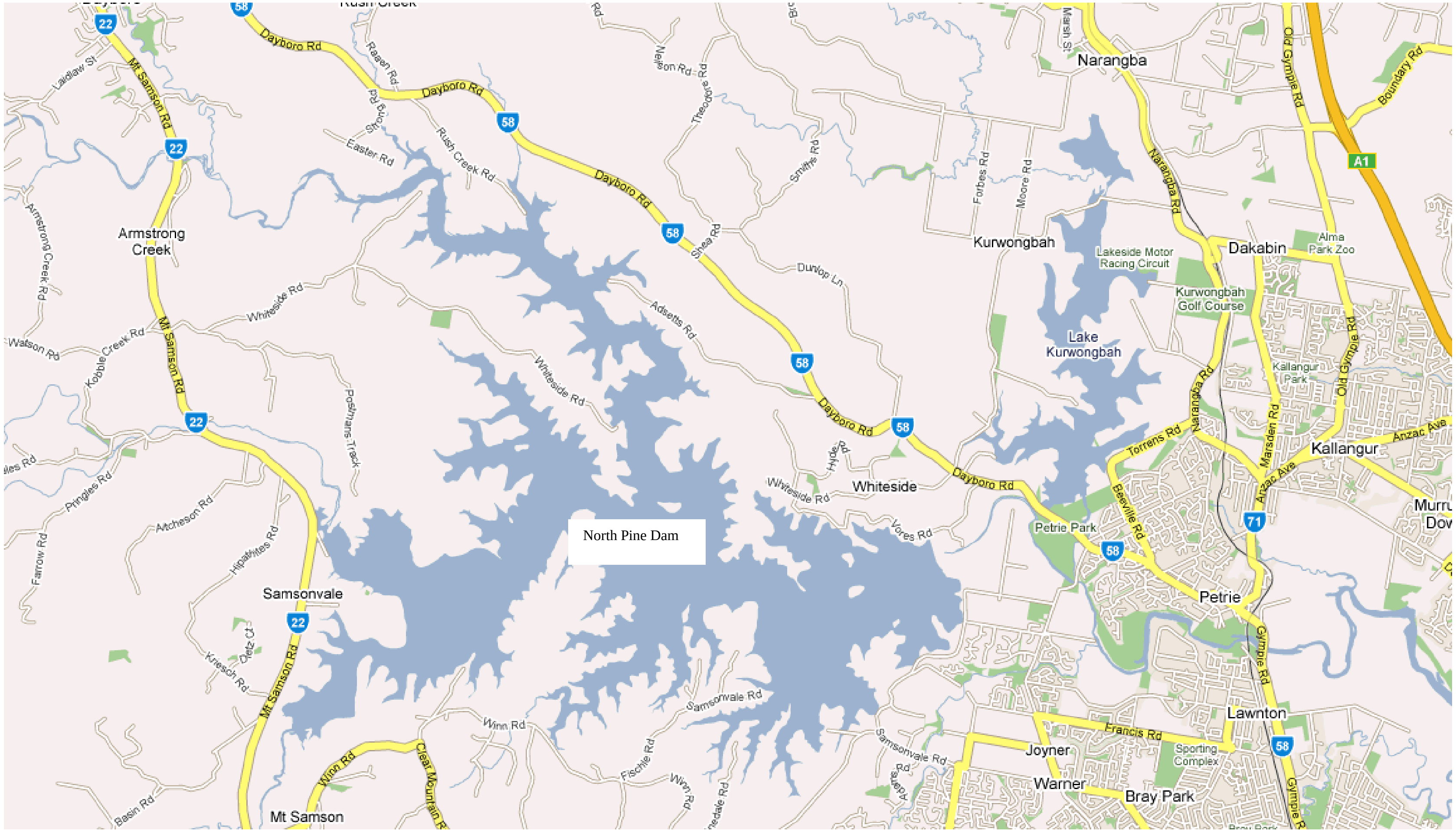
An auxiliary gate operating system installed in 1997/98 comprises a trailer-mounted motor with petrol driven generator, which can be used to operate the winches from the crest of the dam. The shafts of the existing electric winch motors have been extended to the level of the dam crest through right angle gear boxes. In the event of failure of both of the mains electric supply and the standby diesel generator, failure or submergence of the electric winch motors, the trailer mounted motor and petrol driven generator must be used to operate the radial gates.

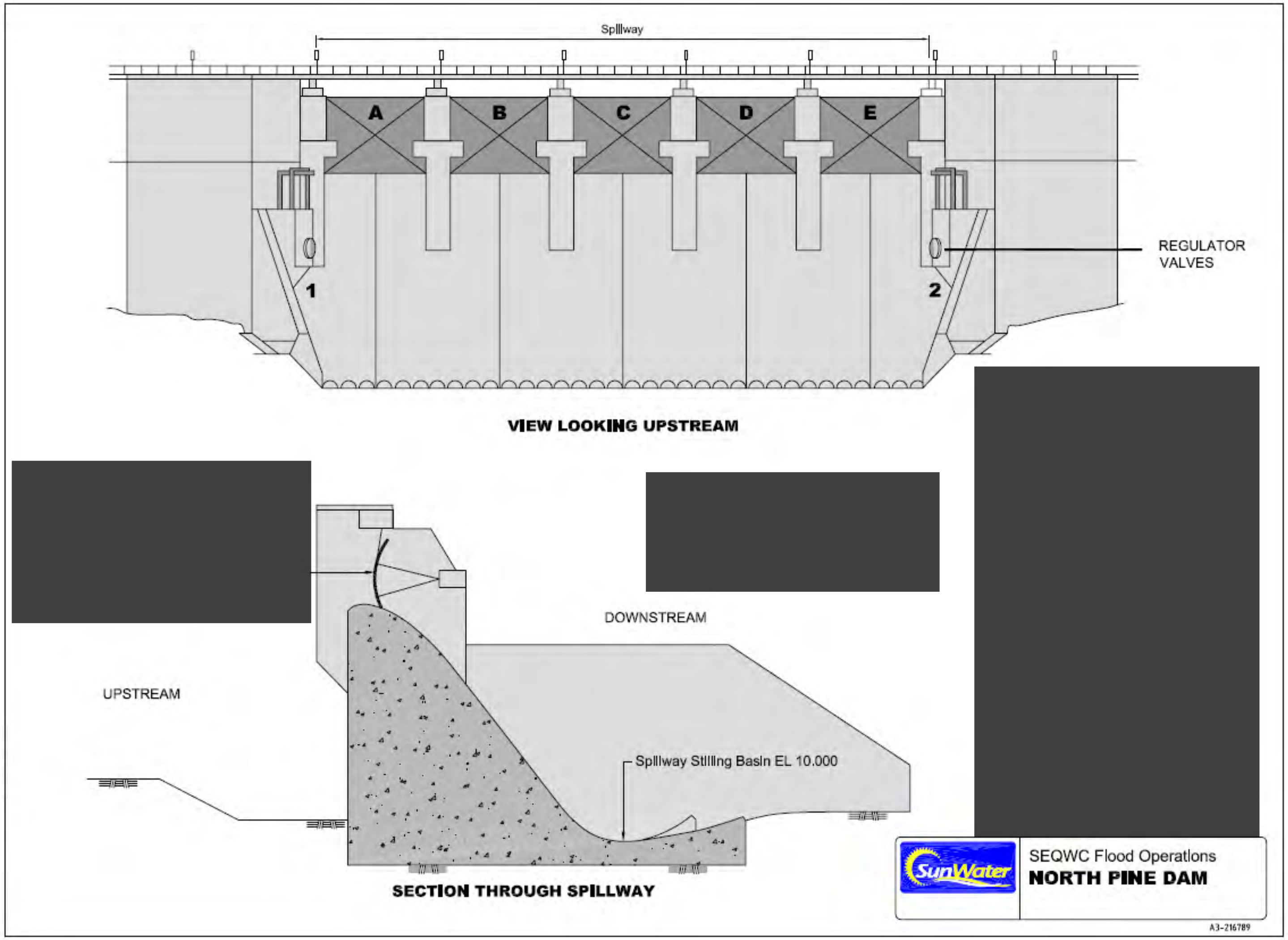
APPENDIX F

HYDROLOGIC INVESTIGATIONS

APPENDIX G
NORTH PINE DAM
PLANS, MAPS AND PHOTOGRAPHS

[redacted]


North Pine Dam
Armstrong Creek
Samsonvale
Mt Samson
Whiteside
Kurwongbah
Lake Kurwongbah
Lakeside Motor Racing Circuit
Kurwongbah Golf Course
Narangba
Dakabin
Alma Park Zoo
Kallangur
Kallangur Park
Petrie
Petrie Park
Lawnton
Joyner
Warner
Bray Park
Sporting Complex
Dayboro Rd
Mt Samson Rd
Whiteside Rd
Samsonvale Rd
Winn Rd
Anzac Ave
Gympie Rd
Old Gympie Rd
Narangba Rd
Torrens Rd
Francis Rd
Boundary Rd


Spillway
A
B
C
D
E
1
2
REGULATOR VALVES
VIEW LOOKING UPSTREAM
[redacted]
[redacted]
[redacted]
DOWNSTREAM
UPSTREAM
Spillway Stilling Basin EL 10.000
SECTION THROUGH SPILLWAY
SunWater
SEQWC Flood Operations
NORTH PINE DAM
A3-216789

Style Definition: Heading 3,Transfer 3

MANUAL

OF

OPERATIONAL PROCEDURES

FOR

FLOOD MITIGATION

AT

NORTH PINE DAM

Revision 5

July 2010

Revision No.	Date	Amendment Details
0	10 December 1986	Original Issue
1	6 October 1992	Complete revision and re-issue
2	13 November 1997	Complete revision and re-issue
3	26 July 2002	Complete revision and re-issue
4	5 September 2007	Complete revision and re-issue
5	July 2010	Complete revision and re-issue

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Preface

Given its size and location, it is imperative that North Pine Dam be operated during flood events in accordance with clearly defined procedures to minimise hazard to life and property. This manual outlines these procedures and is an approved Flood Mitigation Manual under Water Supply Act 2008.

The Manual in its current form was developed in 1992 and the basis of this document was a manual written in 1986 covering flood operations at the dam. Four revisions of the Manual have occurred since 1992 to account for updates to the Flood Alert Network and the Real Time Flood Models and to account for institutional and legislative changes.

The primary objectives of the procedures contained in this Manual are essentially the same as those contained in previous Manual versions. These objectives in order of importance are:

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- 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.

In meeting these objectives, the dam must be operated to account for the potential effects of closely spaced Flood Events. Accordingly, normal procedures require stored floodwaters to be emptied from the dam as quickly as possible while meeting all flood mitigation objectives.

1.2 Meaning of Terms

In this manual, save where a contrary definition appears -

"Act" means the *Water Supply (Safety and Reliability) Act 2008*;

"AEP" means annual exceedance probability, the probability of a specified event being exceeded in any year;

"Agency" includes a person, a local government and a department of state government within the meaning of the Acts Interpretation Act 1954;

"AHD" means Australian Height Datum;

"Chairperson" means the Chairperson of Seqwater;

“Chief Executive” means the Director General of the Department of Environment and Resource Management or nominated delegate;

“Controlled Document” means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

“Dam” means the dam to which this manual applies, that is North Pine Dam;

“Dam Supervisor” means the senior on-site officer at North Pine Dam;

“Duty Flood Operations Engineer” means the Senior Flood Operations Engineer or Flood Operations Engineer rostered on duty to be in charge of Flood Operations at the dam;

“EL” means elevation in metres Australian Height Datum;

“Flood Event” is a situation where the Duty Flood Operations Engineer expects the water level at the dam to exceed the Full Supply Level;

“Flood Operations Centre” means the Centre used by Flood Operations Engineers to manage Flood Events;

“Flood Operations Engineer” means a person designated to direct flood operations at the dam in accordance with Section 2.4 of this manual;

“FSL” or “Full Supply Level” means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

“Gauge” when referred to in (m) means river level referenced to AHD, and when referred to in (m^3/s) means flow rate in cubic metres per second;

“Manual” or “Manual of Operational Procedures for Flood Mitigation at North Pine Dam” means the current version of this manual;

“Senior Flood Operations Engineer” means a person designated in accordance with Section 2.3 of this manual under whose general direction the procedures in this manual must be carried out;

“Seqwater” means the Queensland Bulk Water Supply Authority trading as Seqwater.

1.3 Purpose of Manual

The purpose of this manual is to define procedures for the operation of North Pine Dam during flood events. The procedures have been developed on the basis that the structural safety of the dam is paramount within the scope of minimising the downstream impacts associated with releasing flood water from the dam.

1.4 Legal Authority

This manual has been prepared as a Flood Mitigation Manual in accordance with Chapter 4 Part 2 of the Act.

1.5 Application and Effect

The procedures in this manual apply to the operation of North Pine Dam for the purpose of flood mitigation, and operation in accordance with the manual shall give the protection from liability provided by Section 374 of the Act.

1.6 Date of Effect

The procedures in this manual shall have effect on and from the date on which this version of the manual is approved by gazette notice.

The manual shall remain in force for the period of approval as determined by the Chief Executive. This approval may be for a period of up to five years.

Before the approval of the manual expires, Seqwater must review and if necessary update the manual and submit a copy to the chief executive for approval.

1.7 Observance of Manual

This manual contains the operational procedures for North Pine Dam for the purposes of flood mitigation and must be used for the operation of the dams during flood events.

1.8 Provision to Variation of Manual

If Seqwater is of the opinion that this manual should be amended, altered or varied, it must submit for approval as soon as practical, an appropriate request to the Chief Executive, setting out the circumstances and the exact nature of the amendment, alteration or variation sought. The Chief Executive may accept, reject or modify the request prior to approval.

1.9 Distribution of Manual

Seqwater must regard the manual as a Controlled Document and ensure that only controlled manuals are used in the direction of flood mitigation activities. Agencies having copies of controlled hardcopies of the manual are listed in Appendix A. Seqwater must maintain a Register of contact persons for issued controlled hardcopies of the manual and must ensure that each issued document is updated whenever amendments or changes are approved.

2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

Pursuant to the provisions of the Act, Seqwater is responsible for operating and maintaining the dam in accordance with this manual in order to retain the protection from liability afforded by the Act. Operators, employees, agents, and contractors working for Seqwater must also comply with this manual to obtain the protection of the Act.

2.2 Operational Arrangements

For the purposes of operation of the dam during Flood Events, Seqwater must ensure that:

- Sufficient numbers of suitably qualified personnel are available to operate the dam if a Flood Event occurs.
- Sufficient numbers of suitably qualified personnel are available to operate the Flood Operations Centre if a Flood Event occurs
- A Duty Flood Operations Engineer is on call at all times. The Duty Flood Operations Engineer must constantly review weather forecasts and catchment rainfall and must declare a Flood Event if the water level at North Pine Dam is expected to exceed Full Supply Level as a result of prevailing or predicted weather conditions.
- A Senior Flood Operations Engineer is designated to be in the charge of Flood Operations at all times during a Flood Event.
- Release of water at the dam during Flood Events is carried out under the direction of the Duty Flood Operations Engineer.
- All practical attempts are made to liaise with the Chairperson and the Chief Executive if the release of water from the Dams during a Flood Event is likely to endanger life or property.

Comment [r1]: There isn't anything in this list about maintaining the dam and in particular the gates in good working order.

2.3 Designation and Responsibilities of Senior Flood Operations Engineer

Seqwater must nominate one or more suitably qualified and experienced persons to undertake the role of Senior Flood Operations Engineer. If approved by the Chief Executive, these persons can be authorised in the Schedule of Authorities (see Section 2.6). When rostered on duty during a Flood Event, the responsibilities of the Senior Flood Engineer are as follows:

- Set the overall strategy for management of the Flood Event in accordance with the objectives of this manual.

- Provide instructions to site staff to make releases of water from the dam during Flood Events that are in accordance with this manual.
- Apply reasonable discretion in managing a Flood Event as described in Section 2.8.

Seqwater must ensure that an adequate number of Senior Flood Operations Engineers are available to manage all Flood Events.

2.4 Designation and Responsibilities of Flood Operations Engineer

Seqwater must nominate one or more suitably qualified and experienced persons to undertake the role of Flood Operations Engineer. If approved by the Chief Executive, these persons can be authorised in the Schedule of Authorities (see Section 2.6). When rostered on duty during a Flood Event, the responsibilities of the Flood Engineer are as follows:

- Direct the operation of the dam during a flood event in accordance with the general strategy determined by the Senior Flood Operations Engineer.
- Follow any direction from the Senior Flood Operations Engineer in relation to applying reasonable discretion in managing a Flood Event as described in Section 2.8. Unless otherwise directed, a Flood Operations Engineer is to follow this manual in managing Flood Events and is not to apply reasonable discretion unless directed by the Senior Flood Operations Engineer or the Chief Executive.
- Provide instructions to site staff to make releases of water from the dam during Flood Events that are in accordance with this manual.

Seqwater must ensure that an adequate number of Flood Operations Engineers are available to manage all Flood Events. Seqwater must also ensure that an adequate number of suitably qualified and experienced persons are available to assist the Flood Operations Engineers during all Floods Events.

2.5 Qualification and Experience of Engineers

Qualifications

All engineers referred to in Sections 2.3 and 2.4 must hold a Certificate of Registration as a Registered Professional Engineer of Queensland and must hold appropriate engineering qualifications to the satisfaction of the Chief Executive.

Comment [r2]: By the way when I looked at the RPEQ register today John Ruffini wasn't in there – I am sure he has been in the past.

At some stage we might want to know their plans for increasing the number of these engineers.

Experience

All engineers referred to in Sections 2.3 and 2.4 must, to the satisfaction of the Chief Executive, have:

1. Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and

2. At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:

   - Investigation, design or construction of major dams;
   - Operation and maintenance of major dams;
   - Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;
   - Applied hydrology with particular reference to flood forecasting and/or flood forecasting systems.

2.6 Schedule of Authorities

Seqwater must maintain a Schedule of Authorities containing a list of the Senior Flood Operations Engineers and Flood Operations Engineers approved by the Chief Executive to direct flood operations at the dams during floods. A copy of the Schedule of Authorities must be provided to the Chief Executive by 30 September of each year.

Seqwater shall nominate suitably qualified and experienced engineers for registration in the Schedule of Authorities as the need arises. Each new nomination must include a validated statement of qualifications and experience as required by the Chief Executive. Seqwater must obtain the approval for all nominations from the Chief Executive prior to their inclusion in the Schedule of Authorities.

If, in the event of unforseen and emergency situations, no Senior Flood Operations Engineer or no Flood Operations Engineer is available from the Schedule of Authorities to manage a Flood Event, Seqwater must temporarily appoint a suitable person or persons and immediately seek ratification from the Chief Executive.

2.7 Training

Seqwater must ensure that operational personnel required for flood operations activities receive adequate training in the various activities involved in flood control operation.

Comment [r3]: I don't believe the chief executive is going to decide the specific training required.

Deleted: as required by the Chief Executive

2.8 Reasonable Discretion

If in the opinion of the Senior Flood Operations Engineer, it is necessary to depart from the procedures set out in this manual to meet the flood mitigation objectives set out in Section 3, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary subject to the following:

- Before exercising discretion under this Section of the manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must make a reasonable attempt to consult with both the Chairperson and Chief Executive.
- The Chief Executive would normally authorise any departures from the manual. However if the Chief Executive cannot be contacted within a reasonable time, departures from the Manual can be authorised by the Chairperson.
- If both the Chairperson and the Chief Executive cannot be contacted within a reasonable time, the Senior Flood Operations Engineer may proceed with the procedures considered necessary and report such action at the earliest opportunity to the Chairperson and Chief Executive.

2.9 Report

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.

3 FLOOD MITIGATION OBJECTIVES

3.1 General

To meet the purpose of the flood operation procedures in this manual, the flood release objectives, listed in descending order of importance, are as follows:

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- 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.

3.2 Structural Safety of Dam

The structural safety of North Pine Dam must be the first consideration in flood release operations. Failure could have catastrophic consequences due to the magnitude of flood damage that would be caused downstream, and also due to the loss of a water supply source.

The most likely cause of damage is overtopping. North Pine Dam consists of a mass concrete section, and earthen embankment sections. Concrete sections can withstand limited overtopping without damage. Embankment sections on the other hand will washout rapidly if overtopped and cause failure of the dam, resulting in severe flooding downstream. The prevention of overtopping is thus of paramount importance.

Comment [r4]: There are a few sentences here that warrant some thought

The safety of the dam therefore depends primarily on the proper operation of the spillway gates, which are used to control maximum flood levels. Such operation in turn relies on the proper functioning of the mechanical hoist mechanisms and their electric power supply and controls. This equipment is located within the dam structure above full supply level and can become inundated if flood releases are not initiated in a timely manner. The critical levels for the operation of the dam and the consequence of their exceedance are as follows:

Comment [r5]: It is not the 'safety of the dam' but the 'ability of the dam to pass floods without overtopping resulting'

Critical Levels for North Pine Dam

Description	AHD (m)	Possible Consequence
Full supply level.	39.60	-
Radial Gate Control Gear.	41.66	Electric motors submerged, use of backup systems required to operate radial gates.
Embankment Crest.	43.28	Breach of embankment by erosion

3.2.1 Extreme Floods and Closely Spaced Large Floods

Formatted: Heading 3,Transfer 3, Don't adjust space between Latin and Asian text

Formatted: Bullets and Numbering

Techniques for estimating extreme floods show that floods are possible which would overtop the dam. Such an overtopping would most likely result in failure of the dam. Such events however may require several days of intense rainfall to produce the necessary runoff.

Deleted: As indicated in the previous section, t

Comment [r6]: According to section 8.1 the peak inflow from critical storms may occur approximately two to four hours after the commencement of heavy rain. The critical duration for the PMP-DF is 36 hours i.e. 1.5 days

Historical records show that there is a significant probability of two or more flood producing storms occurring in the Pine River system within a short time of each other. Therefore, unless determined otherwise by the Senior Flood Operations Engineer in accordance with Section 2.8, the aim during a Flood Event should be to empty stored floodwaters as quickly as possible while meeting all flood mitigation objectives.

Deleted:

3.3 Minimise disruption to Downstream Communities

Formatted: Bullets and Numbering

While North Pine Dam provides only limited flood mitigation benefits in terms of retaining flood water above Full Supply Level, flood releases can result in the submergence of bridges and public areas. Accordingly, the operation of the dam should not prolong this inundation unnecessarily.

The gates of the dam should be operated such that outflow should not exceed inflow under most circumstances.

3.4 Retain the Storage at Full Supply Level at the Conclusion of the Flood Event

Formatted: Bullets and Numbering

As North Pine Dam is a primary urban water supply for South East Queensland, it is important that all opportunities to fill the dam are taken. There should be no reason why the dams should not be full following a Flood Event.

3.5 Minimising Impacts to Riparian Flora and Fauna

Formatted: Bullets and Numbering

During the drain down phase, consideration is to be given to minimising the impacts on riparian flora and fauna. In particular, strategies aimed at reducing fish deaths in the vicinity of the dam walls are to be instigated, provided such procedures do not adversely impact on other flood mitigation objectives.

4 FLOOD CLASSIFICATION

For the reference purposes of this manual, four magnitudes of flooding are classified as follows:

1. Minor Flooding

Causes inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.

2. Moderate Flooding

In addition to the impacts experienced during Minor Flooding, the evacuation of some houses may be required. Main traffic routes may be impacted. The area of inundation is substantial in rural areas requiring the removal of stock.

3. Major Flooding

In addition to the impacts experienced during Moderate Flooding, extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required. The 1974 flood that impacted on the Ipswich and Brisbane areas is classified as a major flood.

4. Extreme Flooding

This causes flooding impacts equal to or in excess of levels previously experienced. In addition to the impacts experienced during Major Floods, the general evacuation of people from significant populated areas is likely to be required.

It should be noted that a flood may not cause the same category of flooding along its entire length and the relevant agencies shall have regard to this when flooding is predicted. The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia.

5 FLOOD MONITORING AND FORECASTING SYSTEM

Comment [r7]: What happens when SEQWater wants to change their flood prediction model?

5.1 General

A real time flood monitoring and forecasting system has been established in the dam catchment. This system employs radio telemetry to collect, transmit and receive rainfall and stream flow information. The system consists of 30 field stations that automatically record rainfall and/or river heights at selected locations in the dam catchments. Some of the 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 potential rainfall in the dam catchments. The RTFM is a suite of hydrologic and hydraulic computer programs that utilise the real time data to assist in the operation of the dams during flood events. Seqwater is responsible for providing and maintaining the RTFM and for ensuring that sufficient data is available to allow proper operation of the RTFM during a Flood Event.

5.2 Operation

The Senior Flood Operations and Flood Operations Engineers use the RTFM for flood monitoring and forecasting during flood events to operate the dams in accordance with this manual. This is done by optimising releases of water from the dams to minimise the impacts of flooding in accordance with the objectives and procedures contained in this manual.

Seqwater is responsible for improving the operation of the RTFM over time by using the following processes:

- Implementing improvements based on Flood Event audits and reviews.
- Improving RTFM calibration as further data becomes available.
- Updating software in line with modern day standards.
- Improving the coverage and reliability of the data collection network to optimise data availability during Flood Events.
- Recommendations by Senior Flood Operations Engineers.

A regular process of internal audit and management review must be maintained by Seqwater to achieve these improvements.

Seqwater must also 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.

Seqwater must also 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.

5.3 Storage of Documentation

The performance of any flood monitoring and forecasting system is reliant on accurate historical data over a long period of time. Seqwater must ensure that all available data and other documentation is appropriately collected and catalogued for future use.

5.4 Key Reference Gauges

Key field station locations have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to relocate field stations from these locations or vary flood classification levels, agreement must first be obtained between Seqwater, Bureau of Meteorology and the Local Government within whose boundaries the locations are situated.

Gauge boards that can be read manually must be maintained by Seqwater as part of the equipment of each key field station. Where possible and practical during Flood events, Seqwater is to have procedures in place for manual reading of these gauge boards in the event of failure of field stations.

Comment [r8]: The gauges shown in Appendix B aren't referenced anywhere in the text.

5.5 Reference Gauge Values

Other agencies such as the Bureau of Meteorology, the Moreton Bay Regional Council and the Brisbane City Council have direct access to the information from field stations for flood assessment purposes. The consultation between agencies is a very important part of the assessment and prediction of flood flows and heights.

Seqwater must ensure that information relevant to the calibration of its field stations is shared with these agencies.

6 COMMUNICATIONS

6.1 Communications between Staff

Seqwater is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Seqwater Flood Operations Centre and site staff at North Pine Dam.

6.2 Dissemination of Information

Agencies other than Seqwater have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public associated with Flood Events. Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public. Agency information requirements are generally as shown in the table below.

The Senior Flood Operations and Flood Operations Engineers must supply information to each of these agencies during Flood Events. The contact information for these Agencies and communication procedures is contained in the Emergency Action Plans for the dam and each agency is to receive updated controlled copies of these documents.

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.

AGENCY INFORMATION REQUIREMENTS

Agency	Activity	Information Required from Flood Operations Centre	Trigger
Bureau of Meteorology	Issue of flood warnings	Actual and predicted lake levels and discharges	Initial gate operations and thereafter at intervals to suit forecasting requirements
Department of Environment and Resource Management	Review of flood operations and discretionary powers	Actual and predicted lake levels and discharges	Initial gate operations
Moreton Bay Regional Council	Flood level information downstream of North Pine Dam	Actual and predicted lake levels and discharges	Initial gate operations
Brisbane City Council	Flood level information for Brisbane City area	Nil (information obtained from BOM)	

6.3 Release of Information to the Public

Seqwater is responsible for the issue of information regarding storage conditions and current and proposed releases from the dam to the public and the media.

The Bureau of Meteorology has responsibility for issuing flood warnings.

The Emergency Services Response Authorities, under the Disaster Management Act 2003, have responsibility for the preparation of a local counter disaster plan and the interpretation of flood forecast information for inclusion in their local flood warnings prepared under the flood sub plan of the counter disaster plan.

7 REVIEW

7.1 Introduction

With the passage of time, neither the technical assumptions nor the physical conditions on which this manual is based may remain unchanged. It is also recognised that the relevance of the manual may change with changing circumstances. It is important therefore, that the manual contain operational procedures which cause the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

This process must involve all personnel involved in the management of Flood Events, to ensure that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based. Variations to the manual may be made in accordance with provisions in Section 1.8.

7.2 Personal Training

Seqwater must report to the Chief Executive by 30 September each year on the training and state of preparedness of operations personnel.

7.3 Monitoring and Forecasting System and Communication Networks

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. The report must assess following in terms of hardware, software and personnel:

- Adequacy of the communication and data gathering facilities
- Reliability of the system over the previous period
- Reliability of the system under prolonged flood conditions
- Accuracy of forecasting flood flows and heights
- The overall state of preparedness of the system

Seqwater must take any action considered necessary for the proper functioning and improvement of this system.

7.4 Operational Review

After each significant flood event, Seqwater must report to the Chief Executive on the effectiveness of the operational procedures contained in this manual. This report must be submitted within six weeks of any flood event that requires mobilisation of the Flood Operations Centre.

7.5 Five Yearly Review

Prior to the expiry of the approval period, Seqwater must review the manual pursuant to provisions of the Act. The review is to take into account the continued suitability of the communication network and the flood monitoring and forecasting system, as well as hydrological and hydraulic engineering assessments of the operational procedures.

8 FLOOD RELEASE OPERATION

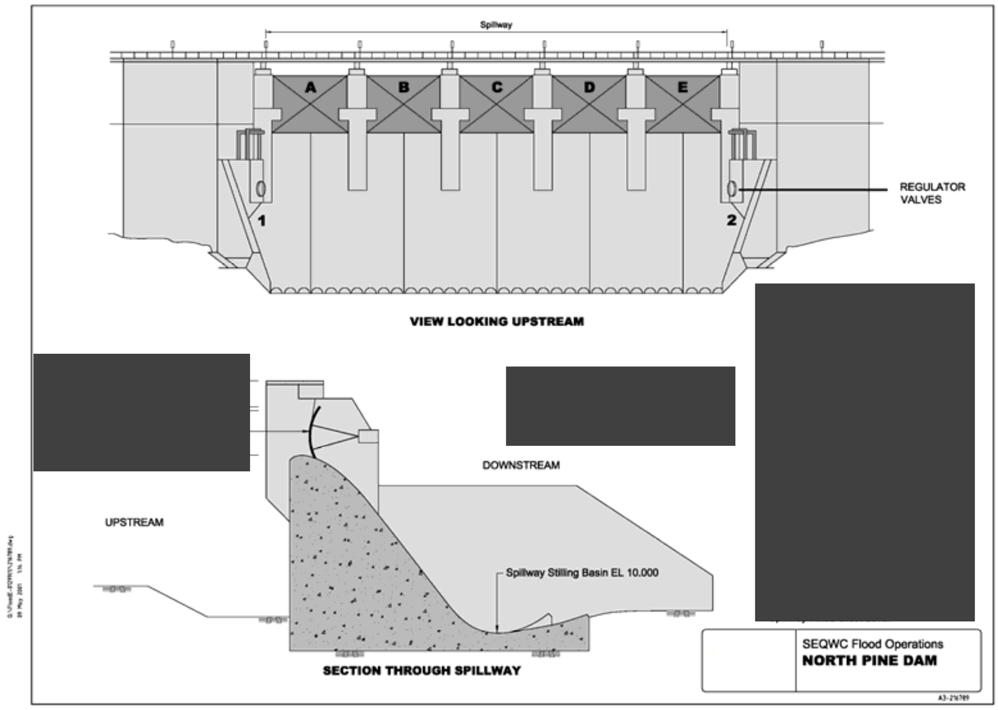
8.1 Introduction

North Pine dam is a water supply dam with only a small flood storage compartment above full supply level. It effectively has no significant provision for flood mitigation and once the dam is full, floods will pass through the reservoir with little mitigation. The peak inflow from critical storms may occur approximately two to four hours after the commencement of heavy rain.

Comment [r9]: Again there is inconsistency with Appendix E which says critical storm duration is generally 12 hours.

8.2 Flood Release Infrastructure

Radial Gates are the primary infrastructure used to release water during flood events at North Pine Dam. The arrangement of the Radial Gates is shown in the diagram below:



8.3 Initial Action

Once a Flood Event is declared, an assessment is to be made of the magnitude of the Flood Event, including:

- A prediction of the maximum storage levels in the dam.
- A prediction of the peak outflow rate from the dam.

Releases from the radial gates should not commence until the lake level exceeds FSL by 50 millimetres (39.65 m AHD).

Prior to releases from the radial gates commencing the Flood Operations Engineer must ensure that the Grant Street causeway is closed and the Moreton Bay Regional Council has been advised of the impact of the proposed flood releases on Youngs Crossing.

8.4 Flood Operations Strategies

The flood release objectives for North Pine Dam, listed in descending order of importance, are as follows:

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- 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.

North Pine Dam effectively has no significant provision for flood mitigation and once the dam is full ensuring the structural safety of the dam is paramount. Accordingly the flood operation strategy is to pass any significant flood through the reservoir, while ensuring that peak outflow generally does not exceed peak inflow while aiming to empty stored floodwaters as quickly as possible. To achieve this strategy, the radial gate opening settings shown in Appendix C are normally used to determine flood releases.

Early releases in small events are permissible to minimise downstream disruption.

Departures from the tables shown in Appendix C are allowed in the following circumstances:

- Pre-release of water is allowed to reduce the risk of dam overtopping.
- Reduction in release rate is allowed once the flood peak has passed to either minimise disruption to the community in areas downstream of the dam or to minimise impacts to riparian flora and fauna.
- At the end of a flood event, additional gate openings may be used to reduce the duration of gate operation and resulting adverse downstream impacts.

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a gate by the immediate opening of a regulator valve (or the reverse operation). This allows for greater control of low flows.

Comment [r10]: There is enough about pre-release elsewhere. Pre-release should generally be done through section 2.8.

Deleted: Unless a decision has been made to commence a pre-release of flood water to control the risk of dam overtopping, r

Comment [r11]: English could be improved. Maybe stop the sentence here and say ‘At the same time the stored floodwater should be emptied as quickly as possible.

Comment [r12]: There is a sentence or two in previous versions about what this entails – one gate increment for every 15 mm storage rise after 2 initial increments at 50 mm rise.. Can we get that back.

Comment [r13]: This is a very open-ended and virtually all-encompassing departure. I don’t like it or as least make it subject to section 2.8.

Comment [r14]: I would have thought the real variations from the Table would come in reasonably static situations to enable gate opening to be scheduled to suit operational circumstances.

8.5 Gate Closing Strategies

In general, gate closing commences when the level in North Pine Dam begins to fall and the closing sequence is generally to occur in the reverse order to opening. The following requirements must be considered when determining gate closure sequences:

Deleted:

- Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.
- The maximum discharge from the dam during closure should generally be less than the peak inflow into North Pine Dam experienced during the event.
- The aim should always be to empty stored floodwaters stored above EL 39.65m as quickly as possible after the flood peak has passed through the dam. However, provided a favourable weather outlook is available, this requirement can be relaxed for the volume between EL 39.65m and EL 39.75m, to minimise downstream impacts.
- To minimise the stranding of fish downstream of the dam, final closure sequences should consider Seqwater procedures relating to fish protection at the dam.

Comment [r15]: Is this level 39.65 or 39.6?

There may be a need to take into account base flow when determining final gate closure. This may mean that the lake level temporarily falls below Full Supply Level to provide for a full dam at the end of the Flood Event.

The regulators may be substituted for gate operations to manage water levels and discharges during small inflows such as during the recession of a Flood Event.

8.6 Gate Operation Sequences

Rapid opening of the radial gates at North Pine dam can cause undesirable rapid rises in downstream river levels. Accordingly, the aim in opening radial gates is to operate the gates one at a time at intervals that will minimise adverse impacts on the river system. The table below shows the target minimum interval for gate operations. This target interval can be reduced if the gates are at risk of being overtopped or the safety of the dam is at risk and operations are generally not allowed to fall more than three openings behind the gate opening settings contained in Appendix C.

TARGET MINIMUM INTERVALS FOR RADIAL GATE OPENING

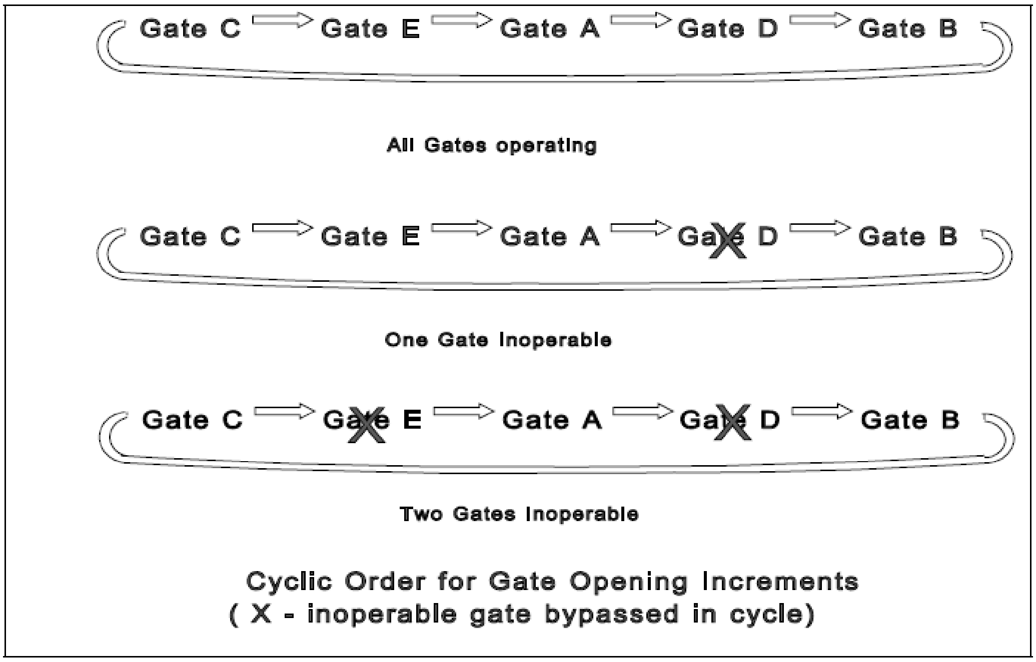
Lake Level	Opening Interval	Closing Interval
Below EL 39.9m	15 min	15 min
EL 39.9m to 40.5m	10 min	10 min
Above EL 40.5m	5 min	5 min

Rapid closure of radial gates is also permissible when there is a requirement to preserve storage or to reduce downstream flooding. When determining gate closure sequences, consideration should also be given to following the calculated natural recession of the flood in the river to aim to ensure that the recession impacts are not greater than those that would have been experienced had the dam not been constructed.

8.7 Protection of the Spillway

To minimise potential damage to the dissipater and the river-bed and banks downstream, the gates must be opened incrementally in accordance with the cyclic sequences shown below.

Gate Operation Sequence



8.8 Gate Failure or Malfunction Procedures

Where one or more gates are inoperable, the sequencing outlined in section 8.7 (above) still applies, except that the inoperable gates must be ignored in the cycle and their increments passed on to the next gate in the sequence. The cumulative number of increments taken by all gates at any particular lake level thus remains unaltered save that the total number of available gate increments has been reduced by inoperable gates. Appendix C contains tables of gate position settings against lake levels for the situations where all gates are operating and where one gate is inoperable.

8.9 Radial Gate Turbulence Considerations

Comment [r16]: I still contend this situation should never happen. You would need to be drawing down the storage to well below full supply level and that is well outside where this manual goes.

Unless in the process of lifting the gates clear of the flow, the bottom edge of the radial gates must always be at least 500 millimetres below the release flow surface. Having the bottom edge of the gates closer to the release flow surface than 500 millimetres may cause unusual turbulence that could adversely impact on the gates. This procedure has never been undertaken in practice and should be observed closely when being undertaken. Variations to the procedure are allowed to protect the structural safety of the dam.

This circumstance is unlikely to occur except under a rare set of conditions.

8.10 Lowering Radial Gates that have been lifted Clear of the Release Flow

When lowering radial gates that have been lifted clear of the release flow, the bottom edge of the gates must be lowered at least 500 millimetres into the flow. Lowering gates into the release flow less than this amount may cause unusual turbulence that could adversely impact on the gates. This procedure has never been undertaken in practice and should be observed closely when being undertaken. Variations to the procedure are allowed to protect the structural safety of the dam.

This circumstance is unlikely to occur except under a rare set of conditions.

Comment [r17]: There is room for a section on relationship with the Emergency Action Plan somewhere not necessarily here.

9 EMERGENCY

9.1 Introduction

While every care has been exercised in the design and construction of the dam, there still remains a low risk that the dam may develop an emergency condition either through flood events or other causes. Experience elsewhere in the world suggests that vigilance is required to recognise emergency flood conditions such as:

- Occurrence of a much larger flood than discharge capacity of the dam;
- Occurrence of a series of large storms in a short period;
- Failure of one or more gates during a flood;
- Development of a piping failure through the embankment;
- Damage to the dam by earthquake;
- Damage to the dam as an act of war or terrorism; and
- Other rare mechanisms.

Responses to these and other conditions are included in the North Pine Dam - Emergency Action Plan.

9.2 Overtopping of Dam

Whatever the circumstances, every endeavour must be made to prevent overtopping of North Pine Dam by the progressive opening of operative spillway gates. Overtopping of the dam is likely to result in a dam failure.

Overtopping may result from inundation the radial gate control equipment and subsequent loss of gate control. Gate openings may be such to ensure this does not occur.

Comment [r18]: Is this may or must?

9.3 Communications Failure

If communications are lost between the Flood Operations Centre and the dam, the officers in charge at the dam are to adopt the procedures set out below. The Dam Supervisor at North Pine Dam is to assume responsibility for flood releases from the Dam. Once it has been established that communications have been lost, the Dam Supervisor at North Pine Dam is to:-

- Take all practicable measures to restore communications and periodically check the lines of communication for any change;
- Follow the procedures set out below to determine the relevant magnitude and duration of releases from North Pine Dam;
- Log all actions in the Event Log;

- Ensure the dam is at full supply level at the end of the event;
- Remain in the general vicinity of the dam while on duty.

Comment [r19]: this is a natural outcome of following Appendix C settings.

The radial gate opening and closing sequences to be used is as set out in Appendix C. The table below shows the target minimum interval for gate operations. This target interval can be reduced if the gates are at risk of being overtopped or the safety of the dam is at risk and operations are not allowed to fall more than three openings behind the gate opening settings contained in Appendix C.

TARGET MINIMUM INTERVALS FOR RADIAL GATE OPENING UNDER LOSS OF COMMUNICATIONS

Lake Level	Opening Interval	Closing Interval
Below EL 39.9m	15 min	15 min
EL 39.9m to 40.5m	10 min	10 min
Above EL 40.5m	5 min	5 min

In the event of one or more radial gates becoming jammed, the remaining gates are to be operated to provide the same total opening for a particular storage level, as shown Appendix C. In these circumstances, gates are generally operated in the order of C, E, A, D, B moving through the sequence shown in the tables.

In a loss of communication scenario, the bulkhead gate is not to be used. At the end of the event, the full supply level of the storage is to be achieved.

APPENDIX A
AGENCIES HOLDING CONTROLLED COPIES OF THIS MANUAL

Agency	Responsible Person	Location
Seqwater	Dam Safety and Source Operations Manager	Brisbane
Seqwater	Principal Engineer Dam Safety	Ipswich
Seqwater	Storage Supervisor	North Pine Dam
Seqwater	Operations Coordinator	North Coast
Seqwater	Senior Flood Operations Engineer	Flood Operations Centre, Brisbane
Department of Environment and Resource Management	Director Dam Safety	Brisbane
Department of Community Safety	Duty Officer – Disaster Management Service	Brisbane
Moreton Bay Regional Council	Local Disaster Response Coordinator	Caboolture
Brisbane City Council	Local Disaster Response Coordinator	Brisbane
Emergency Management Queensland	Regional Director, Brisbane District	Brisbane

APPENDIX B
KEY REFERENCE GAUGES

Moreton Bay Regional Council

Gauge	Flood Classification			
	Minor	**Moderate**	**Major**	**1974 Flood**
Grant Street, Whiteside	Any release from dam	-	-	-
Youngs Crossing	8-10m^3/s			
Railway Bridge, Wyllie Park, Petrie	4.0m	5.0m	6.0m	5.1m
Railway Bridge, South Pine River, Bald Hills	-	3.5m	6.0m	5.18m

Note: Heights are in metres AHD

APPENDIX C
GATE & VALVE SETTINGS

Discharge from North Pine Dam may be controlled by:

- Five radial gates
- Two regulator valves, and/or;
- A low level river release valve with a daily capacity of about 85 ML/d.

RADIAL GATE SETTINGS

Gate Setting	Gate Opening (m)	Top of Gate (EL)	Gate Setting	Gate Opening (m)	Top of Gate (EL)
1	0.152	40.362	13	3.810	41.885
2	0.457	40.547	14	4.115	41.940
3	0.762	40.720	15	4.420	41.984
4	1.067	40.886	16	4.724	42.016
5	1.372	41.041	17	5.029	42.037
6	1.676	41.185	18	5.334	42.047
7	1.981	41.316	19	5.639	42.047
8	2.286	41.349	20	5.944	42.047
9	2.591	41.549	21	6.248	42.047
10	2.896	41.650	22	6.553	42.047
11	3.200	41.740	23*	6.858	42.047
12	3.505	41.817			

* Gate should be fully open

Formatted: Left

RADIAL GATE SETTINGS

All Gates Operational								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	closed	closed	1	closed	1	2	32	E
39.715	1	closed	1	closed	1	3	48	A
39.730	1	closed	1	1	1	4	64	D
39.745	1	1	1	1	1	5	80	B
39.760	1	1	2	1	1	6	104	C
39.775	1	1	2	1	2	7	129	E
39.790	2	1	2	1	2	8	153	A
39.805	2	1	2	2	2	9	177	D
39.820	2	2	2	2	2	10	201	B
39.835	2	2	3	2	2	11	228	C
39.850	2	2	3	2	3	12	254	E
39.865	3	2	3	2	3	13	281	A
39.880	3	2	3	3	3	14	307	D
39.895	3	3	3	3	3	15	334	B
39.910	3	3	4	3	3	16	362	C
39.925	3	3	4	3	4	17	390	E
39.940	4	3	4	3	4	18	417	A
39.955	4	3	4	4	4	19	445	D
39.970	4	4	4	4	4	20	473	B
39.985	4	4	5	4	4	21	500	C
40.000	4	4	5	4	5	22	527	E
40.015	5	4	5	4	5	23	554	A
40.030	5	4	5	5	5	24	581	D
40.045	5	5	5	5	5	25	608	B
40.060	5	5	6	5	5	26	636	C
40.075	5	5	6	5	6	27	664	E
40.090	6	5	6	5	6	28	692	A
40.105	6	5	6	6	6	29	720	D
40.120	6	6	6	6	6	30	748	B
40.135	6	6	7	6	6	31	776	C
40.150	6	6	7	6	7	32	804	E
40.165	7	6	7	6	7	33	832	A
40.180	7	6	7	7	7	34	860	D
40.195	7	7	7	7	7	35	888	B
40.210	7	7	8	7	7	36	916	C
40.225	7	7	8	7	8	37	943	E
40.240	8	7	8	7	8	38	970	A
40.255	8	7	8	8	8	39	998	D
40.270	8	8	8	8	8	40	1025	B
40.285	8	8	9	8	8	41	1052	C
40.300	8	8	9	8	9	42	1079	E
40.315	9	8	9	8	9	43	1106	A
40.330	9	8	9	9	9	44	1133	D
40.345	9	9	9	9	9	45	1160	B

All Gates Operational								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	9	9	10	9	9	46	1187	C
40.375	9	9	10	9	10	47	1213	E
40.390	10	9	10	9	10	48	1240	A
40.405	10	9	10	10	10	49	1266	D
40.420	10	10	10	10	10	50	1293	B
40.435	10	10	11	10	10	51	1320	C
40.450	10	10	11	10	11	52	1347	E
40.465	11	10	11	10	11	53	1374	A
40.480	11	10	11	11	11	54	1401	D
40.495	11	11	11	11	11	55	1428	B
40.510	11	11	12	11	11	56	1455	C
40.525	11	11	12	11	12	57	1482	E
40.540	12	11	12	11	12	58	1510	A
40.555	12	11	12	12	12	59	1537	D
40.570	12	12	12	12	12	60	1564	B
40.585	12	12	13	12	12	61	1593	C
40.600	12	12	13	12	13	62	1621	E
40.615	13	12	13	12	13	63	1650	A
40.630	13	12	13	13	13	64	1678	D
40.645	13	13	13	13	13	65	1707	B
40.660	13	13	14	13	13	66	1736	C
40.675	13	13	14	13	14	67	1765	E
40.690	14	13	14	13	14	68	1794	A
40.705	14	13	14	14	14	69	1823	D
40.720	14	14	14	14	14	70	1852	B
40.735	14	14	15	14	14	71	1883	C
40.750	14	14	15	14	15	72	1914	E
40.765	15	14	15	14	15	73	1946	A
40.780	15	14	15	15	15	74	1978	D
40.795	15	15	15	15	15	75	2009	B
40.810	15	15	16	15	15	76	2044	C
40.825	15	15	16	15	16	77	2079	E
40.840	16	15	16	15	16	78	2114	A
40.855	16	15	16	16	16	79	2148	D
40.870	16	16	16	16	16	80	2183	B
40.885	16	16	17	16	16	81	2222	C
40.900	16	16	17	16	17	82	2260	E
40.915	17	16	17	16	17	83	2299	A
40.930	17	16	17	17	17	84	2337	D
40.945	17	17	17	17	17	85	2376	B
40.960	17	17	18	17	17	86	2415	C
40.975	17	17	18	17	18	87	2453	E
40.990	18	17	18	17	18	88	2491	A
41.005	18	17	18	18	18	89	2530	D
41.020	18	18	18	18	18	90	2568	B
41.035	18	18	19	18	18	91	2601	C
41.050	18	18	19	18	19	92	2635	E

All Gates Operational								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gates Operated
41.065	19	18	19	18	19	93	2668	A
41.080	19	18	19	19	19	94	2701	D
41.095	19	19	19	19	19	95	2734	B
41.110	19	19	20	19	19	96	2773	C
41.125	19	19	20	19	20	97	2806	E
41.140	20	19	20	19	20	98	2842	A
41.155	20	19	20	20	20	99	2878	D
41.170	20	20	20	20	20	100	2913	B
41.185	20	20	21	20	20	101	3026	C
41.200	20	20	21	20	21	102	3142	E
41.215	21	20	21	20	21	103	3260	A
41.230	21	20	21	21	21	104	3382	D
41.245	21	21	21	21	21	105	3506	B
41.260	21	21	22	21	21	106	3515	C
41.275	21	21	22	21	22	107	3524	E
41.290	22	21	22	21	22	108	3532	A
41.305	22	21	22	22	22	109	3541	D
41.320	22	22	22	22	22	110	3550	B
41.335	22	22	23	22	22	111	3559	C
41.350	22	22	23	22	23	112	3567	E
41.365	23	22	23	22	23	113	3576	A
41.380	23	22	23	23	23	114	3585	D
41.395	23	23	23	23	23	115	3594	B

Gate A Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	closed	closed	1	closed	1	2	32	E
39.715	closed	closed	1	1	1	3	48	D
39.730	closed	1	1	1	1	4	64	B
39.745	closed	1	2	1	1	5	88	C
39.760	closed	1	2	1	2	6	112	E
39.775	closed	1	2	2	2	7	137	D
39.790	closed	2	2	2	2	8	161	B
39.805	closed	2	3	2	2	9	187	C
39.820	closed	2	3	2	3	10	213	E
39.835	closed	2	3	3	3	11	240	D
39.850	closed	3	3	3	3	12	266	B
39.865	closed	3	4	3	3	13	294	C
39.880	closed	3	4	3	4	14	322	E
39.895	closed	3	4	4	4	15	349	D
39.910	closed	4	4	4	4	16	377	B
39.925	closed	4	5	4	4	17	404	C
39.940	closed	4	5	4	5	18	430	E
39.955	closed	4	5	5	5	19	457	D
39.970	closed	5	5	5	5	20	484	B
39.985	closed	5	6	5	5	21	512	C
40.000	closed	5	6	5	6	22	539	E
40.015	closed	5	6	6	6	23	567	D
40.030	closed	6	6	6	6	24	595	B
40.045	closed	6	7	6	6	25	623	C
40.060	closed	6	7	6	7	26	650	E
40.075	closed	6	7	7	7	27	678	D
40.090	closed	7	7	7	7	28	706	B
40.105	closed	7	8	7	7	29	732	C
40.120	closed	7	8	7	8	30	759	E
40.135	closed	7	8	8	8	31	786	D
40.150	closed	8	8	8	8	32	812	B
40.165	closed	8	9	8	8	33	839	C
40.180	closed	8	9	8	9	34	866	E
40.195	closed	8	9	9	9	35	893	D
40.210	closed	9	9	9	9	36	920	B
40.225	closed	9	10	9	9	37	946	C
40.240	closed	9	10	9	10	38	972	E
40.255	closed	9	10	10	10	39	998	D
40.270	closed	10	10	10	10	40	1024	B
40.285	closed	10	11	10	10	41	1050	C
40.300	closed	10	11	10	11	42	1077	E
40.315	closed	10	11	11	11	43	1103	D
40.330	closed	11	11	11	11	44	1130	B
40.345	closed	11	12	11	11	45	1156	C

Gate A Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	closed	11	12	11	12	46	1183	E
40.375	closed	11	12	12	12	47	1210	D
40.390	closed	12	12	12	12	48	1237	B
40.405	closed	12	13	12	12	49	1264	C
40.420	closed	12	13	12	13	50	1292	E
40.435	closed	12	13	13	13	51	1320	D
40.450	closed	13	13	13	13	52	1348	B
40.465	closed	13	14	13	13	53	1377	C
40.480	closed	13	14	13	14	54	1405	E
40.495	closed	13	14	14	14	55	1433	D
40.510	closed	14	14	14	14	56	1462	B
40.525	closed	14	15	14	14	57	1492	C
40.540	closed	14	15	14	15	58	1523	E
40.555	closed	14	15	15	15	59	1554	D
40.570	closed	15	15	15	15	60	1585	B
40.585	closed	15	16	15	15	61	1619	C
40.600	closed	15	16	15	16	62	1653	E
40.615	closed	15	16	16	16	63	1687	D
40.630	closed	16	16	16	16	64	1721	B
40.645	closed	16	17	16	16	65	1759	C
40.660	closed	16	17	16	17	66	1797	E
40.675	closed	16	17	17	17	67	1834	D
40.690	closed	17	17	17	17	68	1872	B
40.705	closed	17	18	17	17	69	1911	C
40.720	closed	17	18	17	18	70	1949	E
40.735	closed	17	18	18	18	71	1988	D
40.750	closed	18	18	18	18	72	2026	B
40.765	closed	18	19	18	18	73	2060	C
40.780	closed	18	19	18	19	74	2094	E
40.795	closed	18	19	19	19	75	2127	D
40.810	closed	19	19	19	19	76	2161	B
40.825	closed	19	20	19	19	77	2277	C
40.840	closed	19	20	19	20	78	2395	E
40.855	closed	19	20	20	20	79	2516	D
40.870	closed	20	20	20	20	80	2639	B
40.885	closed	20	21	20	20	81	2645	C
40.900	closed	20	21	20	21	82	2650	E
40.915	closed	20	21	21	21	83	2655	D
40.930	closed	21	21	21	21	84	2660	B
40.945	closed	21	22	21	21	85	2667	C
40.960	closed	21	22	21	22	86	2674	E
40.975	closed	21	22	22	22	87	2680	D
40.990	closed	22	22	22	22	88	2687	B
41.005	closed	22	23	22	22	89	2694	C
41.020	closed	22	23	22	23	90	2701	E
41.035	closed	22	23	23	23	91	2708	D
41.050	closed	23	23	23	23	92	2715	B

Gate A Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
41.065	closed	23	23	23	23	92	2722	-
41.080	closed	23	23	23	23	92	2729	-
41.095	closed	23	23	23	23	92	2736	-
41.110	closed	23	23	23	23	92	2742	-
41.125	closed	23	23	23	23	92	2749	-
41.140	closed	23	23	23	23	92	2756	-
41.155	closed	23	23	23	23	92	2763	-
41.170	closed	23	23	23	23	92	2770	-
41.185	closed	23	23	23	23	92	2777	-
41.200	closed	23	23	23	23	92	2784	-
41.215	closed	23	23	23	23	92	2791	-
41.230	closed	23	23	23	23	92	2798	-
41.245	closed	23	23	23	23	92	2805	-
41.260	closed	23	23	23	23	92	2812	-
41.275	closed	23	23	23	23	92	2819	-
41.290	closed	23	23	23	23	92	2826	-
41.305	closed	23	23	23	23	92	2833	-
41.320	closed	23	23	23	23	92	2840	-
41.335	closed	23	23	23	23	92	2847	-
41.350	closed	23	23	23	23	92	2854	-
41.365	closed	23	23	23	23	92	2861	-
41.380	closed	23	23	23	23	92	2868	-
41.395	closed	23	23	23	23	92	2875	-

Gate B Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	closed	closed	1	closed	1	2	32	E
39.715	1	closed	1	closed	1	3	48	A
39.730	1	closed	1	1	1	4	64	D
39.745	1	closed	2	1	1	5	88	C
39.760	1	closed	2	1	2	6	112	E
39.775	2	closed	2	1	2	7	137	A
39.790	2	closed	2	2	2	8	161	D
39.805	2	closed	3	2	2	9	187	C
39.820	2	closed	3	2	3	10	213	E
39.835	3	closed	3	2	3	11	240	A
39.850	3	closed	3	3	3	12	266	D
39.865	3	closed	4	3	3	13	294	C
39.880	3	closed	4	3	4	14	322	E
39.895	4	closed	4	3	4	15	349	A
39.910	4	closed	4	4	4	16	377	D
39.925	4	closed	5	4	4	17	404	C
39.940	4	closed	5	4	5	18	430	E
39.955	5	closed	5	4	5	19	457	A
39.970	5	closed	5	5	5	20	484	D
39.985	5	closed	6	5	5	21	512	C
40.000	5	closed	6	5	6	22	539	E
40.015	6	closed	6	5	6	23	567	A
40.030	6	closed	6	6	6	24	595	D
40.045	6	closed	7	6	6	25	623	C
40.060	6	closed	7	6	7	26	650	E
40.075	7	closed	7	6	7	27	678	A
40.090	7	closed	7	7	7	28	706	D
40.105	7	closed	8	7	7	29	732	C
40.120	7	closed	8	7	8	30	759	E
40.135	8	closed	8	7	8	31	786	A
40.150	8	closed	8	8	8	32	812	D
40.165	8	closed	9	8	8	33	839	C
40.180	8	closed	9	8	9	34	866	E
40.195	9	closed	9	8	9	35	893	A
40.210	9	closed	9	9	9	36	920	D
40.225	9	closed	10	9	9	37	946	C
40.240	9	closed	10	9	10	38	972	E
40.255	10	closed	10	9	10	39	998	A
40.270	10	closed	10	10	10	40	1024	D
40.285	10	closed	11	10	10	41	1050	C
40.300	10	closed	11	10	11	42	1077	E
40.315	11	closed	11	10	11	43	1103	A
40.330	11	closed	11	11	11	44	1130	D
40.345	11	closed	12	11	11	45	1156	C

Gate B Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	11	closed	12	11	12	46	1183	E
40.375	12	closed	12	11	12	47	1210	A
40.390	12	closed	12	12	12	48	1237	D
40.405	12	closed	13	12	12	49	1264	C
40.420	12	closed	13	12	13	50	1292	E
40.435	13	closed	13	12	13	51	1320	A
40.450	13	closed	13	13	13	52	1348	D
40.465	13	closed	14	13	13	53	1377	C
40.480	13	closed	14	13	14	54	1405	E
40.495	14	closed	14	13	14	55	1433	A
40.510	14	closed	14	14	14	56	1462	D
40.525	14	closed	15	14	14	57	1492	C
40.540	14	closed	15	14	15	58	1523	E
40.555	15	closed	15	14	15	59	1554	A
40.570	15	closed	15	15	15	60	1585	D
40.585	15	closed	16	15	15	61	1619	C
40.600	15	closed	16	15	16	62	1653	E
40.615	16	closed	16	15	16	63	1687	A
40.630	16	closed	16	16	16	64	1721	D
40.645	16	closed	17	16	16	65	1759	C
40.660	16	closed	17	16	17	66	1797	E
40.675	17	closed	17	16	17	67	1834	A
40.690	17	closed	17	17	17	68	1872	D
40.705	17	closed	18	17	17	69	1911	C
40.720	17	closed	18	17	18	70	1949	E
40.735	18	closed	18	17	18	71	1988	A
40.750	18	closed	18	18	18	72	2026	D
40.765	18	closed	19	18	18	73	2060	C
40.780	18	closed	19	18	19	74	2094	E
40.795	19	closed	19	18	19	75	2127	A
40.810	19	closed	19	19	19	76	2161	D
40.825	19	closed	20	19	19	77	2277	C
40.840	19	closed	20	19	20	78	2395	E
40.855	20	closed	20	19	20	79	2516	A
40.870	20	closed	20	20	20	80	2639	D
40.885	20	closed	21	20	20	81	2645	C
40.900	20	closed	21	20	21	82	2650	E
40.915	21	closed	21	20	21	83	2655	A
40.930	21	closed	21	21	21	84	2660	D
40.945	21	closed	22	21	21	85	2667	C
40.960	21	closed	22	21	22	86	2674	E
40.975	22	closed	22	21	22	87	2680	A
40.990	22	closed	22	22	22	88	2687	D
41.005	22	closed	23	22	22	89	2694	C
41.020	22	closed	23	22	23	90	2701	E
41.035	23	closed	23	22	23	91	2708	A
41.050	23	closed	23	23	23	92	2715	D

Gate B Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gates Operated
41.065	23	closed	23	23	23	92	2722	-
41.080	23	closed	23	23	23	92	2729	-
41.095	23	closed	23	23	23	92	2736	-
41.110	23	closed	23	23	23	92	2742	-
41.125	23	closed	23	23	23	92	2749	-
41.140	23	closed	23	23	23	92	2756	-
41.155	23	closed	23	23	23	92	2763	-
41.170	23	closed	23	23	23	92	2770	-
41.185	23	closed	23	23	23	92	2777	-
41.200	23	closed	23	23	23	92	2784	-
41.215	23	closed	23	23	23	92	2791	-
41.230	23	closed	23	23	23	92	2798	-
41.245	23	closed	23	23	23	92	2805	-
41.260	23	closed	23	23	23	92	2812	-
41.275	23	closed	23	23	23	92	2819	-
41.290	23	closed	23	23	23	92	2826	-
41.305	23	closed	23	23	23	92	2833	-
41.320	23	closed	23	23	23	92	2840	-
41.335	23	closed	23	23	23	92	2847	-
41.350	23	closed	23	23	23	92	2854	-
41.365	23	closed	23	23	23	92	2861	-
41.380	23	closed	23	23	23	92	2868	-
41.395	23	closed	23	23	23	92	2875	-

Gate C Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	closed	closed	1	1	16	E
39.700	1	closed	closed	closed	1	2	32	A
39.715	1	closed	closed	1	1	3	48	D
39.730	1	1	closed	1	1	4	64	B
39.745	1	1	closed	1	2	5	88	E
39.760	2	1	closed	1	2	6	112	A
39.775	2	1	closed	2	2	7	137	D
39.790	2	2	closed	2	2	8	161	B
39.805	2	2	closed	2	3	9	187	E
39.820	3	2	closed	2	3	10	213	A
39.835	3	2	closed	3	3	11	240	D
39.850	3	3	closed	3	3	12	266	B
39.865	3	3	closed	3	4	13	294	E
39.880	4	3	closed	3	4	14	322	A
39.895	4	3	closed	4	4	15	349	D
39.910	4	4	closed	4	4	16	377	B
39.925	4	4	closed	4	5	17	404	E
39.940	5	4	closed	4	5	18	430	A
39.955	5	4	closed	5	5	19	457	D
39.970	5	5	closed	5	5	20	484	B
39.985	5	5	closed	5	6	21	512	E
40.000	6	5	closed	5	6	22	539	A
40.015	6	5	closed	6	6	23	567	D
40.030	6	6	closed	6	6	24	595	B
40.045	6	6	closed	6	7	25	623	E
40.060	7	6	closed	6	7	26	650	A
40.075	7	6	closed	7	7	27	678	D
40.090	7	7	closed	7	7	28	706	B
40.105	7	7	closed	7	8	29	732	E
40.120	8	7	closed	7	8	30	759	A
40.135	8	7	closed	8	8	31	786	D
40.150	8	8	closed	8	8	32	812	B
40.165	8	8	closed	8	9	33	839	E
40.180	9	8	closed	8	9	34	866	A
40.195	9	8	closed	9	9	35	893	D
40.210	9	9	closed	9	9	36	920	B
40.225	9	9	closed	9	10	37	946	E
40.240	10	9	closed	9	10	38	972	A
40.255	10	9	closed	10	10	39	998	D
40.270	10	10	closed	10	10	40	1024	B
40.285	10	10	closed	10	11	41	1050	E
40.300	11	10	closed	10	11	42	1077	A
40.315	11	10	closed	11	11	43	1103	D
40.330	11	11	closed	11	11	44	1130	B
40.345	11	11	closed	11	12	45	1156	E

Gate C Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	12	11	closed	11	12	46	1183	A
40.375	12	11	closed	12	12	47	1210	D
40.390	12	12	closed	12	12	48	1237	B
40.405	12	12	closed	12	13	49	1264	E
40.420	13	12	closed	12	13	50	1292	A
40.435	13	12	closed	13	13	51	1320	D
40.450	13	13	closed	13	13	52	1348	B
40.465	13	13	closed	13	14	53	1377	E
40.480	14	13	closed	13	14	54	1405	A
40.495	14	13	closed	14	14	55	1433	D
40.510	14	14	closed	14	14	56	1462	B
40.525	14	14	closed	14	15	57	1492	E
40.540	15	14	closed	14	15	58	1523	A
40.555	15	14	closed	15	15	59	1554	D
40.570	15	15	closed	15	15	60	1585	B
40.585	15	15	closed	15	16	61	1619	E
40.600	16	15	closed	15	16	62	1653	A
40.615	16	15	closed	16	16	63	1687	D
40.630	16	16	closed	16	16	64	1721	B
40.645	16	16	closed	16	17	65	1759	E
40.660	17	16	closed	16	17	66	1797	A
40.675	17	16	closed	17	17	67	1834	D
40.690	17	17	closed	17	17	68	1872	B
40.705	17	17	closed	17	18	69	1911	E
40.720	18	17	closed	17	18	70	1949	A
40.735	18	17	closed	18	18	71	1988	D
40.750	18	18	closed	18	18	72	2026	B
40.765	18	18	closed	18	19	73	2060	E
40.780	19	18	closed	18	19	74	2094	A
40.795	19	18	closed	19	19	75	2127	D
40.810	19	19	closed	19	19	76	2161	B
40.825	19	19	closed	19	20	77	2277	E
40.840	20	19	closed	19	20	78	2395	A
40.855	20	19	closed	20	20	79	2516	D
40.870	20	20	closed	20	20	80	2639	B
40.885	20	20	closed	20	21	81	2645	E
40.900	21	20	closed	20	21	82	2650	A
40.915	21	20	closed	21	21	83	2655	D
40.930	21	21	closed	21	21	84	2660	B
40.945	21	21	closed	21	22	85	2667	E
40.960	22	21	closed	21	22	86	2674	A
40.975	22	21	closed	22	22	87	2680	D
40.990	22	22	closed	22	22	88	2687	B
41.005	22	22	closed	22	23	89	2694	E
41.020	23	22	closed	22	23	90	2701	A
41.035	23	22	closed	23	23	91	2708	D
41.050	23	23	closed	23	23	92	2715	B

Gate C Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
41.065	23	23	closed	23	23	92	2722	-
41.080	23	23	closed	23	23	92	2729	-
41.095	23	23	closed	23	23	92	2736	-
41.110	23	23	closed	23	23	92	2742	-
41.125	23	23	closed	23	23	92	2749	-
41.140	23	23	closed	23	23	92	2756	-
41.155	23	23	closed	23	23	92	2763	-
41.170	23	23	closed	23	23	92	2770	-
41.185	23	23	closed	23	23	92	2777	-
41.200	23	23	closed	23	23	92	2784	-
41.215	23	23	closed	23	23	92	2791	-
41.230	23	23	closed	23	23	92	2798	-
41.245	23	23	closed	23	23	92	2805	-
41.260	23	23	closed	23	23	92	2812	-
41.275	23	23	closed	23	23	92	2819	-
41.290	23	23	closed	23	23	92	2826	-
41.305	23	23	closed	23	23	92	2833	-
41.320	23	23	closed	23	23	92	2840	-
41.335	23	23	closed	23	23	92	2847	-
41.350	23	23	closed	23	23	92	2854	-
41.365	23	23	closed	23	23	92	2861	-
41.380	23	23	closed	23	23	92	2868	-
41.395	23	23	closed	23	23	92	2875	-

Gate D Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	closed	closed	1	closed	1	2	32	E
39.715	1	closed	1	closed	1	3	48	A
39.730	1	1	1	closed	1	4	64	B
39.745	1	1	2	closed	1	5	88	C
39.760	1	1	2	closed	2	6	112	E
39.775	2	1	2	closed	2	7	137	A
39.790	2	2	2	closed	2	8	161	B
39.805	2	2	3	closed	2	9	187	C
39.820	2	2	3	closed	3	10	213	E
39.835	3	2	3	closed	3	11	240	A
39.850	3	3	3	closed	3	12	266	B
39.865	3	3	4	closed	3	13	294	C
39.880	3	3	4	closed	4	14	322	E
39.895	4	3	4	closed	4	15	349	A
39.910	4	4	4	closed	4	16	377	B
39.925	4	4	5	closed	4	17	404	C
39.940	4	4	5	closed	5	18	430	E
39.955	5	4	5	closed	5	19	457	A
39.970	5	5	5	closed	5	20	484	B
39.985	5	5	6	closed	5	21	512	C
40.000	5	5	6	closed	6	22	539	E
40.015	6	5	6	closed	6	23	567	A
40.030	6	6	6	closed	6	24	595	B
40.045	6	6	7	closed	6	25	623	C
40.060	6	6	7	closed	7	26	650	E
40.075	7	6	7	closed	7	27	678	A
40.090	7	7	7	closed	7	28	706	B
40.105	7	7	8	closed	7	29	732	C
40.120	7	7	8	closed	8	30	759	E
40.135	8	7	8	closed	8	31	786	A
40.150	8	8	8	closed	8	32	812	B
40.165	8	8	9	closed	8	33	839	C
40.180	8	8	9	closed	9	34	866	E
40.195	9	8	9	closed	9	35	893	A
40.210	9	9	9	closed	9	36	920	B
40.225	9	9	10	closed	9	37	946	C
40.240	9	9	10	closed	10	38	972	E
40.255	10	9	10	closed	10	39	998	A
40.270	10	10	10	closed	10	40	1024	B
40.285	10	10	11	closed	10	41	1050	C
40.300	10	10	11	closed	11	42	1077	E
40.315	11	10	11	closed	11	43	1103	A
40.330	11	11	11	closed	11	44	1130	B
40.345	11	11	12	closed	11	45	1156	C

Gate D Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	11	11	12	closed	12	46	1183	E
40.375	12	11	12	closed	12	47	1210	A
40.390	12	12	12	closed	12	48	1237	B
40.405	12	12	13	closed	12	49	1264	C
40.420	12	12	13	closed	13	50	1292	E
40.435	13	12	13	closed	13	51	1320	A
40.450	13	13	13	closed	13	52	1348	B
40.465	13	13	14	closed	13	53	1377	C
40.480	13	13	14	closed	14	54	1405	E
40.495	14	13	14	closed	14	55	1433	A
40.510	14	14	14	closed	14	56	1462	B
40.525	14	14	15	closed	14	57	1492	C
40.540	14	14	15	closed	15	58	1523	E
40.555	15	14	15	closed	15	59	1554	A
40.570	15	15	15	closed	15	60	1585	B
40.585	15	15	16	closed	15	61	1619	C
40.600	15	15	16	closed	16	62	1653	E
40.615	16	15	16	closed	16	63	1687	A
40.630	16	16	16	closed	16	64	1721	B
40.645	16	16	17	closed	16	65	1759	C
40.660	16	16	17	closed	17	66	1797	E
40.675	17	16	17	closed	17	67	1834	A
40.690	17	17	17	closed	17	68	1872	B
40.705	17	17	18	closed	17	69	1911	C
40.720	17	17	18	closed	18	70	1949	E
40.735	18	17	18	closed	18	71	1988	A
40.750	18	18	18	closed	18	72	2026	B
40.765	18	18	19	closed	18	73	2060	C
40.780	18	18	19	closed	19	74	2094	E
40.795	19	18	19	closed	19	75	2127	A
40.810	19	19	19	closed	19	76	2161	B
40.825	19	19	20	closed	19	77	2277	C
40.840	19	19	20	closed	20	78	2395	E
40.855	20	19	20	closed	20	79	2516	A
40.870	20	20	20	closed	20	80	2639	B
40.885	20	20	21	closed	20	81	2645	C
40.900	20	20	21	closed	21	82	2650	E
40.915	21	20	21	closed	21	83	2655	A
40.930	21	21	21	closed	21	84	2660	B
40.945	21	21	22	closed	21	85	2667	C
40.960	21	21	22	closed	22	86	2674	E
40.975	22	21	22	closed	22	87	2680	A
40.990	22	22	22	closed	22	88	2687	B
41.005	22	22	23	closed	22	89	2694	C
41.020	22	22	23	closed	23	90	2701	E
41.035	23	22	23	closed	23	91	2708	A
41.050	23	23	23	closed	23	92	2715	B

Gate D Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
41.065	23	23	23	closed	23	92	2722	-
41.080	23	23	23	closed	23	92	2729	-
41.095	23	23	23	closed	23	92	2736	-
41.110	23	23	23	closed	23	92	2742	-
41.125	23	23	23	closed	23	92	2749	-
41.140	23	23	23	closed	23	92	2756	-
41.155	23	23	23	closed	23	92	2763	-
41.170	23	23	23	closed	23	92	2770	-
41.185	23	23	23	closed	23	92	2777	-
41.200	23	23	23	closed	23	92	2784	-
41.215	23	23	23	closed	23	92	2791	-
41.230	23	23	23	closed	23	92	2798	-
41.245	23	23	23	closed	23	92	2805	-
41.260	23	23	23	closed	23	92	2812	-
41.275	23	23	23	closed	23	92	2819	-
41.290	23	23	23	closed	23	92	2826	-
41.305	23	23	23	closed	23	92	2833	-
41.320	23	23	23	closed	23	92	2840	-
41.335	23	23	23	closed	23	92	2847	-
41.350	23	23	23	closed	23	92	2854	-
41.365	23	23	23	closed	23	92	2861	-
41.380	23	23	23	closed	23	92	2868	-
41.395	23	23	23	closed	23	92	2875	-

Gate E Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	1	closed	1	closed	closed	2	32	A
39.715	1	closed	1	1	closed	3	48	D
39.730	1	1	1	1	closed	4	64	B
39.745	1	1	2	1	closed	5	88	C
39.760	2	1	2	1	closed	6	112	A
39.775	2	1	2	2	closed	7	137	D
39.790	2	2	2	2	closed	8	161	B
39.805	2	2	3	2	closed	9	187	C
39.820	3	2	3	2	closed	10	213	A
39.835	3	2	3	3	closed	11	240	D
39.850	3	3	3	3	closed	12	266	B
39.865	3	3	4	3	closed	13	294	C
39.880	4	3	4	3	closed	14	322	A
39.895	4	3	4	4	closed	15	349	D
39.910	4	4	4	4	closed	16	377	B
39.925	4	4	5	4	closed	17	404	C
39.940	5	4	5	4	closed	18	430	A
39.955	5	4	5	5	closed	19	457	D
39.970	5	5	5	5	closed	20	484	B
39.985	5	5	6	5	closed	21	512	C
40.000	6	5	6	5	closed	22	539	A
40.015	6	5	6	6	closed	23	567	D
40.030	6	6	6	6	closed	24	595	B
40.045	6	6	7	6	closed	25	623	C
40.060	7	6	7	6	closed	26	650	A
40.075	7	6	7	7	closed	27	678	D
40.090	7	7	7	7	closed	28	706	B
40.105	7	7	8	7	closed	29	732	C
40.120	8	7	8	7	closed	30	759	A
40.135	8	7	8	8	closed	31	786	D
40.150	8	8	8	8	closed	32	812	B
40.165	8	8	9	8	closed	33	839	C
40.180	9	8	9	8	closed	34	866	A
40.195	9	8	9	9	closed	35	893	D
40.210	9	9	9	9	closed	36	920	B
40.225	9	9	10	9	closed	37	946	C
40.240	10	9	10	9	closed	38	972	A
40.255	10	9	10	10	closed	39	998	D
40.270	10	10	10	10	closed	40	1024	B
40.285	10	10	11	10	closed	41	1050	C
40.300	11	10	11	10	closed	42	1077	A
40.315	11	10	11	11	closed	43	1103	D
40.330	11	11	11	11	closed	44	1130	B
40.345	11	11	12	11	closed	45	1156	C

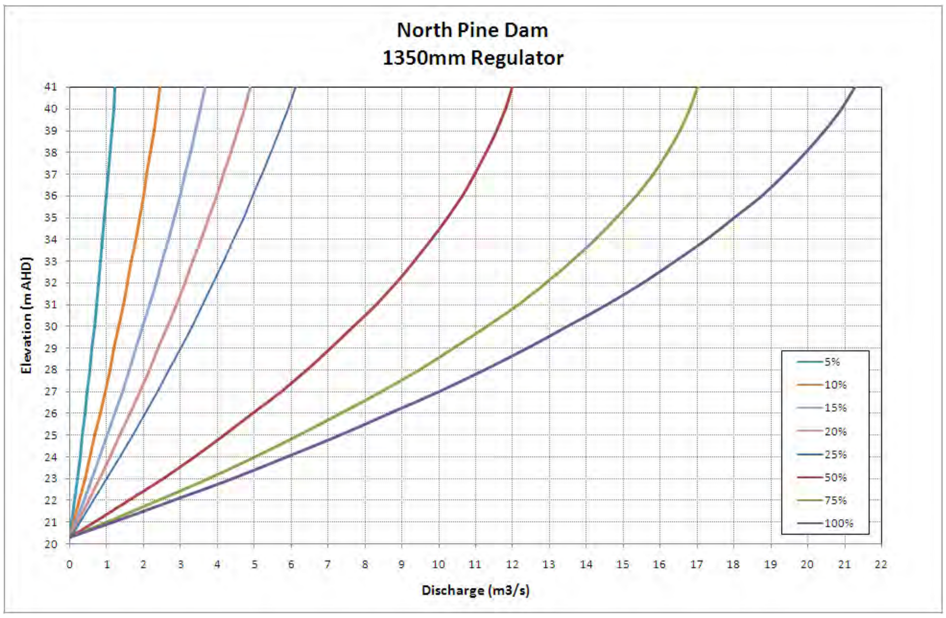
Gate E Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	12	11	12	11	closed	46	1183	A
40.375	12	11	12	12	closed	47	1210	D
40.390	12	12	12	12	closed	48	1237	B
40.405	12	12	13	12	closed	49	1264	C
40.420	13	12	13	12	closed	50	1292	A
40.435	13	12	13	13	closed	51	1320	D
40.450	13	13	13	13	closed	52	1348	B
40.465	13	13	14	13	closed	53	1377	C
40.480	14	13	14	13	closed	54	1405	A
40.495	14	13	14	14	closed	55	1433	D
40.510	14	14	14	14	closed	56	1462	B
40.525	14	14	15	14	closed	57	1492	C
40.540	15	14	15	14	closed	58	1523	A
40.555	15	14	15	15	closed	59	1554	D
40.570	15	15	15	15	closed	60	1585	B
40.585	15	15	16	15	closed	61	1619	C
40.600	16	15	16	15	closed	62	1653	A
40.615	16	15	16	16	closed	63	1687	D
40.630	16	16	16	16	closed	64	1721	B
40.645	16	16	17	16	closed	65	1759	C
40.660	17	16	17	16	closed	66	1797	A
40.675	17	16	17	17	closed	67	1834	D
40.690	17	17	17	17	closed	68	1872	B
40.705	17	17	18	17	closed	69	1911	C
40.720	18	17	18	17	closed	70	1949	A
40.735	18	17	18	18	closed	71	1988	D
40.750	18	18	18	18	closed	72	2026	B
40.765	18	18	19	18	closed	73	2060	C
40.780	19	18	19	18	closed	74	2094	A
40.795	19	18	19	19	closed	75	2127	D
40.810	19	19	19	19	closed	76	2161	B
40.825	19	19	20	19	closed	77	2277	C
40.840	20	19	20	19	closed	78	2395	A
40.855	20	19	20	20	closed	79	2516	D
40.870	20	20	20	20	closed	80	2639	B
40.885	20	20	21	20	closed	81	2645	C
40.900	21	20	21	20	closed	82	2650	A
40.915	21	20	21	21	closed	83	2655	D
40.930	21	21	21	21	closed	84	2660	B
40.945	21	21	22	21	closed	85	2667	C
40.960	22	21	22	21	closed	86	2674	A
40.975	22	21	22	22	closed	87	2680	D
40.990	22	22	22	22	closed	88	2687	B
41.005	22	22	23	22	closed	89	2694	C
41.020	23	22	23	22	closed	90	2701	A
41.035	23	22	23	23	closed	91	2708	D
41.050	23	23	23	23	closed	92	2715	B

Gate E Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
41.065	23	23	23	23	closed	92	2722	-
41.080	23	23	23	23	closed	92	2729	-
41.095	23	23	23	23	closed	92	2736	-
41.110	23	23	23	23	closed	92	2742	-
41.125	23	23	23	23	closed	92	2749	-
41.140	23	23	23	23	closed	92	2756	-
41.155	23	23	23	23	closed	92	2763	-
41.170	23	23	23	23	closed	92	2770	-
41.185	23	23	23	23	closed	92	2777	-
41.200	23	23	23	23	closed	92	2784	-
41.215	23	23	23	23	closed	92	2791	-
41.230	23	23	23	23	closed	92	2798	-
41.245	23	23	23	23	closed	92	2805	-
41.260	23	23	23	23	closed	92	2812	-
41.275	23	23	23	23	closed	92	2819	-
41.290	23	23	23	23	closed	92	2826	-
41.305	23	23	23	23	closed	92	2833	-
41.320	23	23	23	23	closed	92	2840	-
41.335	23	23	23	23	closed	92	2847	-
41.350	23	23	23	23	closed	92	2854	-
41.365	23	23	23	23	closed	92	2861	-
41.380	23	23	23	23	closed	92	2868	-
41.395	23	23	23	23	closed	92	2875	-

1350mm Regulator

EL	Opening (%)								Opening (%)							
	5	10	15	20	25	50	75	100	5	10	15	20	25	50	75	100
m AHD	m3/s								ML/d							
20.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0	0
21.0	0.1	0.1	0.2	0.2	0.3	0.7	1.0	1.2	5	9	14	18	23	59	87	102
22.0	0.1	0.3	0.4	0.5	0.6	1.6	2.4	2.8	11	22	33	44	55	139	208	243
23.0	0.2	0.4	0.6	0.8	1.0	2.5	3.7	4.4	17	34	52	69	86	217	323	379
24.0	0.3	0.5	0.8	1.1	1.3	3.4	5.0	5.9	23	47	70	93	117	291	432	508
25.0	0.3	0.7	1.0	1.4	1.7	4.2	6.2	7.3	29	59	88	117	146	362	536	632
26.0	0.4	0.8	1.2	1.6	2.0	5.0	7.4	8.7	35	70	105	140	176	429	635	751
27.0	0.5	0.9	1.4	1.9	2.4	5.7	8.4	10.0	41	82	122	163	204	493	729	863
28.0	0.5	1.1	1.6	2.1	2.7	6.4	9.5	11.2	46	93	139	185	232	554	817	970
29.0	0.6	1.2	1.8	2.4	3.0	7.1	10.4	12.4	52	104	155	207	259	611	899	1071
30.0	0.7	1.3	2.0	2.6	3.3	7.7	11.3	13.5	57	114	171	228	285	665	976	1166
31.0	0.7	1.4	2.2	2.9	3.6	8.3	12.1	14.5	62	124	186	249	311	716	1048	1256
32.0	0.8	1.6	2.3	3.1	3.9	8.8	12.9	15.5	67	134	201	269	336	763	1115	1340
33.0	0.8	1.7	2.5	3.3	4.2	9.3	13.6	16.4	72	144	216	288	360	807	1176	1418
34.0	0.9	1.8	2.7	3.6	4.4	9.8	14.2	17.3	77	153	230	307	383	847	1231	1491
35.0	0.9	1.9	2.8	3.8	4.7	10.2	14.8	18.0	81	162	244	325	406	884	1281	1558
36.0	1.0	2.0	3.0	4.0	5.0	10.6	15.3	18.7	86	171	257	343	428	918	1326	1619
37.0	1.0	2.1	3.1	4.2	5.2	11.0	15.8	19.4	90	180	270	360	450	949	1366	1674
38.0	1.1	2.2	3.3	4.4	5.4	11.3	16.2	19.9	94	188	282	376	470	976	1400	1724
39.0	1.1	2.3	3.4	4.5	5.7	11.6	16.5	20.5	98	196	294	392	490	999	1428	1768
40.0	1.2	2.4	3.5	4.7	5.9	11.8	16.8	20.9	102	204	306	408	510	1020	1452	1806
41.0	1.2	2.4	3.7	4.9	6.1	12.0	17.0	21.3	106	211	317	423	528	1036	1469	1838

Comment [r20]: Is there a minimum opening that should be used?



APPENDIX D

NORTH PINE DAM AUXILIARY EQUIPMENT

The spillway gates at North Pine Dam are raised and lowered using electric motor driven winches. These motors are normally powered from the mains electric supply. In the event of a failure of the mains supply, a standby diesel generator (located on level 2 of the dam) automatically cuts in to maintain electric supply.

Review of the North Pine Dam hydrology has shown that extreme events can submerge the five radial gate electric winch motors that are located on platforms beneath the bridge deck forming the dam crest. During such an event the electric winch motors would not operate and the winches would not be accessible to enable operation using the compressed air system.

An auxiliary gate operating system installed in 1997/98 comprises a trailer-mounted motor with petrol driven generator, which can be used to operate the winches from the crest of the dam. The shafts of the existing electric winch motors have been extended to the level of the dam crest through right angle gear boxes. In the event of failure of both of the mains electric supply and the standby diesel generator, failure or submergence of the electric winch motors, the trailer mounted motor and petrol driven generator must be used to operate the radial gates.

APPENDIX E

HYDROLOGIC INVESTIGATIONS

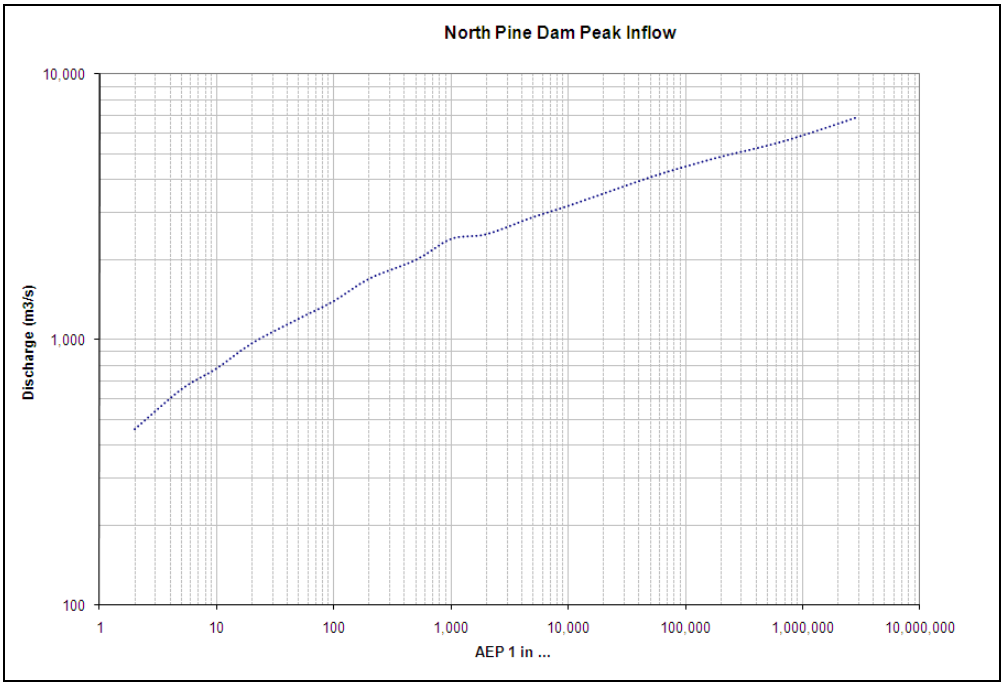
The design flood hydrology for North Pine Dam was updated by SunWater in October 2007 (North Pine Dam Design Flood Hydrology, Oct 2007).

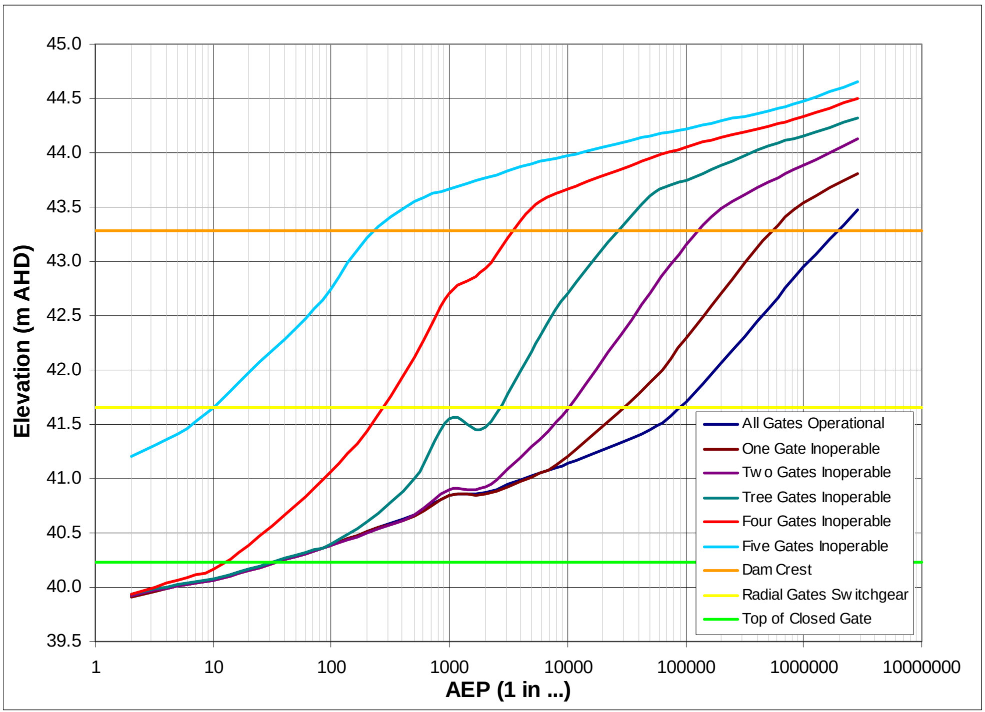
Flood frequency analysis of the flood records at GS120101a Youngs Crossing (pre dam) suggested that the 1974 flood was about a 1 in 100 AEP event.

An URBS runoff-routing model of the North Pine was developed and calibrated to three pre-dam floods and four post dam events. While there was a reasonable amount of rainfall data available, calibration of the model was hampered by the lack of key water level data; gauge heights at Youngs Crossing in 1974 (due to gauge failure) and North Pine Dam headwater levels in post dam events.

Design rainfalls were determined using the methodologies outlined in the Generalised Short Duration Method and Generalised Tropical Storm Method Revised. The appropriate temporal patterns suggested by these methodologies were adopted.

The flows derived using the design event approach closely matched pre-dam flood frequency estimates, giving a degree of confidence in the adopted methodology.





Based on the findings of this hydrologic study for North Pine Dam, it is concluded that;

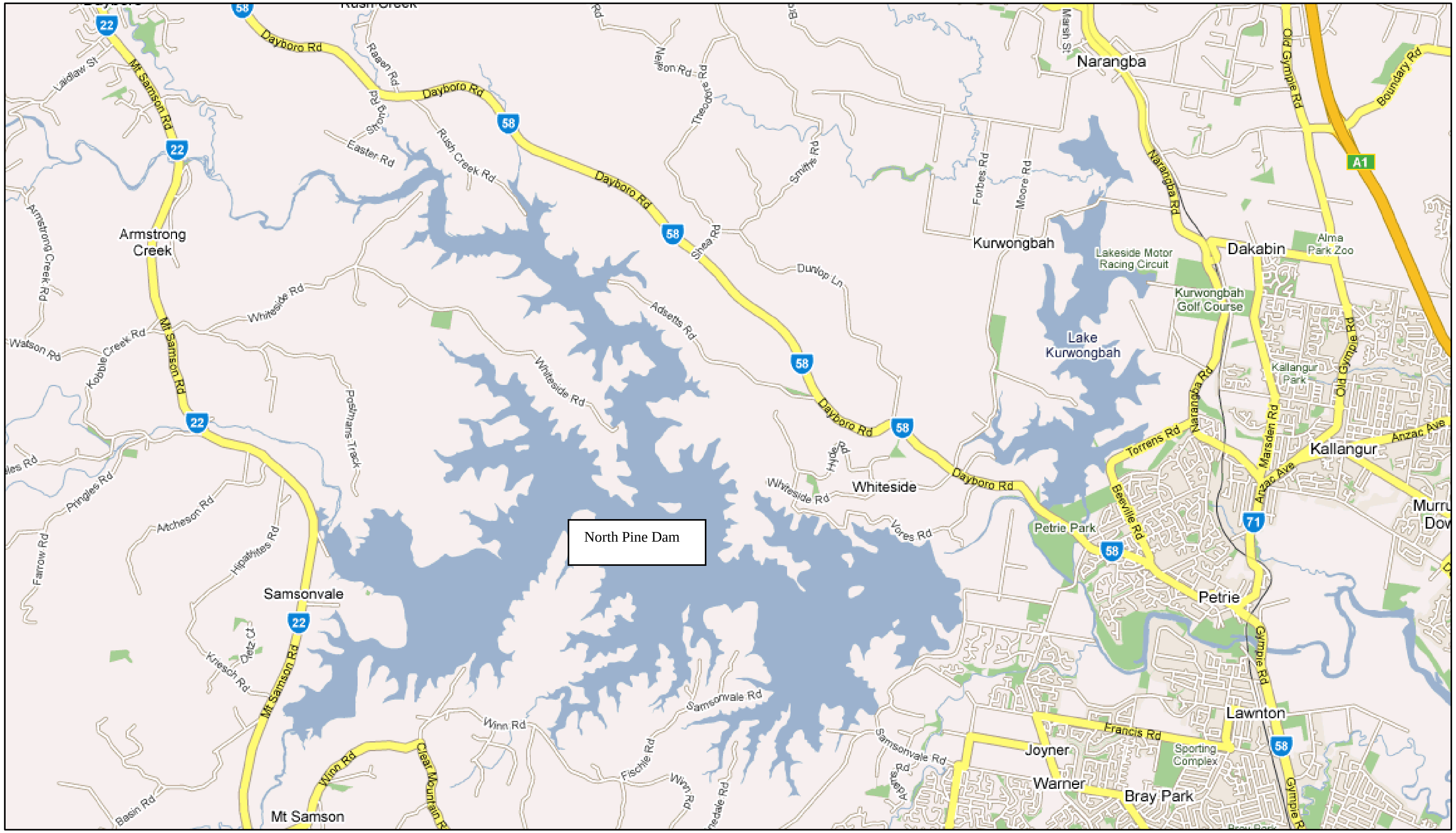
- The notional AEP of the PMP for North Pine Dam is 1 in 2,900,000.
- The critical storm duration for the inflow is generally the 12 hour storm except for the very frequent and very rare events which tend to be longer.
- The 24 hour PMPDF produces the highest peak inflow of 6,900 m^3/s.
- Under normal conditions with all gates operating, the critical duration of the outflow remains generally as 12 hours for events between 1 in 20 and 1 in 200 AEP and for the 1 in 2000 AEP event. For other AEPs, the critical duration increases up to 36 hours.
- The Acceptable Flood Capacity with one gate inoperable is approximately 3,960 m^3/s or 61% of the PMPDF for the 24 hour critical duration storm.
- With all gates operating normally,
    - The 36 hour PMPDF produces the highest peak outflow of 5,400 m^3/s.
    - The AEP of the DCF is about 1 in 2,000,000.
    - In the PMPDF, the dam crest is overtopped for a period of about 12 hours, reached a maximum height of 0.19 metres above the crest.
    - The PMF outflow may be as high as 6,500 m^3/s for a critical duration storm of 36 hours.
- With one gate inoperable,
    - The 36 hour PMPDF produces the highest peak outflow of 5,800 m^3/s.
    - The AEP of the DCF is about 1 in 550,000.

- With one gate inoperable, In the PMPDF, the dam crest is overtopped for a period of about 23 hours, reached a maximum height of 0.53 metres above the crest.

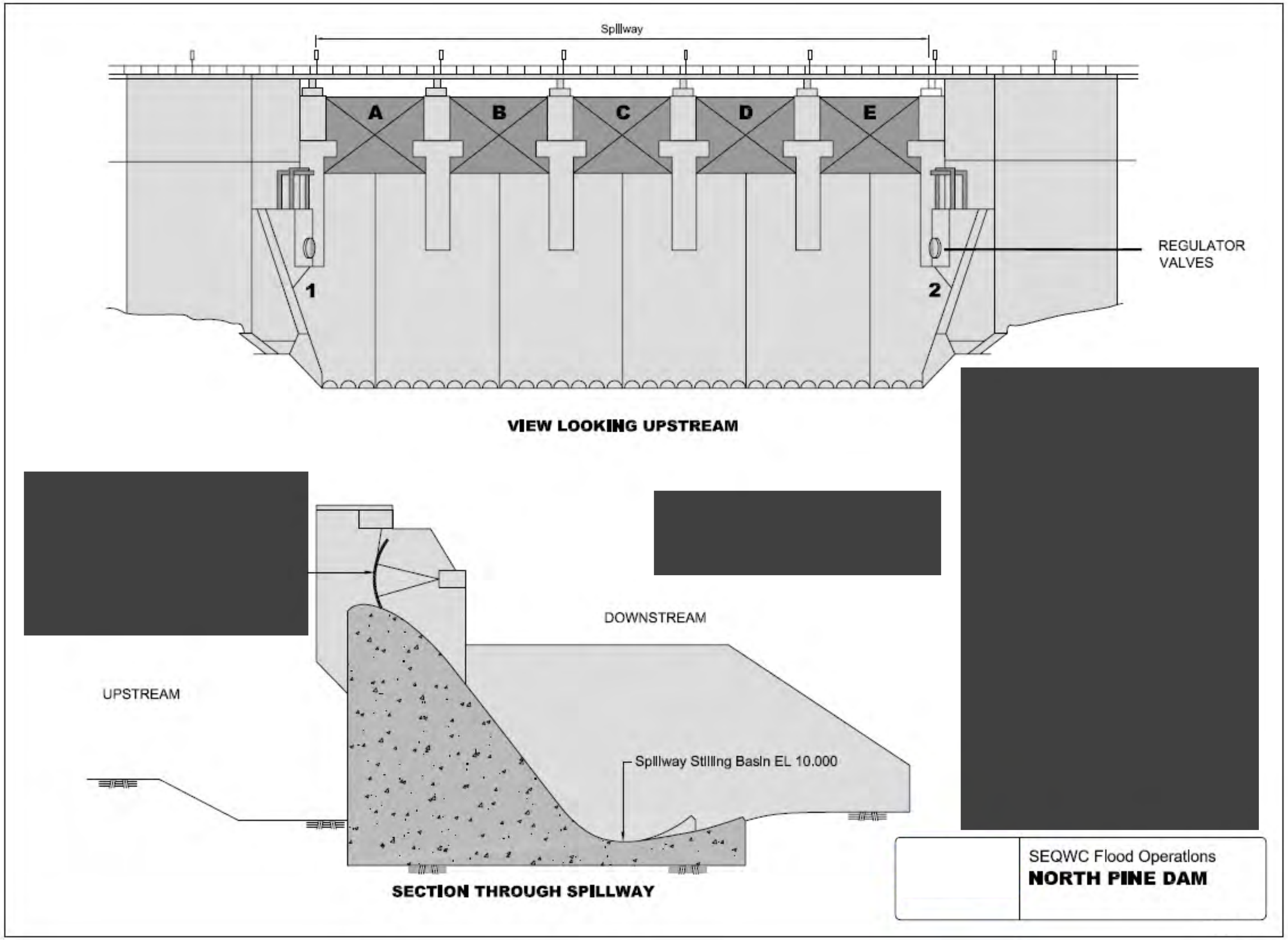
- **APPENDIX F**

NORTH PINE DAM
PLANS, MAPS AND PHOTOGRAPHS

[redacted]


North Pine Dam
Narangba
Armstrong Creek
Kurwongbah
Lake Kurwongbah
Dakabin
Kallangur
Whiteside
Petrie Park
Petrie
Samsonvale
Lawnton
Joyner
Warner
Bray Park
Mt Samson
Dayboro Rd
Mt Samson Rd
Lakeside Motor Racing Circuit
Kurwongbah Golf Course
Alma Park Zoo
Sporting Complex


Grant St
Lake Kurwongbah
North Pine Dam
Youngs Crossing
Petrie


Spillway
A
B
C
D
E
1
2
REGULATOR VALVES
VIEW LOOKING UPSTREAM
[redacted]
[redacted]
[redacted]
DOWNSTREAM
UPSTREAM
Spillway Stilling Basin EL 10.000
SECTION THROUGH SPILLWAY
SEQWC Flood Operations
NORTH PINE DAM

Guppy Ron

Subject: FW: North Pine Dam Flood Mitigation Manual

Attachments: NPD-Rev 5 (Final) with comments2.doc

From: Guppy Ron
Sent: Thursday, 12 August 2010 2:17 PM
To: 'John Tibaldi'
Subject: North Pine Dam Flood Mitigation Manual

John

As mentioned earlier there are a few changes we would like to see made to the manual before going through the approval process - see attachment. I don't think there is anything very significant but if you are worried about something let me know. Otherwise we'll wait for a new letter from Peter Borrowes.

NPD-Rev 5 (Final) with comment...

Ron Guppy
Principal Engineer (Dam Safety)

Office of the Water Supply Regulator
Telephone [redacted] **Facsimile** [redacted]

Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

Style Definition: Heading 3,Transfer 3

MANUAL

OF

OPERATIONAL PROCEDURES

FOR

FLOOD MITIGATION

AT

NORTH PINE DAM

Revision 5

July 2010

Revision No.	Date	Amendment Details
0	10 December 1986	Original Issue
1	6 October 1992	Complete revision and re-issue
2	13 November 1997	Complete revision and re-issue
3	26 July 2002	Complete revision and re-issue
4	5 September 2007	Complete revision and re-issue
5	July 2010	Complete revision and re-issue

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Preface

Given its size and location, it is imperative that North Pine Dam be operated during flood events in accordance with clearly defined procedures to minimise hazard to life and property. This manual outlines these procedures and is an approved Flood Mitigation Manual under Water Supply Act 2008.

The Manual in its current form was developed in 1992 and the basis of this document was a manual written in 1986 covering flood operations at the dam. Four revisions of the Manual have occurred since 1992 to account for updates to the Flood Alert Network and the Real Time Flood Models and to account for institutional and legislative changes.

The primary objectives of the procedures contained in this Manual are essentially the same as those contained in previous Manual versions. These objectives in order of importance are:

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- 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.

In meeting these objectives, the dam must be operated to account for the potential effects of closely spaced Flood Events. Accordingly, normal procedures require stored floodwaters to be emptied from the dam as quickly as possible while meeting all flood mitigation objectives.

1.2 Meaning of Terms

In this manual, save where a contrary definition appears -

"Act" means the *Water Supply (Safety and Reliability) Act 2008*;

"AEP" means annual exceedance probability, the probability of a specified event being exceeded in any year;

"Agency" includes a person, a local government and a department of state government within the meaning of the Acts Interpretation Act 1954;

"AHD" means Australian Height Datum;

"Chairperson" means the Chairperson of Seqwater;

"Chief Executive" means the Director General of the Department of Environment and Resource Management or nominated delegate;

"Controlled Document" means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

"Dam" means the dam to which this manual applies, that is North Pine Dam;

"Dam Supervisor" means the senior on-site officer at North Pine Dam;

"Duty Flood Operations Engineer" means the Senior Flood Operations Engineer or Flood Operations Engineer rostered on duty to be in charge of Flood Operations at the dam;

"EL" means elevation in metres Australian Height Datum;

"Flood Event" is a situation where the Duty Flood Operations Engineer expects the water level at the dam to exceed the Full Supply Level;

"Flood Operations Centre" means the Centre used by Flood Operations Engineers to manage Flood Events;

"Flood Operations Engineer" means a person designated to direct flood operations at the dam in accordance with Section 2.4 of this manual;

"FSL" or "Full Supply Level" means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

"Gauge" when referred to in (m) means river level referenced to AHD, and when referred to in (m^3/s) means flow rate in cubic metres per second;

"Manual" or "Manual of Operational Procedures for Flood Mitigation at North Pine Dam" means the current version of this manual;

"Senior Flood Operations Engineer" means a person designated in accordance with Section 2.3 of this manual under whose general direction the procedures in this manual must be carried out;

"Seqwater" means the Queensland Bulk Water Supply Authority trading as Seqwater.

1.3 Purpose of Manual

The purpose of this manual is to define procedures for the operation of North Pine Dam during flood events. The procedures have been developed on the basis that the structural safety of the dam is paramount within the scope of minimising the downstream impacts associated with releasing flood water from the dam.

1.4 Legal Authority

This manual has been prepared as a Flood Mitigation Manual in accordance with Chapter 4 Part 2 of the Act.

1.5 Application and Effect

The procedures in this manual apply to the operation of North Pine Dam for the purpose of flood mitigation, and operation in accordance with the manual shall give the protection from liability provided by Section 374 of the Act.

1.6 Date of Effect

The procedures in this manual shall have effect on and from the date on which this version of the manual is approved by gazette notice.

The manual shall remain in force for the period of approval as determined by the Chief Executive. This approval may be for a period of up to five years.

Before the approval of the manual expires, Seqwater must review and if necessary update the manual and submit a copy to the chief executive for approval.

1.7 Observance of Manual

This manual contains the operational procedures for North Pine Dam for the purposes of flood mitigation and must be used for the operation of the dams during flood events.

1.8 Provision to Variation of Manual

If Seqwater is of the opinion that this manual should be amended, altered or varied, it must submit for approval as soon as practical, an appropriate request to the Chief Executive, setting out the circumstances and the exact nature of the amendment, alteration or variation sought. The Chief Executive may accept, reject or modify the request prior to approval.

1.9 Distribution of Manual

Seqwater must regard the manual as a Controlled Document and ensure that only controlled manuals are used in the direction of flood mitigation activities. Agencies having copies of controlled hardcopies of the manual are listed in Appendix A. Seqwater must maintain a Register of contact persons for issued controlled hardcopies of the manual and must ensure that each issued document is updated whenever amendments or changes are approved.

2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

Pursuant to the provisions of the Act, Seqwater is responsible for operating and maintaining the dam in accordance with this manual in order to retain the protection from liability afforded by the Act. Operators, employees, agents, and contractors working for Seqwater must also comply with this manual to obtain the protection of the Act.

2.2 Operational Arrangements

For the purposes of operation of the dam during Flood Events, Seqwater must ensure that:

- Sufficient numbers of suitably qualified personnel are available to operate the dam if a Flood Event occurs.
- The radial gates and outlet valves are maintained in good working order at all times and capable of operating unless the Senior Flood Operations Engineer agrees to them being taken out of service.
- Sufficient numbers of suitably qualified personnel are available to operate the Flood Operations Centre if a Flood Event occurs
- A Duty Flood Operations Engineer is on call at all times. The Duty Flood Operations Engineer must constantly review weather forecasts and catchment rainfall and must declare a Flood Event if the water level at North Pine Dam is expected to exceed Full Supply Level as a result of prevailing or predicted weather conditions.
- A Senior Flood Operations Engineer is designated to be in the charge of Flood Operations at all times during a Flood Event.
- Release of water at the dam during Flood Events is carried out under the direction of the Duty Flood Operations Engineer.
- All practical attempts are made to liaise with the Chairperson and the Chief Executive if the release of water from the Dams during a Flood Event is likely to endanger life or property.

Formatted: Bullets and Numbering

2.3 Designation and Responsibilities of Senior Flood Operations Engineer

Seqwater must nominate one or more suitably qualified and experienced persons to undertake the role of Senior Flood Operations Engineer. If approved by the Chief Executive, these persons can be authorised in the Schedule of Authorities (see Section 2.6). When rostered on duty during a Flood Event, the responsibilities of the Senior Flood Engineer are as follows:

- Set the overall strategy for management of the Flood Event in accordance with the objectives of this manual.
- Provide instructions to site staff to make releases of water from the dam during Flood Events that are in accordance with this manual.
- Apply reasonable discretion in managing a Flood Event as described in Section 2.8.

Seqwater must ensure that an adequate number of Senior Flood Operations Engineers are available to manage all Flood Events.

2.4 Designation and Responsibilities of Flood Operations Engineer

Seqwater must nominate one or more suitably qualified and experienced persons to undertake the role of Flood Operations Engineer. If approved by the Chief Executive, these persons can be authorised in the Schedule of Authorities (see Section 2.6). When rostered on duty during a Flood Event, the responsibilities of the Flood Engineer are as follows:

- Direct the operation of the dam during a flood event in accordance with the general strategy determined by the Senior Flood Operations Engineer.
- Follow any direction from the Senior Flood Operations Engineer in relation to applying reasonable discretion in managing a Flood Event as described in Section 2.8. Unless otherwise directed, a Flood Operations Engineer is to follow this manual in managing Flood Events and is not to apply reasonable discretion unless directed by the Senior Flood Operations Engineer or the Chief Executive.
- Provide instructions to site staff to make releases of water from the dam during Flood Events that are in accordance with this manual.

Seqwater must ensure that an adequate number of Flood Operations Engineers are available to manage all Flood Events. Seqwater must also ensure that an adequate number of suitably qualified and experienced persons are available to assist the Flood Operations Engineers during all Floods Events.

2.5 Qualification and Experience of Engineers

Qualifications

All engineers referred to in Sections 2.3 and 2.4 must hold a Certificate of Registration as a Registered Professional Engineer of Queensland and must hold appropriate engineering qualifications to the satisfaction of the Chief Executive.

Experience

All engineers referred to in Sections 2.3 and 2.4 must, to the satisfaction of the Chief Executive, have:

1. Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and

2. At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:

    - Investigation, design or construction of major dams;
    - Operation and maintenance of major dams;
    - Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;
    - Applied hydrology with particular reference to flood forecasting and/or flood forecasting systems.

2.6 Schedule of Authorities

Seqwater must maintain a Schedule of Authorities containing a list of the Senior Flood Operations Engineers and Flood Operations Engineers approved by the Chief Executive to direct flood operations at the dams during floods. A copy of the Schedule of Authorities must be provided to the Chief Executive by 30 September of each year.

Seqwater shall nominate suitably qualified and experienced engineers for registration in the Schedule of Authorities as the need arises. Each new nomination must include a validated statement of qualifications and experience as required by the Chief Executive. Seqwater must obtain the approval for all nominations from the Chief Executive prior to their inclusion in the Schedule of Authorities.

If, in the event of unforseen and emergency situations, no Senior Flood Operations Engineer or no Flood Operations Engineer is available from the Schedule of Authorities to manage a Flood Event, Seqwater must temporarily appoint a suitable person or persons and immediately seek ratification from the Chief Executive.

2.7 Training

Seqwater must ensure that operational personnel required for flood operations activities receive adequate training in the various activities involved in flood control operation.

Deleted: as required by the Chief Executive

2.8 Reasonable Discretion

If in the opinion of the Senior Flood Operations Engineer, it is necessary to depart from the procedures set out in this manual to meet the flood mitigation objectives set out in Section 3, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary subject to the following:

- Before exercising discretion under this Section of the manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must make a reasonable attempt to consult with both the Chairperson and Chief Executive.
- The Chief Executive would normally authorise any departures from the manual. However if the Chief Executive cannot be contacted within a reasonable time, departures from the Manual can be authorised by the Chairperson.
- If both the Chairperson and the Chief Executive cannot be contacted within a reasonable time, the Senior Flood Operations Engineer may proceed with the procedures considered necessary and report such action at the earliest opportunity to the Chairperson and Chief Executive.

2.9 Report

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.

3 FLOOD MITIGATION OBJECTIVES

3.1 General

To meet the purpose of the flood operation procedures in this manual, the flood release objectives, listed in descending order of importance, are as follows:

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- 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.

3.2 Structural Safety of Dam

The structural safety of North Pine Dam must be the first consideration in flood release operations. Failure could have catastrophic consequences due to the magnitude of flood damage that would be caused downstream, and also due to the loss of a water supply source.

The most likely cause of damage is overtopping. North Pine Dam consists of a mass concrete section, and earthen embankment sections. Concrete sections can withstand limited overtopping without damage. Embankment sections on the other hand will washout rapidly if overtopped and cause failure of the dam, resulting in severe flooding downstream. The prevention of overtopping is thus of paramount importance.

The safety of the dam therefore depends primarily on the proper operation of the spillway gates, which are used to control maximum flood levels. Such operation in turn relies on the proper functioning of the mechanical hoist mechanisms and their electric power supply and controls. This equipment is located within the dam structure above full supply level and can become inundated if flood releases are not initiated in a timely manner. The critical levels for the operation of the dam and the consequence of their exceedance are as follows:

Critical Levels for North Pine Dam

Description	AHD (m)	Possible Consequence
Full supply level.	39.60	-
Radial Gate Control Gear.	41.66	Electric motors submerged, use of backup systems required to operate radial gates.
Embankment Crest.	43.28	Breach of embankment by erosion

3.3 Extreme Floods and Closely Spaced Large Floods

Techniques for estimating extreme floods show that floods are possible which would overtop the dam. Such an overtopping would most likely result in failure of the dam. Such events however may require several days of intense rainfall to produce the necessary runoff.

Deleted: As indicated in the previous section, t

Historical records show that there is a significant probability of two or more flood producing storms occurring in the Pine River system within a short time of each other. Therefore, unless determined otherwise by the Senior Flood Operations Engineer in accordance with Section 2.8, the aim during a Flood Event should be to empty stored floodwaters as quickly as possible while meeting all flood mitigation objectives.

Deleted:

3.4 Minimise disruption to Downstream Communities

While North Pine Dam provides only limited flood mitigation benefits in terms of retaining flood water above Full Supply Level, flood releases can result in the submergence of bridges and public areas. Accordingly, the operation of the dam should not prolong this inundation unnecessarily.

The gates of the dam should be operated such that outflow should not exceed inflow under most circumstances.

3.5 Retain the Storage at Full Supply Level at the Conclusion of the Flood Event

As North Pine Dam is a primary urban water supply for South East Queensland, it is important that all opportunities to fill the dam are taken. There should be no reason why the dams should not be full following a Flood Event.

3.6 Minimising Impacts to Riparian Flora and Fauna

During the drain down phase, consideration is to be given to minimising the impacts on riparian flora and fauna. In particular, strategies aimed at reducing fish deaths in the vicinity of the dam walls are to be instigated, provided such procedures do not adversely impact on other flood mitigation objectives.

4 FLOOD CLASSIFICATION

For the reference purposes of this manual, four magnitudes of flooding are classified as follows:

1. Minor Flooding

Causes inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.

2. Moderate Flooding

In addition to the impacts experienced during Minor Flooding, the evacuation of some houses may be required. Main traffic routes may be impacted. The area of inundation is substantial in rural areas requiring the removal of stock.

3. Major Flooding

In addition to the impacts experienced during Moderate Flooding, extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required. The 1974 flood that impacted on the Ipswich and Brisbane areas is classified as a major flood.

4. Extreme Flooding

This causes flooding impacts equal to or in excess of levels previously experienced. In addition to the impacts experienced during Major Floods, the general evacuation of people from significant populated areas is likely to be required.

It should be noted that a flood may not cause the same category of flooding along its entire length and the relevant agencies shall have regard to this when flooding is predicted. The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia.

5 FLOOD MONITORING AND FORECASTING SYSTEM

5.1 General

A real time flood monitoring and forecasting system has been established in the dam catchment. This system employs radio telemetry to collect, transmit and receive rainfall and stream flow information. The system consists of 30 field stations that automatically record rainfall and/or river heights at selected locations in the dam catchments. Some of the 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 potential rainfall in the dam catchments. The RTFM is a suite of hydrologic and hydraulic computer programs that utilise the real time data to assist in the operation of the dams during flood events. Seqwater is responsible for providing and maintaining the RTFM and for ensuring that sufficient data is available to allow proper operation of the RTFM during a Flood Event.

5.2 Operation

The Senior Flood Operations and Flood Operations Engineers use the RTFM for flood monitoring and forecasting during flood events to operate the dams in accordance with this manual. This is done by optimising releases of water from the dams to minimise the impacts of flooding in accordance with the objectives and procedures contained in this manual.

Seqwater is responsible for improving the operation of the RTFM over time by using the following processes:

- Implementing improvements based on Flood Event audits and reviews.
- Improving RTFM calibration as further data becomes available.
- Updating software in line with modern day standards.
- Improving the coverage and reliability of the data collection network to optimise data availability during Flood Events.
- Recommendations by Senior Flood Operations Engineers.

A regular process of internal audit and management review must be maintained by Seqwater to achieve these improvements.

Seqwater must also 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.

Seqwater must also 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.

5.3 Storage of Documentation

The performance of any flood monitoring and forecasting system is reliant on accurate historical data over a long period of time. Seqwater must ensure that all available data and other documentation is appropriately collected and catalogued for future use.

5.4 Key Reference Gauges

The key field station locations listed in Appendix B have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to relocate field stations from these locations or vary flood classification levels, agreement must first be obtained between Seqwater, Bureau of Meteorology and the Local Government within whose boundaries the locations are situated.

Deleted: K

Gauge boards that can be read manually must be maintained by Seqwater as part of the equipment of each key field station. Where possible and practical during Flood events, Seqwater is to have procedures in place for manual reading of these gauge boards in the event of failure of field stations.

5.5 Reference Gauge Values

Other agencies such as the Bureau of Meteorology, the Moreton Bay Regional Council and the Brisbane City Council have direct access to the information from field stations for flood assessment purposes. The consultation between agencies is a very important part of the assessment and prediction of flood flows and heights.

Seqwater must ensure that information relevant to the calibration of its field stations is shared with these agencies.

6 COMMUNICATIONS

6.1 Communications between Staff

Seqwater is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Seqwater Flood Operations Centre and site staff at North Pine Dam.

6.2 Dissemination of Information

Agencies other than Seqwater have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public associated with Flood Events. Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public. Agency information requirements are generally as shown in the table below.

The Senior Flood Operations and Flood Operations Engineers must supply information to each of these agencies during Flood Events. The contact information for these Agencies and communication procedures is contained in the Emergency Action Plans for the dam and each agency is to receive updated controlled copies of these documents.

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.

AGENCY INFORMATION REQUIREMENTS

Agency	Activity	Information Required from Flood Operations Centre	Trigger
Bureau of Meteorology	Issue of flood warnings	Actual and predicted lake levels and discharges	Initial gate operations and thereafter at intervals to suit forecasting requirements
Department of Environment and Resource Management	Review of flood operations and discretionary powers	Actual and predicted lake levels and discharges	Initial gate operations
Moreton Bay Regional Council	Flood level information downstream of North Pine Dam	Actual and predicted lake levels and discharges	Initial gate operations
Brisbane City Council	Flood level information for Brisbane City area	Nil (information obtained from BOM)	

6.3 Release of Information to the Public

Seqwater is responsible for the issue of information regarding storage conditions and current and proposed releases from the dam to the public and the media.

The Bureau of Meteorology has responsibility for issuing flood warnings.

The Emergency Services Response Authorities, under the Disaster Management Act 2003, have responsibility for the preparation of a local counter disaster plan and the interpretation of flood forecast information for inclusion in their local flood warnings prepared under the flood sub plan of the counter disaster plan.

7 REVIEW

7.1 Introduction

With the passage of time, either the technical assumptions or the physical conditions on which this manual is based may change. It is also recognised that the relevance of the manual may change with changing circumstances. It is important therefore, that the manual contain operational procedures which cause the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

Deleted: n

Deleted: n

Deleted: remain un

Deleted: d

This process must involve all personnel involved in the management of Flood Events, to ensure that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based. Variations to the manual may be made in accordance with provisions in Section 1.8.

7.2 Personal Training

Seqwater must report to the Chief Executive by 30 September each year on the training and state of preparedness of operations personnel.

7.3 Monitoring and Forecasting System and Communication Networks

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. The report must assess the following in terms of hardware, software and personnel:

- Adequacy of the communication and data gathering facilities
- Reliability of the system over the previous period
- Reliability of the system under prolonged flood conditions
- Accuracy of forecasting flood flows and heights
- The overall state of preparedness of the system

Seqwater must take any action considered necessary for the proper functioning and improvement of this system.

7.4 Operational Review

After each significant flood event, Seqwater must report to the Chief Executive on the effectiveness of the operational procedures contained in this manual. This report must be submitted within six weeks of any flood event that requires mobilisation of the Flood Operations Centre.

7.5 Five Yearly Review

Prior to the expiry of the approval period, Seqwater must review the manual pursuant to provisions of the Act. The review is to take into account the continued suitability of the communication network and the flood monitoring and forecasting system, as well as hydrological and hydraulic engineering assessments of the operational procedures.

8 FLOOD RELEASE OPERATION

8.1 Introduction

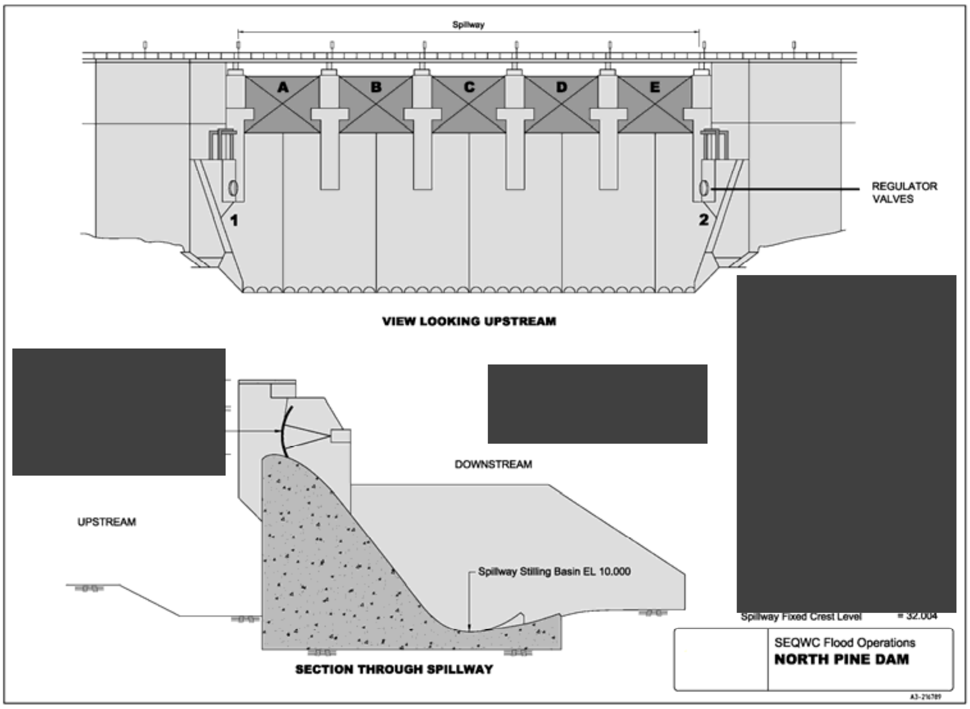
North Pine dam is a water supply dam with only a small flood storage compartment above full supply level. It effectively has no significant provision for flood mitigation and once the dam is full, floods will pass through the reservoir with little mitigation. Significant inflow may occur approximately two to four hours after the commencement of heavy rain.

Deleted: The peak

Deleted: from critical storms

8.2 Flood Release Infrastructure

Radial Gates are the primary infrastructure used to release water during flood events at North Pine Dam. The arrangement of the Radial Gates is shown in the diagram below:



8.3 Initial Action

Once a Flood Event is declared, an assessment is to be made of the magnitude of the Flood Event, including:

- A prediction of the maximum storage levels in the dam.

- A prediction of the peak outflow rate from the dam.

Releases from the radial gates should not commence until the lake level exceeds FSL by 50 millimetres (39.65 m AHD).

Deleted: Unless a decision has been made to commence a pre-release of flood water to control the risk of dam overtopping, r

Prior to releases from the radial gates commencing the Flood Operations Engineer must ensure that the Grant Street causeway is closed and the Moreton Bay Regional Council has been advised of the impact of the proposed flood releases on Youngs Crossing.

8.4 Flood Operations Strategies

The flood release objectives for North Pine Dam, listed in descending order of importance, are as follows:

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- 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.

North Pine Dam effectively has no significant provision for flood mitigation and once the dam is full ensuring the structural safety of the dam is paramount. Accordingly the flood operation strategy is to pass any significant flood through the reservoir, while ensuring that peak outflow generally does not exceed peak inflow while aiming to empty stored floodwaters as quickly as possible. To achieve this strategy, the radial gate opening settings shown in Appendix C are normally used to determine flood releases.

Early releases in small events are permissible to minimise downstream disruption.

Departures from the tables shown in Appendix C are allowed in the following circumstances:

- Subject to the provisions of section 2.8 pre-release of water is allowed to reduce the risk of dam overtopping.
- Reduction in release rate is allowed once the flood peak has passed to either minimise disruption to the community in areas downstream of the dam or to minimise impacts to riparian flora and fauna.
- At the end of a flood event, additional gate openings may be used to reduce the duration of gate operation and resulting adverse downstream impacts.

Deleted: P

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a gate by the immediate opening of a regulator valve (or the reverse operation). This allows for greater control of low flows.

8.5 Gate Closing Strategies

In general, gate closing commences when the level in North Pine Dam begins to fall and the closing sequence is generally to occur in the reverse order to opening. The following requirements must be considered when determining gate closure sequences:

Deleted:

- Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.
- The maximum discharge from the dam during closure should generally be less than the peak inflow into North Pine Dam experienced during the event.
- The aim should always be to empty stored floodwaters stored above EL 39.65m as quickly as possible after the flood peak has passed through the dam. However, provided a favourable weather outlook is available, this requirement can be relaxed for the volume between EL 39.65m and EL 39.75m, to minimise downstream impacts.
- To minimise the stranding of fish downstream of the dam, final closure sequences should consider Seqwater procedures relating to fish protection at the dam.

Comment [r1]: Is this level 39.65 or 39.6? We believe it should be 39.6.

Comment [r2]: As per previous comment

There may be a need to take into account base flow when determining final gate closure. This may mean that the lake level temporarily falls below Full Supply Level to provide for a full dam at the end of the Flood Event.

The regulators may be substituted for gate operations to manage water levels and discharges during small inflows such as during the recession of a Flood Event.

8.6 Gate Operation Sequences

Rapid opening of the radial gates at North Pine dam can cause undesirable rapid rises in downstream river levels. Accordingly, the aim in opening radial gates is to operate the gates one at a time at intervals that will minimise adverse impacts on the river system. The table below shows the target minimum interval for gate operations. This target interval can be reduced if the gates are at risk of being overtopped or the safety of the dam is at risk and operations are generally not allowed to fall more than three openings behind the gate opening settings contained in Appendix C.

TARGET MINIMUM INTERVALS FOR RADIAL GATE OPENING

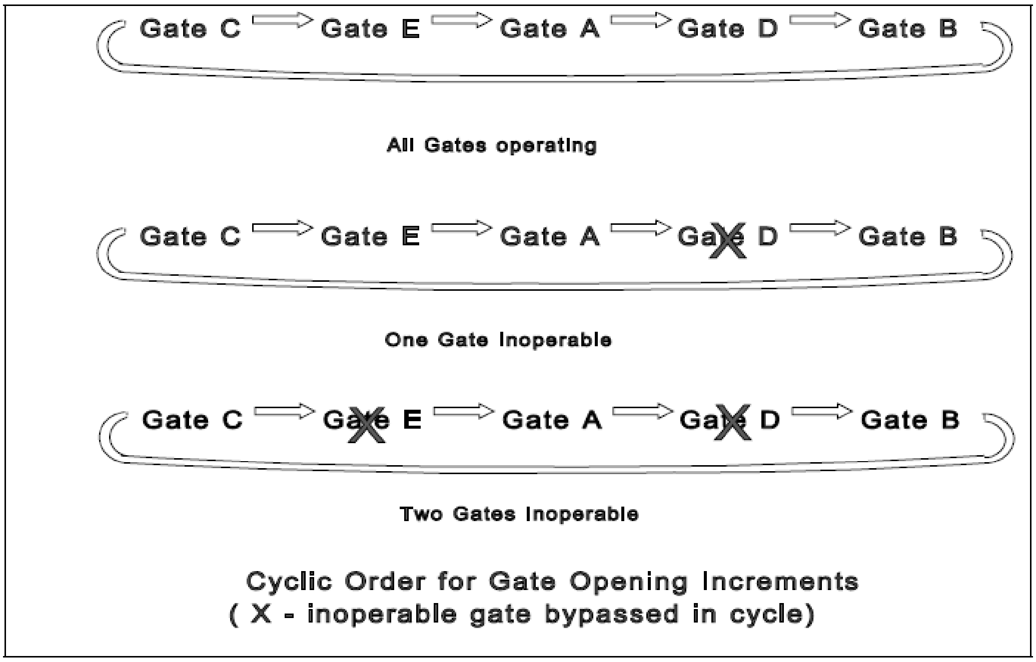
Lake Level	Opening Interval	Closing Interval
Below EL 39.9m	15 min	15 min
EL 39.9m to 40.5m	10 min	10 min
Above EL 40.5m	5 min	5 min

Rapid closure of radial gates is also permissible when there is a requirement to preserve storage or to reduce downstream flooding. When determining gate closure sequences, consideration should also be given to following the calculated natural recession of the flood in the river to aim to ensure that the recession impacts are not greater than those that would have been experienced had the dam not been constructed.

8.7 Protection of the Spillway

To minimise potential damage to the dissipater and the river-bed and banks downstream, the gates must be opened incrementally in accordance with the cyclic sequences shown below.

Gate Operation Sequence



8.8 Gate Failure or Malfunction Procedures

Where one or more gates are inoperable, the sequencing outlined in section 8.7 (above) still applies, except that the inoperable gates must be ignored in the cycle and their increments passed on to the next gate in the sequence. The cumulative number of increments taken by all gates at any particular lake level thus remains unaltered save that the total number of available gate increments has been reduced by inoperable gates. Appendix C contains tables of gate position settings against lake levels for the situations where all gates are operating and where one gate is inoperable.

8.9 Radial Gate Turbulence Considerations

Unless in the process of lifting the gates clear of the flow, the bottom edge of the radial gates must always be at least 500 millimetres below the release flow surface. Having the bottom edge of the gates closer to the release flow surface than 500 millimetres may cause unusual turbulence that could adversely impact on the gates. This procedure has never been undertaken in practice and should be observed closely when being undertaken. Variations to the procedure are allowed to protect the structural safety of the dam.

This circumstance is unlikely to occur except under a rare set of conditions.

8.10 Lowering Radial Gates that have been lifted Clear of the Release Flow

When lowering radial gates that have been lifted clear of the release flow, the bottom edge of the gates must be lowered at least 500 millimetres into the flow. Lowering gates into the release flow less than this amount may cause unusual turbulence that could adversely impact on the gates. This procedure has never been undertaken in practice and should be observed closely when being undertaken. Variations to the procedure are allowed to protect the structural safety of the dam.

This circumstance is unlikely to occur except under a rare set of conditions.

9 EMERGENCY

9.1 Introduction

While every care has been exercised in the design and construction of the dam, there still remains a low risk that the dam may develop an emergency condition either through flood events or other causes. Experience elsewhere in the world suggests that vigilance is required to recognise emergency flood conditions such as:

- Occurrence of a much larger flood than discharge capacity of the dam;
- Occurrence of a series of large storms in a short period;
- Failure of one or more gates during a flood;
- Development of a piping failure through the embankment;
- Damage to the dam by earthquake;
- Damage to the dam as an act of war or terrorism; and
- Other rare mechanisms.

Responses to these and other conditions are included in the North Pine Dam - Emergency Action Plan.

9.2 Overtopping of Dam

Whatever the circumstances, every endeavour must be made to prevent overtopping of North Pine Dam by the progressive opening of operative spillway gates. Overtopping of the dam is likely to result in a dam failure.

Overtopping may result from inundation the radial gate control equipment and subsequent loss of gate control. Gate openings should be such to ensure this does not occur.

Deleted: may

9.3 Communications Failure

If communications are lost between the Flood Operations Centre and the dam, the officers in charge at the dam are to adopt the procedures set out below. The Dam Supervisor at North Pine Dam is to assume responsibility for flood releases from the Dam. Once it has been established that communications have been lost, the Dam Supervisor at North Pine Dam is to:-

- Take all practicable measures to restore communications and periodically check the lines of communication for any change;
- Follow the procedures set out below to determine the relevant magnitude and duration of releases from North Pine Dam;
- Log all actions in the Event Log;

- Ensure the dam is at full supply level at the end of the event;
- Remain in the general vicinity of the dam while on duty.

The radial gate opening and closing sequence to be used is as set out in Appendix C. The table below shows the target minimum interval for gate operations. This target interval can be reduced if the gates are at risk of being overtopped or the safety of the dam is at risk and operations are not allowed to fall more than three openings behind the gate opening settings contained in Appendix C.

TARGET MINIMUM INTERVALS FOR RADIAL GATE OPENING UNDER LOSS OF COMMUNICATIONS

Lake Level	Opening Interval	Closing Interval
Below EL 39.9m	15 min	15 min
EL 39.9m to 40.5m	10 min	10 min
Above EL 40.5m	5 min	5 min

In the event of one or more radial gates becoming jammed, the remaining gates are to be operated to provide the same total opening for a particular storage level, as shown Appendix C. In these circumstances, gates are generally operated in the order of C, E, A, D, B moving through the sequence shown in the tables.

In a loss of communication scenario, the bulkhead gate is not to be used. At the end of the event, the full supply level of the storage is to be achieved.

APPENDIX A
AGENCIES HOLDING CONTROLLED COPIES OF THIS MANUAL

Agency	Responsible Person	Location
Seqwater	Dam Safety and Source Operations Manager	Brisbane
Seqwater	Principal Engineer Dam Safety	Ipswich
Seqwater	Storage Supervisor	North Pine Dam
Seqwater	Operations Coordinator	North Coast
Seqwater	Senior Flood Operations Engineer	Flood Operations Centre, Brisbane
Department of Environment and Resource Management	Director Dam Safety	Brisbane
Department of Community Safety	Duty Officer – Disaster Management Service	Brisbane
Moreton Bay Regional Council	Local Disaster Response Coordinator	Caboolture
Brisbane City Council	Local Disaster Response Coordinator	Brisbane
Emergency Management Queensland	Regional Director, Brisbane District	Brisbane

APPENDIX B
KEY REFERENCE GAUGES

Moreton Bay Regional Council

Gauge	Flood Classification			
	Minor	Moderate	Major	1974 Flood
Grant Street, Whiteside	Any release from dam	-	-	-
Youngs Crossing	8-10m^3/s			
Railway Bridge, Wyllie Park, Petrie	4.0m	5.0m	6.0m	5.1m
Railway Bridge, South Pine River, Bald Hills	-	3.5m	6.0m	5.18m

Note: Heights are in metres AHD

APPENDIX C
GATE & VALVE SETTINGS

Discharge from North Pine Dam may be controlled by:

- Five radial gates
- Two regulator valves, and/or;
- A low level river release valve with a daily capacity of about 85 ML/d.

RADIAL GATE SETTINGS

Gate Setting	Gate Opening (m)	Top of Gate (EL)	Gate Setting	Gate Opening (m)	Top of Gate (EL)
1	0.152	40.362	13	3.810	41.885
2	0.457	40.547	14	4.115	41.940
3	0.762	40.720	15	4.420	41.984
4	1.067	40.886	16	4.724	42.016
5	1.372	41.041	17	5.029	42.037
6	1.676	41.185	18	5.334	42.047
7	1.981	41.316	19	5.639	42.047
8	2.286	41.349	20	5.944	42.047
9	2.591	41.549	21	6.248	42.047
10	2.896	41.650	22	6.553	42.047
11	3.200	41.740	23*	6.858	42.047
12	3.505	41.817			

* Gate should be fully open

Formatted: Left

RADIAL GATE SETTINGS

All Gates Operational								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	closed	closed	1	closed	1	2	32	E
39.715	1	closed	1	closed	1	3	48	A
39.730	1	closed	1	1	1	4	64	D
39.745	1	1	1	1	1	5	80	B
39.760	1	1	2	1	1	6	104	C
39.775	1	1	2	1	2	7	129	E
39.790	2	1	2	1	2	8	153	A
39.805	2	1	2	2	2	9	177	D
39.820	2	2	2	2	2	10	201	B
39.835	2	2	3	2	2	11	228	C
39.850	2	2	3	2	3	12	254	E
39.865	3	2	3	2	3	13	281	A
39.880	3	2	3	3	3	14	307	D
39.895	3	3	3	3	3	15	334	B
39.910	3	3	4	3	3	16	362	C
39.925	3	3	4	3	4	17	390	E
39.940	4	3	4	3	4	18	417	A
39.955	4	3	4	4	4	19	445	D
39.970	4	4	4	4	4	20	473	B
39.985	4	4	5	4	4	21	500	C
40.000	4	4	5	4	5	22	527	E
40.015	5	4	5	4	5	23	554	A
40.030	5	4	5	5	5	24	581	D
40.045	5	5	5	5	5	25	608	B
40.060	5	5	6	5	5	26	636	C
40.075	5	5	6	5	6	27	664	E
40.090	6	5	6	5	6	28	692	A
40.105	6	5	6	6	6	29	720	D
40.120	6	6	6	6	6	30	748	B
40.135	6	6	7	6	6	31	776	C
40.150	6	6	7	6	7	32	804	E
40.165	7	6	7	6	7	33	832	A
40.180	7	6	7	7	7	34	860	D
40.195	7	7	7	7	7	35	888	B
40.210	7	7	8	7	7	36	916	C
40.225	7	7	8	7	8	37	943	E
40.240	8	7	8	7	8	38	970	A
40.255	8	7	8	8	8	39	998	D
40.270	8	8	8	8	8	40	1025	B
40.285	8	8	9	8	8	41	1052	C
40.300	8	8	9	8	9	42	1079	E
40.315	9	8	9	8	9	43	1106	A
40.330	9	8	9	9	9	44	1133	D
40.345	9	9	9	9	9	45	1160	B

All Gates Operational								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	9	9	10	9	9	46	1187	C
40.375	9	9	10	9	10	47	1213	E
40.390	10	9	10	9	10	48	1240	A
40.405	10	9	10	10	10	49	1266	D
40.420	10	10	10	10	10	50	1293	B
40.435	10	10	11	10	10	51	1320	C
40.450	10	10	11	10	11	52	1347	E
40.465	11	10	11	10	11	53	1374	A
40.480	11	10	11	11	11	54	1401	D
40.495	11	11	11	11	11	55	1428	B
40.510	11	11	12	11	11	56	1455	C
40.525	11	11	12	11	12	57	1482	E
40.540	12	11	12	11	12	58	1510	A
40.555	12	11	12	12	12	59	1537	D
40.570	12	12	12	12	12	60	1564	B
40.585	12	12	13	12	12	61	1593	C
40.600	12	12	13	12	13	62	1621	E
40.615	13	12	13	12	13	63	1650	A
40.630	13	12	13	13	13	64	1678	D
40.645	13	13	13	13	13	65	1707	B
40.660	13	13	14	13	13	66	1736	C
40.675	13	13	14	13	14	67	1765	E
40.690	14	13	14	13	14	68	1794	A
40.705	14	13	14	14	14	69	1823	D
40.720	14	14	14	14	14	70	1852	B
40.735	14	14	15	14	14	71	1883	C
40.750	14	14	15	14	15	72	1914	E
40.765	15	14	15	14	15	73	1946	A
40.780	15	14	15	15	15	74	1978	D
40.795	15	15	15	15	15	75	2009	B
40.810	15	15	16	15	15	76	2044	C
40.825	15	15	16	15	16	77	2079	E
40.840	16	15	16	15	16	78	2114	A
40.855	16	15	16	16	16	79	2148	D
40.870	16	16	16	16	16	80	2183	B
40.885	16	16	17	16	16	81	2222	C
40.900	16	16	17	16	17	82	2260	E
40.915	17	16	17	16	17	83	2299	A
40.930	17	16	17	17	17	84	2337	D
40.945	17	17	17	17	17	85	2376	B
40.960	17	17	18	17	17	86	2415	C
40.975	17	17	18	17	18	87	2453	E
40.990	18	17	18	17	18	88	2491	A
41.005	18	17	18	18	18	89	2530	D
41.020	18	18	18	18	18	90	2568	B
41.035	18	18	19	18	18	91	2601	C
41.050	18	18	19	18	19	92	2635	E

All Gates Operational								
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Total Opening**	**Discharge (m^3/sec)**	**Gates Operated**
41.065	19	18	19	18	19	93	2668	A
41.080	19	18	19	19	19	94	2701	D
41.095	19	19	19	19	19	95	2734	B
41.110	19	19	20	19	19	96	2773	C
41.125	19	19	20	19	20	97	2806	E
41.140	20	19	20	19	20	98	2842	A
41.155	20	19	20	20	20	99	2878	D
41.170	20	20	20	20	20	100	2913	B
41.185	20	20	21	20	20	101	3026	C
41.200	20	20	21	20	21	102	3142	E
41.215	21	20	21	20	21	103	3260	A
41.230	21	20	21	21	21	104	3382	D
41.245	21	21	21	21	21	105	3506	B
41.260	21	21	22	21	21	106	3515	C
41.275	21	21	22	21	22	107	3524	E
41.290	22	21	22	21	22	108	3532	A
41.305	22	21	22	22	22	109	3541	D
41.320	22	22	22	22	22	110	3550	B
41.335	22	22	23	22	22	111	3559	C
41.350	22	22	23	22	23	112	3567	E
41.365	23	22	23	22	23	113	3576	A
41.380	23	22	23	23	23	114	3585	D
41.395	23	23	23	23	23	115	3594	B

Gate A Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	closed	closed	1	closed	1	2	32	E
39.715	closed	closed	1	1	1	3	48	D
39.730	closed	1	1	1	1	4	64	B
39.745	closed	1	2	1	1	5	88	C
39.760	closed	1	2	1	2	6	112	E
39.775	closed	1	2	2	2	7	137	D
39.790	closed	2	2	2	2	8	161	B
39.805	closed	2	3	2	2	9	187	C
39.820	closed	2	3	2	3	10	213	E
39.835	closed	2	3	3	3	11	240	D
39.850	closed	3	3	3	3	12	266	B
39.865	closed	3	4	3	3	13	294	C
39.880	closed	3	4	3	4	14	322	E
39.895	closed	3	4	4	4	15	349	D
39.910	closed	4	4	4	4	16	377	B
39.925	closed	4	5	4	4	17	404	C
39.940	closed	4	5	4	5	18	430	E
39.955	closed	4	5	5	5	19	457	D
39.970	closed	5	5	5	5	20	484	B
39.985	closed	5	6	5	5	21	512	C
40.000	closed	5	6	5	6	22	539	E
40.015	closed	5	6	6	6	23	567	D
40.030	closed	6	6	6	6	24	595	B
40.045	closed	6	7	6	6	25	623	C
40.060	closed	6	7	6	7	26	650	E
40.075	closed	6	7	7	7	27	678	D
40.090	closed	7	7	7	7	28	706	B
40.105	closed	7	8	7	7	29	732	C
40.120	closed	7	8	7	8	30	759	E
40.135	closed	7	8	8	8	31	786	D
40.150	closed	8	8	8	8	32	812	B
40.165	closed	8	9	8	8	33	839	C
40.180	closed	8	9	8	9	34	866	E
40.195	closed	8	9	9	9	35	893	D
40.210	closed	9	9	9	9	36	920	B
40.225	closed	9	10	9	9	37	946	C
40.240	closed	9	10	9	10	38	972	E
40.255	closed	9	10	10	10	39	998	D
40.270	closed	10	10	10	10	40	1024	B
40.285	closed	10	11	10	10	41	1050	C
40.300	closed	10	11	10	11	42	1077	E
40.315	closed	10	11	11	11	43	1103	D
40.330	closed	11	11	11	11	44	1130	B
40.345	closed	11	12	11	11	45	1156	C

Gate A Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	closed	11	12	11	12	46	1183	E
40.375	closed	11	12	12	12	47	1210	D
40.390	closed	12	12	12	12	48	1237	B
40.405	closed	12	13	12	12	49	1264	C
40.420	closed	12	13	12	13	50	1292	E
40.435	closed	12	13	13	13	51	1320	D
40.450	closed	13	13	13	13	52	1348	B
40.465	closed	13	14	13	13	53	1377	C
40.480	closed	13	14	13	14	54	1405	E
40.495	closed	13	14	14	14	55	1433	D
40.510	closed	14	14	14	14	56	1462	B
40.525	closed	14	15	14	14	57	1492	C
40.540	closed	14	15	14	15	58	1523	E
40.555	closed	14	15	15	15	59	1554	D
40.570	closed	15	15	15	15	60	1585	B
40.585	closed	15	16	15	15	61	1619	C
40.600	closed	15	16	15	16	62	1653	E
40.615	closed	15	16	16	16	63	1687	D
40.630	closed	16	16	16	16	64	1721	B
40.645	closed	16	17	16	16	65	1759	C
40.660	closed	16	17	16	17	66	1797	E
40.675	closed	16	17	17	17	67	1834	D
40.690	closed	17	17	17	17	68	1872	B
40.705	closed	17	18	17	17	69	1911	C
40.720	closed	17	18	17	18	70	1949	E
40.735	closed	17	18	18	18	71	1988	D
40.750	closed	18	18	18	18	72	2026	B
40.765	closed	18	19	18	18	73	2060	C
40.780	closed	18	19	18	19	74	2094	E
40.795	closed	18	19	19	19	75	2127	D
40.810	closed	19	19	19	19	76	2161	B
40.825	closed	19	20	19	19	77	2277	C
40.840	closed	19	20	19	20	78	2395	E
40.855	closed	19	20	20	20	79	2516	D
40.870	closed	20	20	20	20	80	2639	B
40.885	closed	20	21	20	20	81	2645	C
40.900	closed	20	21	20	21	82	2650	E
40.915	closed	20	21	21	21	83	2655	D
40.930	closed	21	21	21	21	84	2660	B
40.945	closed	21	22	21	21	85	2667	C
40.960	closed	21	22	21	22	86	2674	E
40.975	closed	21	22	22	22	87	2680	D
40.990	closed	22	22	22	22	88	2687	B
41.005	closed	22	23	22	22	89	2694	C
41.020	closed	22	23	22	23	90	2701	E
41.035	closed	22	23	23	23	91	2708	D
41.050	closed	23	23	23	23	92	2715	B

Gate A Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
41.065	closed	23	23	23	23	92	2722	-
41.080	closed	23	23	23	23	92	2729	-
41.095	closed	23	23	23	23	92	2736	-
41.110	closed	23	23	23	23	92	2742	-
41.125	closed	23	23	23	23	92	2749	-
41.140	closed	23	23	23	23	92	2756	-
41.155	closed	23	23	23	23	92	2763	-
41.170	closed	23	23	23	23	92	2770	-
41.185	closed	23	23	23	23	92	2777	-
41.200	closed	23	23	23	23	92	2784	-
41.215	closed	23	23	23	23	92	2791	-
41.230	closed	23	23	23	23	92	2798	-
41.245	closed	23	23	23	23	92	2805	-
41.260	closed	23	23	23	23	92	2812	-
41.275	closed	23	23	23	23	92	2819	-
41.290	closed	23	23	23	23	92	2826	-
41.305	closed	23	23	23	23	92	2833	-
41.320	closed	23	23	23	23	92	2840	-
41.335	closed	23	23	23	23	92	2847	-
41.350	closed	23	23	23	23	92	2854	-
41.365	closed	23	23	23	23	92	2861	-
41.380	closed	23	23	23	23	92	2868	-
41.395	closed	23	23	23	23	92	2875	-

Gate B Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	closed	closed	1	closed	1	2	32	E
39.715	1	closed	1	closed	1	3	48	A
39.730	1	closed	1	1	1	4	64	D
39.745	1	closed	2	1	1	5	88	C
39.760	1	closed	2	1	2	6	112	E
39.775	2	closed	2	1	2	7	137	A
39.790	2	closed	2	2	2	8	161	D
39.805	2	closed	3	2	2	9	187	C
39.820	2	closed	3	2	3	10	213	E
39.835	3	closed	3	2	3	11	240	A
39.850	3	closed	3	3	3	12	266	D
39.865	3	closed	4	3	3	13	294	C
39.880	3	closed	4	3	4	14	322	E
39.895	4	closed	4	3	4	15	349	A
39.910	4	closed	4	4	4	16	377	D
39.925	4	closed	5	4	4	17	404	C
39.940	4	closed	5	4	5	18	430	E
39.955	5	closed	5	4	5	19	457	A
39.970	5	closed	5	5	5	20	484	D
39.985	5	closed	6	5	5	21	512	C
40.000	5	closed	6	5	6	22	539	E
40.015	6	closed	6	5	6	23	567	A
40.030	6	closed	6	6	6	24	595	D
40.045	6	closed	7	6	6	25	623	C
40.060	6	closed	7	6	7	26	650	E
40.075	7	closed	7	6	7	27	678	A
40.090	7	closed	7	7	7	28	706	D
40.105	7	closed	8	7	7	29	732	C
40.120	7	closed	8	7	8	30	759	E
40.135	8	closed	8	7	8	31	786	A
40.150	8	closed	8	8	8	32	812	D
40.165	8	closed	9	8	8	33	839	C
40.180	8	closed	9	8	9	34	866	E
40.195	9	closed	9	8	9	35	893	A
40.210	9	closed	9	9	9	36	920	D
40.225	9	closed	10	9	9	37	946	C
40.240	9	closed	10	9	10	38	972	E
40.255	10	closed	10	9	10	39	998	A
40.270	10	closed	10	10	10	40	1024	D
40.285	10	closed	11	10	10	41	1050	C
40.300	10	closed	11	10	11	42	1077	E
40.315	11	closed	11	10	11	43	1103	A
40.330	11	closed	11	11	11	44	1130	D
40.345	11	closed	12	11	11	45	1156	C

Gate B Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	11	closed	12	11	12	46	1183	E
40.375	12	closed	12	11	12	47	1210	A
40.390	12	closed	12	12	12	48	1237	D
40.405	12	closed	13	12	12	49	1264	C
40.420	12	closed	13	12	13	50	1292	E
40.435	13	closed	13	12	13	51	1320	A
40.450	13	closed	13	13	13	52	1348	D
40.465	13	closed	14	13	13	53	1377	C
40.480	13	closed	14	13	14	54	1405	E
40.495	14	closed	14	13	14	55	1433	A
40.510	14	closed	14	14	14	56	1462	D
40.525	14	closed	15	14	14	57	1492	C
40.540	14	closed	15	14	15	58	1523	E
40.555	15	closed	15	14	15	59	1554	A
40.570	15	closed	15	15	15	60	1585	D
40.585	15	closed	16	15	15	61	1619	C
40.600	15	closed	16	15	16	62	1653	E
40.615	16	closed	16	15	16	63	1687	A
40.630	16	closed	16	16	16	64	1721	D
40.645	16	closed	17	16	16	65	1759	C
40.660	16	closed	17	16	17	66	1797	E
40.675	17	closed	17	16	17	67	1834	A
40.690	17	closed	17	17	17	68	1872	D
40.705	17	closed	18	17	17	69	1911	C
40.720	17	closed	18	17	18	70	1949	E
40.735	18	closed	18	17	18	71	1988	A
40.750	18	closed	18	18	18	72	2026	D
40.765	18	closed	19	18	18	73	2060	C
40.780	18	closed	19	18	19	74	2094	E
40.795	19	closed	19	18	19	75	2127	A
40.810	19	closed	19	19	19	76	2161	D
40.825	19	closed	20	19	19	77	2277	C
40.840	19	closed	20	19	20	78	2395	E
40.855	20	closed	20	19	20	79	2516	A
40.870	20	closed	20	20	20	80	2639	D
40.885	20	closed	21	20	20	81	2645	C
40.900	20	closed	21	20	21	82	2650	E
40.915	21	closed	21	20	21	83	2655	A
40.930	21	closed	21	21	21	84	2660	D
40.945	21	closed	22	21	21	85	2667	C
40.960	21	closed	22	21	22	86	2674	E
40.975	22	closed	22	21	22	87	2680	A
40.990	22	closed	22	22	22	88	2687	D
41.005	22	closed	23	22	22	89	2694	C
41.020	22	closed	23	22	23	90	2701	E
41.035	23	closed	23	22	23	91	2708	A
41.050	23	closed	23	23	23	92	2715	D

Gate B Stuck or Inoperable								
Level (m AHD)	**Gate A**	**Gate B**	**Gate C**	**Gate D**	**Gate E**	**Total Opening**	**Discharge (m^3/sec)**	**Gates Operated**
41.065	23	closed	23	23	23	92	2722	-
41.080	23	closed	23	23	23	92	2729	-
41.095	23	closed	23	23	23	92	2736	-
41.110	23	closed	23	23	23	92	2742	-
41.125	23	closed	23	23	23	92	2749	-
41.140	23	closed	23	23	23	92	2756	-
41.155	23	closed	23	23	23	92	2763	-
41.170	23	closed	23	23	23	92	2770	-
41.185	23	closed	23	23	23	92	2777	-
41.200	23	closed	23	23	23	92	2784	-
41.215	23	closed	23	23	23	92	2791	-
41.230	23	closed	23	23	23	92	2798	-
41.245	23	closed	23	23	23	92	2805	-
41.260	23	closed	23	23	23	92	2812	-
41.275	23	closed	23	23	23	92	2819	-
41.290	23	closed	23	23	23	92	2826	-
41.305	23	closed	23	23	23	92	2833	-
41.320	23	closed	23	23	23	92	2840	-
41.335	23	closed	23	23	23	92	2847	-
41.350	23	closed	23	23	23	92	2854	-
41.365	23	closed	23	23	23	92	2861	-
41.380	23	closed	23	23	23	92	2868	-
41.395	23	closed	23	23	23	92	2875	-

Gate C Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	closed	closed	1	1	16	E
39.700	1	closed	closed	closed	1	2	32	A
39.715	1	closed	closed	1	1	3	48	D
39.730	1	1	closed	1	1	4	64	B
39.745	1	1	closed	1	2	5	88	E
39.760	2	1	closed	1	2	6	112	A
39.775	2	1	closed	2	2	7	137	D
39.790	2	2	closed	2	2	8	161	B
39.805	2	2	closed	2	3	9	187	E
39.820	3	2	closed	2	3	10	213	A
39.835	3	2	closed	3	3	11	240	D
39.850	3	3	closed	3	3	12	266	B
39.865	3	3	closed	3	4	13	294	E
39.880	4	3	closed	3	4	14	322	A
39.895	4	3	closed	4	4	15	349	D
39.910	4	4	closed	4	4	16	377	B
39.925	4	4	closed	4	5	17	404	E
39.940	5	4	closed	4	5	18	430	A
39.955	5	4	closed	5	5	19	457	D
39.970	5	5	closed	5	5	20	484	B
39.985	5	5	closed	5	6	21	512	E
40.000	6	5	closed	5	6	22	539	A
40.015	6	5	closed	6	6	23	567	D
40.030	6	6	closed	6	6	24	595	B
40.045	6	6	closed	6	7	25	623	E
40.060	7	6	closed	6	7	26	650	A
40.075	7	6	closed	7	7	27	678	D
40.090	7	7	closed	7	7	28	706	B
40.105	7	7	closed	7	8	29	732	E
40.120	8	7	closed	7	8	30	759	A
40.135	8	7	closed	8	8	31	786	D
40.150	8	8	closed	8	8	32	812	B
40.165	8	8	closed	8	9	33	839	E
40.180	9	8	closed	8	9	34	866	A
40.195	9	8	closed	9	9	35	893	D
40.210	9	9	closed	9	9	36	920	B
40.225	9	9	closed	9	10	37	946	E
40.240	10	9	closed	9	10	38	972	A
40.255	10	9	closed	10	10	39	998	D
40.270	10	10	closed	10	10	40	1024	B
40.285	10	10	closed	10	11	41	1050	E
40.300	11	10	closed	10	11	42	1077	A
40.315	11	10	closed	11	11	43	1103	D
40.330	11	11	closed	11	11	44	1130	B
40.345	11	11	closed	11	12	45	1156	E

Gate C Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	12	11	closed	11	12	46	1183	A
40.375	12	11	closed	12	12	47	1210	D
40.390	12	12	closed	12	12	48	1237	B
40.405	12	12	closed	12	13	49	1264	E
40.420	13	12	closed	12	13	50	1292	A
40.435	13	12	closed	13	13	51	1320	D
40.450	13	13	closed	13	13	52	1348	B
40.465	13	13	closed	13	14	53	1377	E
40.480	14	13	closed	13	14	54	1405	A
40.495	14	13	closed	14	14	55	1433	D
40.510	14	14	closed	14	14	56	1462	B
40.525	14	14	closed	14	15	57	1492	E
40.540	15	14	closed	14	15	58	1523	A
40.555	15	14	closed	15	15	59	1554	D
40.570	15	15	closed	15	15	60	1585	B
40.585	15	15	closed	15	16	61	1619	E
40.600	16	15	closed	15	16	62	1653	A
40.615	16	15	closed	16	16	63	1687	D
40.630	16	16	closed	16	16	64	1721	B
40.645	16	16	closed	16	17	65	1759	E
40.660	17	16	closed	16	17	66	1797	A
40.675	17	16	closed	17	17	67	1834	D
40.690	17	17	closed	17	17	68	1872	B
40.705	17	17	closed	17	18	69	1911	E
40.720	18	17	closed	17	18	70	1949	A
40.735	18	17	closed	18	18	71	1988	D
40.750	18	18	closed	18	18	72	2026	B
40.765	18	18	closed	18	19	73	2060	E
40.780	19	18	closed	18	19	74	2094	A
40.795	19	18	closed	19	19	75	2127	D
40.810	19	19	closed	19	19	76	2161	B
40.825	19	19	closed	19	20	77	2277	E
40.840	20	19	closed	19	20	78	2395	A
40.855	20	19	closed	20	20	79	2516	D
40.870	20	20	closed	20	20	80	2639	B
40.885	20	20	closed	20	21	81	2645	E
40.900	21	20	closed	20	21	82	2650	A
40.915	21	20	closed	21	21	83	2655	D
40.930	21	21	closed	21	21	84	2660	B
40.945	21	21	closed	21	22	85	2667	E
40.960	22	21	closed	21	22	86	2674	A
40.975	22	21	closed	22	22	87	2680	D
40.990	22	22	closed	22	22	88	2687	B
41.005	22	22	closed	22	23	89	2694	E
41.020	23	22	closed	22	23	90	2701	A
41.035	23	22	closed	23	23	91	2708	D
41.050	23	23	closed	23	23	92	2715	B

Gate C Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
41.065	23	23	closed	23	23	92	2722	-
41.080	23	23	closed	23	23	92	2729	-
41.095	23	23	closed	23	23	92	2736	-
41.110	23	23	closed	23	23	92	2742	-
41.125	23	23	closed	23	23	92	2749	-
41.140	23	23	closed	23	23	92	2756	-
41.155	23	23	closed	23	23	92	2763	-
41.170	23	23	closed	23	23	92	2770	-
41.185	23	23	closed	23	23	92	2777	-
41.200	23	23	closed	23	23	92	2784	-
41.215	23	23	closed	23	23	92	2791	-
41.230	23	23	closed	23	23	92	2798	-
41.245	23	23	closed	23	23	92	2805	-
41.260	23	23	closed	23	23	92	2812	-
41.275	23	23	closed	23	23	92	2819	-
41.290	23	23	closed	23	23	92	2826	-
41.305	23	23	closed	23	23	92	2833	-
41.320	23	23	closed	23	23	92	2840	-
41.335	23	23	closed	23	23	92	2847	-
41.350	23	23	closed	23	23	92	2854	-
41.365	23	23	closed	23	23	92	2861	-
41.380	23	23	closed	23	23	92	2868	-
41.395	23	23	closed	23	23	92	2875	-

Gate D Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	closed	closed	1	closed	1	2	32	E
39.715	1	closed	1	closed	1	3	48	A
39.730	1	1	1	closed	1	4	64	B
39.745	1	1	2	closed	1	5	88	C
39.760	1	1	2	closed	2	6	112	E
39.775	2	1	2	closed	2	7	137	A
39.790	2	2	2	closed	2	8	161	B
39.805	2	2	3	closed	2	9	187	C
39.820	2	2	3	closed	3	10	213	E
39.835	3	2	3	closed	3	11	240	A
39.850	3	3	3	closed	3	12	266	B
39.865	3	3	4	closed	3	13	294	C
39.880	3	3	4	closed	4	14	322	E
39.895	4	3	4	closed	4	15	349	A
39.910	4	4	4	closed	4	16	377	B
39.925	4	4	5	closed	4	17	404	C
39.940	4	4	5	closed	5	18	430	E
39.955	5	4	5	closed	5	19	457	A
39.970	5	5	5	closed	5	20	484	B
39.985	5	5	6	closed	5	21	512	C
40.000	5	5	6	closed	6	22	539	E
40.015	6	5	6	closed	6	23	567	A
40.030	6	6	6	closed	6	24	595	B
40.045	6	6	7	closed	6	25	623	C
40.060	6	6	7	closed	7	26	650	E
40.075	7	6	7	closed	7	27	678	A
40.090	7	7	7	closed	7	28	706	B
40.105	7	7	8	closed	7	29	732	C
40.120	7	7	8	closed	8	30	759	E
40.135	8	7	8	closed	8	31	786	A
40.150	8	8	8	closed	8	32	812	B
40.165	8	8	9	closed	8	33	839	C
40.180	8	8	9	closed	9	34	866	E
40.195	9	8	9	closed	9	35	893	A
40.210	9	9	9	closed	9	36	920	B
40.225	9	9	10	closed	9	37	946	C
40.240	9	9	10	closed	10	38	972	E
40.255	10	9	10	closed	10	39	998	A
40.270	10	10	10	closed	10	40	1024	B
40.285	10	10	11	closed	10	41	1050	C
40.300	10	10	11	closed	11	42	1077	E
40.315	11	10	11	closed	11	43	1103	A
40.330	11	11	11	closed	11	44	1130	B
40.345	11	11	12	closed	11	45	1156	C

Gate D Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	11	11	12	closed	12	46	1183	E
40.375	12	11	12	closed	12	47	1210	A
40.390	12	12	12	closed	12	48	1237	B
40.405	12	12	13	closed	12	49	1264	C
40.420	12	12	13	closed	13	50	1292	E
40.435	13	12	13	closed	13	51	1320	A
40.450	13	13	13	closed	13	52	1348	B
40.465	13	13	14	closed	13	53	1377	C
40.480	13	13	14	closed	14	54	1405	E
40.495	14	13	14	closed	14	55	1433	A
40.510	14	14	14	closed	14	56	1462	B
40.525	14	14	15	closed	14	57	1492	C
40.540	14	14	15	closed	15	58	1523	E
40.555	15	14	15	closed	15	59	1554	A
40.570	15	15	15	closed	15	60	1585	B
40.585	15	15	16	closed	15	61	1619	C
40.600	15	15	16	closed	16	62	1653	E
40.615	16	15	16	closed	16	63	1687	A
40.630	16	16	16	closed	16	64	1721	B
40.645	16	16	17	closed	16	65	1759	C
40.660	16	16	17	closed	17	66	1797	E
40.675	17	16	17	closed	17	67	1834	A
40.690	17	17	17	closed	17	68	1872	B
40.705	17	17	18	closed	17	69	1911	C
40.720	17	17	18	closed	18	70	1949	E
40.735	18	17	18	closed	18	71	1988	A
40.750	18	18	18	closed	18	72	2026	B
40.765	18	18	19	closed	18	73	2060	C
40.780	18	18	19	closed	19	74	2094	E
40.795	19	18	19	closed	19	75	2127	A
40.810	19	19	19	closed	19	76	2161	B
40.825	19	19	20	closed	19	77	2277	C
40.840	19	19	20	closed	20	78	2395	E
40.855	20	19	20	closed	20	79	2516	A
40.870	20	20	20	closed	20	80	2639	B
40.885	20	20	21	closed	20	81	2645	C
40.900	20	20	21	closed	21	82	2650	E
40.915	21	20	21	closed	21	83	2655	A
40.930	21	21	21	closed	21	84	2660	B
40.945	21	21	22	closed	21	85	2667	C
40.960	21	21	22	closed	22	86	2674	E
40.975	22	21	22	closed	22	87	2680	A
40.990	22	22	22	closed	22	88	2687	B
41.005	22	22	23	closed	22	89	2694	C
41.020	22	22	23	closed	23	90	2701	E
41.035	23	22	23	closed	23	91	2708	A
41.050	23	23	23	closed	23	92	2715	B

Gate D Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
41.065	23	23	23	closed	23	92	2722	-
41.080	23	23	23	closed	23	92	2729	-
41.095	23	23	23	closed	23	92	2736	-
41.110	23	23	23	closed	23	92	2742	-
41.125	23	23	23	closed	23	92	2749	-
41.140	23	23	23	closed	23	92	2756	-
41.155	23	23	23	closed	23	92	2763	-
41.170	23	23	23	closed	23	92	2770	-
41.185	23	23	23	closed	23	92	2777	-
41.200	23	23	23	closed	23	92	2784	-
41.215	23	23	23	closed	23	92	2791	-
41.230	23	23	23	closed	23	92	2798	-
41.245	23	23	23	closed	23	92	2805	-
41.260	23	23	23	closed	23	92	2812	-
41.275	23	23	23	closed	23	92	2819	-
41.290	23	23	23	closed	23	92	2826	-
41.305	23	23	23	closed	23	92	2833	-
41.320	23	23	23	closed	23	92	2840	-
41.335	23	23	23	closed	23	92	2847	-
41.350	23	23	23	closed	23	92	2854	-
41.365	23	23	23	closed	23	92	2861	-
41.380	23	23	23	closed	23	92	2868	-
41.395	23	23	23	closed	23	92	2875	-

Gate E Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
39.600	closed	closed	closed	closed	closed	0	0	-
39.650	closed	closed	1	closed	closed	1	16	C
39.700	1	closed	1	closed	closed	2	32	A
39.715	1	closed	1	1	closed	3	48	D
39.730	1	1	1	1	closed	4	64	B
39.745	1	1	2	1	closed	5	88	C
39.760	2	1	2	1	closed	6	112	A
39.775	2	1	2	2	closed	7	137	D
39.790	2	2	2	2	closed	8	161	B
39.805	2	2	3	2	closed	9	187	C
39.820	3	2	3	2	closed	10	213	A
39.835	3	2	3	3	closed	11	240	D
39.850	3	3	3	3	closed	12	266	B
39.865	3	3	4	3	closed	13	294	C
39.880	4	3	4	3	closed	14	322	A
39.895	4	3	4	4	closed	15	349	D
39.910	4	4	4	4	closed	16	377	B
39.925	4	4	5	4	closed	17	404	C
39.940	5	4	5	4	closed	18	430	A
39.955	5	4	5	5	closed	19	457	D
39.970	5	5	5	5	closed	20	484	B
39.985	5	5	6	5	closed	21	512	C
40.000	6	5	6	5	closed	22	539	A
40.015	6	5	6	6	closed	23	567	D
40.030	6	6	6	6	closed	24	595	B
40.045	6	6	7	6	closed	25	623	C
40.060	7	6	7	6	closed	26	650	A
40.075	7	6	7	7	closed	27	678	D
40.090	7	7	7	7	closed	28	706	B
40.105	7	7	8	7	closed	29	732	C
40.120	8	7	8	7	closed	30	759	A
40.135	8	7	8	8	closed	31	786	D
40.150	8	8	8	8	closed	32	812	B
40.165	8	8	9	8	closed	33	839	C
40.180	9	8	9	8	closed	34	866	A
40.195	9	8	9	9	closed	35	893	D
40.210	9	9	9	9	closed	36	920	B
40.225	9	9	10	9	closed	37	946	C
40.240	10	9	10	9	closed	38	972	A
40.255	10	9	10	10	closed	39	998	D
40.270	10	10	10	10	closed	40	1024	B
40.285	10	10	11	10	closed	41	1050	C
40.300	11	10	11	10	closed	42	1077	A
40.315	11	10	11	11	closed	43	1103	D
40.330	11	11	11	11	closed	44	1130	B
40.345	11	11	12	11	closed	45	1156	C

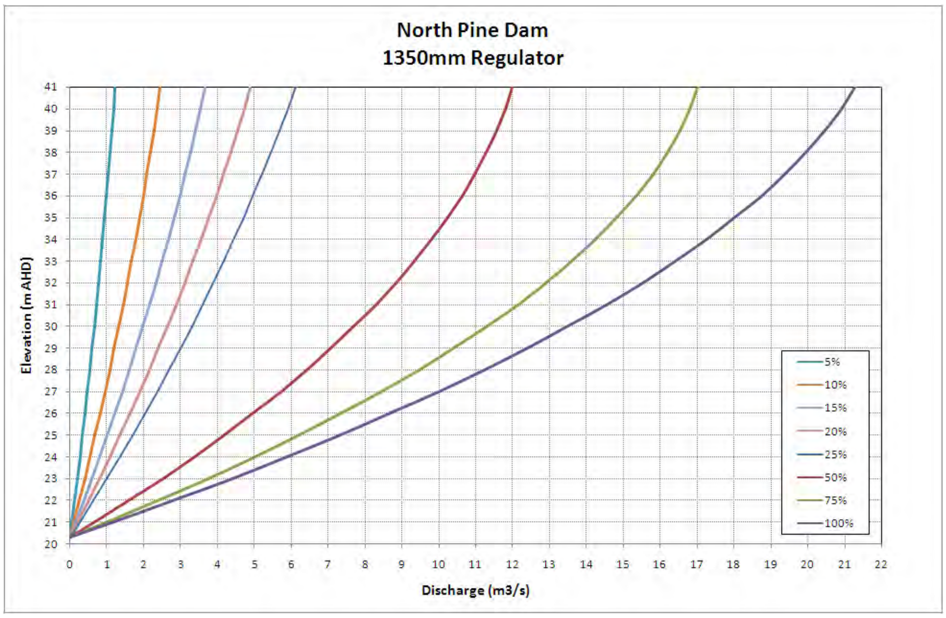
Gate E Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
40.360	12	11	12	11	closed	46	1183	A
40.375	12	11	12	12	closed	47	1210	D
40.390	12	12	12	12	closed	48	1237	B
40.405	12	12	13	12	closed	49	1264	C
40.420	13	12	13	12	closed	50	1292	A
40.435	13	12	13	13	closed	51	1320	D
40.450	13	13	13	13	closed	52	1348	B
40.465	13	13	14	13	closed	53	1377	C
40.480	14	13	14	13	closed	54	1405	A
40.495	14	13	14	14	closed	55	1433	D
40.510	14	14	14	14	closed	56	1462	B
40.525	14	14	15	14	closed	57	1492	C
40.540	15	14	15	14	closed	58	1523	A
40.555	15	14	15	15	closed	59	1554	D
40.570	15	15	15	15	closed	60	1585	B
40.585	15	15	16	15	closed	61	1619	C
40.600	16	15	16	15	closed	62	1653	A
40.615	16	15	16	16	closed	63	1687	D
40.630	16	16	16	16	closed	64	1721	B
40.645	16	16	17	16	closed	65	1759	C
40.660	17	16	17	16	closed	66	1797	A
40.675	17	16	17	17	closed	67	1834	D
40.690	17	17	17	17	closed	68	1872	B
40.705	17	17	18	17	closed	69	1911	C
40.720	18	17	18	17	closed	70	1949	A
40.735	18	17	18	18	closed	71	1988	D
40.750	18	18	18	18	closed	72	2026	B
40.765	18	18	19	18	closed	73	2060	C
40.780	19	18	19	18	closed	74	2094	A
40.795	19	18	19	19	closed	75	2127	D
40.810	19	19	19	19	closed	76	2161	B
40.825	19	19	20	19	closed	77	2277	C
40.840	20	19	20	19	closed	78	2395	A
40.855	20	19	20	20	closed	79	2516	D
40.870	20	20	20	20	closed	80	2639	B
40.885	20	20	21	20	closed	81	2645	C
40.900	21	20	21	20	closed	82	2650	A
40.915	21	20	21	21	closed	83	2655	D
40.930	21	21	21	21	closed	84	2660	B
40.945	21	21	22	21	closed	85	2667	C
40.960	22	21	22	21	closed	86	2674	A
40.975	22	21	22	22	closed	87	2680	D
40.990	22	22	22	22	closed	88	2687	B
41.005	22	22	23	22	closed	89	2694	C
41.020	23	22	23	22	closed	90	2701	A
41.035	23	22	23	23	closed	91	2708	D
41.050	23	23	23	23	closed	92	2715	B

Gate E Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m^3/sec)	Gate Operated
41.065	23	23	23	23	closed	92	2722	-
41.080	23	23	23	23	closed	92	2729	-
41.095	23	23	23	23	closed	92	2736	-
41.110	23	23	23	23	closed	92	2742	-
41.125	23	23	23	23	closed	92	2749	-
41.140	23	23	23	23	closed	92	2756	-
41.155	23	23	23	23	closed	92	2763	-
41.170	23	23	23	23	closed	92	2770	-
41.185	23	23	23	23	closed	92	2777	-
41.200	23	23	23	23	closed	92	2784	-
41.215	23	23	23	23	closed	92	2791	-
41.230	23	23	23	23	closed	92	2798	-
41.245	23	23	23	23	closed	92	2805	-
41.260	23	23	23	23	closed	92	2812	-
41.275	23	23	23	23	closed	92	2819	-
41.290	23	23	23	23	closed	92	2826	-
41.305	23	23	23	23	closed	92	2833	-
41.320	23	23	23	23	closed	92	2840	-
41.335	23	23	23	23	closed	92	2847	-
41.350	23	23	23	23	closed	92	2854	-
41.365	23	23	23	23	closed	92	2861	-
41.380	23	23	23	23	closed	92	2868	-
41.395	23	23	23	23	closed	92	2875	-

1350mm Regulator

EL	Opening (%)								Opening (%)							
	5	10	15	20	25	50	75	100	5	10	15	20	25	50	75	100
m AHD	m3/s								ML/d							
20.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0	0
21.0	0.1	0.1	0.2	0.2	0.3	0.7	1.0	1.2	5	9	14	18	23	59	87	102
22.0	0.1	0.3	0.4	0.5	0.6	1.6	2.4	2.8	11	22	33	44	55	139	208	243
23.0	0.2	0.4	0.6	0.8	1.0	2.5	3.7	4.4	17	34	52	69	86	217	323	379
24.0	0.3	0.5	0.8	1.1	1.3	3.4	5.0	5.9	23	47	70	93	117	291	432	508
25.0	0.3	0.7	1.0	1.4	1.7	4.2	6.2	7.3	29	59	88	117	146	362	536	632
26.0	0.4	0.8	1.2	1.6	2.0	5.0	7.4	8.7	35	70	105	140	176	429	635	751
27.0	0.5	0.9	1.4	1.9	2.4	5.7	8.4	10.0	41	82	122	163	204	493	729	863
28.0	0.5	1.1	1.6	2.1	2.7	6.4	9.5	11.2	46	93	139	185	232	554	817	970
29.0	0.6	1.2	1.8	2.4	3.0	7.1	10.4	12.4	52	104	155	207	259	611	899	1071
30.0	0.7	1.3	2.0	2.6	3.3	7.7	11.3	13.5	57	114	171	228	285	665	976	1166
31.0	0.7	1.4	2.2	2.9	3.6	8.3	12.1	14.5	62	124	186	249	311	716	1048	1256
32.0	0.8	1.6	2.3	3.1	3.9	8.8	12.9	15.5	67	134	201	269	336	763	1115	1340
33.0	0.8	1.7	2.5	3.3	4.2	9.3	13.6	16.4	72	144	216	288	360	807	1176	1418
34.0	0.9	1.8	2.7	3.6	4.4	9.8	14.2	17.3	77	153	230	307	383	847	1231	1491
35.0	0.9	1.9	2.8	3.8	4.7	10.2	14.8	18.0	81	162	244	325	406	884	1281	1558
36.0	1.0	2.0	3.0	4.0	5.0	10.6	15.3	18.7	86	171	257	343	428	918	1326	1619
37.0	1.0	2.1	3.1	4.2	5.2	11.0	15.8	19.4	90	180	270	360	450	949	1366	1674
38.0	1.1	2.2	3.3	4.4	5.4	11.3	16.2	19.9	94	188	282	376	470	976	1400	1724
39.0	1.1	2.3	3.4	4.5	5.7	11.6	16.5	20.5	98	196	294	392	490	999	1428	1768
40.0	1.2	2.4	3.5	4.7	5.9	11.8	16.8	20.9	102	204	306	408	510	1020	1452	1806
41.0	1.2	2.4	3.7	4.9	6.1	12.0	17.0	21.3	106	211	317	423	528	1036	1469	1838

Comment [r3]: Is there a minimum opening that should be used?



APPENDIX D

NORTH PINE DAM AUXILIARY EQUIPMENT

The spillway gates at North Pine Dam are raised and lowered using electric motor driven winches. These motors are normally powered from the mains electric supply. In the event of a failure of the mains supply, a standby diesel generator (located on level 2 of the dam) automatically cuts in to maintain electric supply.

Review of the North Pine Dam hydrology has shown that extreme events can submerge the five radial gate electric winch motors that are located on platforms beneath the bridge deck forming the dam crest. During such an event the electric winch motors would not operate and the winches would not be accessible to enable operation using the compressed air system.

An auxiliary gate operating system installed in 1997/98 comprises a trailer-mounted motor with petrol driven generator, which can be used to operate the winches from the crest of the dam. The shafts of the existing electric winch motors have been extended to the level of the dam crest through right angle gear boxes. In the event of failure of both of the mains electric supply and the standby diesel generator, failure or submergence of the electric winch motors, the trailer mounted motor and petrol driven generator must be used to operate the radial gates.

APPENDIX E

HYDROLOGIC INVESTIGATIONS

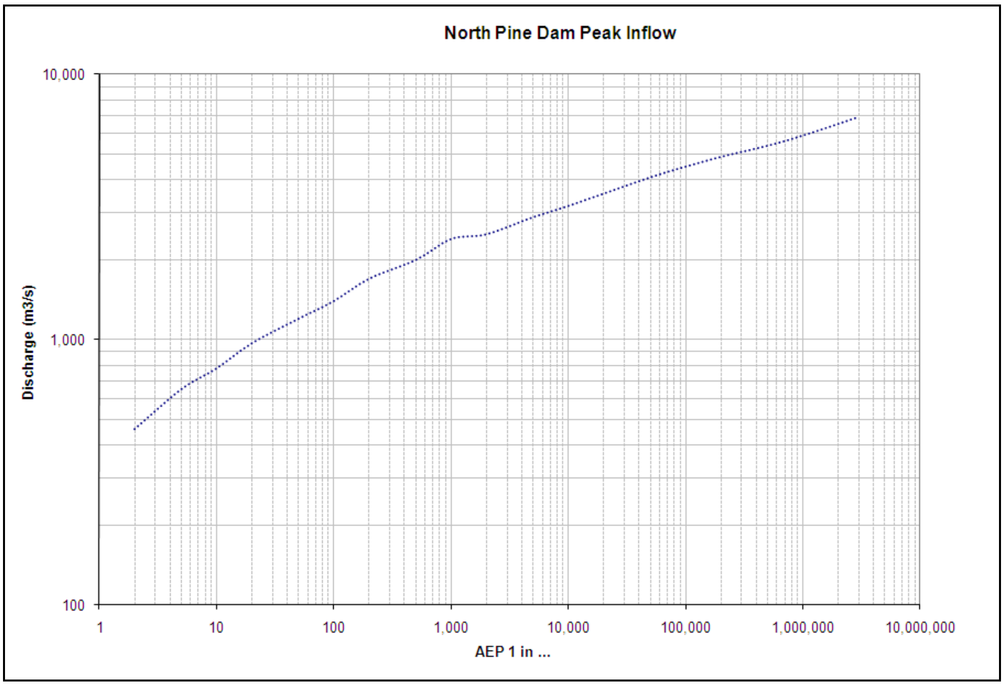
The design flood hydrology for North Pine Dam was updated by SunWater in October 2007 (North Pine Dam Design Flood Hydrology, Oct 2007).

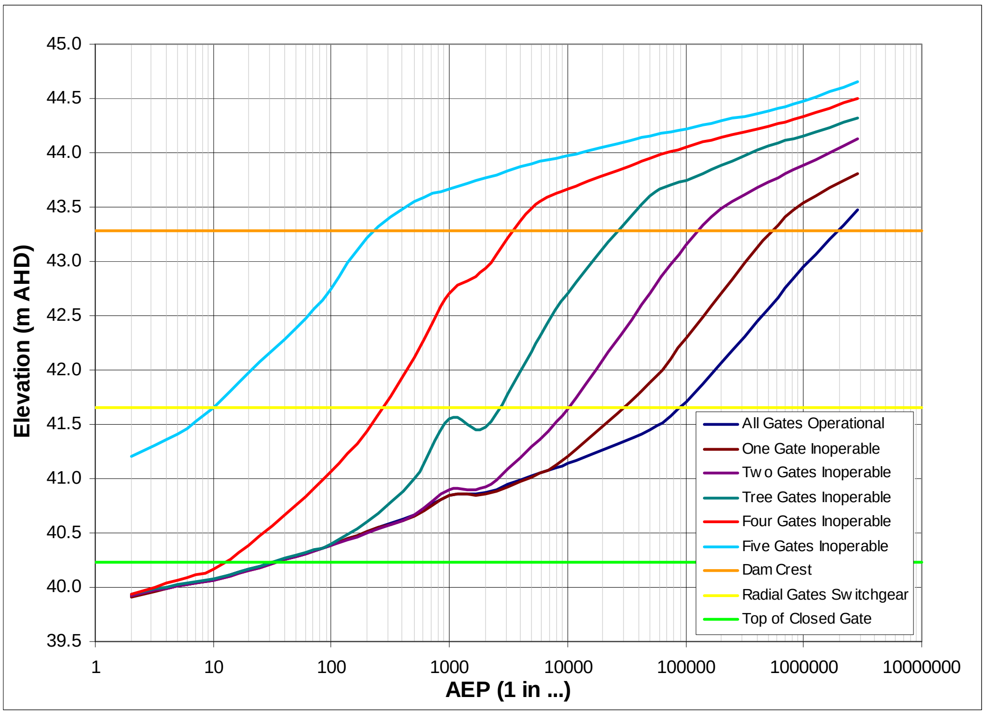
Flood frequency analysis of the flood records at GS120101a Youngs Crossing (pre dam) suggested that the 1974 flood was about a 1 in 100 AEP event.

An URBS runoff-routing model of the North Pine was developed and calibrated to three pre-dam floods and four post dam events. While there was a reasonable amount of rainfall data available, calibration of the model was hampered by the lack of key water level data; gauge heights at Youngs Crossing in 1974 (due to gauge failure) and North Pine Dam headwater levels in post dam events.

Design rainfalls were determined using the methodologies outlined in the Generalised Short Duration Method and Generalised Tropical Storm Method Revised. The appropriate temporal patterns suggested by these methodologies were adopted.

The flows derived using the design event approach closely matched pre-dam flood frequency estimates, giving a degree of confidence in the adopted methodology.





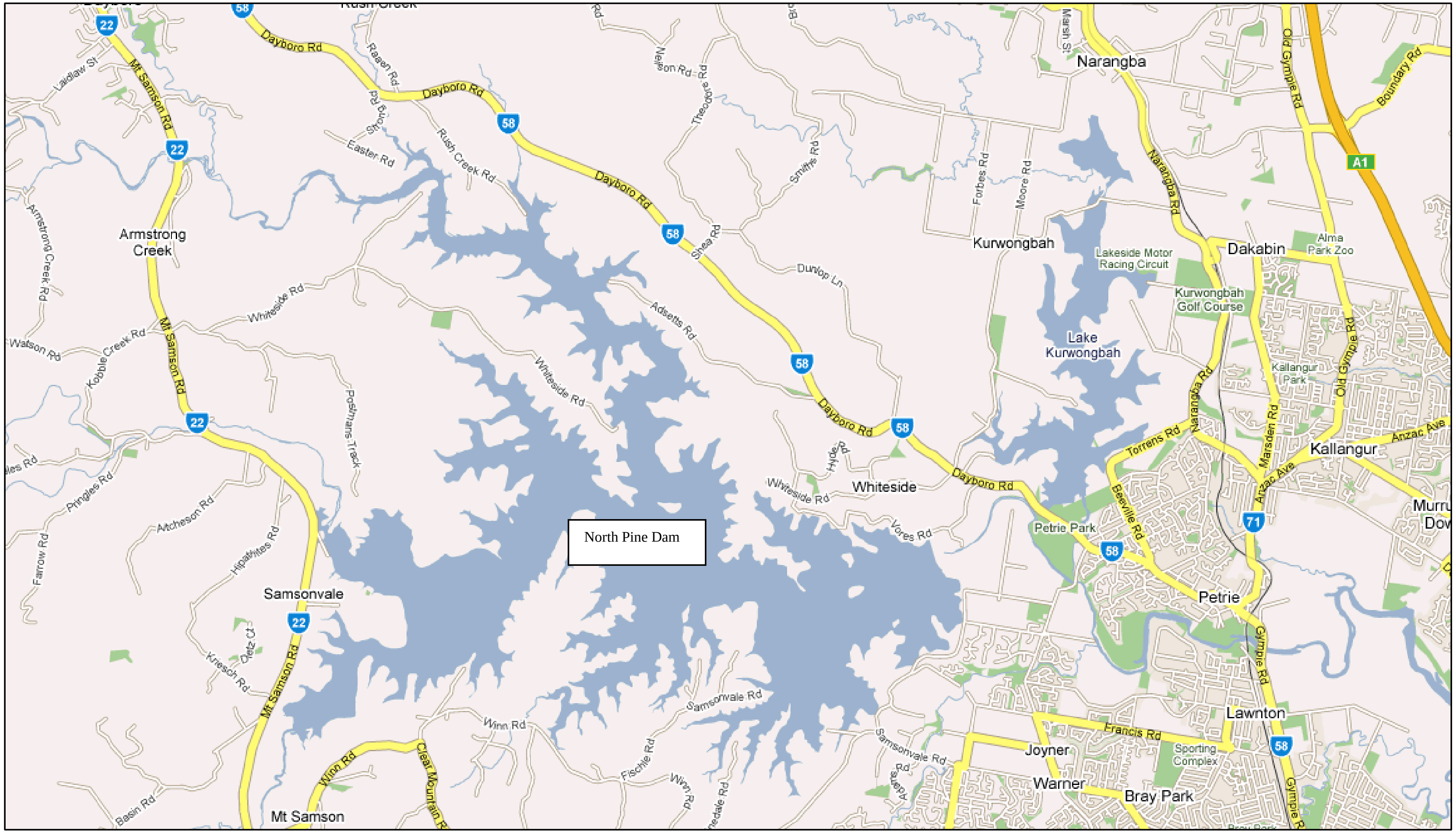
Based on the findings of this hydrologic study for North Pine Dam, it is concluded that;

- The notional AEP of the PMP for North Pine Dam is 1 in 2,900,000.
- The critical storm duration for the inflow is generally the 12 hour storm except for the very frequent and very rare events which tend to be longer.
- The 24 hour PMPDF produces the highest peak inflow of 6,900 m^3/s.
- Under normal conditions with all gates operating, the critical duration of the outflow remains generally as 12 hours for events between 1 in 20 and 1 in 200 AEP and for the 1 in 2000 AEP event. For other AEPs, the critical duration increases up to 36 hours.
- The Acceptable Flood Capacity with one gate inoperable is approximately 3,960 m^3/s or 61% of the PMPDF for the 24 hour critical duration storm.
- With all gates operating normally,
  - The 36 hour PMPDF produces the highest peak outflow of 5,400 m^3/s.
  - The AEP of the DCF is about 1 in 2,000,000.
  - In the PMPDF, the dam crest is overtopped for a period of about 12 hours, reached a maximum height of 0.19 metres above the crest.
  - The PMF outflow may be as high as 6,500 m^3/s for a critical duration storm of 36 hours.
- With one gate inoperable,
  - The 36 hour PMPDF produces the highest peak outflow of 5,800 m^3/s.
  - The AEP of the DCF is about 1 in 550,000.

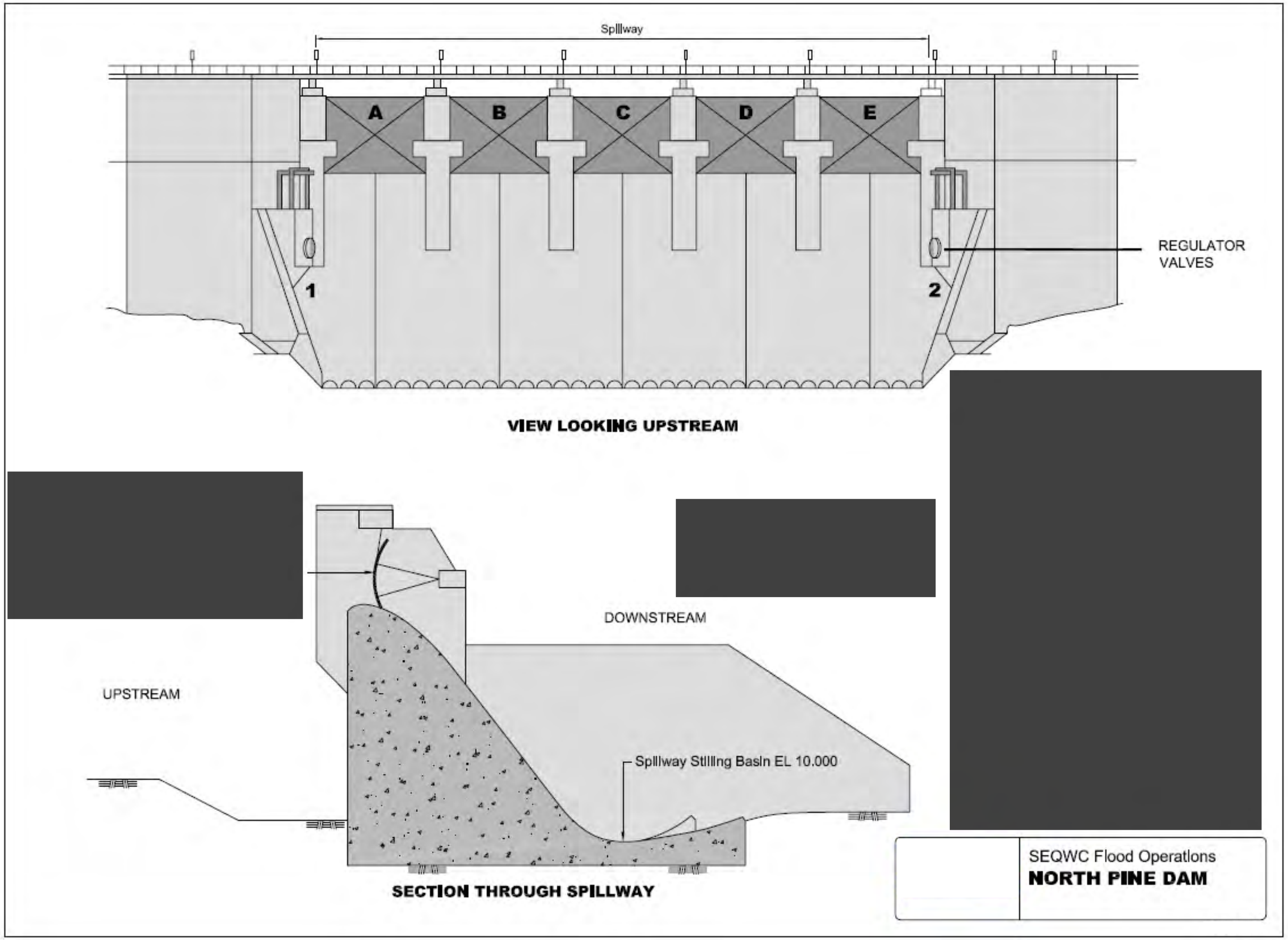
- With one gate inoperable, In the PMPDF, the dam crest is overtopped for a period of about 23 hours, reached a maximum height of 0.53 metres above the crest.

- **APPENDIX F**

NORTH PINE DAM
PLANS, MAPS AND PHOTOGRAPHS


North Pine Dam
Narangba
Kurwongbah
Dakabin
Lake Kurwongbah
Lakeside Motor Racing Circuit
Kurwongbah Golf Course
Alma Park Zoo
Kallangur
Whiteside
Petrie Park
Petrie
Lawnton
Joyner
Warner
Bray Park
Armstrong Creek
Samsonvale
Mt Samson
Dayboro Rd
Mt Samson Rd
Samsonvale Rd
Gympie Rd
Anzac Ave
Francis Rd
Whiteside Rd
Winn Rd


Grant St
Lake Kurwongbah
North Pine Dam
Youngs Crossing
Petrie


Spillway
A
B
C
D
E
1
2
REGULATOR VALVES
VIEW LOOKING UPSTREAM
[redacted]
[redacted]
DOWNSTREAM
UPSTREAM
Spillway Stilling Basin EL 10.000
SECTION THROUGH SPILLWAY
[redacted]
SEQWC Flood Operations
NORTH PINE DAM

seqwater
WATER FOR LIFE

MANUAL

OF

OPERATIONAL PROCEDURES

FOR

FLOOD MITIGATION

AT

NORTH PINE DAM

Revision 5
August 2010

seqwater
WATER FOR LIFE

When contacting Seqwater please ask for John Tibaldi
Telephone: [redacted]
Reference: 09-000048

DOCUMENT RECEIVED BY DERM
File No. ....
File Location. ....
27 AUG 2010
Action By ....
Registered Y/N
Doc. Code ....

13 August 2010

Mr Peter Allen
Director Dam Safety (Water Supply)
Department of Natural Resources and Water
PO Box 2454
BRISBANE QLD 4001

Dear Mr Allen

MANUAL OF OPERATIONAL PROCEDURES FOR FLOOD MITIGATION AT NORTH PINE DAM

I refer to my letter of 5 July concerning the above in which I submitted a new draft Manual to you for gazettal. I understand that upon review of the draft Manual, you have suggested some amendments prior to gazettal. These amendments have now been made and an updated manual is attached both in electronic and hardcopy format.

Accordingly, I request that you approve the updated Manual by gazette notice, in accordance with the provisions of Chapter 4 (Part 2) of the Water Supply (Safety and Reliability) Act 2008. I trust the information provided is in accordance with your requirements and I ask that you contact me on 3035 5538, should any issues arise that impact on the requested approval.

Yours faithfully

[redacted]

Peter Borrows
CEO
QLD Bulk Water Supply Authority *trading as* Seqwater

Att:

- Revised Manual of Operational Procedures for Flood Mitigation at North Pine, August 2010 (Hardcopy and electronic format).

From Allen Peter **Date** Thursday, 25 November 2010 1:56:40 PM
To Guppy Ron
Cc
Subject RE: North Pine Dam Flood Mitigation Manual

Ron,

As discussed, given the nature of the minor changes to the North Pine Manual, I am prepared to accept the latest version. I have therefore completed the decision form for Procedure 5.1 approving the Manual. Can you please proceed with the preparation of the Gazettal notice?

Peter Allen

Director Dam Safety (Water Supply)

Office of the Water Supply Regulator

Telephone[redacted] **Mobile**[redacted] **Facsimile** [redacted]

Email [redacted]
www.derm.qld.gov.au

From: Guppy Ron
Sent: Wednesday, 24 November 2010 3:04 PM
To: Allen Peter
Subject: North Pine Dam Flood Mitigation Manual

While the current approved manual does not expire till 28/9/2012 SEQWater have already requested by letter of 13th August 2010 approval of an updated manual. In the lead up to this request we had a number of discussions with SEQWater and the Senior Flood Operations Engineers to get content we believed was satisfactory. The changes proposed to the currently gazetted manual are considered quite minor. The operational changes are confined to the final stages of draining the storage back to FSL - the last 150mm - and are included to increase the flexibility with operations so that inundation of Young's Crossing downstream of the dam and fish recovery can be managed better.

Given the recent interest in the Wivenhoe and Somerset Dams Manual maybe we should circulate this latest revision to others before it is approved. The only Council really affected by releases is Moreton Bay Regional Council. Brisbane City being to the south of the South Pine River has limited connection for normal operations. Beside them, there is potentially EMQ and Water Grid Manager (?). Also are you aware of anything that was brought up about the other manual that warrants revisions here.

As you are aware this dam is not able to be operated as a flood mitigation storage because of the very limited capacity to store water above FSL and the rapid catchment response. Full Supply Level is at EL 39.6 and the top of the radial gates when closed is EL 40.2 so the dam needs to operated on a 'what comes in must go out' basis.

Otherwise if you're happy with as it is I can prepare a recommendation for gazettal of the manual.

Ron Guppy
Principal Engineer (Dam Safety)

Office of the Water Supply Regulator
Telephone [redacted]**Facsimile** [redacted]

Mobile [redacted] **Email**: [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

From Guppy Ron **Date** Friday, 17 December 2010 11:23:59 AM
To 'John Tibaldi'
Cc Allen Peter
Subject North Pine Dam Flood Mitigation Manual

FMM Gazettal_16_12_10.pdf (94 KB HTML)

John

The approval notice (copy attached) for the latest revision of the North Pine Dam Manual appears in today's gazette. I'll get a formal letter to Seqwater away within the next week.

<<FMM Gazettal_16_12_10.pdf>>

Ron Guppy
Principal Engineer (Dam Safety)
Office of the Water Supply Regulator
Telephone [redacted] **Facsimile** [redacted]
Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

Deleted:

South East Queensland
WATER CORPORATION
LIMITED

MANUAL

OF

OPERATIONAL PROCEDURES

FOR FLOOD MITIGATION

FOR

WIVENHOE DAM

AND SOMERSET DAM

Deleted: ¶
¶

Revision No.	Date	Amendment Details
0	27 October 1968	Original Issue
1	6 October 1992	Complete revision and re-issue
2	13 November 1997	Complete revision and re-issue
3	24 August 1998	Change to page 23
4	6 September 2002	Complete revision and re-issue
5	4 October 2004	Complete revision
6	20 December 2004	Miscellaneous amendments and re-issue
7	6 March 200	Complete Revision

Deleted: : 6

Deleted: December 2004

Deleted:

TABLE OF CONTENTS

Deleted: ¶

Deleted:
¶
¶

Deleted: : 6

Deleted: December 2004

Deleted:
Deleted: : 6
Deleted: December 2004

Deleted:

Deleted: **1 INTRODUCTION**
¶
1.1 Preface ¶
1.2 Meaning of Terms ¶
1.3 Purpose of Manual ¶
1.4 Legal Authority ¶
1.5 Application and Effect ¶
1.6 Date of Effect ¶
1.7 Observance of Manual ¶
1.8 Provision for Variations to Manual ¶
1.9 Distribution of Manual ¶
2 DIRECTION OF OPERATIONS ¶
2.1 Statutory Operation ¶
2.1.1 Designation of Senior Flood Operations Engineer ¶
2.1.2 Designation of Flood Operations Engineer ¶
2.2 Qualifications and Experience of Engineers ¶
2.2.1 Qualifications ¶
2.2.2 Experience ¶
2.3 Schedule of Authorities ¶
2.4 Training ¶
2.5 Dam Operation Arrangements ¶
2.6 Responsibilities of the Senior Flood Operations Engineer ¶
2.7 Responsibilities of the Flood Operations Engineer ¶
2.8 Reasonable Discretion ¶
2.9 Report ¶
3 FLOOD MITIGATION OBJECTIVES ¶
3.1 General ¶
3.2 Structural Safety of Dams ¶
3.2.1 Wivenhoe Dam ¶
3.2.2 Somerset Dam ¶
3.2.3 Extreme Floods and Closely Spaced Large Floods ¶
3.3 Inundation of Urban Areas ¶
3.4 Disruption to Rural Areas 15¶
3.5 Provision of Pumping Pool for Power Station ¶
3.6 Disruption to Navigation ¶
4 FLOOD CLASSIFICATION ¶
¶
5 FLOOD MONITORING AND WARNING SYSTEM ¶
5.1 General ¶
5.2 Operation ¶
5.3 Storage of Documentation ¶
5.4 Key Reference Gauges ¶
5.5 Reference Gauge Values ¶
6 COMMUNICATIONS ¶
6.1 Communications between Staff ¶
6.2 Dissemination of Information ¶
6.3 Release of Information to the Public ¶
7 REVIEW ¶
7.1 Introduction ¶
7.2 Personnel Training ¶
7.3 Monitoring and Warning System and Communication Networks ¶
7.4 Operational Review ¶
7.5 Five Yearly Review ¶
8 WIVENHOE DAM OPERATIONAL PROCEDURES ¶ ... [1]

Deleted: : 6

Deleted: December 2004

1 INTRODUCTION

Deleted: Page Break
¶
¶
¶
¶
¶
¶
¶
Section Break (Odd Page)

1.1 Preface

Given their size and location, it is imperative that Wivenhoe and Somerset Dams be operated during flood events in accordance with clearly defined procedures to minimise hazard to life and property.

Recognising this, the South East Queensland Water Board Act required a manual be prepared of operational procedures for the dams during floods. With changes to the controlling legislation, the manual became an approved flood mitigation manual under *Water Act 2000* (extract in Appendix A).

This Manual is the result of a review of the 2002 revision of the Manual. The South East Queensland Water Corporation is required to review, update the Manual if necessary, and submit it to the Chief Executive for approval prior to its expiry. Any amendments to the basic operating procedures need to be treated similarly.

Formatted: Highlight

Prior to the 1998 version of the manual, an expanded flood monitoring and warning radio telemetry network (ALERT) was installed in the Brisbane River Catchment. Additionally, a computerised flood operational model that allows for rainfall and river modelling in real time based on data from the ALERT system was developed, implemented and fully commissioned. The accuracy and reliability of the system during a flood event has now been proven.

The primary objectives have not varied from those defined in the previous manual. These remain ensuring safety of the dams, their ability to deal with extreme and closely spaced floods, and protection of urban areas. The basic operational procedures have also essentially remained the same. Wivenhoe Dam and Somerset Dam are operated in conjunction so as to maximise the overall flood mitigation capabilities of the two dams. The procedures outlined in this Manual are based on the operation of the dams in tandem.

The changes to the 2002 version of the manual have arisen out of the spillway upgrade process for Wivenhoe Dam with the addition of the three bay right abutment fuse plug spillway. The changes enable Wivenhoe Dam to pass a 1:100,000 AEP flood event. The manual covers the provisions introduced to cover flood operations of the dams including the auxiliary spillway.

Formatted: Highlight

Deleted: during the construction period for the spillway upgrade and for flood operations after theses provisions become operational.¶

Deleted: : 6

Deleted: December 2004

Meaning of Terms

In this Manual, save where a contrary definition appears -

"Act"
means the *Water Act 2000*;

“AEP”
means annual exceedance probability, the probability of a specified event being exceeded in any year.

"Agency"
includes a person, a local government and a department of state government within the meaning of the Acts Interpretation Act 1954;

"AHD"
means Australian Height Datum;

"Bureau of Meteorology"
means the Commonwealth Bureau of Meteorology;

"Chairperson"
means the Chairperson of the South East Queensland Water Corporation;

"Chief Executive"
means the Chief Executive or Director General of the Department of Natural Resources, Mines and Water;

Deleted: Department of Natural Resources and Mines

Deleted: , Mines & Energy

"Controlled Document"
means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

“Corporation”
means the South East Queensland Water Corporation;

"Dams"
means dams to which this Manual applies, that is Wivenhoe Dam and Somerset Dam;

"Dam Supervisor"
means the senior on-site officer at Wivenhoe or Somerset Dam as the case may be;

"EL"
means elevation in metres from Australian Height Datum;

"Flood Operations Engineer"
means the person designated at the time to direct the operations of Wivenhoe Dam and Somerset Dam under the general direction of the Senior Flood Operations Engineer and in accordance with the procedures in this Manual;

Deleted: : 6

Deleted: December 2004

"FSL" or "FULL SUPPLY LEVEL"
means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

"Gauge"
when referred to in (m) means river level referenced to AHD, and
when referred to in (m^3/sec) means flow rate in cubic metres per second;

"Headworks Operator"
for the purposes of this manual the Headworks Operator is the South-East Queensland Water Corporation and any operator engaged by it, as the context permits

"Manual" or "Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam"
means the current version of this Manual;

"Power Station"
means the Wivenhoe pumped storage hydro-electric power station associated with Wivenhoe Dam and Split-Yard Creek Dam;

"Senior Flood Operations Engineer"
means the senior person designated at the time pursuant to Section 2.1 of this Manual under whose general direction the procedures in this Manual must be carried out;

"South East Queensland Water Corporation"
means South East Queensland Water Corporation Limited, Registered Public Company, ABN 14 008 729 766

Deleted: : 6

Deleted: December 2004

1.2 Purpose of Manual

Formatted: Bullets and Numbering

The purpose of this Manual is to define procedures for the operation of Wivenhoe Dam and Somerset Dam to reduce, so far as practicable, the effects of flooding, by the proper control and regulation in time of headworks under the control of the Corporation, with due regard to the safety of the structures comprising those headworks.

For the purpose of this Manual, the Corporation adopts the policy that the community is to be protected to the maximum extent practical against flood hazards recognising the limitations on being able to:

- identify all potential flood hazards and their likelihood,
- remove or reduce community vulnerability to flood hazards,
- effectively respond to flooding, and
- provide resources in a cost effective manner.

1.3 Legal Authority

Formatted: Bullets and Numbering

This manual has been prepared as a Flood Mitigation Manual in accordance with the provisions of Part 6 Division 2 of the Act.

1.4 Application and Effect

Formatted: Bullets and Numbering

The procedures in this Manual apply to the operation of Wivenhoe Dam and Somerset Dam for the purpose of flood mitigation, and operation in accordance with the manual shall give the protection from liability provided by Section 500 of *Water Act 2000*.

1.5 Date of Effect

Formatted: Bullets and Numbering

The procedures in this Manual shall have effect on and from the date on which this version of the Manual is approved by gazette notice.

The Manual shall remain in force for the period of approval as determined by the chief executive. This approval may be for a period of up to five years.

Before the approval of the Manual expires, the Corporation must review and if necessary update the Manual and submit a copy to the chief executive for approval.

1.6 Observance of Manual

Formatted: Bullets and Numbering

This Manual contains the operational procedures for Wivenhoe Dam and Somerset Dam for the purposes of flood mitigation, and must be applied by the Headworks Operator for the operation of the dams.

Deleted: : 6

Deleted: December 2004

1.7 Provision for Variations to Manual

Deleted: ¶

Formatted: Bullets and Numbering

If the Corporation is of the opinion that the procedures in this Manual should be amended, altered or varied, it must submit for approval as soon as practical a request, which is in accordance with the flood mitigation provisions of the *Water Act 2000*, to the Chief Executive setting out the circumstances and the exact nature of the amendment, alteration or variation sought. The Chief Executive may require the Corporation amend the Manual by written notice.

1.8 Distribution of Manual

Formatted: Bullets and Numbering

The Corporation must regard the manual as a Controlled Document and ensure that only controlled manuals are used in the direction of flood mitigation activities. Agencies having copies of Controlled Documents are listed in Appendix B. The Corporation must maintain a Register of Contact Persons for Controlled Documents and ensure that each issued document is updated whenever amendments or changes are approved.

Before using this Manual for the direction of flood control, the Headworks Operator must ensure that it is the current version of the Controlled Document.

Deleted: : 6

Deleted: December 2004

2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

Pursuant to the provisions of the Act, the Corporation is responsible for and has the duty for operation and maintenance of Wivenhoe Dam and Somerset Dam.

The Headworks Operator is responsible for operating and maintaining Wivenhoe and Somerset Dams in accordance with this Manual and whilst the South-East Queensland Water Corporation may contract with other parties for the purpose of discharging its responsibilities as Headworks Operator, the Corporation remains responsible to ensure that operators, employees, agents, and contractors comply with this manual in order to retain the protection from liability afforded by Section 500 of the Act. Operators, employees, agents, and contractors also must comply with this Manual to obtain the protection of Section 500 of the Act.

2.1.1 Designation of Senior Flood Operations Engineer

The Headworks Operator must ensure that the procedures set out in this Manual are carried out under the general direction of a suitably qualified and experienced person who shall be referred to hereafter as the Senior Flood Operations Engineer. Only a person authorised in the Schedule of Authorities can give the general direction for carrying out procedures set out in this Manual.

2.1.2 Designation of Flood Operations Engineer

The Headworks Operator must have available or on standby at all times a suitably qualified and experienced Flood Operations Engineer to direct the operation of the dams during floods in accordance with the general strategy determined by the Senior Flood Operations Engineer.

The Headworks Operator must ensure that flood control of the dams is under the direction of a Flood Operations Engineer at all times. Only a person authorised in the Schedule of Authorities can direct the flood operation of the dams.

The Headworks Operator must also employ an adequate number of suitably qualified and experienced persons to assist the Flood Operations Engineer in the operation of the dams during floods.

2.2 Qualifications and Experience of Engineers

2.2.1 Qualifications

All engineers referred to in Section 2.1 must meet all applicable requirements of registration or certification under any relevant State Act, and must hold appropriate engineering qualifications to the satisfaction of the Chief Executive.

Deleted: : 6

Deleted: December 2004

2.2.2 Experience

All engineers referred to in Section 2.1 must, to the satisfaction of the Chief Executive, have:

(1) Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and

(2) At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:

(a) Investigation, design or construction of major dams;

(b) Operation and maintenance of major dams;

(c) Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;

(d) Applied hydrology with particular reference to flood forecasting and flood warning systems.

2.3 Schedule of Authorities

The Corporation must maintain a Schedule of Authorities containing a list of the Senior Flood Operations Engineers and Flood Operations Engineers approved to direct flood operations at the dams during floods. A copy of the Schedule of Authority must be provided to the chief executive by 1st September of each year.

The Headworks Operator shall, as the need arises, nominate suitably qualified and experienced engineers for registration in the Schedule of Authorities as Senior Flood Operations Engineers and Flood Operations Engineers. Each new nomination must include a copy of any certificate required under Section 2.2 and a validated statement of qualifications and experience.

The Headworks Operator must obtain the approval for all nominations from the Chief Executive prior to their inclusion in the Schedule of Authorities.

If, in the event of unforseen and emergency situations, no Senior Flood Operations Engineer or no Flood Operations Engineer is available from the Schedule of Authorities, the Headworks Operator must temporarily appoint a suitable person or persons and immediately seek ratification from the Chief Executive.

2.4 Training

The Headworks Operator must ensure that operational personnel required for flood control operations receive adequate training in the various activities involved in flood control operation.

Deleted: : 6

Deleted: December 2004

2.5 Dam Operation Arrangements

For the purposes of operation of the dams during times of flood, the Headworks Operator must ensure that:

(a) The operation be carried out under the general direction of the Senior Flood Operations Engineer, and

(b) In the direction of operations which may knowingly endanger life or property, the Senior Flood Operations Engineer must where practical liaise with the Chairperson of the Corporation and the Chief Executive or nominated delegate.

2.6 Responsibilities of the Senior Flood Operations Engineer

The Senior Flood Operations Engineer is responsible for the overall direction of flood operations.

Except insofar as reasonable discretion is provided for in Section 2.8 of this Manual, the Senior Flood Operations Engineer must ensure that the operational procedures for the dam shall be in accordance with this Manual.

2.7 Responsibilities of the Flood Operations Engineer

The Flood Operations Engineer must apply the operational procedures in accordance with this manual and the direction set for flood operations. In so doing, account must be taken of prevailing weather conditions, the probability of follow up storms and the ability of the dams to discharge excess flood waters in the period between rainfall events or in the period from the time of detection of conditions associated with the development storm cells, to the likely time of occurrence of the rainfall.

2.8 Reasonable Discretion

If in the opinion of the Senior Flood Operations Engineer, based on available information and professional experience, it is necessary to depart from the procedures set out in this manual, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary to meet the situation, provided that the Senior Flood Operations Engineer observes the flood mitigation objectives set out in Section 3 of this Manual when exercising such reasonable discretion.

Before exercising discretion under this Section of the Manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must consult with such of the following persons as are available at the time that the discretion has to be exercised:

the Chairperson of the Corporation, and
the Chief Executive or nominated delegate.

If not able to contact any of the above within a reasonable time, the Senior Flood Operations Engineer may proceed with such other procedures considered as necessary to meet the situation and report such action at the earliest opportunity to the above persons.

Deleted: t
Deleted: Operations Engineer
Deleted: i
Deleted: : 6
Deleted: December 2004

2.9 Report

The Senior Flood Operations Engineer must prepare a report to the Headworks Operator after each event that requires flood operation of the dams and the report must contain details of the procedures used, the reasons therefore and other pertinent information. The Headworks Operator must forward the report to the Chief Executive together with any comments within six weeks of the completion of the event referred to.

3 FLOOD MITIGATION OBJECTIVES

3.1 General

To meet the purpose of the flood operational procedures in this Manual, the following objectives, listed in descending order of importance, are as follows:

(a) Ensure the structural safety of the dams;

(b) Provide optimum protection of urbanised areas from inundation;

(c) Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;

(d) Minimise disruption and impact upon Wivenhoe Power Station;

(e) Minimise disruption to navigation in the Brisbane River.

3.2 Structural Safety of Dams

The structural safety of the dams must be the first consideration in the operation of the dams for the purpose of flood mitigation.

3.2.1 Wivenhoe Dam

The structural safety of Wivenhoe Dam is of paramount importance. Structural failure of Wivenhoe Dam would have catastrophic consequences.

Wivenhoe Dam is predominantly a central core rockfill dam. Such dams are not resistant to overtopping and are susceptible to breaching should such an event occur. Overtopping is considered a major threat to the security of Wivenhoe Dam. Works were undertaken between May 2004 and December 2005 to build an auxiliary spillway to cope with the 1:100,000 AEP flood event without overtopping of the dam. The auxiliary spillway consists of a three bay fixed crest spillway that includes erodible fuse plug embankments that are designed to initiate at varying trigger levels.

The auxiliary spillway works in conjunction with the existing gated spillway. The design intent of the auxiliary spillway is to try and ensure that the existing spillway gates are fully opened by the time the first fuse plug bay is initiated. This is on the basis that the discharges through the existing spillway will result in less damage than allowing discharges through the auxiliary spillway.

The damage from the initiation of the fuse plug bays will be confined to the area immediately below the spillway return channel, with the routing effects of the reach to Savages Crossing reducing the peak in flooding further downstream in the Brisbane River.

3.2.2 Somerset Dam

The structural safety of Somerset Dam also is of paramount importance. Failure of Somerset Dam could have catastrophic consequences.

Deleted: are being undertaken between

Deleted: : 6

Deleted: December 2004

Whilst Wivenhoe Dam has the capacity to mitigate the flood effects of such a failure in the absence of any other flooding, if the failure were to occur during major flooding, Wivenhoe Dam could be overtopped and destroyed also.

Somerset Dam is a mass concrete dam. Such dams can withstand limited overtopping without damage. Failure of such structures is rare but when they do occur, they occur suddenly without warning, creating very severe and destructive flood waves.

Deleted: ¶
¶
¶
¶

3.2.3 Extreme Floods and Closely Spaced Large Floods

Techniques for estimating extreme floods indicate that floods are possible which would overtop both dams. In the case of Wivenhoe Dam such an overtopping would most likely result in the destruction of the dam itself. Such events however require several days of intense rainfall to produce the necessary runoff.

Historical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane River system within a short time of each other. In order to be prepared to meet such a situation, the stored floodwaters from one storm should be discharged from the dams after a flood as quickly as would be consistent with the other major operating principles. Typically the Senior Flood Operations Engineer should aim to empty stored floodwaters within seven days after the flood peak has passed through the lower reaches of the Brisbane River. In a very large flood, this time frame may not be achievable because of downstream flood conditions and it may be necessary to extend the emptying period by several days.

The discharges should be regulated so as to have little impact on the urban reaches of the Brisbane River taking into account inflows into the river downstream of the dams. However they may result in submergence of some bridges. 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.

3.3 Inundation of Urban Areas

The prime purpose of incorporating flood mitigation measures into Wivenhoe Dam and Somerset Dam is to reduce flooding in the urban areas on the flood plains below Wivenhoe Dam. The peak flows of floods emanating from the upper catchments of Brisbane and Stanley Rivers can be reduced by using the flood-gates to control releases from the dams, taking into account flooding derived from the lower Brisbane River catchments.

The auxiliary spillway constructed at Wivenhoe Dam incorporates fuse plugs. Triggering of a fuse plug will increase floods levels downstream. Where possible, gate operations at both Wivenhoe and Somerset dams should be formulated to prevent operation of the fuse plug. This is likely to be only possible when the forecast peak water level for Wivenhoe Dam just exceeds the trigger level for the fuse plug and sufficient time is available to alter releases.

Deleted: being

Deleted: in 2004 and 2005

3.4 Disruption to Rural Areas

While the dams are being used for flood mitigation purposes, bridges and areas upstream of the dams may be temporarily inundated. Downstream of the dam, bridges and lower river

Deleted: : 6

Deleted: December 2004

terraces will be submerged. The operation of the dams should not prolong this inundation unnecessarily. The deck levels of bridges potentially inundated during flood events are shown on the Drawings in Appendix D.

3.5 Provision of Pumping Pool for Power Station

The power station is not affected by the reservoir level in Wivenhoe Dam during floods other than the impacts high tail water levels have on the efficiency of the power station. The power station does however require a pumping pool for operation. The loss of storage by dam failure would render the power station inoperative.

3.6 Disruption to Navigation

The disruption to navigation in the Brisbane River has been given the lower priority. The effect of flood flows upon navigation in the river varies widely.

Large ships can be manoeuvred in the river at considerable flood flows. On the other hand, barges and dredges are affected by low flows which lower salinity thus decreasing the density of the water which in turn causes craft to sit lower in the water, sometimes bottoming. The Moggill Ferry is also affected by low flood flows.

A short emptying period for the flood storage compartment of the dams is consistent with Objectives (c) and (e) of Section 3.1, which are closely related.

Deleted: : 6

Deleted: December 2004

4 FLOOD CLASSIFICATION

For the reference purposes of this Manual, five magnitudes of flooding are classified as follows:

Fresh
This causes only very low-level bridges to be submerged.

Minor Flooding
This causes inconvenience such as closing minor roads and the submergence of low-level bridges. Some urban properties are affected.

Moderate Flooding
This causes inundation of low-lying areas and may require the evacuation of some houses and/or business premises. Traffic bridges may be closed.

Major Flooding
This causes flooding of appreciable urban areas. Properties may become isolated. Major disruption occurs to traffic. Evacuation of many houses and business premises may be required.

Extreme Flooding
This causes flooding well in excess of floods in living memory and general evacuation of whole areas are likely to be required.

Usually a flood does not cause the same category of flooding along its entire length and the relevant agencies shall have regard to this when flooding is predicted.

(The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia)

Deleted:

Deleted: : 6

Deleted: December 2004

5 FLOOD MONITORING AND WARNING SYSTEM

5.1 General

A real time flood monitoring and warning system is established in the Brisbane Valley. This system is based upon an event reporting protocol. A radio telemetry system (ALERT) is used to collect, transmit and receive rainfall and streamflow information. The system consists of more than 50 field stations that automatically record rainfall and/or river heights at selected locations in the Stanley and Brisbane River catchments. Some of the field stations are owned by the Corporation with the remainder belonging to other agencies.

The rainfall and river height data is transmitted by radio telemetry, via repeater stations, to base stations at the head office of the Headworks Operator (and the Corporation). There the data is processed in real time by computer programs to assess what is occurring in the catchments in terms of flood flows and what could occur if weather conditions continued, or changed.

Other agencies with their own base stations can, and do, receive data transmissions direct, and so collect and are able to process rainfall and streamflow information appropriate to their needs.

The real time flood model (RTFM) is a suite of hydrologic and hydraulic computer programs that utilise the real time ALERT data to assist in the operation of the dams during flood events.

5.2 Operation

The Headworks Operator is responsible for operating the computer model provided by the Corporation for flood monitoring and forecasting during flood events to optimise flood gate operations and minimise the impacts of flooding.

It is the responsibility of the Corporation to maintain and keep calibrated its own equipment; and to enter into such arrangements with other agencies or to provide such further equipment as the Corporation deems necessary for the Headworks Operator to properly operate the computer model for flood monitoring and forecasting.

A system such as this is expected to improve over time due to:

- improved operation and reliability with experience,
- improved calibration as further data becomes available,
- software upgrades, and
- the number, type and locations of sensors being varied.

A regular process of internal audit and management review must be maintained to achieve this.

A log of the performance of all field equipment necessary to properly operate the computer model must be kept by the Corporation. The log is to also include all revised field calibrations and changes to the number, type and locations of gauges. Entries onto the log are to be notified to the Headworks Operator without delay in writing.

Deleted: ¶

Deleted: : 6

Deleted: December 2004

A log of the performance of the system (ALERT and RTFM) must be kept by the Senior Flood Operations Engineer. Any faults to the computer hardware or software, and any faults to field equipment which the Corporation has not advised the Headworks Operator of, are to be notified to the Corporation without delay in writing. The Corporation must promptly attend to the matters under its control and refer other matters to the appropriate agencies.

Whenever the Senior Flood Operations Engineer considers that the performance and functionality of the system can be improved, by whatever means, a recommendation must be made to the Headworks Operator accordingly. The Headworks Operator must promptly consider, act on, or refer such recommendations to the Corporation as it considers appropriate.

5.3 Storage of Documentation

The performance of any flood monitoring and warning system is reliant on accurate historical data over a long period of time. The Senior Flood Operations Engineer must ensure that all available data and other documentation is appropriately collected and catalogued as approved by the Corporation, for future use.

5.4 Key Reference Gauges

Key field station locations have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to relocate field stations from these locations, or vary flood classification levels, agreement must first be obtained between the Corporation, Headworks Operator, Bureau of Meteorology and the Local Governments within whose boundaries the locations are situated. The locations and gauge readings at which the various classifications of flooding occur are contained in Appendix D.

Gauge boards that can be read manually must be maintained as part of the equipment of each key field station. The Corporation must have procedures to ensure such gauge boards are read in the event of failure of field stations to operate.

5.5 Reference Gauge Values

Other agencies such as the Bureau of Meteorology, Ipswich City Council and the Brisbane City Council have direct access to the information from field stations for flood assessment purposes. The consultation between agencies is a very important part of the assessment and prediction of flood flows and heights.

The Corporation must ensure that information relative to the calibration of the Corporation’s field stations is shared with such agencies.

Deleted: : 6

Deleted: December 2004

6 COMMUNICATIONS

6.1 Communications between Staff

The Corporation is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams.

The Headworks Operator is responsible for ensuring that adequate communication exists at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams. Where equipment deficiencies are detected during normal operations, such deficiencies are to be reported within one week to the Corporation for timely corrective action.

6.2 Dissemination of Information

Other agencies have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public. Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public. Agency information requirements are generally as shown in Table 6.1.

The Flood Operations Engineer must supply information to each of these agencies during dam releases. For this purpose, the Corporation must maintain a Register of Contact Persons for Information, their means of contact including back up systems, and the specific information, including the timing, to be supplied to each. The Corporation must ensure that each agency receives a copy of the updated Register of Contact Persons for Information whenever amendments are made, but at least every 6 months.

The Corporation, Headworks Operator, Senior Flood Operations Engineer and Flood Operations Engineer must liaise and consult with the agencies with a view to ensuring all information relative to the flood event is consistent, and used and disseminated in accordance with agreed responsibilities.

All enquiries other than provided for in the Register of Contact Persons for Information, either to the Headworks Operator, the Senior Flood Operations Engineer, the Flood Operations Engineer or dam site staff must be referred to the Corporation. The Corporation must provide a mechanism to receive these enquiries from the time it is advised that releases from the dams are likely until flood release operations are completed.

Deleted: : 6

Deleted: December 2004

TABLE 6.1 - AGENCY INFORMATION REQUIREMENTS

Agency	Activity	Information Requirement from SEQWC Flood Centre	Trigger
Bureau of Meteorology	Issue of flood warnings for Brisbane River basin	Actual and projected discharges from Wivenhoe Dam Actual and projected discharges from Somerset Dam	Initial gate operations and thereafter at intervals to suit forecasting requirements.
Natural Resources and Mines	Review of flood operations and discretionary powers.	Actual and predicted lake levels and discharges	
Kilcoy Shire Council	Flood level information upstream of Somerset Dam	Actual and predicted lake levels, Somerset Dam	Somerset Dam water level predicted to exceed EL 102
Esk Shire Council	Flood Level information upstream and downstream of Wivenhoe Dam	Actual and predicted lake levels and discharges, Wivenhoe Dam	Initial Wivenhoe Dam gate operation.
Ipswich City Council	Flood level information for Ipswich City area	Nil (information obtained from BoM)	
Brisbane City Council	Flood level information for Brisbane City area	Nil (information obtained from BoM)	

Deleted: & Energy

Deleted: : 6

Deleted: December 2004

6.3 Release of Information to the Public

The Corporation is responsible for the issue of information regarding storage conditions and current and proposed releases from the dams to the public and the media.

The Bureau of Meteorology has responsibility for issuing flood warnings.

The Emergency Services Response Authorities, under the Disaster Management Act 2003, have responsibility for the preparation of a local counter disaster plan hence the interpretation of flood forecast information for inclusion in their local flood warnings prepared under the flood sub plan of the counter disaster plan.

Deleted: : 6

Deleted: December 2004

7 REVIEW

7.1 Introduction

This review of the Manual has addressed the mechanisms of delegation and control of the dams in periods of operation of the dams for flood mitigation. It is known overtopping of the dams can result should floods occur which are derived from lesser rainfall than the probable maximum precipitation storm or from the combination of two lesser storms in close proximity. The dams may also overtop in the eventuality that the flood-gate control systems or fuse plugs fail to operate as planned or partially malfunction during the passage of a major flood or combination of floods.

Procedures and systems have been developed that should enable lower risk operation of the dams for flood mitigation purposes. This technology is intended to provide longer warning times and the capability of examining options to optimise the safety of the dams and minimise the hazard potential and risk to the community.

With the passage of time neither the technical assumptions nor the physical conditions on which this Manual is based may remain unchanged. It is also recognised that the relevance of the Manual may change with changing circumstances.

It is important, therefore, that the Manual contain operational procedures which in themselves cause the Manual's procedures, and the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

The checking and reviewing process must involve the Headworks Operator and all associated operations personnel in order that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based.

Variations to the Manual may be made in accordance with provisions in Section 1.8.

7.2 Personnel Training

The Headworks Operator must report to the Corporation by 30th September each year on the training and state of preparedness of operations personnel. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources, Mines and Water within 14 days of it being received by the Corporation.

Deleted: Department of Natural Resources and Mines

Deleted: , Mines & Energy

Deleted: ¶

Formatted: Bullets and Numbering

7.3 Monitoring and Warning System and Communication Networks

The Headworks Operator must provide a report to the Corporation by the 1st May and 1st November of each year; and after each flood event. The report must assess in terms of hardware, software and personnel, the :

- adequacy of the communication and data gathering facilities,
- reliability of the system over the previous period,
- reliability of the system under prolonged flood conditions,
- accuracy of forecasting flood flows and heights, and
- the overall state of preparedness of the system.

Deleted: : 6

Deleted: December 2004

The Corporation must review the report, and taking into account its own log of the performance of the field equipment, take any action considered necessary for the proper functioning and improvement of the system. . A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources, Mines and Water within 14 days of it being received by the Corporation.

Deleted: and

Deleted: ,

Deleted: & Energy

7.4 Operational Review

After each significant flood event, the Corporation must review the effectiveness of the operational procedures contained in this manual. The Headworks Operator is required to prepare a report for submission to the Corporation within six weeks of any flood event that requires mobilisation of the Flood Control Centre. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources, Mines and Water within 14 days of it being received by the Corporation.

Deleted: ,

Deleted: and

Deleted: Mines & Energy

7.5 Five Yearly Review

Prior to the expiry of the approval period, the Corporation must review the Manual pursuant to Section 6 Division 2 of the Act. The review is to take into account the continued suitability of the communication network, and the flood monitoring and warning system as well as hydrological and hydraulic engineering assessments of the operational procedures. The hydrologic investigations performed for the purpose of this manual are discussed in Appendix I.

Deleted: : 6

Deleted: December 2004

8 WIVENHOE DAM OPERATIONAL PROCEDURES

8.1 Introduction

Wivenhoe Dam is capable of being operated in a number of ways to reduce flooding in the Brisbane River downstream of the dam, depending on the part of the catchment in which the flood originates and depending also on the magnitude of the flood. Maximum overall flood mitigation effect will be achieved by operating Wivenhoe Dam in conjunction with Somerset Dam.

A general plan and cross-section of Wivenhoe Dam, and relevant elevations are included in Appendix J. Storage and discharge data are included in Appendix E.

The reservoir volume above FSL of EL 67.0 is available as temporary flood storage. How much of the available flood storage compartment is utilised, will depend on the initial reservoir level below FSL, the magnitude of the flood being regulated and the procedures adopted. Spiltyard Creek Dam is part of the overall Wivenhoe Area Project and it forms the upper pumped storage of the peak power generation scheme. Splityard Creek Dam impounds a volume of 28 700 ML at its normal full supply level (EL 166.5). The contents of Splityard Creek Dam can be emptied into Lake Wivenhoe within 12 hours by releasing water through the power station conduits. This volume of water can affect the level in Wivenhoe Dam by up to 300mm when Wivenhoe Dam is close to FSL. Operation of the power station and therefore also release of water from Splityard Creek Dam to Lake Wivenhoe is outside the control of the Corporation. The operational level of Splityard Creek Dam should be considered when assessing the various trigger levels of Wivenhoe Dam.

The Corporation has acquired land above FSL to a level of EL 75.0 to provide temporary flood storage. Reasonable care must be exercised to confine the flood rises to below this level. This requirement should be ignored in the case of extreme floods that threaten the safety of the dams.

8.2 Auxiliary Spillway

The auxiliary spillway for Wivenhoe Dam constructed in 2004/05 as part of an upgrade to improve flood adequacy consists of a three bay fuse plug spillway located on the right abutment of the main embankment. In association with other works carried out at the dam, the dam crest flood is now assessed as having an annual exceedance probability (AEP) of approximately 1 in 100,000. Another one bay fuse plug spillway may be constructed at Saddle Dam Two in the future to provide full protection against the Probable Maxmimum Flood.

Deleted: being
Deleted: at
Deleted: being
Deleted: this will give
Deleted: t

Pertinent information about the auxiliary spillway, including the initiation level for the specific bays is given in Table 8.1.

TABLE 8.1 -RIGHT BANK FUSE PLUG DETAILS

Auxiliary Spillway Component	Spillway Crest Control Type	Spillway Crest Width (m)	Spillway Crest Level (m AHD)	Fuse Plug Pilot Channel Invert Level (m AHD)	Lake Level corresponding to Fuse Plug Pilot Channel Invert Level* (m AHD)
Central fuse plug bay	Ogee	34	67	75.7	75.7
Right hand side fuse plug bay	Ogee	64.5	67	76.2	76.23+
Left hand side fuse plug bay	Ogee	65.5	67	76.7	76.78++

* Lake Water Level is as per that measured at the Headwater Gauge.
Initiation of Fuse Plug is expected to occur when the Lake Water Level exceeds the Lake Level at Fuse Plug Pilot Channel by 0.10 - 0.15 m

\+ Includes 0.03m of drawdown from the Fuse Plug Pilot Channel Invert to the Lake Water Level

++ Includes 0.08m of drawdown from the Fuse Plug Pilot Channel Invert to the Lake Water Level

8.3 Initial Flood Control Action

When indications are received of an imminent flood, the flood control operation of the dam must commence with the storing of all inflow of the Brisbane River in Wivenhoe Dam, whilst an assessment is made of the origin and magnitude of the flood. The spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding EL 67.25.

8.4 Regulator and Gate Operation Sequences

Rapid opening of outlets (spillway gates and regulators) can cause hydraulic surges and other effects in the Brisbane River that can endanger life and property and may sometimes have other adverse effects. Under normal gate operations, the gates and regulators are therefore to be operated one at a time at intervals that will minimise adverse impacts on the river system.

Rapid closure of the gates can affect river-bank stability. Rapid closure of more than one gate at a time should only be used when time is critical and there is a requirement to correct a malfunction to preserve storage or to reduce downstream flooding rapidly. For flood operations where time is not critical, longer closure intervals should be used. The minimum closure intervals specified below are based on the recession limb of natural flood hydrographs such as the January 1974 flood.

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a gate by the immediate opening of a regulator valve (or the reverse operation). This allows for greater control of low flows and enables a smooth transition and closure as slow as possible to prevent the stranding of fish downstream of Wivenhoe Dam.

Except as provided for in Procedure 4 of Section 8.4 where it is necessary to prevent operation of a fuse plug or to have the gates clear of the spillway flow prior to the fuse plug operating and as indicated above, the gate opening and closing intervals as shown in Table 8.2 are the most rapid permitted for flood mitigation purposes.

Deleted: ¶
Deleted: at
Deleted: Initiation
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: 5
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: ¶
Deleted: 7.2
Deleted: ¶
¶
Formatted: Bullets and Numbering
Deleted: p
Deleted: : 6
Deleted: December 2004

TABLE 8.2 - MINIMUM INTERVALS FOR NORMAL GATE OPERATIONS

500 mm Incremental gate openings	10 minutes
500 mm Incremental gate closures	20 minutes
Full regulator opening or closures	30 minutes

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions, or when gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool, which has been excavated into erodible sandstone rock, and cause non-predictable erosion. Upstream migration of this erosion is to be avoided. The wing walls adjacent to the flip bucket deflect the discharge away from the walls of the plunge pool when gates 1 and 5 are operated.

Therefore in operating the spillway, the principles to be observed are, in order of priority:

(i) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

(ii) The flow in the spillway is to be symmetrical.

Under normal operation, only one gate is to be opened at any one time and the sequences given in Table 8.3 are to be adopted:

Deleted: : 6

Deleted: December 2004

TABLE 8.3 – RADIAL GATE OPENING SEQUENCES[1]

Approximate Discharge Range	Gate opening sequence[2]	Comments
(a) Up to 330 m^3/sec	Open Gate 3 up to 3.5 metres	Gates 1, 2, 4 & 5 remain closed
(b) 330 m^3/sec to 575 m^3/sec	Gate 3 at 3.5 metres Open Gates 2 & 4 alternately to 0.5 metre Open Gate 3 to 4.0 metre Open Gates 2 & 4 alternately to 1.0 metre	Gates 1 & 5 remain closed unless discharge from Gates 2 & 4 impinges on side wall of plunge pool proceed to (c)
(c) 575 m^3/sec to 1160 m^3/sec	Gate 3 kept at 4.0 metres Open Gates 1 & 5 alternately one increment followed by Gates 2 & 4 alternately one increment Repeat Step until at the end of the sequence Gates 1 & 5 are open 1.5 metres and Gates 2 & 4 are open 2.5 metres	Flow in spillway to be as symmetrical as possible Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5
(d) 1160 m^3/sec to 1385 m^3/sec	Open Gate 3 to 4.0 metres Open Gates 1 & 5 alternately to 2.0 metres followed by opening Gates 2 & 4 alternately to 3.0 metres	Flow in spillway to be as symmetrical as possible Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5
(e) 1385 m^3/sec to 2290 m^3/sec	Open ALL gates to 5.0 metre openings	Flow in spillway to be as symmetrical as possible Gates 2 & 4 are to have openings not less than Gates 1 & 5 or not more than 1.0 metre more than Gates 1 & 5 Gate 3 is to have an opening not less than Gates 2 & 4 or not more than 1.0 metre more than Gates 2 & 4.
(f) Greater than 2290 m^3/sec	Open ALL gates incrementally in the sequence 3, 2, 4, 1, 5[3]	Flow in spillway to be as symmetrical as possible Gate 3 to have the largest opening Gates 2 & 4 are to have openings greater than Gates 1 & 5

1 Gates are numbered 1 to 5 from the left bank looking downstream.
2 Gate movements are to normally occur in 500 mm increments.
3 When the accelerated opening rate applies, gate-opening increments of 1.0 metres may be used.

Deleted: gate opening
Deleted: : 6
Deleted: December 2004

Gate operating procedures in the event of equipment failure are contained in Appendix G. If one or more gates are inoperable during the course of the flood event, the gate openings of the remaining gates are to be adjusted to compensate. These adjustments should ensure that:

a) the impact of the flow on the sidewalls of the plunge pool should be minimised, and
b) the flow in the spillway is as symmetrical as practicable.

In general, gate closing is to occur in the reverse order. The final gate closure should occur when the lake level has returned to Full Supply Level.

8.5 Flood Control Procedures

When the preliminary estimation of the degree of expected flooding has been made, the operating procedures set out hereunder shall be used at Wivenhoe Dam in line with the Flood Mitigation Objectives.

When considering the discharge to be made from both Wivenhoe Dam and Somerset Dam under particular procedures, the total discharge for each dam from all sources is to be considered when determining the appropriate openings for gates, valves and sluices.

The flood control procedures to be adopted commence with Procedure 1 and extend through to Procedure 4 as the magnitude of the flood as predicted by the real time flood model increases. Table 8.5 summarises the application for each procedure for the initial filling of Wivenhoe Dam. Once Wivenhoe Dam has peaked and the drainage phase has commenced the indicative limits will not apply.

Procedure 1

Under Procedure 1, water is to be released from Wivenhoe Dam with care being taken not to prematurely submerge the downstream bridges. The limiting condition for Procedure 1 is the submergence of Mt Crosby Weir Bridge that occurs at approximately 1,900 m^3/sec.

The procedure adopted primarily depends on the level in Wivenhoe Dam and the discharge emanating from Lockyer Creek.

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. Except in the drainage phase releases are not to exceed the values given in Table 8.4:-

Deleted: : 6
Deleted: December 2004

TABLE 8.4 – WIVENHOE DAM, PROCEDURE 1 MAXIMUM RELEASE RATES

Lake Level in Wivenhoe Dam	Maximum Release Rate (m^3/sec)
67.00 - 67.25	0
67.25 - 67.50	110
67.50 - 67.75	380
67.75 - 68.00	500
68.00 - 68.25	900
68.25 - 68.50	1900

The following subsets of Procedure 1 were originally developed by the Brisbane City Council to cater for limiting the submergence of the various low-level downstream bridges. The procedures require a great deal of control over releases and knowledge of discharges from Lockyer Creek.

In general, the releases from Wivenhoe Dam are controlled such that the combined flow from Lockyer Creek and Wivenhoe Dam is less than the limiting values to delay the submergence of particular bridges.

Procedure 1A *Savages Crossing & Colleges Crossing*

For: Lake level between 67.25 and 67.5 m AHD [Maximum Release 110 m^3/sec]

Endeavour to maintain Twin Bridges trafficable by limiting releases at Wivenhoe Dam to a maximum of 50 m^3/sec and by reducing this rate of release if run-off from Lockyer Creek is likely to cause the bridges to be overtopped. The bridges become untrafficable at a flow of about 55 m^3/sec.

Once Twin Bridges are overtopped by run-off from Lockyer Creek, release to be directed towards maintaining College's Crossing trafficable by adjusting the rate of release so that the combined flow rate at College's Crossing is less than 175 m^3/sec.

Procedure 1B *Noogoorah Bridge (Burtons Bridge)*

For: Lake level between 67.50 and 67.75 m AHD [Maximum Release 380 m^3/sec]

Initially endeavour to maintain College's Crossing trafficable. This becomes untrafficable at a flow of about 175 m^3/sec. No consideration to be given to keeping Twin Bridges trafficable.

Once College's Crossing is flooded by the run-off from Lockyer Creek and the downstream section of the Brisbane River, releases to be set to achieve a combined flow of about 380 m^3/sec at the Noogoorah Bridge Crossing. This bridge becomes untrafficable at a flow of about 430 m^3/sec.

Deleted: : 6

Deleted: December 2004

Procedure 1C *Kholo Bridge*

For: Lake level between 67.75 and 68.00 m AHD [Maximum Release 500 m^3/sec]

Initially endeavour to maintain Noogoorah Bridge trafficable. No consideration to be given to keeping College's Crossing trafficable.

Once Noogoorah Bridge is flooded by the run-off from Lockyer Creek and the downstream section of the Brisbane River, releases to be set to keep Kholo Bridge trafficable. This bridge becomes untrafficable at a flow rate of about 550 m^3/sec.

Procedure 1D *Mt Crosby Weir Bridge*

For: Lake level between 68.00 and 68.25 m AHD [Maximum Release 900 m^3/sec]

Initially endeavour to maintain Kholo Bridge trafficable. No consideration to be given to keeping Noogoorah Bridge trafficable.

Once Kholo Bridge is flooded by the run-off from Lockyer Creek and the downstream section of the Brisbane River, releases to be set to keep Mt Crosby Bridge trafficable. This bridge becomes untrafficable at a flow of 1,900 m^3/sec.

Procedure 1E *Mt Crosby Weir Bridge*

For: Lake level between 68.25 and 68.50 m AHD [Maximum Release 1,900 m^3/sec]

Similar to Procedure 1D, but with an upper release limit of 1,900 m^3/sec.

If the level reaches EL 68.5 m AHD in Wivenhoe Dam, operations switch to Procedure 2 or 3 as appropriate.

Procedure 2 may be bypassed if it is clear from the flood modelling that Procedure 3 will be activated.

Procedure 2

Under Procedure 2, water is to be released from Wivenhoe Dam with care being taken not to submerge Fernvale Bridge and Mt Crosby Weir Bridge prematurely. Typically releases will take place on the rising limb of the flow from Lockyer Creek. If this flow is sufficient to submerge Mt Crosby Weir bridge (1,900 m^3/sec), releases are to be increased such that the combined flow from Lockyer Creek and Wivenhoe Dam releases does not exceed either:-

(i) 3,500 m^3/sec at Lowood or
(ii) the greater of the peak flow of Lockyer Creek or the predicted peak flood flow of the Bremer River.

Deleted: : 6
Deleted: December 2004

Should the Mt Crosby Weir Bridge be flooded by flows from catchments downstream of Wivenhoe Dam, the upper limit of the combined Lockyer Creek flow and releases from Wivenhoe Dam shall, subject to (i) and (ii) above, not exceed 3,500 m^3/sec at Lowood.

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

Procedure 3

Under Procedure 3, water is to be released from Wivenhoe Dam such that the combined Lockyer Creek flood flow and Wivenhoe Dam release is not to exceed 3,500 m^3/sec at Lowood. The releases are to be regulated such that the total regulated flow at Moggill gauge downstream of the Bremer River junction does not exceed 4,000 m^3/sec [which is the upper limit for non-damaging flows for the urban reaches of the Brisbane River].

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

Procedure 4

This procedure normally comes into effect when the water level in Wivenhoe Dam reaches EL 74. However the Senior Flood Operations Engineer may seek to invoke the discretionary powers of Section 2.8 if earlier commencement is able to prevent triggering of a fuse plug.

Deleted: *s*

Under Procedure 4 the release rate is increased as the safety of the dam becomes the priority. Opening of the gates is to occur until the storage level of Wivenhoe Dam begins to fall.

If required, the minimum time interval between gate openings can be reduced or successive gate openings of the same gate may be used in this procedure as considered appropriate. In addition to dam safety issues, the impact of rapidly increasing discharge from Wivenhoe Dam on downstream reaches should be considered in determining these intervals

Sub-procedures 4A, and 4B have been developed for use depending on the expected peak water level in the dam.

Deleted: *and 4C*

Deleted: *the stage of construction of the auxiliary spillway and the*

Deleted: ***Procedures 4A and 4B are only to be applied once the auxiliary spillway fuse plug is functional. This is expected to be in the latter part of 2005. In the interim, Procedure 4C is applicable.¶***

Procedure 4A

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

Gate openings are to occur at the minimum intervals and sequences as specified in Section 8.3. Opening of the gates is to continue until the storage level of Wivenhoe Dam begins to fall.

Deleted: *s*

Deleted: : 6

Deleted: December 2004

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

Procedure 4B

Procedure 4B applies once indications are the peak flood level in Wivenhoe Dam will exceed EL75.5 using the minimum gate opening intervals for normal operation as specified in Section 8.3 i.e. it is expected that the fuse plug will be triggered under normal operation.

In this procedure the minimum time interval between gate openings is able to be reduced and successive gate openings of the same gate may be made.

If the real time flood model using a 1 metre in 10 minute gate opening procedure, predicts a peak water level in Wivenhoe Dam of less than EL 75.5, the gates may be raised at a rate to maximise flood storage capacity but to prevent the first fuse plug from initiating.

Otherwise the gates are to be raised at a rate to ensure they are out of the water before the initiation of the first fuse plug (if possible). Where practicable, the gates are to be in the fully open position before the dam water level reaches EL 75.7 m AHD.

In addition to dam safety issues, the impact of rapidly increasing discharge from Wivenhoe Dam on downstream reaches should be considered in determining these intervals.

The effect of varying the operational procedures at Somerset Dam in keeping the peak flood level at Wivenhoe Dam below EL 75.7 may also be investigated using the real time flood model.

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

Deleted: s

Deleted: Procedure 4C

Procedure 4C applies only during the construction phase of the right bank auxiliary spillway.

Opening of the gates is to occur until the storage level of Wivenhoe Dam begins to fall. The minimum time interval between gate openings can be reduced or successive gate openings of the same gate may be used in this procedure as considered appropriate for ensuring the safety of the dam. In addition to dam safety issues, the impact of rapidly increasing discharge from Wivenhoe Dam on downstream reaches should be considered in determining these intervals.

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

Deleted: : 6

Deleted: December 2004

TABLE 8.5 WIVENHOE DAM – NORMAL RELEASE OPERATING PROCEDURES: INITIAL FILLING

Procedure	Reservoir Level	Applicable Limits		
0	EL < 67.25	$Q_{Wivenhoe} = 0\ m^3/sec$ ... i.e No Releases		
1A	67.25 < EL < 67.50	$Q_{Wivenhoe} < 110\ m^3/sec$	$Q_{Colleges\ Crossing} < 175\ m^3/sec$ with care taken not to submerge Twin Bridges prematurely	
1B	67.25 < EL < 67.50	$Q_{Wivenhoe} < 380\ m^3/sec$	$Q_{Burtons/Noogoorah} < 430\ m^3/sec$ with care taken not to submerge Colleges Crossing prematurely	
1C	67.75 < EL < 68.00	$Q_{Wivenhoe} < 500\ m^3/sec$	$Q_{Kholo} < 550\ m^3/sec$ with care taken not to submerge Burtons/Noogoorah prematurely	
1D	68.00 < EL < 68.25	$Q_{Wivenhoe} < 900\ m^3/sec$	$Q_{MtCrosby} < 1900 m^3/sec$ with care taken not to submerge Kholo prematurely	
1E	68.25 < EL < 68.50	$Q_{Wivenhoe} < 1500\ m^3/sec$	$Q_{MtCrosby} < 1900 m^3/sec$ with care taken not to submerge Kholo prematurely	
2	68.50 < EL < 74.00	$Q_{Lowood} < 3500\ m^3/sec$	Q_{Lowood} < peak of Lockyer <u>and</u> Q_{Lowood} < peak of Bremer	Gates are <u>NOT</u> to be overtopped
3	68.50 < EL < 74.00	$Q_{Lowood} < 3500\ m^3/sec$	$Q_{Moggill} < 4000\ m^3/sec$	
4	EL > 74.00[4]	Gates are to be opened until reservoir level begins to fall		

4 Once water level exceeds EL 74.0, operating procedures are dependant on the predicted peak water level.

Deleted: : 6

Deleted: December 2004

8.6 Closing Procedures

If at the time the lake level in Wivenhoe Dam begins to fall, the combined flow at Lowood is in excess of 3500 m^3/sec, then the combined flow at Lowood is to be reduced to 3500 m^3/sec as quickly as practicable having regard to Section 3, and is to remain at this rate until final gate closure procedures can commence.

Gate closing procedures should be initiated having regard to the following requirements:

a) Early release of stored water to regain flood-mitigating ability for any subsequent flood inflows as described in Section 3.2.3.

b) The total discharge from Wivenhoe Dam from all sources is to be considered when considering appropriate closing procedures. This includes any discharge from triggered fuse plugs.

c) Gate operation procedures as described in Section 8.4.

d) Establishment of storage at FSL at completion of flood events.

e) Downstream impact of the discharges. To prevent the stranding of fish downstream of the dam, closures below flows of 275 m^3/sec should be undertaken as slow as practicable and if possible such closures should occur during daylight hours on a weekday so that personnel are available for fish rescue.

If the flood storage compartments of Wivenhoe Dam and Somerset Dam can be emptied within the prescribed time of seven days, the release from Wivenhoe Dam should be limited to between 1900 m^3/sec and 3500 m^3/sec. In such circumstances, the release from the dam should be less than the peak flow into the lake. Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.

8.7 Modification to Flood Operating Procedures if a Fuse Plug triggers prematurely

Where the operation of a fuse plug spillway bay has been triggered prior to its design initiation level being reached, the flood operation procedures are to be modified such that:

- the discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;
- the gates are to be operated, to the extent possible, so that the same discharge restrictions apply as would have if the fuse plug embankment was intact.

8.8 Modification to Flood Operating Procedures if a subsequent flood event occurs prior to the reconstruction of Triggered Fuse Plugs

Deleted: : 6

Deleted: December 2004

Where the operation of any or all of the fuse plug spillway bays has been triggered and a flood event occurs before the fuse plug can be reinstated, the flood operation procedures are to be modified such that:

- the discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;

- the gates are to be operated, to the extent possible, so that the same discharge restrictions apply as would have if the fuse plug embankment was intact.

Deleted: **<#>Additional Provisions during Construction Works 2004/05¶**
¶
<#>Auxiliary Spillway Area¶
¶
The embankment forming the temporary road diversion that acts as a coffer dam is to be retained in place until the construction of the fuse plug has proceeded past EL 74, and then its removal is only to proceed once the written approval of a Senior Flood Operations Engineer has been obtained.¶
¶
<#>Gated Spillway Area¶
¶
The following provisions will apply for works undertaken within the gated spillway:¶
¶
<#>The opening of spillway gates to discharge floodwaters is at the sole discretion of the Senior Flood Operations Engineer;¶
¶
<#>There is to be no obstruction of any spillway bay without the written approval of the Senior Flood Operations Engineer;¶
¶
<#>All gates are to be capable of being operated at short notice during a flood if required. To ensure this capability is maintained Table 8.6 specifies limitations that apply to the number of bays in which works may be occurring at any time. This table also nominates a target notice period to be provided by the Senior Flood Operations Engineer for the removal of construction material from the spillway bays prior to their use for releases. However the Senior Flood Operations Engineer is not constrained to provide this length of notice before operating any particular gate if its earlier operation is considered nec ... [2]

Deleted: : 6

Deleted: December 2004

9 SOMERSET DAM OPERATIONAL PROCEDURES

9.1 Introduction

Somerset Dam is capable of being operated in a number of ways to regulate Stanley River floods. Somerset Dam and Wivenhoe Dam are meant to be operated in conjunction to optimise the flood mitigation capacity downstream of Wivenhoe Dam.

A general plan and cross-section of Somerset Dam, and relevant dam operating levels are included in Appendix J.

The discharge capacities for various storage levels of Somerset Dam are listed in Appendix F.

9.2 Initial Flood Control Action

Upon indications being received of a significant inflow, the flood control operation of the dam shall commence with the raising of any closed gates and the closure of all low level regulators and sluices, whilst an assessment is made of the origin and magnitude of the flood.

9.3 Regulator and Gate Operation Procedures

The following minimum intervals must be observed whilst opening and closing regulators, sluices and crest gates at Somerset Dam for flood mitigation purposes:

TABLE 9.1- MINIMUM INTERVALS, NORMAL OPERATION, SOMERSET DAM

	OPENING	CLOSING
Regulators	30 minutes	60 minutes
Sluice Gates	120 minutes	180 minutes
Crest Gates	Gates are normally open	

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a sluice gate by the immediate opening of one or more regulator valves (or the reverse operation). This allows for greater control of low flows and enables a smooth transition on opening and closing sequences.

Deleted: : 6

Deleted: December 2004

9.4 Flood Control Procedure

It is essential that the operating procedures adopted should not endanger the safety of Wivenhoe Dam downstream. Within this constraint, the Senior Flood Operations Engineer must adopt a procedure for the operation of Somerset Dam such that:

a) the structural safety of Somerset Dam is not endangered;

b) the Upper Brisbane River flood flow plus Somerset Dam releases does not cause Wivenhoe Dam to be overtopped.

The normal operating procedure to be used for Somerset Dam is as follows.

The crest gates are raised to enable uncontrolled discharge. The low level regulators and sluices are to be kept closed until either:

(i) the lake level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

In the case of (i) above the opening of the regulators and sluices is not to increase the inflow to Wivenhoe Dam above the peak inflow from the Brisbane River just passed or, if possible, not to cause the Wivenhoe Dam lake level to exceed EL 74.

In the case of (ii) above, the Senior Flood Operations Engineer must direct the operation of the low-level regulators and sluices to ensure the safety of Somerset Dam. If the water level and predicted inflows are such that the safety of Somerset Dam is not an overriding concern, operations are to target a correlation of water levels in Somerset Dam and Wivenhoe Dam as set out in Table 9.2 such that the relative flood storage between the flood level in Wivenhoe Dam and EL 80 is the same as the relative flood storage between the flood level in Somerset Dam and EL 107.46, the non-spillway crest level in Somerset Dam.

TABLE 9.2 – Water Level Correlation Targets

Somerset Lake Level M AHD	Wivenhoe Lake Level m AHD
102.5 103.5 104.5 105.5	72.073.675.276.878.580.0

Deleted: free-board

Deleted: 77

Deleted: free-board

Deleted: 72

Deleted: ¶
73

Deleted: ¶
74

Deleted: ¶
75

Deleted: ¶
76

Deleted: ¶
77

Deleted: : 6

Deleted: December 2004

106.5 107.46	

The constraints applicable to case (i) operation above do not apply to case (ii) operation.

If the flood event emanates from the Stanley River catchment only, without significant runoff in the Upper Brisbane River catchment, the operation of Somerset Dam will proceed on the basis that Wivenhoe Dam has peaked as per (i) above.

The Somerset Dam gates and valves may also be temporarily closed if such action is able to prevent a fuse plug from initiating. Such closure is not to threaten the safety of the dam

Deleted: : 6

Deleted: December 2004

10 EMERGENCY FLOOD OPERATIONS

10.1 Introduction

While every care has been exercised in the design and construction of the dams, there still remains a low risk that the dams may develop an emergency condition either through flood events or other causes. Experience elsewhere in the world suggests that vigilance is required to recognise emergency flood conditions such as:

- Occurrence of a much larger flood than the discharge capacity of the dam;
- Occurrence of a series of large storms in a short period;
- Failure of one or more gates during a flood.
- Development of a piping failure through the embankment of Wivenhoe Dam;
- Damage to the dams by earthquake;
- Damage to the dams as an act of war or terrorism;
- Other uncommon mechanisms.

Responses to these and other conditions are included in separate Emergency Action Plans.

10.2 Overtopping of Dams

Whatever the circumstances, every endeavour must be made to prevent overtopping of Wivenhoe Dam by the progressive opening of operative spillway gates. The probability of overtopping of Wivenhoe Dam will be significantly reduced following the completion of the auxiliary spillway.

In the event that the probability of overtopping of Wivenhoe Dam is unacceptably high, then as an absolute last resort the saddle dams may be breached. Such actions must only be initiated with the agreement of the Chief Executive.

Deleted: ¶

Somerset Dam should, if possible, not be overtopped by flood water but, if Wivenhoe Dam is threatened by overtopping, the release of water from Somerset Dam is to be reduced, for example by the use of its spillway gates, even at the risk of overtopping Somerset Dam in order to prevent, if possible, the overtopping of Wivenhoe Dam.

10.3 Communications Failure

In the event of normal communications being lost between the Flood Operations Engineer and either Wivenhoe Dam or Somerset Dam, the dam supervisor at that dam is to maintain contact with the dam supervisor at the other dam, to receive instructions through the remaining communications link.

Deleted: : 6

Deleted: December 2004

In the event of normal communications being lost between the Flood Operations Engineer and both Wivenhoe Dam and Somerset Dam, the dam supervisors at each dam are to adopt the procedures set out below during flood events, and are to maintain contact with each other, where possible.

If all communications are lost between the Flood Operations Engineer, Wivenhoe Dam and Somerset Dam, the officers in charge at each dam are to adopt the procedures set out below.

10.3.1 Wivenhoe Dam Emergency Procedure

In the event of total communication failure, the minimum gate openings related to lake levels up to EL 74 are set out in the Table 10.1 are to be maintained for both opening and closing operations. Once the lake level exceeds EL 74 the gates are to be raised at the rate of 1 metre per 10 minutes till the water level peaks or the gates are fully open.

Table 10.1 Minimum Gate Openings Wivenhoe Dam

Lake Level m AHD	Gate 3 Opening (m)	Gates 2 & 4 Opening (m)	Gates 1 & 5 Opening (m)	Total Discharge m^3/sec
67.0		-	-	0
67.5	0.5	-	-	50
68.0	1.5	-	-	155
68.5	2.5	-	-	260
69.0	3.5	0.5	-	470
69.5	4.0	1.0	-	640
70.0	4.0	1.5	0.5	875
70.5	4.0	2.0	1.0	1115
71.0	4.0	2.5	1.5	1365
71.5	4.5	2.5	2.0	1560
72.0	4.5	3.0	2.5	1820
72.5	5.0	4.0	3.0	2250
73.0	5.0	5.0	5.0	2960
73.5	6.5	6.5	6.5	3850
74.0	8.0	8.0	8.0	4750

Deleted: : 6

Deleted: December 2004

>74.0	Gates are to be raised at the rate of 1 metre per 10 minutes till the water level peaks or gates are fully open	
75.7	Gates are to be fully open before the first fuse plug triggers at this level.	

If one or more gates become inoperable, then by reference to Table E-2 the gate openings of operable gates are to be increased in order that the discharges for the lake levels shown in Table 10.1 are achieved.

If, because of compliance with the provisions of Section 8.3 and the high inflow rate, the minimum gate openings cannot be maintained, the time intervals between successive openings shown in Table 8.2 are to be halved.

If the actual gate openings fall more than three settings below the cumulative number of minimum settings of Table 10.1, then successive gate operations are to be carried out as rapidly as possible until the minimum settings are achieved. Under these circumstances, it may be necessary to operate more than one gate at any one time.

10.3.2 Somerset Dam Emergency Procedure

In the event of total communication failure, the spillway gates are to be kept raised to allow uncontrolled discharge. The regulators and sluices are to be kept closed until either:

(i) the level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

The level in Wivenhoe Dam can be determined locally by the Dam Supervisor at Somerset Dam from the tailwater gauge located just downstream of Somerset Dam.

In the case of (i) above, the opening of the regulators and sluices is not to increase the level in Wivenhoe Dam above the peak level already attained. Section 9.3 on regulator and gate operation interval is to be observed.

In the case of (ii) above, the regulators and sluices are to be operated such that the relative flood storage between the flood level in Wivenhoe Dam and EL 80 is the same as the relative flood storage between the flood level in Somerset Dam and the non-spillway crest level in Somerset Dam (EL 107.46). Table 10.2 gives

Deleted: free-board

Deleted: 77

Deleted: free-board

Deleted: : 6

Deleted: December 2004

the water level correlations. The low level outlets in Somerset Dam are not to be opened if the water level in Wivenhoe Dam exceeds the level set out below for given water levels in Somerset Dam.

TABLE 10.2 – Water Level Correlation Targets

Somerset Lake Level m AHD	Wivenhoe Lake Level m AHD
102.5 103.5 104.5 105.5 106.5 107.46	72.073.675.276.878.580.0

Deleted: 72
Deleted: ¶ 73
Deleted: ¶ 74
Deleted: ¶ 75
Deleted: ¶ 76
Deleted: ¶ 77

The constraints applicable to case (i) operation above do not apply to case (ii) operation.

10.4 Equipment Failure

In the event of equipment failure the action to be taken is indicated in Appendix G for Wivenhoe Dam and Appendix H for Somerset Dam.

Deleted: : 6
Deleted: December 2004

APPENDIX A EXTRACT FROM WATER ACT 2000

Division 2 – Flood Mitigation

Owners of certain dams must prepare flood mitigation manual

496.(1) A regulation may nominate an owner of a dam as an owner who must prepare a manual (a "flood mitigation manual") of operational procedures for flood mitigation for the dam.

(2) The regulation must nominate the time by which the owner must comply with section 497(1).

Approving flood mitigation manual

497.(1) The owner must give the chief executive a copy of the flood mitigation manual for the chief executive's approval.

(2) The chief executive may, by gazette notice, approve the manual.

(3) The approval may be for a period of not more than 5 years.

(4) The chief executive may get advice from an advisory council before approving the manual.

Amending flood mitigation manual

498.(1) The chief executive may require the owner, by notice, to amend the flood mitigation manual.

(2) The owner must comply with the chief executive's request under subsection (1).

(3) The chief executive must, by gazette notice, approve the manual as amended.

(4) The approval of the manual as amended must be for-

(a) the balance of the period of the approval for the manual before amendment; or

(b) a period of not more than 5 years from the day the manual as amended was approved.

Deleted: : 6

Deleted: December 2004

(5) The chief executive may get advice from an advisory council before approving the manual as amended.

Regular reviews of flood mitigation manual

499. Before the approval for the flood mitigation manual expires, the owner must-
review, and if necessary, update the manual; and
give a copy of it to the chief executive under section 497.

Deleted: ¶

Deleted: ¶

Protection from liability for complying with flood mitigation manual

500.(1) The chief executive or a member of the council does not incur civil liability for an act done, or omission made, honestly and without negligence under this division.

(2) An owner who observes the operational procedures in a flood mitigation manual approved by the chief executive 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" includes-

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

b) an employee of the owner or operator of the dam; or

c) an agent of the owner or operator of the dam

Deleted: : 6

Deleted: December 2004

APPENDIX B AGENCIES HOLDING DOCUMENTS

AGENCIES HOLDING CONTROLLED DOCUMENTS OF MANUAL OF OPERATIONAL PROCEDURES FOR FLOOD MITIGATION FOR WIVENHOE DAM AND SOMERSET DAM

Dam Owner	South East Queensland Water Corporation
Emergency Services	Department of Emergency Services, Disaster Management Service Brisbane City Counter Disaster Committee Esk Shire Counter Disaster Committee Ipswich City Counter Disaster Committee Kilcoy Shire Counter Disaster Committee
Severe Weather Warning Authority	Bureau of Meteorology
Primary Response Authorities	Brisbane City Council Esk Shire Council Ipswich City Council Kilcoy Shire Council

Deleted: : 6

Deleted: December 2004

Regulator of Dam Safety	Department of Natural Resources and Mines and Water
Dams Operator	SunWater

The Corporation must keep a register of contact persons of holders of controlled documents (Section 1.9 refers).

Deleted: ,

Deleted: & Energy

Deleted: : 6

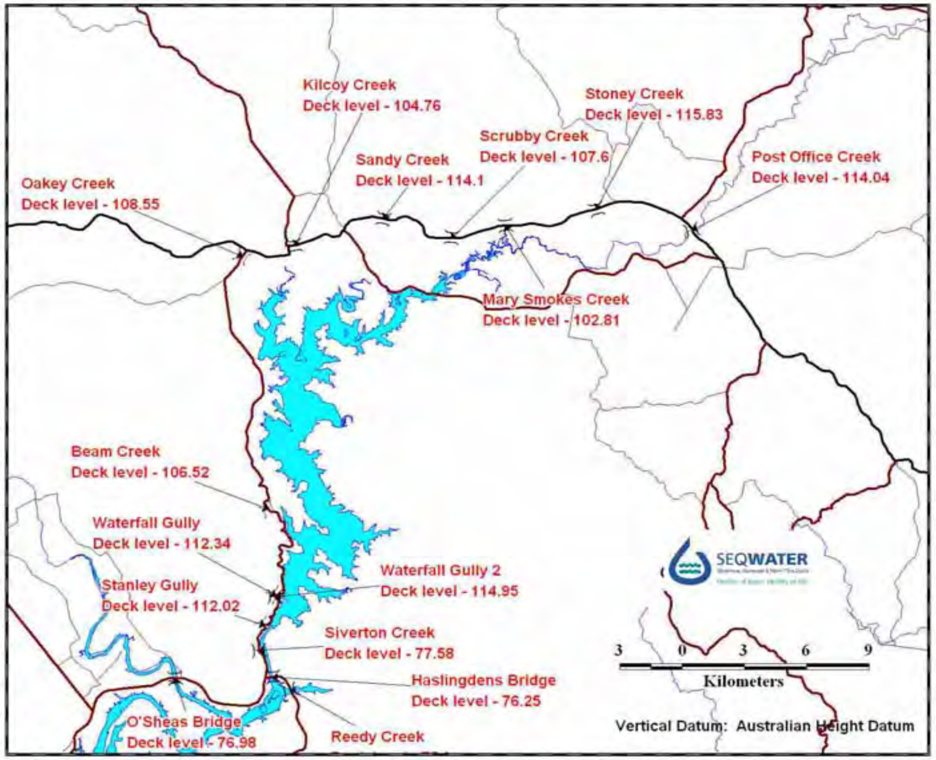
Deleted: December 2004

APPENDIX C BRIDGE DECK LEVELS

Roads Upstream of Somerset Dam

Deleted: : 6

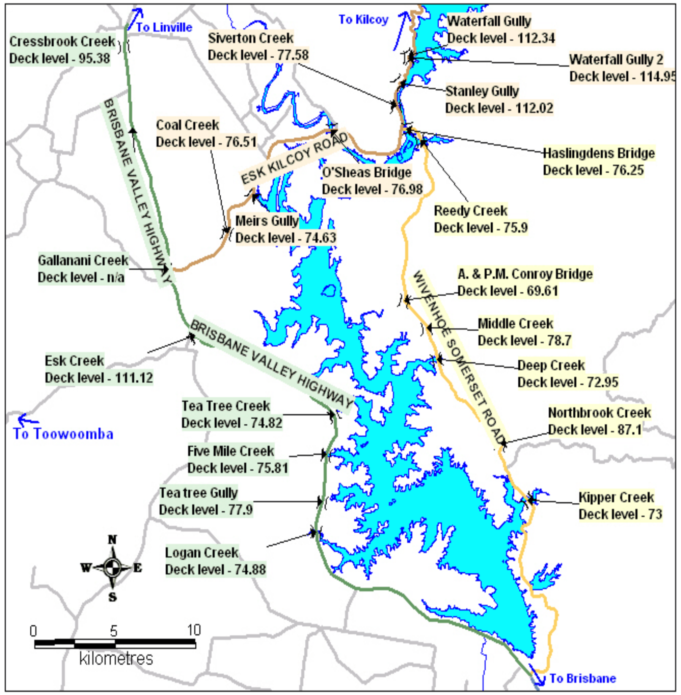
Deleted: December 2004



Deleted: : 6

Deleted: December 2004

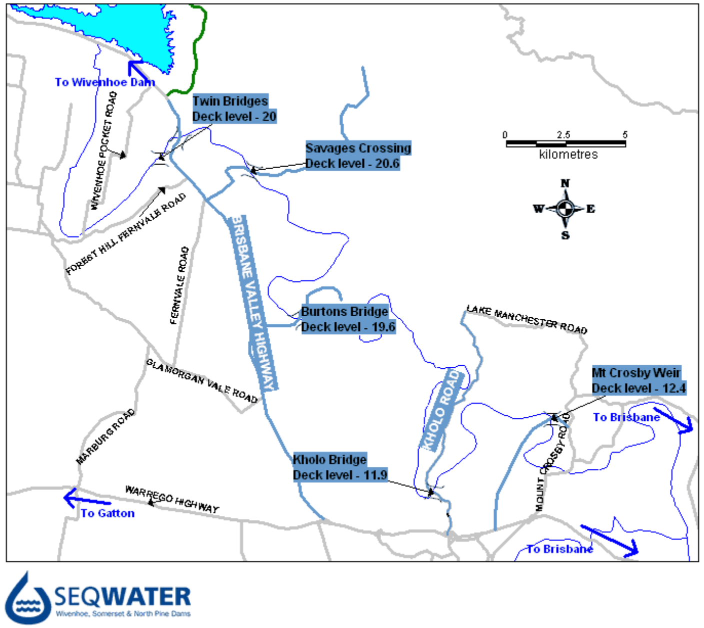
Roads Surrounding Wivenhoe Dam



SEQWATER
Wivenhoe, Somerset & North Pine Dams

Deleted: : 6
Deleted: December 2004

Bridges Downstream of Wivenhoe Dam



Deleted: : 6

Deleted: December 2004

Table D.1. KEY REFERENCE GAUGES

<table>
<tr><th rowspan="3">Location</th><th rowspan="3">GZ</th><th rowspan="3">1974 Gauge Height</th><th colspan="2">Minor</th><th colspan="2">Moderate</th><th colspan="2">Major</th></tr>
<tr><th>Gauge Height</th><th>Flow</th><th>Gauge Height</th><th>Flow</th><th>Gauge Height</th><th>Flow</th></tr>
<tr><th>m</th><th>m³/s</th><th>m</th><th>m³/s</th><th>m</th><th>m³/s</th></tr>
<tr><td>Stanley R at Somerset Dam*</td><td>0.00 AHD</td><td>-</td><td>103.0</td><td></td><td>105.0</td><td></td><td>106.0</td><td></td></tr>
<tr><td>Brisbane R at Lowood</td><td>23.68 AHD</td><td>22.02</td><td>8.0</td><td rowspan="4">1000</td><td>15.0</td><td rowspan="4">3300</td><td>20.0</td><td rowspan="4">6000</td></tr>
<tr><td>Brisbane R at Lowood*</td><td>22.74 SD</td><td>-</td><td>8.6</td><td>15.9</td><td>21.2</td></tr>
<tr><td>Brisbane R at Savages Crossing*</td><td>18.43 AHD</td><td>23.79</td><td>9.0</td><td>16.0</td><td>21.0</td></tr>
<tr><td>Brisbane R at Mt Crosby*</td><td>0.00 AHD</td><td>26.74</td><td>11.0</td><td>13.0</td><td>21.0</td></tr>
<tr><td>Bremer R at Ipswich*</td><td>0.00 AHD</td><td>20.70</td><td>7.0</td><td></td><td>9.0</td><td></td><td>11.7</td><td></td></tr>
<tr><td>Brisbane R at Moggill*</td><td>0.00 AHD</td><td>19.95</td><td>10.0</td><td rowspan="3">4000</td><td>13.0</td><td rowspan="3">5000</td><td>15.5</td><td rowspan="3">6500</td></tr>
<tr><td>Brisbane R at Jindalee Br*</td><td>0.00 AHD</td><td>14.10</td><td>6.0</td><td>8.0</td><td>10.0</td></tr>
<tr><td>Brisbane R at City Gauge*</td><td>0.00 AHD</td><td>5.45</td><td>1.7</td><td>2.6</td><td>3.5</td></tr>
</table>

* Indicates an automatic gauge
Flows are approximate only and gauge heights are tide dependent in the lower reaches.
A complete list of the latest river heights can be found at http://www.bom.gov.au

Deleted: : 6

Deleted: December 2004

Table D.2. SUBMERGENCE FLOWS FOR BRIDGES

AMTD	Bridge Name	Location	Estimated Submergence Flow m^3/sec
140	Twin Bridges	Wivenhoe Pocket Road, Fernvale	50
132	Savage’s Crossing	Banks Creek Road, Fernvale	130
87	College's Crossing	Mt Crosby Rd, Karana Downs	175-200*
120	Burton's Bridge	E Summerville Road, Borallon	430
100	Kholo Bridge	Kholo Rd, Ipswich	550
91	Mt.Crosby Weir Bridge	Allawah Rd, Mt Crosby	1900
136	Fernvale Bridge	Brisbane Valley Hwy, Fernvale	2000

* Affected by tides.

Deleted: : 6

Deleted: December 2004

APPENDIX E WIVENHOE DAM TECHNICAL DATA

TABLE E1 STORAGE AND UNCONTROLLED GATE DISCHARGES

Lake level M AHD	Storage Capacity 10^6 m^3	*** Flood Capacity 10^6 m^3	** Net Inflow per 1mm rise per hour m^3/sec	* Discharge per Regulator m^3/sec	* Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
57.0	414	-	11.10	24.9	0	50
57.5	453	-	12.04	25.2	4	69
58.0	466	-	12.97	25.4	15	128
58.5	494	-	13.90	25.7	32	211
59.0	523	-	14.84	25.9	53	316
59.5	553	-	15.77	26.2	77	439
60.0	584	-	16.71	26.4	105	579
60.5	616	-	17.64	26.6	136	735
61.0	649	-	18.58	26.9	170	905
61.5	683	-	19.51	27.1	207	1 090
62.0	719	-	20.45	27.3	246	1 290
62.5	756	-	21.38	27.5	288	1 495
63.0	795	-	22.32	27.8	333	1 720
63.5	835	-	23.25	28.0	379	1 950
64.0	877	-	24.19	28.2	428	2 195
64.5	920	-	25.12	28.4	479	2 450
65.0	965	-	26.06	28.7	532	2 720
65.5	1 012	-	26.99	28.9	587	2 995
66.0	1 061	-	27.92	29.1	645	3 280
66.5	1 112	-	28.86	29.3	704	3 580
67.0	1 165	0	29.79	29.5	765	3 885
67.5	1 220	56	30.73	29.7	828	4 200
68.0	1 276	112	31.66	29.9	893	4 525
68.5	1 334	171	32.60	30.1	959	4 860
69.0	1 393	230	33.53	30.3	1 028	5 200
69.5	1 454	290	34.47	30.5	1 098	5 550
70.0	1 517	350	35.40	30.7	1 170	5 910
70.5	1 581	418	36.33	30.9	1 244	6 280
71.0	1 647	485	37.27	31.1	1 319	6 660
71.5	1 714	550	38.20	31.3	1 396	7 040
72.0	1 783	615	39.14	31.5	1 474	7 430
72.5	1 854	683	40.07	31.7	1 554	7 840
73.0	1 926	750	41.01	31.9	1 636	8 240
73.5	2 000	830	41.94	32.1	1 719	8 660
74.0	2 076	910	42.87	32.3	1 804	9 080
74.5	2 153	995	43.81	32.5	1 890	9 520
75.0	2 232	1 080	44.74	32.7	1 978	9 960
75.5	2 313	1 160	45.68	32.9	2 067	10 400

Deleted: : 6

Deleted: December 2004

76.0 ****	2 395	1 240	46.61	33.1	2 158	10 860
76.5	2 480	1 258	47.55	33.3	2 250	11 320
77.0	2 566	1 420	48.48	33.4	2 343	11 780
77.5	2 655	1 500	49.41	36.6	2 438	12 260
78.0	2 746	1 580	50.35	33.8	2 535	12 740
78.5	2 839	1 680	51.28	34.0	2 632	13 230
79.0	2 934	1 780	51.28	34.2	2 731	13 730
79.5	3 032	1 867	52.22	34.4	2 832	14 230
80.0	3 132	1 966	52.22	34.5	2 891	14 455

* This is the maximum discharge of an individual spillway bay or regulator. Total discharge is calculated by adding the contributions of each gate or regulator. There are two (2) regulators to five (5) spillway bays.

** This assumes that all gates and sluices are closed. Discharges through the spillway have to be added to the above figures to calculate the actual inflow into the reservoir.

*** The temporary storage above normal Full Supply Level of EL 67.0.

**** The first fuse plug is designed to trigger at EL75.7. Above this level, fuse plug flows from Table E.3 need to be added to give the full outflow.

TABLE E2 CONTROLLED GATE DISCHARGES

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
67.0	0	49	98	146	194	240	285	329	372	413	453	492	530	567	603	639	675	709	744	765															
67.2	0	49	99	148	196	243	288	333	376	418	458	498	537	574	611	648	684	720	755	790															
67.4	0	50	100	149	198	245	291	336	380	422	464	504	543	582	619	657	693	730	766	802	815														
67.6	0	50	101	151	200	248	294	340	384	427	469	510	550	589	627	665	702	740	777	814	841														
67.8	0	51	102	152	202	250	297	343	388	432	474	515	556	596	635	673	712	750	787	825	863	867													
68.0	0	51	103	154	204	253	300	347	392	436	479	521	562	603	642	682	721	759	798	837	876	893													
68.2	0	52	104	155	206	255	303	350	396	441	484	527	569	610	650	690	729	769	808	848	888	919													
68.4	0	52	105	156	207	257	306	354	400	445	489	532	575	616	657	698	738	778	818	859	899	940	946												
68.6	0	53	105	158	209	260	309	357	404	450	494	538	581	623	665	706	747	788	829	870	911	953	973												
68.8	0	53	106	159	211	262	312	360	408	454	499	543	587	630	672	714	755	797	838	880	923	965	1000												
69.0	0	54	107	160	213	264	315	364	412	458	504	549	593	636	679	722	764	806	848	891	934	977	1022	1028											
69.2	0	54	108	162	215	267	317	367	415	463	509	554	599	643	686	729	772	815	858	901	945	989	1035	1056											
69.4	0	54	109	163	217	269	320	370	419	467	514	560	605	649	693	737	780	824	868	912	956	1001	1047	1084											
69.6	0	55	110	164	218	271	323	373	423	471	518	565	611	656	700	744	789	833	877	922	967	1013	1060	1107	1112										
69.8	0	55	111	166	220	273	326	377	427	475	523	570	616	662	707	752	797	842	887	932	978	1025	1072	1121	1141										
70.0	0	56	112	167	222	276	328	380	430	479	528	575	622	668	714	759	805	850	896	942	989	1036	1085	1134	1170										
70.2	0	56	112	168	224	278	331	383	434	484	532	580	628	674	721	767	813	859	905	952	1000	1048	1097	1147	1198	1199									
70.4	0	56	113	170	225	280	334	386	437	488	537	586	633	680	727	774	821	867	914	962	1010	1059	1109	1160	1212	1229									

UNCONTROLLED
DISCHARGE

Deleted: 52.22

Deleted:

Deleted: outfl

Deleted: ow.¶

Deleted: ¶
Section Break (Next Page)

Deleted: : 6

Deleted: December 2004

70.6	0	57	114	171	227	282	336	389	441	492	542	591	639	687	734	781	828	876	923	972	1020	1070	1121	1173	1226	1258			
70.8	0	57	115	172	229	284	339	392	445	496	546	596	644	693	741	788	836	884	932	981	1031	1081	1133	1185	1239	1289			
71.0	0	58	116	173	230	286	341	395	448	500	551	601	650	699	747	795	844	892	941	991	1041	1092	1144	1198	1252	1309	1319		
71.2	0	58	117	175	232	289	344	398	452	504	555	605	655	705	754	802	851	900	950	1000	1051	1103	1156	1210	1266	1323	1349		
71.4	0	58	117	176	234	291	347	401	455	508	559	610	661	710	760	809	859	908	959	1009	1061	1114	1167	1222	1279	1337	1380		
71.6	0	59	118	177	235	293	349	404	458	512	564	615	666	716	766	816	866	916	967	1019	1071	1124	1179	1234	1292	1350	1410	1411	
71.8	0	59	119	178	237	295	352	407	462	515	568	620	671	722	773	823	874	924	976	1028	1081	1135	1190	1246	1304	1364	1425	1443	
72.0	0	60	120	180	239	297	354	410	465	519	572	625	676	728	779	830	881	932	984	1037	1091	1145	1201	1258	1317	1377	1439	1474	
72.2	0	60	121	181	240	299	357	413	469	523	577	629	682	733	785	837	888	940	993	1046	1100	1156	1212	1270	1330	1391	1454	1506	
72.4	0	60	121	182	242	301	359	416	472	527	581	634	687	739	791	843	895	948	1001	1055	1110	1166	1223	1282	1342	1404	1468	1533	1538
72.6	0	61	122	183	243	303	361	419	475	531	585	639	692	745	797	850	903	956	1009	1064	1119	1176	1234	1293	1354	1417	1482	1548	1570
72.8	0	61	123	184	245	305	364	422	478	534	589	643	697	750	803	856	910	963	1018	1073	1129	1186	1245	1305	1367	1430	1496	1563	1603

TABLE E2 CONTROLLED GATE DISCHARGES (continued)

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
73.0	0	62	124	185	247	307	366	425	482	538	593	648	702	756	809	863	917	971	1026	1081	1138	1196	1255	1316	1379	1443	1509	1577	1636						
73.2	2	62	124	187	248	309	369	427	485	542	597	653	707	761	815	869	924	978	1034	1090	1147	1206	1266	1327	1391	1456	1523	1592	1663	1669		UNCONTROLLED			
73.4	6	62	125	188	250	311	371	430	488	545	602	657	712	767	821	876	931	986	1042	1099	1156	1216	1276	1339	1403	1469	1536	1606	1678	1702			DISCHARGE		
73.6	11	64	126	189	251	313	373	433	491	549	606	662	717	772	827	882	937	993	1050	1107	1166	1225	1287	1350	1414	1481	1550	1620	1693	1736					
73.8	17	69	127	190	253	315	376	436	495	553	610	666	722	778	833	888	944	1001	1058	1116	1175	1235	1297	1361	1426	1494	1563	1635	1708	1770					
74.0	23	74	129	191	254	317	378	438	498	556	614	671	727	783	839	895	951	1008	1065	1124	1184	1245	1307	1372	1438	1506	1576	1648	1723	1800	1804				
74.2	31	80	133	192	256	319	380	441	501	560	618	675	732	788	845	901	958	1015	1073	1132	1192	1254	1317	1382	1449	1518	1589	1662	1738	1815	1838				
74.4	39	87	139	195	257	321	383	444	504	563	622	679	737	793	850	907	964	1022	1081	1140	1201	1264	1327	1393	1461	1530	1602	1676	1752	1831	1873				
74.6	47	94	145	200	259	322	385	447	507	567	626	684	741	799	856	913	971	1029	1089	1149	1210	1273	1337	1404	1472	1542	1615	1690	1767	1846	1908				
74.8	56	103	153	206	262	324	387	449	510	570	629	688	746	804	862	919	978	1036	1096	1157	1219	1282	1347	1414	1483	1554	1628	1703	1781	1861	1943				
75.0	66	112	161	213	267	326	390	452	513	574	633	692	751	809	867	926	984	1044	1104	1165	1227	1291	1357	1425	1494	1566	1640	1717	1795	1876	1960	1978			
75.2	76	121	169	220	274	330	392	455	516	577	637	697	756	814	873	932	991	1051	1111	1173	1236	1301	1367	1435	1506	1578	1653	1730	1809	1891	1976	2013			
75.4	87	131	178	229	281	336	394	457	519	581	641	701	760	819	878	938	997	1057	1119	1181	1245	1310	1377	1446	1517	1590	1665	1743	1823	1906	1992	2049			
75.6	98	141	188	237	289	343	399	460	522	584	645	705	765	824	884	944	1004	1064	1126	1189	1253	1319	1386	1456	1527	1601	1678	1756	1837	1921	2007	2085			
75.8	109	152	198	247	298	350	405	463	525	587	649	709	769	829	889	949	1010	1071	1133	1197	1261	1328	1396	1466	1538	1613	1690	1769	1851	1936	2023	2112	2121		
		OVERTOPPING of GATE																																	
76.0	121	164	209	257	307	359	412	468	528	591	652	713	774	834	895	955	1016	1078	1141	1205	1270	1337	1405	1476	1549	1624	1702	1782	1865	1950	2038	2129	2158		
76.2	133	175	220	268	317	368	421	475	532	594	656	718	779	839	900	961	1023	1085	1148	1212	1278	1346	1415	1486	1560	1636	1714	1795	1878	1965	2053	2145	2194		
76.4	146	187	232	279	327	378	429	483	539	597	660	722	783	844	906	967	1029	1092	1155	1220	1286	1354	1424	1496	1570	1647	1726	1808	1892	1979	2069	2161	2231		
76.6	159	200	244	290	338	388	439	492	546	603	664	726	788	849	911	973	1035	1098	1162	1228	1295	1363	1434	1506	1581	1658	1738	1820	1905	1993	2084	2177	2268		
76.8	173	213	257	302	350	399	449	501	554	610	668	730	792	854	916	978	1041	1105	1170	1235	1303	1372	1443	1516	1591	1669	1750	1833	1919	2007	2099	2193	2289	2306	
			OVERTOPPING of GATE																																
77.0	186	226	270	315	362	410	460	511	564	618	674	734	797	859	921	984	1047	1112	1177	1243	1311	1380	1452	1526	1602	1680	1762	1845	1932	2021	2113	2208	2306	2343	
77.2	200	240	283	328	374	422	471	522	574	627	682	739	801	864	927	990	1054	1118	1184	1250	1319	1389	1461	1536	1612	1691	1773	1858	1945	2035	2128	2224	2322	2381	
77.4	215	254	297	341	387	435	483	533	584	637	691	747	806	869	932	996	1060	1125	1191	1258	1327	1398	1470	1545	1622	1702	1785	1870	1958	2049	2143	2239	2339	2419	
77.6	230	269	311	355	400	447	496	545	595	647	700	756	813	873	937	1001	1066	1131	1198	1265	1335	1406	1479	1555	1633	1713	1796	1882	1971	2063	2157	2255	2355	2457	
77.8	245	283	325	369	414	461	508	557	607	658	711	765	821	880	942	1007	1072	1138	1205	1273	1343	1414	1488	1564	1643	1724	1808	1894	1984	2076	2172	2270	2371	2475	2496
78.0	260	299	340	383	428	474	522	570	619	670	722	775	831	888	948	1012	1078	1144	1211	1280	1351	1423	1497	1574	1653	1735	1819	1907	1997	2090	2186	2285	2387	2492	2535

Deleted: : 6

Deleted: December 2004

TABLE E2 CONTROLLED GATE DISCHARGES (continued)

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
											OVERTOPPING of GATE					
79.0	342	379	419	460	504	548	594	640	688	736	786	837	889	943	999	1057
80.0	431	466	505	545	587	630	675	720	766	813	861	910	961	1013	1068	1124

Water EL (m AHD)	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
79.0	1117	1180	1246	1316	1389	1464	1541	1620	1703	1787	1875	1966	2060	2156	2257	2360	2466	2575	2687
	OVERTOPPING of GATE																		
80.0	1182	1243	1306	1372	1441	1513	1589	1668	1751	1838	1929	2023	2121	2221	2325	2432	2542	2655	2772

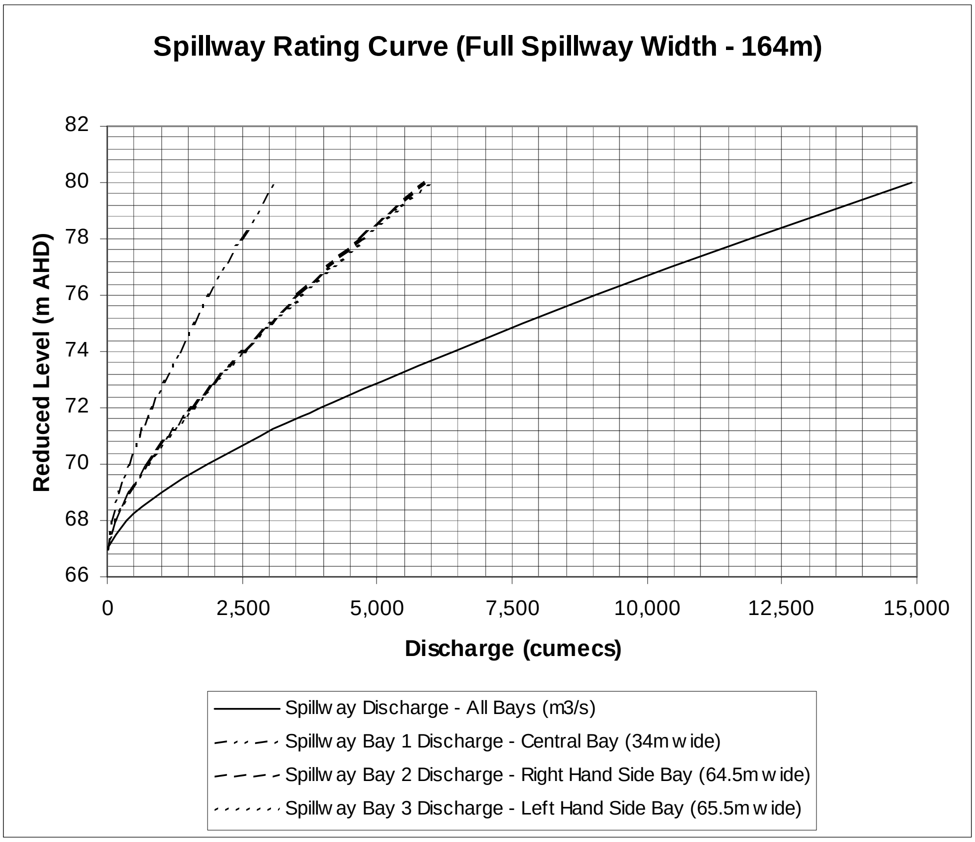
(The table needs cells reformatted) – Rob Ayre

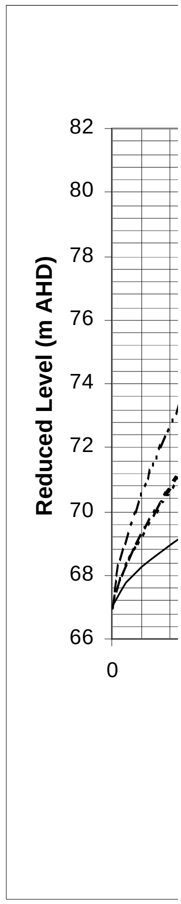
Deleted: : 6

Deleted: December 2004

TABLE E.3 – WIVENHOE DAM AUXILIARY SPILLWAY RATING TABLE

Storage Level (m AHD)	Spillway Discharge - All Bays (m3/s)	Discharge Central Bay (34m wide)	Discharge Right Side Bay (64.5m wide)	Discharge Left Side Bay (65.5m wide)
67	0	0	0	0
68	361	75	142	144
69	1,020	212	401	408
70	1,858	385	731	742
71	2,847	590	1,120	1,137
72	3,961	821	1,558	1,582
74	6,409	1,329	2,521	2,560
76	9,033	1,873	3,553	3,608
78	11,907	2,468	4,683	4,755
80	14,913	3,092	5,865	5,956





Deleted:

Deleted: : 6

Deleted: December 2004

APPENDIX F SOMERSET DAM TECHNICAL DATA

Table F-l STORAGE AND DISCHARGE FOR SOMERSET DAM

Lake level M AHD	Reservoir Capacity 10^6 m^3	Temporary Flood Storage 10^6 m^3	Net Inflow per 1mm rise per hour m^3/sec	* Discharge per Regulator m^3/sec	* Discharge per Sluice m^3/sec	* Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
90.0	120.3	-	5.29	57	163	-	1 529
90.5	129.5	-	5.50	58	165	-	1 550
91.0	139.3	-	4.88	58	167	-	1 572
91.5	149.6	-	5.28	59	170	-	1 593
92.0	160.5	-	5.68	60	172	-	1 614
92.5	172.0	-	6.09	60	174	-	1 635
93.0	184.1	-	6.79	61	176	-	1 655
93.5	196.7	-	7.10	62	179	-	1 676
94.0	210.0	-	7.43	62	181	-	1 695
94.5	224.0	-	7.78	63	183	-	1 715
95.0	238.5	-	8.15	64	185	-	1 735
95.5	253.6	-	8.54	64	187	-	1 754
96.0	269.3	-	8.95	65	189	-	1 773
96.5	285.6	-	9.37	66	191	-	1 792
97.0	302.7	-	9.81	66	193	-	1 810
97.5	320.7	-	10.28	67	195	-	1 829
98.0	339.5	-	10.76	67	197	-	1 847
98.5	359.2	-	11.25	68	199	-	1 865
99.0	379.8	0.0	11.77	69	201	-	1 883
99.5	401.4	21.5	12.31	69	203	-	1 901
100.0	428.9	49.0	13.28	70	205	-	1 918
100.5	447.5	67.6	13.83	70	207	0	1 937
101.0	472.2	92.3	14.39	71	209	4	1 989
101.5	498.0	118.1	14.95	72	211	13	2 076
102.0	524.9	145.1	15.53	72	212	25	2 189
102.5	553.1	173.3	16.11	73	214	40	2 325
103.0	582.6	202.7	16.70	73	216	58	2 482
103.5	613.2	233.4	17.30	74	218	78	2 659
104.0	645.1	265.3	17.90	74	220	100	2 854
104.5	678.3	298.4	18.52	75	221	125	3 067
105.0	712.7	332.8	19.14	75	223	151	3 296
105.5	748.3	368.4	19.78	76	225	180	3 542
106.0	785.2	405.4	20.42	76	226	211	3 803
106.5	823.4	443.6	21.07	77	228	243	4 079
107.0	863.1	483.2	21.73	78	230	278	4 370
107.5	904.0	524.2	22.39	78	232	314	4 675

* This is the maximum discharge of an individual gate or regulator. Total discharge is calculated by adding the contributions of each gate or regulator.

Regulator - Discharge regulator valve of which there are four (4).
Sluice - Sluice gate of which there are eight (8).
Spillway - Overflow section of dam controlled by eight (8) radial gates.
Temporary Flood- The temporary storage above the normal full supply level of El 99 m (AHD) Storage

Deleted: : 6
Deleted: December 2004

APPENDIX G WIVENHOE DAM GATE OPERATION CONSIDERATIONS

Full size plans of Wivenhoe Dam, and Operations and Maintenance Manuals for Wivenhoe Dam are held by the Corporation and the Headworks Operator and are available at the site. Operations and Maintenance Manuals relevant to the flood operation of the gates are:

(a) "Master Manual and Drawings."

(b) "Radial and Penstock Gate Hoists and Drawings."

G.1. SPILLWAY OPERATION PRINCIPLES

The radial gates are sequentially numbered from 1 to 5 from left to right looking in the downstream direction. Appendix I shows the general arrangement of the spillway area.

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions, or when gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool, which has been excavated into erodible sandstone rock, and cause non-predictable erosion. Upstream migration of this erosion is to be avoided. The wing walls adjacent to the flip bucket deflect the discharge away from the walls of the plunge pool when gates 1 and 5 are operated.

Therefore in operating the spillway, the principles to be observed are, in order of priority:

(i) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

(ii) The flow in the spillway is to be symmetrical.

The main purpose of gating the spillway is to exercise maximum control over the flow in the Brisbane River insofar as river flows in excess of 4 000 m^3/sec cause damage to urban areas downstream. The gates also allow the routing of much larger floods with substantial flood mitigation being achieved.

G.2. RADIAL GATE OPERATING PRINCIPLE

Each radial gate consists of a cylindrical upstream skinplate segment that is attached to the radial arms. The cylindrical axis is horizontal. Each gate rotates about two spherical trunnion bearings that are on this axis.

The position of the gate is controlled by hydraulically driven winches that are located on the piers beside the gates. Wire ropes are attached to the downstream face of the skin plate through a pulley system. The hydraulic motors work off a common pressure manifold and under perfectly matched conditions, will give an equal lifting force to each side of the gate. This system does not sense rope travel and will take up slack rope. It cannot prevent or correct skewing of the skin plate segment between the piers. If skewing occurs, skids will come into contact with the side seal plates to limit movement.

Deleted: : 6

Deleted: December 2004

It is not possible to operate a winch independently of the other winch attached to the gate.

When the hydraulic motors are not energised, the gates are held in position by spring loaded friction brakes on the winches. There are two brake bands per winch and each band is capable of supporting half the weight of the gate. One winch can support the total weight of a gate on both its brake bands but not on one.

G.3. RADIAL GATES OPERATING LIMITATIONS

G.3.1. Opening and Closing Rate

The aperture opening rate of each gate is limited to 500 mm/minute.

Aperture movement is limited by a programmable timer that stops gate movement after a set period of time.

G.3.2. Alternate Consecutive Operation

To maintain symmetry of discharge in the spillway, either gates 1 and 5 or gates 2 and 4 are to be operated in alternate consecutive increments. The power for gate operation comes from two independent electric hydraulic pumps, each of which is capable of operating one gate at a time.

The normal hydraulic pressure source for each gate is as follows:

GATES	POWER SOURCE
Radial Gates 1 & 2, and Penstock Gate Hoist	Electric hydraulic pump 1
Radial Gates 3, 4 & 5	Electric hydraulic pump 2

In the event that an electric hydraulic pump fails, hydraulic pressure can be redirected from the other power source, but concurrent operation of more than one gate from a single power source is not possible.

Deleted: : 6

Deleted: December 2004

G.3.3. Overtopping

While the radial gates have been designed to withstand overtopping, it should be avoided if possible. The reservoir levels and the structural state of the radial gates when in the closed position are as follows:

Reservoir Level m AHD	Condition	Radial Gate Stress Condition with Gate Closed
73	Top of closed gate	Normal
77	Design Flood Level	33% Overstress
80	Crest Level	Critical

Deleted: 79

Once overtopped, the gates become inoperable when the lifting tackle is fouled by debris from the overflow. The gates remain structurally secure until the reservoir level exceeds EL 77. The ability to control floods however may be lost.

G.3.4. Gate Dropping

Under no circumstances are the gates to be dropped. The lower skin plate sections are overstressed if a freefall of 60 mm is arrested by the seal plate on the spillway.

If a gate becomes stuck in an open position, it is to be freed by applying positive lifting forces. Under no circumstances are the winches to be unloaded and the direct weight of the gates used to yield the obstruction.

G.3.5. Operation in High Wind

Other than in periods of mitigation of medium and major floods, the gates are not to be raised or lowered when clear of water, during periods of high winds. The gates can however, be held on the brakes in any position in the presence of high wind.

The term "high wind" means any wind that causes twisting or movement of the gate. While a precise figure cannot be placed on these velocities, further experience over time may allow a figure to be determined.

This limitation is required to prevent the gate from twisting from skew on one side to skew on the other side. While the gate is being raised or lowered, skewing cannot be prevented by the hydraulic lifting system and any impact forces encountered may damage the gate.

G.3.6. Maintenance

No more than one gate is to be inoperable at any one time for maintenance. The maintenance is to be scheduled so that the spillway bay can be cleared of obstructions in a reasonable time to allow its use in the event of major flooding.

Deleted: : 6

Deleted: December 2004

G.4. BULKHEAD GATE OPERATING LIMITATIONS

The bulkhead gate can be used to control discharge in an emergency situation where a radial gate is inoperable. It is transported to, and lowered upstream of the inoperable radial gate by means of the gantry crane. The following conditions apply:

(a) The bulkhead gate can always be lowered with any type of underflow; and

(b) It is not possible to raise the bulkhead gate once it has been lowered past certain levels depending on upstream conditions without there being a pool of water between it and the radial gate. (Department of Primary Industries Wivenhoe Dam Design Report, September 1995 refers).

It is thus possible to preserve storage by effectively closing the spillway even with one radial gate inoperable. It will not be possible to raise the bulkhead gate until the radial gate behind has been repaired and is again storing water between the bulkhead gate and itself.

The bulkhead gate is not to be used for flood regulation until the reservoir level is falling and not likely to rise within the period needed to repair the inoperable radial gate.

G.4.1. Opening and Closing Rates

The spillway gantry crane is to be used to raise and lower the bulkhead gate. The crane operates at two speeds, 1.5 and 3.0 m/min. When within the bulkhead gate guides, the bulkhead gate is to be moved only at 1.5 m/min.

G.4.2. Overtopping

In the event that the bulkhead gate is overtopped (reservoir level exceeds EL 69 when bulkhead gate is closed), it cannot be removed unless a pool of water fills the space between it and the radial gate behind. The closed bulkhead becomes critically stressed when the reservoir level overtops it to EL 71.4.

It is not possible to engage the lifting tackle while overtopping is occurring. While there is any risk that the bulkhead gate may be overtopped, the lifting gear is to be left engaged so that the gate can be raised once the downstream radial gate becomes operable.

G.4.3. Discharge Regulation

In the event that a radial gate is inoperable in a partially open position, the bulkhead gate can be used for flow regulation provided that the lower lip of the radial gate is clear of the underflow jet.

Where a pool exists between the bulkhead gate and a radial gate under flow conditions, the bulkhead gate will be subjected to additional pull-down and possibly subjected to vortex-induced vibrations. When this condition occurs, the bulkhead gate is to be lowered to dewater the pool. The bulkhead gate can then be adjusted to regulate the flow provided the underflow jet remains below the lower lip of the radial gate.

Deleted: : 6

Deleted: December 2004

G.5. RADIAL GATE OPERATING PROCEDURES

G.5.1. Normal Operating Procedure

This procedure is specified in Section 8.3

G.5.2. One Gate Inoperable

Under certain abnormal conditions, it may not be possible to operate one gate. The following procedures are to be adopted.

(a) Gate 3 Inoperable

If bay 3 is blocked for any reason, gates 2 and 4 are to be used to regulate flood discharges, until the discharge impinges on the walls of the plunge pool. Gates 1 and 5 are then to be opened sufficiently to deflect the discharge into the plunge pool.

The bottoms of gates 1 and 5 are to be maintained at or below those of gates 2 and 4 respectively.

(b) Either Gate 2 or 4 Inoperable

If either bay 2 or 4 is blocked for any reason during a flood, normal gate operating procedures are to be adopted, except that only the operable gate 2 or 4 is available for flood regulation beyond 500 m^3/sec and not both.

(c) Either Gate 1 or 5 Inoperable

If either bay 1 or 5 is blocked for any reason during a flood, normal gate operating procedures are to be adopted until the discharge impinges on the walls of the plunge pool. Thereafter the operable gate 1 or 5 is to be used in lieu of using the radial gate adjacent to the inoperable gate. The other radial gates are to be used in the normal way to control discharge.

In the event of a major flood, where the full discharge capacity of the four operable radial gates is required, these gates are to be used to their full capacity to protect the embankment from overtopping.

G.6. EQUIPMENT MALFUNCTION

Normal gate operation is by means of two electric hydraulic pumps supplied by external mains supply electric power, with pump number 1 connected to gates 1 and 2 and the penstock gate, while pump number 2 is connected to gates 3, 4 and 5.

Normal gate operation may not be possible in the event of equipment malfunctions during the passing of a flood. The procedures to be followed under various possible events are outlined below.

G.6.1. Blackout - Failure of External Electric Power

A diesel electric generator automatically starts up. It supplies enough power to the two electric hydraulic pumps to operate the gates normally.

In the event that the diesel electric generator fails, the radial gates can still be operated by means of the emergency diesel hydraulic pump as described in G.6.3 below.

G.6.2. Failure of One Electric Hydraulic Pump

In the event that one electric hydraulic pump fails, the connecting valves between pumps are to be switched such that both sets of hydraulic lines are connected to the operable pump, thus permitting operation of all 5 gates, one gate at a time.

G.6.3. Failure of Two Electric Hydraulic Pumps

In the event that both electric hydraulic pumps fail, the emergency diesel hydraulic pump is to be used to operate the gates, one gate at a time.

G.6.4. Rupture of Hydraulic Lines

Hydraulic power is delivered from the sets of hydraulic lines beneath the gantry service bridge deck to each winch via a single hydraulic line. There is no bypass circuit. In the event that one of these lines is ruptured, the associated radial gate becomes inoperable via this system. Any ruptures in the hydraulic lines are to be repaired immediately. A trailer mounted hydraulic system is available to connect to auxiliary hydraulic lines on the service bridge deck, that can operate one gate at a time.

G.6.5. Contamination of Winch Brakes

The gates are not to be raised if the brake bands on the winch drums are contaminated with oil or other low friction contaminant.

When the hydraulic power is off the gates are held only by the winch brakes. Oil contamination will reduce their holding capacity and possibly allow the gate to fall.

The brake bands are to be inspected regularly and cleaned immediately if any contamination is observed.

G.6.6. Mechanical Failure of Winch

In the event that a winch fails, the radial gate affected becomes inoperable.

(i) Loss of hydraulic power to the winches results in the spring loaded friction brakes holding the gate in its current position.

(ii) Loss of lift from one winch jams the gate between the piers until the uplift is equalised on each side of the gate again. If the gate is in a raised position, this event causes the side skids to come into contact with the pier sides.

(iii) Without hydraulic power applied, the winch drums are restrained by brakes. If both brakes fail, the gate falls. A free fall of more than 60 mm causes structural damage to the gate. In the event that one brake fails, the gate jams between the piers.

Deleted: : 6

Deleted: December 2004

G.6.7. Fouling of Lifting Tackle

The lifting tackle consists of blocks, wire ropes and winch drums. If the gate is overtopped, debris may be collected on the wire ropes that may in turn foul the blocks or the winch drums. This may result in jamming of the wire rope or in uneven lifting, both of which may cause the gate to jam.

The preventative measure is not to allow the gate to be overtopped.

G.6.8. Fouling of Side Skids

The side skids have been designed to limit the side-sway and skew of the radial gates during operation. Under ideal conditions, the skids should not be in contact with the side seal plates.

If the winches are lifting the gates unevenly or in a skewed position, the lifting gear should be adjusted if possible.

Deleted: : 6

Deleted: December 2004

APPENDIX H SOMERSET DAM AUXILIARY EQUIPMENT

H.1. DISCHARGE REGULATION

The normal operating procedure for Somerset Dam in the event of a flood requires the spillway gates to be raised to provide an uncontrolled spillway followed by opening of the low level outlets some time later.

Sketches of the spillway and low level outlets are shown in Appendix J. Somerset Dam is equipped with spillway gates, sluice gates and regulators to control the discharge from the dam. Because the dam is a combined water supply and flood control dam, the spillway is above the FSL and the sluice gates and regulators are 6-10 metres above stream-bed level. It is crucial to the water supply function of the dam that the low level outlets be able to be shut down after their flood release function is completed to ensure that storage is not lost.

Failure of any spillway gate lifting machinery could restrict the discharge capacity of the spillway with resultant risk of overtopping of the dam.

H.2. EMERGENCY POWER SUPPLY

In the event of a power failure at Somerset Dam, the emergency diesel alternator is to be started. The alternator can supply power to the gantry crane, and all gate machinery. If the emergency diesel alternator cannot be started or breaks down during a power failure, the spillway gates and sluice gates are to be operated using the electric motor drive facilities on the winches and a mobile generator.

H.3. FAILURE OF SPILLWAY GATES MACHINERY

If a spillway gate cannot be raised due to failure of the lifting machinery, the gantry crane may be attached to the gate and the gate raised using the gantry crane.

H.4. FAILURE OF SLUICE GATE MACHINERY

In the event of a sluice gate being jammed in the open position or the lifting machinery failing, the coaster gate is to be lowered over the inlet to the sluice to preserve the water supply storage.

If a sluice gate cannot be raised due to failure of the lifting machinery, repairs are to be carried out immediately.

H.5. FAILURE OF REGULATOR MACHINERY

If the regulator gate cannot be lowered and the regulator cones cannot be closed, the regulator coaster gate is to be lowered over the inlet to the regulator. Some damage may be caused to the seals on the coaster gate in this instance, but the resultant leakage will not result in the loss of the water supply storage.

Deleted: : 6

Deleted: December 2004

APPENDIX I HYDROLOGIC INVESTIGATIONS

I.1. INTRODUCTION

This appendix describes hydrologic analyses performed as part of the review of design flood hydrology Corporation's dams. This study included an examination of the existing operating procedures for Wivenhoe Dam and Somerset Dam and it includes the use of the latest techniques in design rainfall estimation.

The analyses were carried out using the most appropriate data available in 2001 and it is recommended that they be revised after the occurrence of a large flood or after the adoption of more advanced methods of hydrologic analysis. The work is summarised in a report entitled, 'Brisbane River – Revision of Flood Hydrology', (DNRM, 2001).

The work summarised here supersedes previous work including that completed during the design stages of Wivenhoe Dam, details of which are contained in the design report on Wivenhoe Dam and the Brisbane River and Pine River Flood Study reports. Revision of the estimates of Probable Maximum Precipitation in 2003, by the Bureau of Meterology, has increased the design flood inflows into the dams. The determination of the Probable Maximum Flood and the impacts on Wivenhoe Dam are included in reports entitled, "Preferred Solution Report" – (Wivenhoe Alliance, 2003). The increase in spillway capacity for Wivenhoe Dam and the resulting effects downstream are included in a report entitled "Design Discharges and Downstream Impacts of the Wivenhoe Dam Upgrade" – (Wivenhoe Alliance, 2004).

Deleted: in 2003

Deleted: ve

Deleted: these figures

I.2 METHOD

There are three components in the hydrologic analyses:

(i) a rainfall analysis to determine both rainfall frequency and Probable Maximum Precipitation (PMP) and also large and rare rainfall events using the CRC-FORGE methodology

(ii) a model of the catchment rainfall runoff process; and

(iii) a model of the flood operations of the two dams.

The Bureau of Meteorology completed several studies of the Probable Maximum Precipitation. The Revised Generalised Tropical Storm Method, (BOM, 2003), which is applicable to areas subject to storms of tropical origin, such as cyclones, was used to determine rainfalls for durations up to seven days. The Probable Maximum Precipitation was estimated for the whole of the Brisbane River catchment, as well as for various sub-catchments. Concurrent rainfall estimates were provided for the remainder of the catchment outside the sub-catchment for which the Probable Maximum Precipitation was provided. The Probable Maximum Precipitation temporal patterns provided by the Bureau of Meteorology were used for all rainfalls.

Deleted: Australian generalised method

Deleted: for

Deleted: and

Deleted: were estimated

The estimation of design rainfalls within the large to rare flood range was performed using the CRC-FORGE methodology as described in Book VI of Australian Rainfall and Runoff (1998). The CRC-FORGE method uses the concept of an expanding region focussed at the site of interest. Design rainfall for frequent events (eg 1 in 50 AEP) are based upon pooled data from a few gauges around the focal point, while design rainfall estimates at the AEP of the limit extrapolation are based upon pooled rainfall data from up to several hundred gauges. Before the data from different sites

Deleted: : 6

Deleted: December 2004

can be pooled, maximum annual rainfalls from each site need to be standardised by dividing by an "index variable".

The rainfall runoff models based on a non-linear runoff routing method were used to estimate the floods. The models were calibrated on recorded storm and flood data. The model calibrations were completed in 1993, (DNRM, 1993) and were not modified for the latest re-assessment.

Models to simulate the flood operation of Somerset and Wivenhoe Dams developed during the mid-eighties were modified to incorporate the new structure of the hydrologic models and to more accurately reflect the operational procedures of the dams. These models were then used to calculate dam discharges for a range of design floods generated using the rainfall estimates and the runoff routing models.

I.3. RAINFALL ANALYSIS RESULTS

The rainfall analysis was performed in two parts, the Probable Maximum Precipitation estimate by the Bureau of Meteorology and the estimation of large to rare events using the CRC-FORGE method. These were used both for design studies for the dam and to test the effects of flood operation procedures.

The estimates of rainfall frequency are listed in Tables I-1 and I-2.

Table I-1
Catchment Rainfall (mm) on Wivenhoe Dam Catchment

Annual Exceedence Probability %	24 Hours	48 Hours	72 Hours
1	199	274	319
0.1	276	393	464
0.01	379	550	659
0.001	712	962	1160
PMP (0.007042)	800	1060	1280

Table I-2
Catchment Rainfall (mm) on Somerset Dam Catchment

Annual Exceedence Probability %	24 Hours	48 Hours	72 Hours
1	302	430	507
0.1	432	649	775
0.01	554	920	1117
0.001	747	1204	1483

I.4. RUNOFF ROUTING MODEL CALIBRATION

Ten floods were used for calibration: July 1965, March 1967, June 1967, January 1968, December 1971, January 1974, January 1976, June 1983, Early April 1989 and Late April 1989. The gauging stations used for model calibration are listed in Table I-3.

Deleted: : 6

Deleted: December 2004

The runoff routing model was calibrated for the nineteen major sub-catchments listed in Table I-4. Each of these models was calibrated for as many sites as possible for each of the ten floods.

Data were missing for some of the stations for some of the floods. The estimated model parameters are given in Table I-4. In all cases relative delay time parameter (k) used in the model is related to reach length.

Table I-3
Gauging Stations used for Model Calibration

Stream	Site	Number	AMTD (km)	Catchment Area (km^2)
Stanley River	Somerset Dam		7.2	1 335
Cooyar Creek	Damsite	143015	12.2	960
Brisbane River	Linville	143007	282.4	2 005
Emu Creek	Boat Mountain	143010	10.1	920
Brisbane River	Gregor's Creek	143009	251.7	3 885
Cressbrook Creek	Damsite	143013	58.6	325
Brisbane River	Middle Creek	143008	187.2	6 710
Brisbane River	Wivenhoe Dam		150.2	7 020
Brisbane River	Savage's Crossing	143001	130.8	10 180
Bremer River	Walloon	143107	37.2	620
Warrill Creek	Amberley	143108	8.7	920
Lockyer Creek	Lyon's Bridge	143210	27.2	2 540
Brisbane River	City		22.7	13 260

Deleted: : 6

Deleted: December 2004

Table I-4
Estimated Model Parameters

Sub-Catchment Name	Model Parameters	
	k	m
Cooyar Creek	43.6	0.8
Brisbane River at Linville	20.6	0.8
Emu Creek at Boat Mountain	37.2	0.8
Brisbane River at Gregors Creek	20.1	0.8
Cressbrook Creek at Cressbrook Dam	34.3	0.8
Stanley River at Somerset Dam	80.7	0.8
Brisbane River at Wivenhoe Dam	108.5	0.8
Lockyer Creek at Helidon	15.0	0.8
Tenthill Creek at Tenthill	19.0	0.8
Lockyer Creek at Lyons Bridge	75.0	0.8
Brisbane River at Savages Crossing	40.0	0.8
Brisbane River at Mount Crosby	47.0	0.8
Bremer River at Walloon	44.0	0.8
Warrill Creek at Kalbar	34.0	0.8
Warrill Creek at Amberley	35.0	0.8
Purga Creek at Loamside	49.0	0.8
Bremer River at Ipswich	15.7	0.8
Brisbane River at Jindalee	20.8	0.8
Brisbane River at Port Office	19.3	0.8

Deleted: M

I.5. WIVENHOE DAM FLOODS

Wivenhoe Dam floods were estimated using the rainfalls and runoff routing model already discussed. Inflows to Wivenhoe Dam, assuming the dam to be in existence and full, were calculated, as well as flow at the dam-site without the dam in the catchment. Two-day storms were found to have the critical storm duration for most cases, though the long duration Probable Maximum Precipitations produced very large flood volumes. Table I-5 lists results for the two-day duration storms.

Table I-5
Wivenhoe Dam Floods
Design Inflows and Outflows for Existing, Stage 1 and Stage 2 Upgrades

Event (1in X)	Peak Inflow (m^3/s)	Peak Outflow (m^3/s)		
		Existing	Stage 1	Stage 2
200	8,300	2,800	2,800	2,800
500	10,500	3,800	3,800	3,800
1,000	12,100	5,300	5,300	5,300
2,000	14,000	6,600	6,600	6,600
5,000	17,200	8,900	10,500 [c]	10,500 [c]
10,000	20,800	11,700	12,500	12,500
22,000 [a]	25,700	12,400 [a]	17,600	17,600
50,000	34,900	- [b]	24,600	24,600
100,000	43,300	- [b]	28,100 [a]	34,900
PMF	49,000	- [b]	- [b]	37,400 [a]

Deleted: : 6

Deleted: December 2004

[a] Dam Crest Flood
[b] Overtops dam wall
[c] Increases due to changes to Procedure 4.

I.6. SOMERSET DAM FLOODS

Somerset Dam floods were estimated using the rainfalls and runoff routing model already discussed. Inflows to Somerset Dam, assuming the dam to be in existence and full, were calculated, as well as flow at the site without the dam in the catchment. The forty-eight hour PMP storm event was found to be critical, though the long duration PMP's produced very large flood volumes. Table I-6 lists results for the forty-eight hour duration storms.

Table I-6
Somerset Dam Floods
(for two-day storm duration)+

AEP %	Peak Inflow (m^3/sec)	Peak Outflow (m^3/sec)	Flood Volume (ML)	Peak Lake Level (m AHD)
1	3,500	1,700	421,000	103.5
0.1	4,500	2,600	690,000	104.5
0.01	6,800	4,700	1,042,000	107.5
0.001	9,200	6,300	1,412,000	109.3
PMF*	16,000	9,600	1,952,800	112.0

+ - NB. This duration does NOT give the maximum Peak Inflow for a given AEP
* - Overtopped, estimated flow based on no dam failure

I.7 FLOOD CONTROL OPERATION MODEL

Floods in the Brisbane River catchment above Wivenhoe Dam can originate in either the Stanley River or upper Brisbane River catchment or both. Both of the dams are capable of being operated in a number of ways, each of which will reduce the flow downstream. However, in order to achieve maximum reduction of flooding downstream of Wivenhoe Dam, it was necessary to review the operations at Somerset and Wivenhoe Dams using a flood operations simulation model.

The most recent flood studies have reviewed the basic hydrologic algorithms in the operational models used in the earlier study and modified them to incorporate additional features relating to gate openings and closings. The revised design flood hydrology and operational model algorithms were then used to re-examine the original five possible operational procedures for each of Somerset Dam and Wivenhoe Dam, giving twenty-five possible combinations to be re-considered. The procedures previously developed for Wivenhoe Dam were designed so that initial release operations did not adversely affect later operations in the event of later rainfall causing the magnitude of the flood to exceed the original estimate.

The procedures previously developed were also designed to restrict flooding in the lower catchment to the lowest level of the following categories where practicable:

(i) low level bridges submerged, Fernvale bridge open;

Deleted: : 6
Deleted: December 2004

(ii) all bridges except Mt. Crosby Weir and to Fernvale bridges submerged;

(iii) all bridges submerged, no damage to urban areas;

(iv) damage to urban areas due to peak flow from downstream catchment, no releases from Wivenhoe Dam contributing to peak flow;

(v) extensive damage to urban areas due to combined Wivenhoe Dam releases and downstream flow, Wivenhoe Dam release component of peak flow minimum practicable.

The previous flood studies recommended that one procedure be selected for the operation at Somerset Dam. This procedure had two advantages over the other procedures tested. Firstly, it was feasible for all magnitudes of Stanley River floods tested and, secondly, it was the simplest procedure to carry out. The re-analysis confirmed this conclusion.

The previous flood studies concluded that procedures for Wivenhoe Dam be reduced to four by combining two procedures into one. The resulting four procedures formed a hierarchy and the procedure to be adopted advances to the next procedure as the flood magnitude increases. The re-analysis confirmed this conclusion.

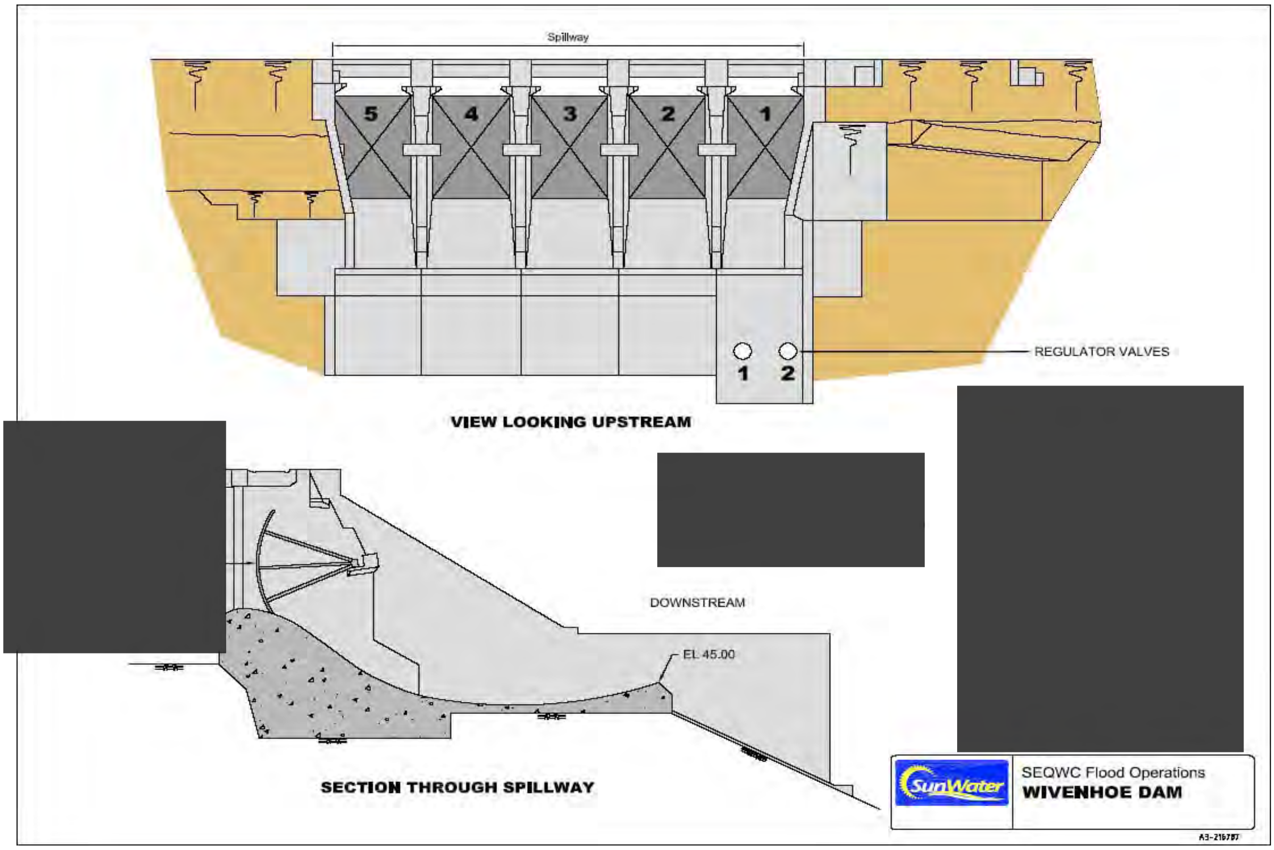
A Real Time Flood Operations Model for Somerset and Wivenhoe has been developed as part of the "Brisbane River and Pine River Flood Studies". This model incorporates the revised operational algorithms.

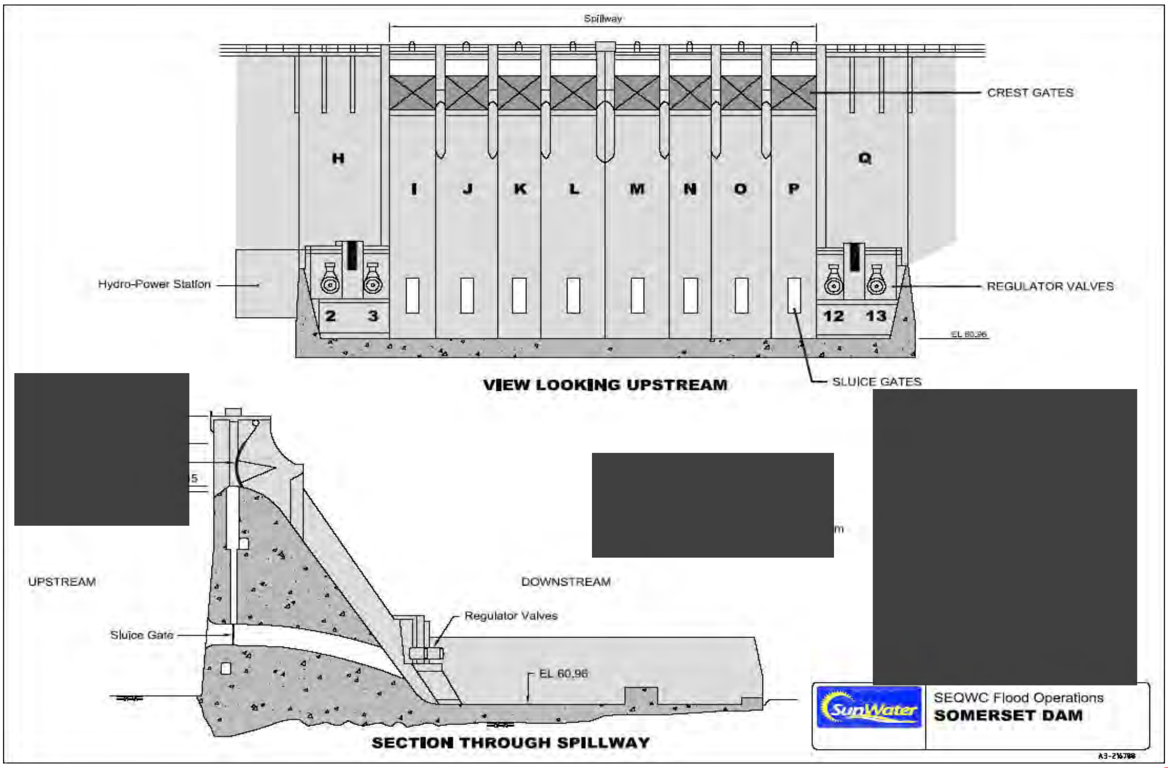
* Assume no failure of Wivenhoe Dam or Somerset Dam

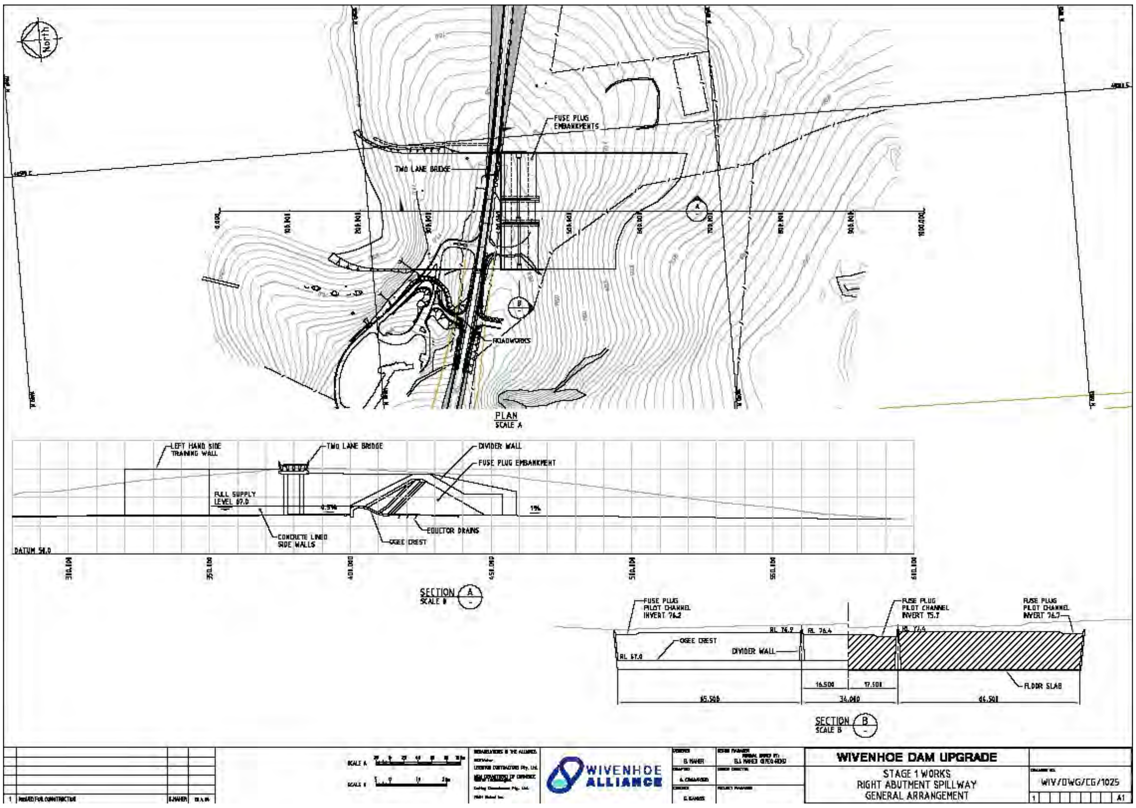
Deleted: : 6

Deleted: December 2004

APPENDIX J DRAWINGS



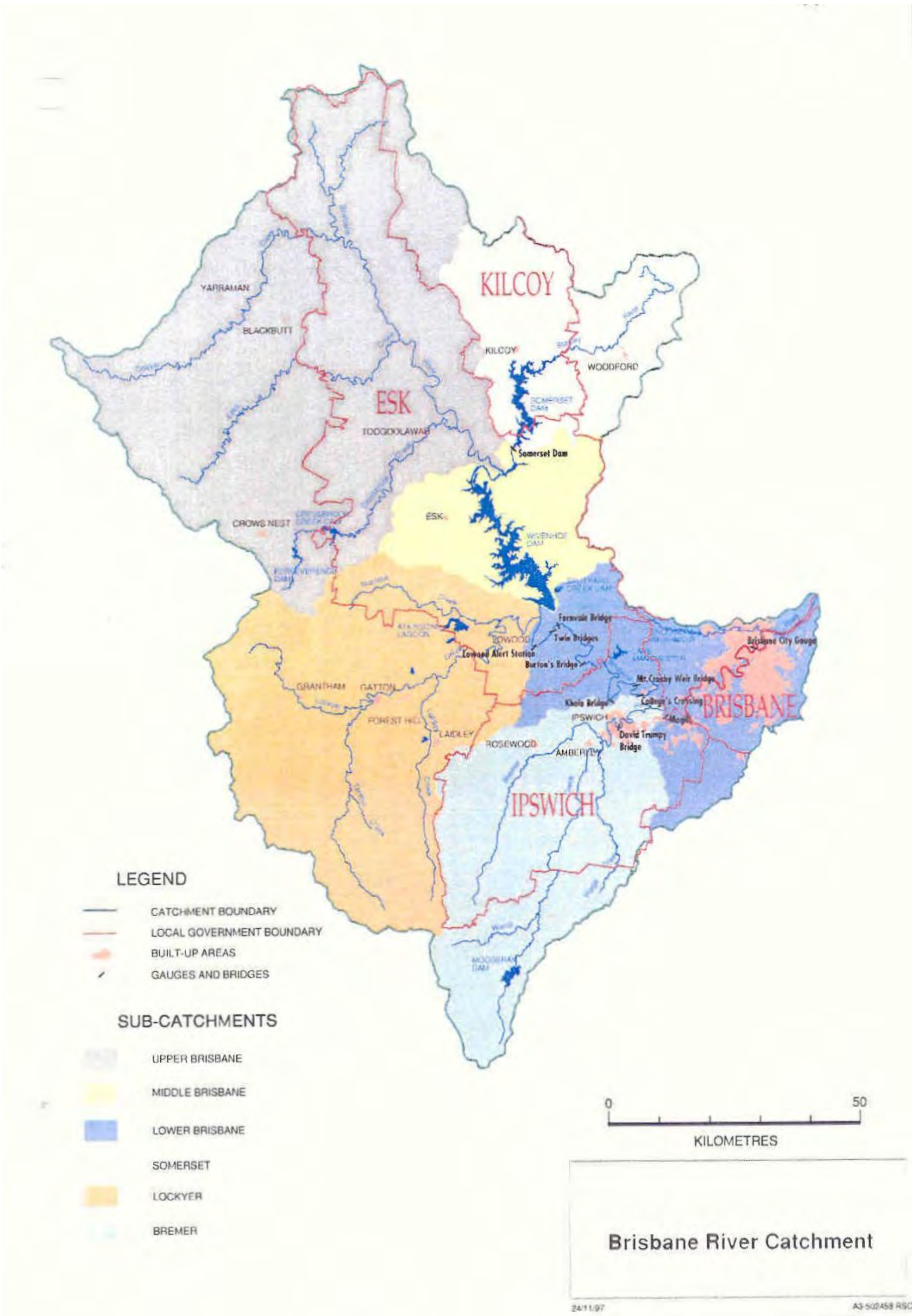




Deleted: : 6

Deleted: December 2004

APPENDIX K BRISBANE RIVER CATCHMENT



Page 8: [1] Deleted	ayrer	7/03/2006 11:44:00 AM

Page 36: [2] Deleted ayrer 28/11/2005 12:19:00 PM

Additional Provisions during Construction Works 2004/05

Auxiliary Spillway Area

The embankment forming the temporary road diversion that acts as a coffer dam is to be retained in place until the construction of the fuse plug has proceeded past EL 74, and then its removal is only to proceed once the written approval of a Senior Flood Operations Engineer has been obtained.

Gated Spillway Area

The following provisions will apply for works undertaken within the gated spillway:

The opening of spillway gates to discharge floodwaters is at the sole discretion of the Senior Flood Operations Engineer;

There is to be no obstruction of any spillway bay without the written approval of the Senior Flood Operations Engineer;

All gates are to be capable of being operated at short notice during a flood if required. To ensure this capability is maintained Table 8.6 specifies limitations that apply to the number of bays in which works may be occurring at any time. This table also nominates a target notice period to be provided by the Senior Flood Operations Engineer for the removal of construction material from the spillway bays prior to their use for releases. However the Senior Flood Operations Engineer is not constrained to provide this length of notice before operating any particular gate if its earlier operation is considered necessary.

Table 8.6 – Gated Spillway Area Works Restrictions

Dam Level	Season	Maximum number of bays that may be occupied at any time	Comments
Below EL 64.0	Winter (May to September)	3	12 hours notice to clear spillway
Below EL 64.0	Summer (October to April)	2	12 hours notice to clear spillway
Above EL 64.0	Winter (May to September)	2	12 hours notice to clear spillway
Above EL 64.0	Summer (October to April)	2	12 hours notice to clear spillway
Above EL 66.0	Flood Season (January to April)	1	Preferably not gate 1 or 5, 6 hours notice to clear spillway

A maximum of one gate may be treated as inoperable and remain closed if a flood will severely damage works if it is opened, and the expected flood magnitude can be catered for with 4 gates. The other gates are to be operated in accordance with the existing flood operational procedures but to compensate for the loss of flow in the closed gate. As the flood rises to the top of the closed gate at an EL 73 m AHD, the gate is incrementally raised to prevent it from being overtopped. It is noted that a large flood is required for the lake level to reach EL 73 m AHD.

The Corporation must prepare a Standing Operating Procedure for the conduct of works in the gated spillway whereby the above provisions are met such the capacity to achieve the dam’s operational objectives is maintained.

Sent 27/3/06

Geoff,

Peter Allen and I have had a look at revised flood operations manual.

There appear to be only two real changes to the operational procedures. These are

- The water level correlation targets in the Somerset Dam procedure (section 9.4) have been changed apparently in recognition of the 'safe' peak water level in Wivenhoe Dam being increased from EL77 to EL80. Can some comment be provided, separate to the procedures document, in support of the change. This probably means outlining the effects of the change. I'm not sure that the proposed changes are for the better.

- The option of breaching the saddle dams (section 10.2) is new in this draft manual. Again some comment should be given in support of the change.

Other things picked up in perusal of the document are:

Page 5 The introduction refers twice to the 2002 version of the Manual. I feel it should refer to the latest version i.e. the 2004 version.

Page 21 Table 6.1 – Natural Resources and Mines is now Natural Resources Mines and Water.

Page 32 Procedure 4A – The trigger level for the first bay is actually EL 75.7. An explanation that an allowance for wave action (?), water level prediction uncertainty (?) and whatever else might be added.

Page 32 The reference in Procedure 4A should be to Section 8.4 rather than Section 8.3

Page 33 Again the reference in Procedure 4B should be to Section 8.4 rather than Section 8.3

Page 35 The page orientation for the next few pages needs correcting.

Page 38 The format of the second column of Table 9.2 needs correcting.

Page 40 Section 10.2 still talks about will be .... following completion of auxiliary spillway

Page 43 The Water Level Correlation Targets table needs correcting.

Page 44 Some minor amendments have been made to this section of the Water Act. Section 498(3) now reads "If the owner complies with the chief executive's request, the chief executive must, by gazette notice, approve the manual as amended" while section 498(4) now starts "The approval of the manual as amended may be for".

Page 45 For Section 499, the second and third lines should be sub-sections (a) and (b) respectively.

Page 46 With reorganisation of Department of Emergency Services, the unit holding the Manual would now be Disaster Operations.

Page 55 The last 4 numbers in the fourth column of Table E1 don't seem right.

Page 58 There is still a note about needing to reformat the table.

Page 59 The title of the chart might be changed to Auxiliary Spillway Rating Curve. The Y-axis might be changed to Lake Level rather than Reduced Level.

Appendix I There are numerous references cited in this appendix, but they are not listed.

Page 70 The AEP of the PMP is 0.0007042% I think.

Another thing you might think about is the reporting requirements of the Manual e.g. of Schedule of Authorities, Register of Contact Persons, State of Preparedness of Operational Personnel and condition of the Monitoring and Warning System and Communication Network (there may be more). Their timing for lodgement is scattered throughout the year. Is this the best way for it to be?

If you have any queries about the above let me know.

Ron Guppy
Principal Engineer, Dam Safety
Water Industry Regulation
Department of Natural Resources, Mines & Water
Level 10, ANZ Bank Building, 324 Queen St
PO Box 2454, Brisbane, QLD 4001
Telephone: [redacted] Facsimile: [redacted]

From: Geoff Hales [mailto:[redacted]
Sent: Wednesday, 15 March 2006 2:40 PM
To: Guppy Ron
Cc: Rob Drury; Barton Maher; Rob.Ayre[redacted]
Subject: FW: Revised Draft Flood Ops Manual - WD-SD

Hi Ron

Please find attached revised copy of WIV-SOM Flood Ops Manual. We have checked and all seems OK, and have asked Rob Ayre to address drawings as per his email.
Just wanted to check you/Peter are happy with changes before we finalise and issue for gazetting. Could you provide us your comments.

Thanks
Geoff

Geoff

Geoff Hales
SEQWater
Wivenhoe Office
mobile [redacted]
phone [redacted] (Mon & Wed)
fax [redacted]

-----Original Message-----
From: Ayre, Rob [mailto:Rob.Ayre [redacted]
Sent: Tuesday, 7 March 2006 4:54 PM
To: Geoff Hales
Cc: Tibaldi, John; Cock, Don; McGrath, Toby; Ruffini, John
Subject: Revised Draft Flood Ops Manual - WD-SD

Geoff

Please find attached a copy of the Revised Draft Flood ops manual.

<<WD-SD-Rev 7.doc>>
I have left the tracked changes on the document so you can see what has been changed. Please note that we have filled in data for Tables E1 and Table E2, however the Alliance should check that these values concur with their CFD modelling results, and if not they should amend accordingly. Table E2 needs reformatting (which is currently being performed by one of our Executive Assistants - she will forward the amended document tomorrow).

Also the drawing in Appendix J needs to be modified to reflect the new Design Flood Level and the mini-hydro arrangements. Please let me know if you wish these changes to be affected.

The drawing of the auxiliary spillway is less than useful. I think that a clearer/simpler drawing showing a section and elevation is all that is required. Have the Alliance got such a drawing or we could produce something along the lines of the other figures?

I am attending an EBA meeting for most of Wednesday, but should be back in the office after 4:00pm if you wish to discuss the revised draft.

Regards

Rob Ayre

Senior Flood Operations Engineer &
Project Manager, Special Projects
Engineering Services
SunWater

William Buck Centre
120 Edward Street
PO Box 15536

City East Q 4002

Phone: [redacted]
Fax:
Mobile:

[redacted]

[redacted]

From: Ayre, Rob [redacted]
Sent: Tuesday, 18 April 2006 2:30 PM
To: ghales [redacted] Guppy Ron
Cc: Tibaldi, John
Subject: WD-SD Flood Ops manual - Response to Ron Guppy's Comments
Attachments: NRMCommentsV7I.doc; IDFigure.xls

Geoff/Ron

The attachments provide feedback to Ron's comments in his email dated 27 March 2006.

I will send the modified manual incorporating the modifications after we have had sign-off from you and Ron regarding the water level correlation targets for Somerset dam.

Regards

Rob Ayre
Senior Flood Operations Engineer &
Project Manager Special Projects
Engineering Services
SunWater

Phone: [redacted]
Fax:
Mobile:

rob.ayre [redacted]

Response to NRMW Comments to Version 7 of Manual

There appear to be only two real changes to the operational procedures. These are

- ***The water level correlation targets in the Somerset Dam procedure (section 9.4) have been changed apparently in recognition of the 'safe' peak water level in Wivenhoe Dam being increased from EL77 to EL80. Can some comment be provided, separate to the procedures document, in support of the change. This probably means outlining the effects of the change. I'm not sure that the proposed changes are for the better.***

The change to the water level correlation targets reflects the new maximum design peak flood level of Wivenhoe Dam (EL80).

The alteration to the target levels is based upon the adjustment the final duty point to EL80 and EL107.46. The main issue is how to progress to this final point when considering the introduction of the auxiliary spillway trigger levels.

It is acknowledged that the change incorporated into the manual actually increases the likelihood of the first fuse plug initiation when compared to the current values (i.e previously EL75.7 and EL106.1, now suggested as EL75.7 and EL104.8). Refer to the attached figure.

The correlation targets originally attempted to match freeboard – raising the Wivenhoe maximum flood level means that a given level in Somerset will now correlate with a higher level in Wivenhoe. If the freeboard criteria was applied this would further increase the likelihood of the first fuse plug initiation (EL75.7 and EL103.2). The suggested relationship was proposed to take advantage of the increased flood storage now available in Wivenhoe Dam, whilst not wanting to increase the likelihood of the initiation of a fuse plug.

It is recommended that these correlation targets be reassessed taking into account the fuse plug triggers. In general a higher level in Somerset should be correlated with the levels in Wivenhoe when each fuse plug is initiated. An example set of targets are shown in the table below, although the exact figures require further investigation. In particular, assessment of the risk of storing more water in Somerset needs to be performed.

The table below shows a possible modification to the original relationship that could also be followed. This is shown as the red diamonds in the accompanying figure. The trade off with this approach is the reduction in freeboard at Somerset dam after the third fuse plug initiates. (i.e. only 0.31 m between the trigger level of fuse plug 3 EL107.15 and the maximum design level of Somerset dam EL107.46).

Table 1 Example Correlation Target Points

Trigger Point	Somerset Lake Level (m AHD)	Wivenhoe Lake Level (m AHD)
Mary Smokes Bridge Imminent Inundation	102.25	72.00
Fuse Plug 1 Initiation	106.10	75.70
Fuse Plug 2 Initiation	106.60	76.23
Fuse Plug 3 Initiation	107.15	76.77
Maximum Dam Design Level	107.46	80.00

Note these are target points, not a target line. The path to each point is not critical, as long as each decision on Somerset gate openings move towards the next point. For example, if modelling indicates that Wivenhoe will reach EL75.7 before Somerset reaches EL106.1, then gate/s should be closed on Somerset.

- ***The option of breaching the saddle dams (section 10.2) is new in this draft manual. Again some comment should be given in support of the change.***

The breaching of the saddle dams was part of previous versions of the manual (i.e. Version 3 24 August 1998). The concept is re-introduced as the existing spillway configurations only provide protection up to the 1 in 100 000 year AEP event and not full Probable Maximum Flood.

Other things picked up in perusal of the document are:

Page 5 ***The introduction refers twice to the 2002 version of the Manual. I feel it should refer to the latest version i.e. the 2004 version.***

Agreed, reference should be made to Version 6 dated 20 December 2004.

Page 21 ***Table 6.1 – Natural Resources and Mines is now Natural Resources Mines and Water.***

Agreed.

Page 32 Procedure 4A – The trigger level for the first bay is actually EL 75.7. An explanation that an allowance for wave action (?), water level prediction uncertainty (?) and whatever else might be added.

Whilst the invert level of the first fuse plug pilot channel is EL75.7, a level of EL75.5 has been adopted as per the recommendation of the Auxiliary Spillway Design Team to allow for possible wave action and uncertainty in forecasting the likely peak lake level.

Page 32 The reference in Procedure 4A should be to Section 8.4 rather than Section 8.3

Agreed.

Page 33 Again the reference in Procedure 4B should be to Section 8.4 rather than Section 8.3

Agreed.

Page 35 The page orientation for the next few pages needs correcting.

Agreed.

Page 38 The format of the second column of Table 9.2 needs correcting.

Agreed.

Page 40 Section 10.2 still talks about will be .... following completion of auxiliary spillway

The tense of the sentence will be changed to read '*has been.....*'

Page 41 The Water Level Correlation Targets table needs correcting.

Agreed.

Page 44 Some minor amendments have been made to this section of the Water Act. Section 498(3) now reads "If the owner complies with the chief executive's request, the chief executive must, by gazette notice, approve the manual as amended" while section 498(4) now starts "The approval of the manual as amended may be for".

Acknowledged, will be incorporated as indicated.

Page 45 For Section 499, the second and third lines should be sub-sections (a) and (b) respectively.

Acknowledged, will be incorporated as indicated.

Page 46 ***With reorganisation of Department of Emergency Services, the unit holding the Manual would now be Disaster Operations.***

Change will be incorporated.

Page 55 ***The last 4 numbers in the fourth column of Table E1 don't seem right.***

Agreed, the last four entries are not correct.

Page 58 ***There is still a note about needing to reformat the table.***

Formatting has been completed, note to be removed.

Page 59 ***The title of the chart might be changed to Auxiliary Spillway Rating Curve. The Y-axis might be changed to Lake Level rather than Reduced Level.***

Agreed, curve was provided by Wivenhoe Alliance and will be adjusted accordingly.

Appendix I ***There are numerous references cited in this appendix, but they are not listed.***

References made in Appendix I will be incorporated into appropriate listing.

Page 70 ***The AEP of the PMP is 0.0007042% I think.***

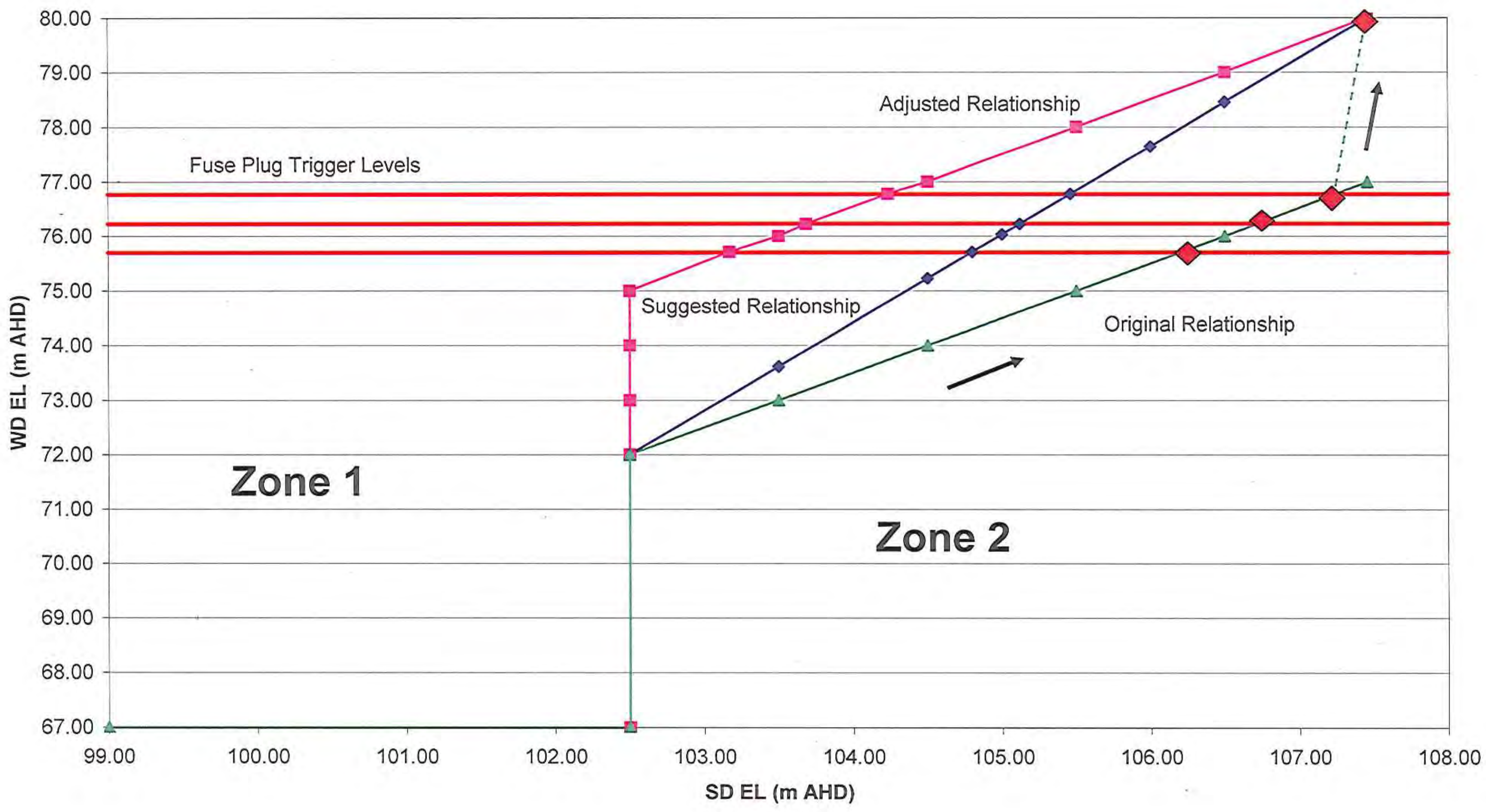
The AEP of the PMP of Wivenhoe Dam is 0.0007042 % as stated (or 1 in 142 250 years). The Wivenhoe Alliance has rounded this value to 1 in 143 000 years in their report 'design discharges and Downstream Impacts of the Wivenhoe Dam Upgrade Q1091, dated Sep 2005).

Another thing you might think about is the reporting requirements of the Manual e.g. of Schedule of Authorities, Register of Contact Persons, State of Preparedness of Operational Personnel and condition of the Monitoring and Warning System and Communication Network (there may be more). Their timing for lodgement is scattered throughout the year. Is this the best way for it to be?

We recommend that prior to the commencement of the wet season (1st October) each year that a statement of preparedness be submitted that covers the aforementioned issues. A separate report on the bi-annual performance of the warning system should also be submitted corresponding to the six monthly assessment. (i.e prior to the end of April each year).

The Register of Contact Persons and Schedule of Authorities should be updated at least annually be preferably every six months.

Revised Interaction Diagram



South East Queensland
WATER CORPORATION
LIMITED

MANUAL

OF

OPERATIONAL PROCEDURES

FOR FLOOD MITIGATION

FOR

WIVENHOE DAM

AND SOMERSET DAM

Revision No.	Date	Amendment Details
0	27 October 1968	Original Issue
1	6 October 1992	Complete revision and re-issue
2	13 November 1997	Complete revision and re-issue
3	24 August 1998	Change to page 23
4	6 September 2002	Complete revision and re-issue
5	4 October 2004	Complete revision
6	20 December 2004	Miscellaneous amendments and re-issue
7	6 June 2007	Complete Revision

Style Definition: Norı
Style Definition: TOC
Tabs: 48 pt, Left + 45
Right,Leader: ...
Style Definition: Tabl
Centered
Style Definition: Tabl
Style Definition: Title
Before: 12 pt, After: 6
Style Definition: Sub
After: 6 pt
Deleted:

Deleted:

Deleted: ¶

TABLE OF CONTENTS

Deleted:

Formatted: Don't adju between Latin and Asia Not at 48 pt + 450.8 p

Formatted: Don't adju between Latin and Asia Not at 48 pt + 450.8 p

Formatted: Don't adju between Latin and Asia Not at 48 pt + 450.8 p

Deleted:

Deleted:

Deleted:
Formatted: Font: 10 pt
Formatted: Bullets and

1. INTRODUCTION

1.1 PREFACE

Given their size and location, it is imperative that Wivenhoe and Somerset Dams be operated during flood events in accordance with clearly defined procedures to minimise hazard to life and property.

Recognising this, the South East Queensland Water Board Act required a manual be prepared of operational procedures for the dams during floods. With changes to the controlling legislation, the manual became an approved flood mitigation manual under *Water Act 2000* (extract in Appendix A).

This Manual is the result of a review of the 2004 revision of the Manual. The South East Queensland Water Corporation is required to review, update the Manual if necessary, and submit it to the Chief Executive for approval prior to its expiry. Any amendments to the basic operating procedures need to be treated similarly.

Prior to the 1998 version of the manual, an expanded flood monitoring and warning radio telemetry network (ALERT) was installed in the Brisbane River Catchment. Additionally, a computerised flood operational model that allows for rainfall and river modelling in real time based on data from the ALERT system was developed, implemented and fully commissioned. The accuracy and reliability of the system during a flood event has now been proven.

The primary objectives have not varied from those defined in the previous manual. These remain ensuring safety of the dams, their ability to deal with extreme and closely spaced floods, and protection of urban areas. The basic operational procedures have also essentially remained the same. Wivenhoe Dam and Somerset Dam are operated in conjunction so as to maximise the overall flood mitigation capabilities of the two dams. The procedures outlined in this Manual are based on the operation of the dams in tandem.

The changes to the 2004 version of the manual have arisen out of the completion of the spillway upgrade for Wivenhoe Dam with the addition of the three bay right abutment fuse plug spillway. The changes enable Wivenhoe Dam to pass a 1:100,000 AEP flood event. The manual covers the provisions introduced to cover flood operations of the dams including the auxiliary spillway.

Deleted: process

1.2 MEANING OF TERMS

In this Manual, save where a contrary definition appears -

"Act"	**means the *Water Act 2000*;**
"AEP"	**means annual exceedance probability, the probability of a specified event being exceeded in any year.**
"Agency"	**includes a person, a local government and a department of state government within the meaning of the Acts Interpretation Act 1954;**

Formatted Table
Formatted: Left
Formatted: Left

Deleted:

Formatted: Font: 10 pt

"AHD"	**means Australian Height Datum;**
"Bureau of Meteorology"	**means the Commonwealth Bureau of Meteorology;**
"Chairperson"	**means the Chairperson of the South East Queensland Water Corporation;**
"Chief Executive"	**means the Chief Executive or Director General of the Department of Natural Resources and Water;**
"Controlled Document"	**means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;**
"Corporation"	**means the South East Queensland Water Corporation;**
"Dams"	**means dams to which this Manual applies, that is Wivenhoe Dam and Somerset Dam;**
"Dam Supervisor"	**means the senior on-site officer at Wivenhoe or Somerset Dam as the case may be;**
"EL"	**means elevation in metres from Australian Height Datum;**
"Flood Operations Engineer"	**means the person designated at the time to direct the operations of Wivenhoe Dam and Somerset Dam under the general direction of the Senior Flood Operations Engineer and in accordance with the procedures in this Manual;**
"FSL" or "FULL SUPPLY LEVEL"	**means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;**
"Gauge"	**when referred to in (m) means river level referenced to AHD, and when referred to in (m3/sec) means flow rate in cubic metres per second;**
"Headworks Operator"	**for the purposes of this manual the Headworks Operator is the South-East Queensland Water Corporation and any operator engaged by it, as the context permits**
"Manual" or "Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam"	**means the current version of this Manual;**
"Power Station"	**means the Wivenhoe pumped storage hydro-electric power station associated with Wivenhoe Dam and Split-Yard Creek Dam;**
"Senior Flood Operations Engineer"	**means the senior person designated at the time pursuant to Section 2.1 of this Manual under whose general direction the procedures in this Manual must be carried out;**
"South East Queensland Water Corporation"	**means South East Queensland Water Corporation Limited, Registered Public Company, ABN 14 008 729 766**

Formatted: Not Superscript/ Subscript

1.3 PURPOSE OF MANUAL

The purpose of this Manual is to define procedures for the operation of Wivenhoe Dam and Somerset Dam to reduce, so far as practicable, the effects of flooding, by the proper control and regulation in time of Headworks under the control of the Corporation, with due regard to the safety of the structures comprising those Headworks.

Deleted: headworks

Deleted: headworks

For the purpose of this Manual, the Corporation adopts the policy that the community is to be protected to the maximum extent practical against flood hazards recognising the limitations on being able to:

- identify all potential flood hazards and their likelihood,
- remove or reduce community vulnerability to flood hazards,
- effectively respond to flooding, and
- provide resources in a cost effective manner.

1.4 LEGAL AUTHORITY

This manual has been prepared as a Flood Mitigation Manual in accordance with the provisions of Part 6 Division 2 of the Act.

1.5 APPLICATION AND EFFECT

The procedures in this Manual apply to the operation of Wivenhoe Dam and Somerset Dam for the purpose of flood mitigation, and operation in accordance with the manual shall give the protection from liability provided by Section 500 of *Water Act 2000.*

1.6 DATE OF EFFECT

The procedures in this Manual shall have effect on and from the date on which this version of the Manual is approved by gazette notice.

The Manual shall remain in force for the period of approval as determined by the chief executive. This approval may be for a period of up to five years.

Before the approval of the Manual expires, the Corporation must review and if necessary update the Manual and submit a copy to the chief executive for approval.

1.7 OBSERVANCE OF MANUAL

This Manual contains the operational procedures for Wivenhoe Dam and Somerset Dam for the purposes of flood mitigation, and must be applied by the Headworks Operator for the operation of the dams.

1.8 PROVISION FOR VARIATIONS TO MANUAL

If the Corporation is of the opinion that the procedures in this Manual should be amended, altered or varied, it must submit for approval as soon as practical a request, which is in accordance with the flood mitigation provisions of the *Water Act 2000*, to the Chief Executive setting out the circumstances and the exact nature of

Deleted:
Formatted: Font: 10 pt

the amendment, alteration or variation sought. The Chief Executive may require the Corporation amend the Manual by written notice.

1.9 DISTRIBUTION OF MANUAL

The Corporation must regard the manual as a Controlled Document and ensure that only controlled manuals are used in the direction of flood mitigation activities. Agencies having copies of Controlled Documents are listed in Appendix B. The Corporation must maintain a Register of Contact Persons for Controlled Documents and ensure that each issued document is updated whenever amendments or changes are approved.

Before using this Manual for the direction of flood control, the Headworks Operator must ensure that it is the current version of the Controlled Document.

Deleted:
Formatted: Font: 10 pt

Deleted:
Formatted: Font: 10 pt
Formatted: Bullets and

2. DIRECTION OF OPERATIONS

2.1 STATUTORY OPERATION

Pursuant to the provisions of the Act, the Corporation is responsible for and has the duty for operation and maintenance of Wivenhoe Dam and Somerset Dam.

The Headworks Operator is responsible for operating and maintaining Wivenhoe and Somerset Dams in accordance with this Manual and whilst the South-East Queensland Water Corporation may contract with other parties for the purpose of discharging its responsibilities as Headworks Operator, the Corporation remains responsible to ensure that operators, employees, agents, and contractors comply with this manual in order to retain the protection from liability afforded by Section 500 of the Act. Operators, employees, agents, and contractors also must comply with this Manual to obtain the protection of Section 500 of the Act.

2.1.1 Designation of Senior Flood Operations Engineer

The Headworks Operator must ensure that the procedures set out in this Manual are carried out under the general direction of a suitably qualified and experienced person who shall be referred to hereafter as the Senior Flood Operations Engineer. Only a person authorised in the Schedule of Authorities can give the general direction for carrying out procedures set out in this Manual.

2.1.2 Designation of Flood Operations Engineer

The Headworks Operator must have available or on standby at all times a suitably qualified and experienced Flood Operations Engineer to direct the operation of the dams during floods in accordance with the general strategy determined by the Senior Flood Operations Engineer.

The Headworks Operator must ensure that flood control of the dams is under the direction of a Flood Operations Engineer at all times. Only a person authorised in the Schedule of Authorities can direct the flood operation of the dams.

The Headworks Operator must also employ an adequate number of suitably qualified and experienced persons to assist the Flood Operations Engineer in the operation of the dams during floods.

2.2 QUALIFICATIONS AND EXPERIENCE OF ENGINEERS

2.2.1 Qualifications

All engineers referred to in Section 2.1 must meet all applicable requirements of registration or certification under any relevant State Act, and must hold appropriate engineering qualifications to the satisfaction of the Chief Executive.

Deleted:

Formatted: Font: 10 pt

2.2.2 Experience

All engineers referred to in Section 2.1 must, to the satisfaction of the Chief Executive, have:

1. Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and

2. At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:

Formatted: Indent: Han Numbered + Level: 1 + N Style: a, b, c, ... + Start a Alignment: Left + Aligned + Tab after: 54 pt + Ind pt

(a) Investigation, design or construction of major dams;

(b) Operation and maintenance of major dams;

(c) Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;

(d) Applied hydrology with particular reference to flood forecasting and flood warning systems.

2.3 SCHEDULE OF AUTHORITIES

The Corporation must maintain a Schedule of Authorities containing a list of the Senior Flood Operations Engineers and Flood Operations Engineers approved to direct flood operations at the dams during floods. A copy of the Schedule of Authority must be provided to the chief executive by 1st September of each year.

The Headworks Operator shall, as the need arises, nominate suitably qualified and experienced engineers for registration in the Schedule of Authorities as Senior Flood Operations Engineers and Flood Operations Engineers. Each new nomination must include a copy of any certificate required under Section 2.2 and a validated statement of qualifications and experience.

The Headworks Operator must obtain the approval for all nominations from the Chief Executive prior to their inclusion in the Schedule of Authorities.

If, in the event of unforseen and emergency situations, no Senior Flood Operations Engineer or no Flood Operations Engineer is available from the Schedule of Authorities, the Headworks Operator must temporarily appoint a suitable person or persons and immediately seek ratification from the Chief Executive.

2.4 TRAINING

The Headworks Operator must ensure that operational personnel required for flood control operations receive adequate training in the various activities involved in flood control operation.

Deleted:

Formatted: Font: 10 pt

2.5 DAM OPERATION ARRANGEMENTS

For the purposes of operation of the dams during times of flood, the Headworks Operator must ensure that:

a) The operation be carried out under the general direction of the Senior Flood Operations Engineer, and

b) In the direction of operations which may knowingly endanger life or property, the Senior Flood Operations Engineer must where practical liaise with the Chairperson of the Corporation and the Chief Executive or nominated delegate.

Deleted: t

Deleted: Operations En

Deleted: i

2.6 RESPONSIBILITIES OF THE SENIOR FLOOD OPERATIONS ENGINEER

The Senior Flood Operations Engineer is responsible for the overall direction of flood operations.

Except insofar as reasonable discretion is provided for in Section 2.8 of this Manual, the Senior Flood Operations Engineer must ensure that the operational procedures for the dam shall be in accordance with this Manual.

2.7 RESPONSIBILITIES OF THE FLOOD OPERATIONS ENGINEER

The Flood Operations Engineer must apply the operational procedures in accordance with this manual and the direction set for flood operations. In so doing, account must be taken of prevailing weather conditions, the probability of follow up storms and the ability of the dams to discharge excess flood waters in the period between rainfall events or in the period from the time of detection of conditions associated with the development storm cells, to the likely time of occurrence of the rainfall.

2.8 REASONABLE DISCRETION

If in the opinion of the Senior Flood Operations Engineer, based on available information and professional experience, it is necessary to depart from the procedures set out in this manual, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary to meet the situation, provided that the Senior Flood Operations Engineer observes the flood mitigation objectives set out in Section 3 of this Manual when exercising such reasonable discretion.

Before exercising discretion under this Section of the Manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must consult with such of the following persons as are available at the time that the discretion has to be exercised:

- the Chairperson of the Corporation, and
- the Chief Executive or nominated delegate.

If not able to contact any of the above within a reasonable time, the Senior Flood Operations Engineer may proceed with such other procedures considered as necessary to meet the situation and report such action at the earliest opportunity to the above persons.

2.9 REPORT

The Senior Flood Operations Engineer must prepare a report to the Headworks Operator after each event that requires flood operation of the dams and the report must contain details of the procedures used, the reasons therefore and other pertinent information. The Headworks Operator must forward the report to the Chief Executive together with any comments within six weeks of the completion of the event referred to.

Deleted:
Formatted: Font: 10 pt
Deleted: ¶
Formatted: Bullets and

Deleted:
Formatted: Font: 10 pt
Formatted: Bullets and

3. FLOOD MITIGATION OBJECTIVES

3.1 GENERAL

To meet the purpose of the flood operational procedures in this Manual, the following objectives, listed in descending order of importance, are as follows:

1. Ensure the structural safety of the dams;
2. Provide optimum protection of urbanised areas from inundation;
3. Operate the existing spillway and the Somerset Dam so as to minimise the frequency of operation of the fuse plug spillway at Wivenhoe.
4. Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;
5. Minimise disruption and impact upon Wivenhoe Power Station;
6. Minimise disruption to navigation in the Brisbane River.

Formatted: Bullets and

3.2 STRUCTURAL SAFETY OF DAMS

The structural safety of the dams must be the first consideration in the operation of the dams for the purpose of flood mitigation.

3.2.1 Wivenhoe Dam

The structural safety of Wivenhoe Dam is of paramount importance. Structural failure of Wivenhoe Dam would have catastrophic consequences.

Wivenhoe Dam is predominantly a central core rockfill dam. Such dams are not resistant to overtopping and are susceptible to breaching should such an event occur. Overtopping is considered a major threat to the security of Wivenhoe Dam. Works were undertaken between May 2004 and December 2005 to build an auxiliary spillway to cope with the 1:100,000 AEP flood event without overtopping of the dam. The auxiliary spillway consists of a three bay fixed crest spillway that includes erodible fuse plug embankments that are designed to initiate at varying trigger levels.

Deleted: are being unde between

The auxiliary spillway works in conjunction with the existing gated spillway. The design intent of the auxiliary spillway is to try and ensure that the existing spillway gates are fully opened by the time the first fuse plug bay is initiated. This is on the basis that the discharges through the existing spillway will result in less damage than allowing discharges through the auxiliary spillway.

The damage from the initiation of the fuse plug bays will be confined to the area immediately below the spillway return channel, with the routing effects of the reach to Savages Crossing reducing the peak in flooding further downstream in the Brisbane River.

3.2.2 Somerset Dam

The structural safety of Somerset Dam also is of paramount importance. Failure of Somerset Dam could have catastrophic consequences.

Whilst Wivenhoe Dam has the capacity to mitigate the flood effects of such a failure in the absence of any other flooding, if the failure were to occur during major flooding, Wivenhoe Dam could be overtopped and destroyed also.

Somerset Dam is a mass concrete dam. Such dams can withstand limited overtopping without damage. Stability analyses of the concrete dam indicated that the accepted stability criteria for a gravity dam are exceeded when the storage level in Somerset Dam exceeds EL109.7m, provided that the sector gates are fully raised. This level is lower if the sector gates were operated during a major flood event.

Due to uncertainties in the analysis and subject to further investigations, it is recommended that Somerset is operated so as not to exceed EL107.46m AHD.

Failure of such structures is rare but when they do occur, they occur suddenly without warning, creating very severe and destructive flood waves.

3.2.3 Extreme Floods and Closely Spaced Large Floods

Techniques for estimating extreme floods indicate that floods are possible which would overtop both dams. In the case of Wivenhoe Dam such an overtopping would most likely result in the destruction of the dam itself. Such events however require several days of intense rainfall to produce the necessary runoff.

Historical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane River system within a short time of each other. In order to be prepared to meet such a situation, the stored floodwaters from one storm should be discharged from the dams after a flood as quickly as would be consistent with the other major operating principles. Typically the Senior Flood Operations Engineer should aim to empty stored floodwaters within seven days after the flood peak has passed through the lower reaches of the Brisbane River. In a very large flood, this time frame may not be achievable because of downstream flood conditions and it may be necessary to extend the emptying period by several days.

The discharges should be regulated so as to have little impact on the urban reaches of the Brisbane River taking into account inflows into the river downstream of the dams. However they may result in submergence of some bridges. 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.

Deleted:

Formatted: Font: 10 pt

3.3 INUNDATION OF URBAN AREAS

The prime purpose of incorporating flood mitigation measures into Wivenhoe Dam and Somerset Dam is to reduce flooding in the urban areas on the flood plains below Wivenhoe Dam. The peak flows of floods emanating from the upper catchments of Brisbane and Stanley Rivers can be reduced by using the flood-gates to control releases from the dams, taking into account flooding derived from the lower Brisbane River catchments.

Formatted: Bullets and

3.4 LIMITING OPERATION OF THE FUSE PLUG SPILLWAY

Deleted: being

Deleted: in 2004 and 20

The auxiliary spillway constructed at Wivenhoe Dam incorporates fuse plugs. Triggering of a fuse plug will increase floods levels downstream. Where possible, gate operations at both Wivenhoe and Somerset dams should be formulated to prevent operation of the fuse plug. This is likely to be only possible when the forecast peak water level for Wivenhoe Dam just exceeds the trigger level for the fuse plug and sufficient time is available to alter releases.

Formatted: Bullets and

3.5 DISRUPTION TO RURAL AREAS

While the dams are being used for flood mitigation purposes, bridges and areas upstream of the dams may be temporarily inundated. Downstream of the dam, bridges and lower river terraces will be submerged. The operation of the dams should not prolong this inundation unnecessarily. The deck levels of bridges potentially inundated during flood events are shown on the Drawings in Appendix D.

Formatted: Bullets and

3.6 PROVISION OF PUMPING POOL FOR POWER STATION

The power station is not affected by the reservoir level in Wivenhoe Dam during floods other than the impacts high tail water levels have on the efficiency of the power station. The power station does however require a pumping pool for operation. The loss of storage by dam failure would render the power station inoperative.

Formatted: Bullets and

3.7 DISRUPTION TO NAVIGATION

The disruption to navigation in the Brisbane River has been given the lower priority. The effect of flood flows upon navigation in the river varies widely.

Large ships can be manoeuvred in the river at considerable flood flows. On the other hand, barges and dredges are affected by low flows which lower salinity thus decreasing the density of the water which in turn causes craft to sit lower in the water, sometimes bottoming. The Moggill Ferry is also affected by low flood flows.

A short emptying period for the flood storage compartment of the dams is consistent with Objectives (c) and (e) of Section 3.1, which are closely related.

Deleted:

Formatted: Font: 10 pt

Formatted: Bullets and

4. FLOOD CLASSIFICATION

For the reference purposes of this Manual, five magnitudes of flooding are classified as follows:

Table 4-1 – Flood Event Descriptions

Event	Description
Fresh	**This causes only very low-level bridges to be submerged.**
Minor Flooding	**This causes inconvenience such as closing minor roads and the submergence of low-level bridges. Some urban properties are affected.**
Moderate Flooding	**This causes inundation of low-lying areas and may require the evacuation of some houses and/or business premises. Traffic bridges may be closed.**
Major Flooding	**This causes flooding of appreciable urban areas. Properties may become isolated. Major disruption occurs to traffic. Evacuation of many houses and business premises may be required.**
Extreme Flooding	**This causes flooding well in excess of floods in living memory and general evacuation of whole areas are likely to be required.**

Usually a flood does not cause the same category of flooding along its entire length and the relevant agencies shall have regard to this when flooding is predicted.

(The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia)

Deleted:

Deleted:
Formatted: Font: 10 pt
Formatted: Bullets and

5. FLOOD MONITORING AND WARNING SYSTEM

5.1 GENERAL

A real time flood monitoring and warning system is established in the Brisbane Valley. This system is based upon an event reporting protocol. A radio telemetry system (ALERT) is used to collect, transmit and receive rainfall and streamflow information. The system consists of more than 50 field stations that automatically record rainfall and/or river heights at selected locations in the Stanley and Brisbane River catchments. Some of the field stations are owned by the Corporation with the remainder belonging to other agencies.

The rainfall and river height data is transmitted by radio telemetry, via repeater stations, to base stations at the head office of the Headworks Operator (and the Corporation). There the data is processed in real time by computer programs to assess what is occurring in the catchments in terms of flood flows and what could occur if weather conditions continued, or changed.

Other agencies with their own base stations can, and do, receive data transmissions direct, and so collect and are able to process rainfall and streamflow information appropriate to their needs.

The real time flood model (RTFM) is a suite of hydrologic and hydraulic computer programs that utilise the real time ALERT data to assist in the operation of the dams during flood events.

5.2 OPERATION

The Headworks Operator is responsible for operating the computer model provided by the Corporation for flood monitoring and forecasting during flood events to optimise flood gate operations and minimise the impacts of flooding.

It is the responsibility of the Corporation to maintain and keep calibrated its own equipment; and to enter into such arrangements with other agencies or to provide such further equipment as the Corporation deems necessary for the Headworks Operator to properly operate the computer model for flood monitoring and forecasting.

A system such as this is expected to improve over time due to:

- improved operation and reliability with experience,
- improved calibration as further data becomes available,
- software upgrades, and
- the number, type and locations of sensors being varied.

Deleted:

Formatted: Font: 10 pt

A regular process of internal audit and management review must be maintained to achieve this.

A log of the performance of all field equipment necessary to properly operate the computer model must be kept by the Corporation. The log is to also include all revised field calibrations and changes to the number, type and locations of gauges. Entries onto the log are to be notified to the Headworks Operator without delay in writing.

A log of the performance of the system (ALERT and RTFM) must be kept by the Senior Flood Operations Engineer. Any faults to the computer hardware or software, and any faults to field equipment which the Corporation has not advised the Headworks Operator of, are to be notified to the Corporation without delay in writing. The Corporation must promptly attend to the matters under its control and refer other matters to the appropriate agencies.

Whenever the Senior Flood Operations Engineer considers that the performance and functionality of the system can be improved, by whatever means, a recommendation must be made to the Headworks Operator accordingly. The Headworks Operator must promptly consider, act on, or refer such recommendations to the Corporation as it considers appropriate.

5.3 STORAGE OF DOCUMENTATION

The performance of any flood monitoring and warning system is reliant on accurate historical data over a long period of time. The Senior Flood Operations Engineer must ensure that all available data and other documentation is appropriately collected and catalogued as approved by the Corporation, for future use.

5.4 KEY REFERENCE GAUGES

Key field station locations have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to relocate field stations from these locations, or vary flood classification levels, agreement must first be obtained between the Corporation, Headworks Operator, Bureau of Meteorology and the Local Governments within whose boundaries the locations are situated. The locations and gauge readings at which the various classifications of flooding occur are contained in Appendix D.

Gauge boards that can be read manually must be maintained as part of the equipment of each key field station. The Corporation must have procedures to ensure such gauge boards are read in the event of failure of field stations to operate.

5.5 REFERENCE GAUGE VALUES

Other agencies such as the Bureau of Meteorology, Ipswich City Council and the Brisbane City Council have direct access to the information from field stations for flood assessment purposes. The consultation between agencies is a very important part of the assessment and prediction of flood flows and heights.

The Corporation must ensure that information relative to the calibration of the Corporation's field stations is shared with such agencies.

6. COMMUNICATIONS

6.1 COMMUNICATIONS BETWEEN STAFF

The Corporation is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams.

The Headworks Operator is responsible for ensuring that adequate communication exists at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams. Where equipment deficiencies are detected during normal operations, such deficiencies are to be reported within one week to the Corporation for timely corrective action.

6.2 DISSEMINATION OF INFORMATION

Other agencies have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public. Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public. Agency information requirements are generally as shown in Table 6.1.

The Flood Operations Engineer must supply information to each of these agencies during dam releases. For this purpose, the Corporation must maintain a Register of Contact Persons for Information, their means of contact including back up systems, and the specific information, including the timing, to be supplied to each. The Corporation must ensure that each agency receives a copy of the updated Register of Contact Persons for Information whenever amendments are made, but at least every 6 months.

The Corporation, Headworks Operator, Senior Flood Operations Engineer and Flood Operations Engineer must liaise and consult with the agencies with a view to ensuring all information relative to the flood event is consistent, and used and disseminated in accordance with agreed responsibilities.

All enquiries other than provided for in the Register of Contact Persons for Information, either to the Headworks Operator, the Senior Flood Operations Engineer, the Flood Operations Engineer or dam site staff must be referred to the Corporation. The Corporation must provide a mechanism to receive these enquiries from the time it is advised that releases from the dams are likely until flood release operations are completed.

Table 6-1 - Agency Information Requirements

Agency	Activity	Information Requirement from SEQWC Flood Centre	Trigger
Bureau of Meteorology	Issue of flood warnings for Brisbane River basin	Actual and projected discharges from Wivenhoe Dam Actual and projected discharges from Somerset Dam	Initial gate operations and ther intervals to suit forecasting rec
Natural Resources and Mines	Review of flood operations and discretionary powers.	Actual and predicted lake levels and discharges	
Kilcoy Shire Council	Flood level information upstream of Somerset Dam	Actual and predicted lake levels, Somerset Dam	Somerset Dam water level pre exceed EL 102
Esk Shire Council	Flood Level information upstream and downstream of Wivenhoe Dam	Actual and predicted lake levels and discharges, Wivenhoe Dam	Initial Wivenhoe Dam gate ope
Ipswich City Council	Flood level information for Ipswich City area	Nil (information obtained from BoM)	
Brisbane City Council	Flood level information for Brisbane City area	Nil (information obtained from BoM)	

6.3 RELEASE OF INFORMATION TO THE PUBLIC

The Corporation is responsible for the issue of information regarding storage conditions and current and proposed releases from the dams to the public and the media.

The Bureau of Meteorology has responsibility for issuing flood warnings.

The Emergency Services Response Authorities, under the Disaster Management Act 2003, have responsibility for the preparation of a local counter disaster plan hence the interpretation of flood forecast information for inclusion in their local flood warnings prepared under the flood sub plan of the counter disaster plan.

Deleted:

Formatted: Font: 10 pt

Formatted: Bullets and I

7. REVIEW

7.1 INTRODUCTION

This review of the Manual has addressed the mechanisms of delegation and control of the dams in periods of operation of the dams for flood mitigation. It is known overtopping of the dams can result should floods occur which are derived from lesser rainfall than the probable maximum precipitation storm or from the combination of two lesser storms in close proximity. The dams may also overtop in the eventuality that the flood-gate control systems or fuse plugs fail to operate as planned or partially malfunction during the passage of a major flood or combination of floods.

Procedures and systems have been developed that should enable lower risk operation of the dams for flood mitigation purposes. This technology is intended to provide longer warning times and the capability of examining options to optimise the safety of the dams and minimise the hazard potential and risk to the community.

With the passage of time neither the technical assumptions nor the physical conditions on which this Manual is based may remain unchanged. It is also recognised that the relevance of the Manual may change with changing circumstances.

It is important, therefore, that the Manual contain operational procedures which in themselves cause the Manual's procedures, and the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

The checking and reviewing process must involve the Headworks Operator and all associated operations personnel in order that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based.

Variations to the Manual may be made in accordance with provisions in Section 1.8.

7.2 PERSONNEL TRAINING

The Headworks Operator must report to the Corporation by 30th September each year on the training and state of preparedness of operations personnel. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources and Water within 14 days of it being received by the Corporation.

Deleted: Department of I
Resources, Mines and W

Deleted:

Formatted: Font: 10 pt

7.3 MONITORING AND WARNING SYSTEM AND COMMUNICATION NETWORKS

The Headworks Operator must provide a report to the Corporation by the 1st May and 1st November of each year; and after each flood event. The report must assess in terms of hardware, software and personnel, the :

- adequacy of the communication and data gathering facilities,
- reliability of the system over the previous period,
- reliability of the system under prolonged flood conditions,
- accuracy of forecasting flood flows and heights, and
- the overall state of preparedness of the system.

The Corporation must review the report, and taking into account its own log of the performance of the field equipment, take any action considered necessary for the proper functioning and improvement of the system. . A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources and Water within 14 days of it being received by the Corporation.

7.4 OPERATIONAL REVIEW

After each significant flood event, the Corporation must review the effectiveness of the operational procedures contained in this manual. The Headworks Operator is required to prepare a report for submission to the Corporation within six weeks of any flood event that requires mobilisation of the Flood Control Centre. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources and Water within 14 days of it being received by the Corporation.

7.5 FIVE YEARLY REVIEW

Prior to the expiry of the approval period, the Corporation must review the Manual pursuant to Section 6 Division 2 of the Act. The review is to take into account the continued suitability of the communication network, and the flood monitoring and warning system as well as hydrological and hydraulic engineering assessments of the operational procedures. The hydrologic investigations performed for the purpose of this manual are discussed in Appendix I.

Deleted:
Formatted: Font: 10 pt
Formatted: Bullets and

8. WIVENHOE DAM OPERATIONAL PROCEDURES

8.1 INTRODUCTION

Wivenhoe Dam is capable of being operated in a number of ways to reduce flooding in the Brisbane River downstream of the dam, depending on the part of the catchment in which the flood originates and depending also on the magnitude of the flood. Maximum overall flood mitigation effect will be achieved by operating Wivenhoe Dam in conjunction with Somerset Dam.

A general plan and cross-section of Wivenhoe Dam, and relevant elevations are included in Appendix J. Storage and discharge data are included in Appendix E.

The reservoir volume above FSL of EL 67.0 is available as temporary flood storage. How much of the available flood storage compartment is utilised, will depend on the initial reservoir level below FSL, the magnitude of the flood being regulated and the procedures adopted. Spiltyard Creek Dam is part of the overall Wivenhoe Area Project and it forms the upper pumped storage of the peak power generation scheme. Splityard Creek Dam impounds a volume of 28 700 ML at its normal full supply level (EL 166.5). The contents of Splityard Creek Dam can be emptied into Lake Wivenhoe within 12 hours by releasing water through the power station conduits. This volume of water can affect the level in Wivenhoe Dam by up to 300mm when Wivenhoe Dam is close to FSL. Operation of the power station and therefore also release of water from Splityard Creek Dam to Lake Wivenhoe is outside the control of the Corporation. The operational level of Splityard Creek Dam should be considered when assessing the various trigger levels of Wivenhoe Dam.

The Corporation has acquired land above FSL to a level of EL 75.0 to provide temporary flood storage. Reasonable care must be exercised to confine the flood rises to below this level. This requirement should be ignored in the case of extreme floods that threaten the safety of the dams.

8.2 AUXILIARY SPILLWAY

The auxiliary spillway for Wivenhoe Dam constructed in 2004/05 as part of an upgrade to improve flood adequacy consists of a three bay fuse plug spillway located on the right abutment of the main embankment. In association with other works carried out at the dam, the dam crest flood is now assessed as having an annual exceedance probability (AEP) of approximately 1 in 100,000. Another one bay fuse plug spillway may be constructed at Saddle Dam Two in the future to provide full protection against the Probable Maximum Flood.

Deleted: being
Deleted: at
Deleted: being
Deleted: this will give
Deleted: t
Deleted: Maxmimum

Pertinent information about the auxiliary spillway, including the initiation level for the specific bays is given in Table 8.1.

Table 8-1 - Right Bank Fuse Plug Details

Auxiliary Spillway Component	Spillway Crest Control Type	Spillway Crest Width (m)	Spillway Crest Level (m AHD)	Fuse Plug Pilot Channel Invert Level (m AHD)	Lake Level corresponding to Fuse Plug Pilot Channel Invert Level * (m AHD)
Central fuse plug bay	Ogee	34	67	75.7	75.7
Right hand side fuse plug bay	Ogee	64.5	67	76.2	76.23+
Left hand side fuse plug bay	Ogee	65.5	67	76.7	76.78++

* Lake Water Level is as per that measured at the Headwater Gauge.

Initiation of Fuse Plug is expected to occur when the Lake Water Level exceeds the Lake Level at Fuse Plug Pilot Channel by 0.10 - 0.15 m

\+ Includes 0.03m of drawdown from the Fuse Plug Pilot Channel Invert to the Lake Water Level

++ Includes 0.08m of drawdown from the Fuse Plug Pilot Channel Invert to the Lake Water Level

8.3 INITIAL FLOOD CONTROL ACTION

When indications are received of an imminent flood, the flood control operation of the dam must commence with the storing of all inflow of the Brisbane River in Wivenhoe Dam, whilst an assessment is made of the origin and magnitude of the flood. The spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding EL 67.25.

8.4 REGULATOR AND GATE OPERATION SEQUENCES

Rapid opening of outlets (spillway gates and regulators) can cause hydraulic surges and other effects in the Brisbane River that can endanger life and property and may sometimes have other adverse effects. Under normal gate operations, the gates and regulators are therefore to be operated one at a time at intervals that will minimise adverse impacts on the river system.

Rapid closure of the gates can affect river-bank stability. Rapid closure of more than one gate at a time should only be used when time is critical and there is a requirement to correct a malfunction to preserve storage or to reduce downstream flooding rapidly. For flood operations where time is not critical, longer closure intervals should be used. The minimum closure intervals specified below are based on the recession limb of natural flood hydrographs such as the January 1974 flood.

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a gate by the immediate opening of a regulator valve (or the reverse operation). This allows for greater control of low flows and enables a smooth transition and closure as slow as possible to prevent the stranding of fish downstream of Wivenhoe Dam.

Deleted:

Formatted: Font: 10 pt

Deleted: p

Except as provided for in Procedure 4 of Section 8.4 where it is necessary to prevent operation of a fuse plug or to have the gates clear of the spillway flow prior to the fuse plug operating and as indicated above, the gate opening and closing intervals as shown in Table 8.2 are the most rapid permitted for flood mitigation purposes.

Table 8-2 - Minimum Intervals For Normal Gate Operations

500 mm Incremental gate openings	10 minutes
500 mm Incremental gate closures	20 minutes
Full regulator opening or closures	30 minutes

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions, or when gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool, which has been excavated into erodible sandstone rock, and cause non-predictable erosion. Upstream migration of this erosion is to be avoided. The wing walls adjacent to the flip bucket deflect the discharge away from the walls of the plunge pool when gates 1 and 5 are operated.

Therefore in operating the spillway, the principles to be observed are, in order of priority:

a) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

b) The flow in the spillway is to be symmetrical.

Under normal operation, only one gate is to be opened at any one time and the sequences given in Table 8.3 are to be adopted:

Deleted:

Formatted: Font: 10 pt

Table 8-3 - Radial Gate Opening Sequences[1]

Approximate Discharge Range		Gate opening sequence2	Comments
(a)	Up to 330 m^3/sec	Open Gate 3 up to 3.5 metres	Gates 1, 2, 4 & 5 remain closed
(b)	330 m^3/sec to 575 m^3/sec	Gate 3 at 3.5 metres Open Gates 2 & 4 alternately to 0.5 metre Open Gate 3 to 4.0 metre Open Gates 2 & 4 alternately to 1.0 metre	Gates 1 & 5 remain closed unless discharge from Gates 2 & 4 impinges on side wall of plunge pool proceed to (c)
(c)	575 m^3/sec to 1160 m^3/sec	Gate 3 kept at 4.0 metres Open Gates 1 & 5 alternately one increment followed by Gates 2 & 4 alternately one increment Repeat Step until at the end of the sequence Gates 1 & 5 are open 1.5 metres and Gates 2 & 4 are open 2.5 metres	Flow in spillway to be as symmetrical as possible Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5
(d)	1160 m^3/sec to 1385 m^3/sec	Open Gate 3 to 4.0 metres Open Gates 1 & 5 alternately to 2.0 metres followed by opening Gates 2 & 4 alternately to 3.0 metres	Flow in spillway to be as symmetrical as possible Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5
(e)	1385 m^3/sec to 2290 m^3/sec	Open ALL gates to 5.0 metre openings	Flow in spillway to be as symmetrical as possible Gates 2 & 4 are to have openings not less than Gates 1 & 5 or not more than 1.0 metre more than Gates 1 & 5 Gate 3 is to have an opening not less than Gates 2 & 4 or not more than 1.0 metre more than Gates 2 & 4.
(f)	Greater than 2290 m^3/sec	Open ALL gates incrementally in the sequence 3, 2, 4, 1, 5[3]	Flow in spillway to be as symmetrical as possible Gate 3 to have the largest opening Gates 2 & 4 are to have openings greater than Gates 1 & 5

1 Gates are numbered 1 to 5 from the left bank looking downstream.

2 Gate movements are to normally occur in 500 mm increments.

3 When the accelerated opening rate applies, gate-opening increments of 1.0 metres may be used.

Deleted: gate opening

Deleted:

Formatted: Font: 10 pt

Gate operating procedures in the event of equipment failure are contained in Appendix G. If one or more gates are inoperable during the course of the flood event, the gate openings of the remaining gates are to be adjusted to compensate. These adjustments should ensure that:

a) the impact of the flow on the sidewalls of the plunge pool should be minimised, and

b) the flow in the spillway is as symmetrical as practicable.

In general, gate closing is to occur in the reverse order. The final gate closure should occur when the lake level has returned to Full Supply Level.

8.5 FLOOD CONTROL PROCEDURES

When the preliminary estimation of the degree of expected flooding has been made, the operating procedures set out hereunder shall be used at Wivenhoe Dam in line with the Flood Mitigation Objectives.

When considering the discharge to be made from both Wivenhoe Dam and Somerset Dam under particular procedures, the total discharge for each dam from all sources is to be considered when determining the appropriate openings for gates, valves and sluices.

The flood control procedures to be adopted commence with Procedure 1 and extend through to Procedure 4 as the magnitude of the flood as predicted by the real time flood model increases. Table 8.5 summarises the application for each procedure for the initial filling of Wivenhoe Dam. Once Wivenhoe Dam has peaked and the drainage phase has commenced the indicative limits will not apply.

Procedure 1

Under Procedure 1, water is to be released from Wivenhoe Dam with care being taken not to prematurely submerge the downstream bridges. The limiting condition for Procedure 1 is the submergence of Mt Crosby Weir Bridge that occurs at approximately 1,900 m^3/sec.

The procedure adopted primarily depends on the level in Wivenhoe Dam and the discharge emanating from Lockyer Creek.

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. Except in the drainage phase releases are not to exceed the values given in Table 8.4:-

Deleted:
Formatted: Font: 10 pt

Table 8-4 - Wivenhoe Dam, Procedure 1 Maximum Release Rates

Lake Level in Wivenhoe Dam	Maximum Release Rate (m^3/sec)
67.00 - 67.25	0
67.25 - 67.50	110
67.50 - 67.75	380
67.75 - 68.00	500
68.00 - 68.25	900
68.25 - 68.50	1900

The following subsets of Procedure 1 were originally developed by the Brisbane City Council to cater for limiting the submergence of the various low-level downstream bridges. The procedures require a great deal of control over releases and knowledge of discharges from Lockyer Creek.

In general, the releases from Wivenhoe Dam are controlled such that the combined flow from Lockyer Creek and Wivenhoe Dam is less than the limiting values to delay the submergence of particular bridges.

Procedure 1A *Savages Crossing & Colleges Crossing*

For: Lake level between 67.25 and 67.5 m AHD [Maximum Release 110 m^3/sec]

Endeavour to maintain Twin Bridges trafficable by limiting releases at Wivenhoe Dam to a maximum of 50 m^3/sec and by reducing this rate of release if run-off from Lockyer Creek is likely to cause the bridges to be overtopped. The bridges become untrafficable at a flow of about 55 m^3/sec.

Once Twin Bridges are overtopped by run-off from Lockyer Creek, release to be directed towards maintaining College's Crossing trafficable by adjusting the rate of release so that the combined flow rate at College's Crossing is less than 175 m^3/sec.

Procedure 1B *Noogoorah Bridge (Burtons Bridge)*

For: Lake level between 67.50 and 67.75 m AHD [Maximum Release 380 m^3/sec]

Initially endeavour to maintain College's Crossing trafficable. This becomes untrafficable at a flow of about 175 m^3/sec. No consideration to be given to keeping Twin Bridges trafficable.

Once College's Crossing is flooded by the run-off from Lockyer Creek and the downstream section of the Brisbane River, releases to be set to achieve a combined flow of about 380 m^3/sec at the Noogoorah Bridge Crossing. This bridge becomes untrafficable at a flow of about 430 m^3/sec.

Procedure 1C *Kholo Bridge*

For: Lake level between 67.75 and 68.00 m AHD [Maximum Release 500 m^3/sec]

Initially endeavour to maintain Noogoorah Bridge trafficable. No consideration to be given to keeping College's Crossing trafficable.

Once Noogoorah Bridge is flooded by the run-off from Lockyer Creek and the downstream section of the Brisbane River, releases to be set to keep Kholo Bridge trafficable. This bridge becomes untrafficable at a flow rate of about 550 m^3/sec.

Procedure 1D *Mt Crosby Weir Bridge*

For: Lake level between 68.00 and 68.25 m AHD [Maximum Release 900 m^3/sec]

Initially endeavour to maintain Kholo Bridge trafficable. No consideration to be given to keeping Noogoorah Bridge trafficable.

Once Kholo Bridge is flooded by the run-off from Lockyer Creek and the downstream section of the Brisbane River, releases to be set to keep Mt Crosby Bridge trafficable. This bridge becomes untrafficable at a flow of 1,900 m^3/sec.

Procedure 1E *Mt Crosby Weir Bridge*

For: Lake level between 68.25 and 68.50 m AHD [Maximum Release 1,900 m^3/sec]

Similar to Procedure 1D, but with an upper release limit of 1,900 m^3/sec.

If the level reaches EL 68.5 m AHD in Wivenhoe Dam, operations switch to Procedure 2 or 3 as appropriate.

Procedure 2 may be bypassed if it is clear from the flood modelling that Procedure 3 will be activated.

Procedure 2

Under Procedure 2, water is to be released from Wivenhoe Dam with care being taken not to submerge Fernvale Bridge and Mt Crosby Weir Bridge prematurely. Typically releases will take place on the rising limb of the flow from Lockyer Creek. If this flow is sufficient to submerge Mt Crosby Weir bridge (1,900 m^3/sec), releases are to be increased such that the combined flow from Lockyer Creek and Wivenhoe Dam releases does not exceed either:-

(i) 3,500 m^3/sec at Lowood or

(ii) the greater of the peak flow of Lockyer Creek or the predicted peak flood flow of the Bremer River.

Should the Mt Crosby Weir Bridge be flooded by flows from catchments downstream of Wivenhoe Dam, the upper limit of the combined Lockyer Creek flow and releases from Wivenhoe Dam shall, subject to (i) and (ii) above, not exceed 3,500 m^3/sec at Lowood.

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

Procedure 3

Under Procedure 3, water is to be released from Wivenhoe Dam such that the combined Lockyer Creek flood flow and Wivenhoe Dam release is not to exceed 3,500 m^3/sec at Lowood. The releases are to be regulated such that the total regulated flow at Moggill gauge downstream of the Bremer River junction does not exceed 4,000 m^3/sec [which is the upper limit for non-damaging flows for the urban reaches of the Brisbane River].

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

Procedure 4

This procedure normally comes into effect when the water level in Wivenhoe Dam reaches EL 74. However the Senior Flood Operations Engineer may seek to invoke the discretionary powers of Section 2.8 if earlier commencement is able to prevent triggering of a fuse plug.

Under Procedure 4 the release rate is increased as the safety of the dam becomes the priority. Opening of the gates is to occur until the storage level of Wivenhoe Dam begins to fall.

If required, the minimum time interval between gate openings can be reduced or successive gate openings of the same gate may be used in this procedure as considered appropriate. In addition to dam safety issues, the impact of rapidly increasing discharge from Wivenhoe Dam on downstream reaches should be considered in determining these intervals

Sub-procedures 4A, and 4B have been developed for use depending on the expected peak water level in the dam.

Deleted:
Formatted: Font: 10 pt
Deleted: s
Deleted: and 4C
Deleted: the stage of co the auxiliary spillway and

Procedure 4A

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

Gate openings are to occur at the minimum intervals and sequences as specified in Section 8.3. Opening of the gates is to continue until the storage level of Wivenhoe Dam begins to fall.

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

Procedure 4B

Procedure 4B applies once indications are the peak flood level in Wivenhoe Dam will exceed EL75.5 using the minimum gate opening intervals for normal operation as specified in Section 8.3 i.e. it is expected that the fuse plug will be triggered under normal operation.

In this procedure the minimum time interval between gate openings is able to be reduced and successive gate openings of the same gate may be made.

If the real time flood model using a 1 metre in 10 minute gate opening procedure, predicts a peak water level in Wivenhoe Dam of less than EL 75.5, the gates may be raised at a rate to maximise flood storage capacity but to prevent the first fuse plug from initiating.

Otherwise the gates are to be raised at a rate to ensure they are out of the water before the initiation of the first fuse plug (if possible). Where practicable, the gates are to be in the fully open position before the dam water level reaches EL 75.7 m AHD.

In addition to dam safety issues, the impact of rapidly increasing discharge from Wivenhoe Dam on downstream reaches should be considered in determining these intervals.

The effect of varying the operational procedures at Somerset Dam in keeping the peak flood level at Wivenhoe Dam below EL 75.7 may also be investigated using the real time flood model.

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

Deleted:

Formatted: Font: 10 pt

Deleted: ***Procedures 4A are only to be applied o auxiliary spillway fuse p functional. This is expe in the latter part of 2005 interim, Procedure 4C is applicable.¶***

Deleted: *s*

Deleted: *s*

Deleted: *Procedure 4C¶
¶
Procedure 4C applies onl construction phase of the auxiliary spillway.¶
¶
Opening of the gates is to the storage level of Wiver begins to fall. ¶
The minimum time interva gate openings can be red successive gate openings same gate may be used i procedure as considered for ensuring the safety of addition to dam safety iss impact of rapidly increasi from Wivenhoe Dam on d reaches should be consid determining these interva
¶
The gate opening constra be overridden when the g overtopped during norma*

Table 8-5 - Wivenhoe Dam – Normal Release Operating Procedures: Initial Filling

Procedure	Reservoir Level	Applicable Limits		
0	EL < 67.25	$Q_{Wivenhoe} = 0\ m^3/sec$ ... i.e No Releases		
1A	67.25 < EL < 67.50	$Q_{Wivenhoe} < 110\ m^3/sec$	QColleges Crossing < 175 m3/sec with care taken not to submerge Twin Bridges prematurely	
1B	67.25 < EL < 67.50	$Q_{Wivenhoe} < 380\ m^3/sec$	QBurtons/Noogoorah < 430 m3/sec with care taken not to submerge Colleges Crossing prematurely	
1C	67.75 < EL < 68.00	$Q_{Wivenhoe} < 500\ m^3/sec$	QKholo < 550 m3/sec with care taken not to submerge Burtons/Noogoorah prematurely	
1D	68.00 < EL < 68.25	$Q_{Wivenhoe} < 900\ m^3/sec$	QMtCrosby < 1900m3/sec with care taken not to submerge Kholo prematurely	
1E	68.25 < EL < 68.50	$Q_{Wivenhoe} < 1500\ m^3/sec$	QMtCrosby < 1900m3/sec with care taken not to submerge Kholo prematurely	
2	68.50 < EL < 74.00	$Q_{Lowood} < 3500\ m^3/sec$	QLowood < peak of Lockyer and QLowood < peak of Bremer	Gates are overtopped
3	68.50 < EL < 74.00	$Q_{Lowood} < 3500\ m^3/sec$	QMoggill < 4000 m3/sec	
4	EL > 74.00[4]	Gates are to be opened until reservoir level begins to fall		

4 Once water level exceeds EL 74.0, operating procedures are dependant on the predicted peak water level.

Deleted:

Formatted: Font: 10 pt

8.6 CLOSING PROCEDURES

If at the time the lake level in Wivenhoe Dam begins to fall, the combined flow at Lowood is in excess of 3500 m^3/sec, then the combined flow at Lowood is to be reduced to 3500 m^3/sec as quickly as practicable having regard to Section 3, and is to remain at this rate until final gate closure procedures can commence.

Gate closing procedures should be initiated having regard to the following requirements:

a) Early release of stored water to regain flood-mitigating ability for any subsequent flood inflows as described in Section 3.2.3.

b) The total discharge from Wivenhoe Dam from all sources is to be considered when considering appropriate closing procedures. This includes any discharge from triggered fuse plugs.

c) Gate operation procedures as described in Section 8.4.

d) Establishment of storage at FSL at completion of flood events.

e) Downstream impact of the discharges. To prevent the stranding of fish downstream of the dam, closures below flows of 275 m^3/sec should be undertaken as slow as practicable and if possible such closures should occur during daylight hours on a weekday so that personnel are available for fish rescue.

If the flood storage compartments of Wivenhoe Dam and Somerset Dam can be emptied within the prescribed time of seven days, the release from Wivenhoe Dam should be limited to between 1900 m^3/sec and 3500 m^3/sec. In such circumstances, the release from the dam should be less than the peak flow into the lake. Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.

8.7 MODIFICATION TO FLOOD OPERATING PROCEDURES IF A FUSE PLUG TRIGGERS PREMATURELY

Where the operation of a fuse plug spillway bay has been triggered prior to its design initiation level being reached, the flood operation procedures are to be modified such that:

- the discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;
- the gates are to be operated, to the extent possible, so that the same discharge restrictions apply as would have if the fuse plug embankment was intact.

Deleted:

Formatted: Font: 10 pt

8.8 MODIFICATION TO FLOOD OPERATING PROCEDURES IF A SUBSEQUENT FLOOD EVENT OCCURS PRIOR TO THE RECONSTRUCTION OF TRIGGERED FUSE PLUGS

Where the operation of any or all of the fuse plug spillway bays has been triggered and a flood event occurs before the fuse plug can be reinstated, the flood operation procedures are to be modified such that:

- the discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;
- the gates are to be operated, to the extent possible, so that the same discharge restrictions apply as would have if the fuse plug embankment was intact.

Deleted: <#>ADDITIONAL PROVISIONS DURING CONSTRUCTION WORKS 20
¶
<#>Auxiliary Spillway Area¶
¶
The embankment forming the temporary road diversion that a coffer dam is to be retained until the construction of the fu has proceeded past EL 74, ar its removal is only to proceed the written approval of a Seni Operations Engineer has beer obtained.¶
¶
<#>Gated Spillway Area¶
¶
The following provisions will a works undertaken within the g spillway:¶
¶
<#>The opening of spillway ga discharge floodwaters is at the discretion of the Senior Flood Operations Engineer;¶
¶
<#>There is to be no obstruct any spillway bay without the w approval of the Senior Flood Operations Engineer;¶
¶
<#>All gates are to be capabl being operated at short notice a flood if required. To ensure capability is maintained Table specifies limitations that apply number of bays in which work be occurring at any time. This also nominates a target notice to be provided by the Senior F Operations Engineer for the re of construction material from t spillway bays prior to their use releases. However the Senio Operations Engineer is not constrained to provide this ler notice before operating any pa gate if its earlier operation is considered necessary.¶
¶
Table 8.6 – Gated Spillway A Works Restrictions¶
¶
Dam Level

Deleted:
Formatted: Font: 10 pt
Formatted: Bullets and Num

9. SOMERSET DAM OPERATIONAL PROCEDURES

9.1 INTRODUCTION

Somerset Dam is capable of being operated in a number of ways to regulate Stanley River floods. Somerset Dam and Wivenhoe Dam are meant to be operated in conjunction to optimise the flood mitigation capacity downstream of Wivenhoe Dam.

A general plan and cross-section of Somerset Dam, and relevant dam operating levels are included in Appendix J.

The discharge capacities for various storage levels of Somerset Dam are listed in Appendix F.

9.2 INITIAL FLOOD CONTROL ACTION

Upon indications being received of a significant inflow, the flood control operation of the dam shall commence with the raising of any closed gates and the closure of all low level regulators and sluices, whilst an assessment is made of the origin and magnitude of the flood.

9.3 REGULATOR AND GATE OPERATION PROCEDURES

The following minimum intervals must be observed whilst opening and closing regulators, sluices and crest gates at Somerset Dam for flood mitigation purposes:

Table 9-1 - Minimum Intervals, Normal Operation, Somerset Dam

	Opening	Closing
Regulators	30 minutes	60 minutes
Sluice Gates	120 minutes	180 minutes
Crest Gates	Gates are normally open	

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a sluice gate by the immediate opening of one or more regulator valves (or the reverse operation). This allows for greater control of low flows and enables a smooth transition on opening and closing sequences.

9.4 FLOOD CONTROL PROCEDURE

It is essential that the operating procedures adopted should not endanger the safety of Wivenhoe Dam downstream. Within this constraint, the Senior Flood Operations Engineer must adopt a procedure for the operation of Somerset Dam such that:

Deleted:
Formatted: Font: 10 pt

a) the structural safety of Somerset Dam is not endangered;

b) the Upper Brisbane River flood flow plus Somerset Dam releases does not cause Wivenhoe Dam to be overtopped.

The normal operating procedure to be used for Somerset Dam is as follows.

The crest gates are raised to enable uncontrolled discharge. The low level regulators and sluices are to be kept closed until either:

(i) the lake level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

In the case of (i) above the opening of the regulators and sluices is not to increase the inflow to Wivenhoe Dam above the peak inflow from the Brisbane River just passed or, if possible, not to cause the Wivenhoe Dam lake level to exceed EL 74.

In the case of (ii) above, the Senior Flood Operations Engineer must direct the operation of the low-level regulators and sluices to ensure the safety of Somerset Dam. If the water level and predicted inflows are such that the safety of Somerset Dam is not an overriding concern, operations are to target a correlation of water levels in Somerset Dam and Wivenhoe Dam as set out in Table 9.2 such that the relative flood storage between the flood level in Wivenhoe Dam and EL 80 is the same as the relative flood storage between the flood level in Somerset Dam and EL 107.46, the non-spillway crest level in Somerset Dam.

Deleted: free-board
Deleted: 77
Deleted: free-board

Table 9-2 - Water Level Correlation Targets

Somerset Lake Level M AHD	Wivenhoe Lake Level m AHD
102.5	72.0
103.5	73.6
104.5	75.2
105.5	76.8
106.5	78.5
107.46	80.0

Deleted: 72
Deleted: ¶ 73
Deleted: ¶ 74
Deleted: ¶ 75
Deleted: ¶ 76
Deleted: ¶ 77

The constraints applicable to case (i) operation above do not apply to case (ii) operation.

If the flood event emanates from the Stanley River catchment only, without significant runoff in the Upper Brisbane River catchment, the operation of Somerset Dam will proceed on the basis that Wivenhoe Dam has peaked as per (i) above.

9.4.1 Somerset Stability

A Review of the stability analyses carried out for Somerset Dam was carried out by Commerce (2005). Recommendations from this report were:-

1. Somerset Dam, on the basis of its known condition, satisfies stability criteria for a storage level of RL 109.75.

2. There is concern that cracking observed in the Upper Gallery walls may also exist above or below the Gallery. While such cracked concrete would just satisfy stability criteria for a storage level of RL 109.75, stability reduces rapidly for higher storage levels and failure could occur at RL 110.1. It is recommended that some exploratory drilling be carried out to determine whether such cracks do exist. A similar recommendation was made in GHD (2000).

3. If the WIVOPS flood operation program still requires that the Somerset spillway gates be lowered if Wivenhoe Dam is in danger of being overtopped, then this Report should be reviewed and the spillway examined in detail to ensure these operations can be undertaken successfully. This type of gate operation is not recommended.

Based on the recommendations of this stability analysis the existing duty point of EL107.46 is to be maintained subject to further investigations. It should be noted that the stability of the dam would appear to be acceptable for higher water levels up to approximately EL109.7m AHD. However, no works have been carried out to ensure that the galleries are not flood flor this water level or erosion protection installed along the toe of the existing dam.

The Sector gates at Somerset are not to be closed into the flow if the storage level has exceeded EL107m AHD. The closure of the sluice gates or valves is acceptable to limit flow into Wivenhoe up to as level of EL107.46. Such closure is not to threaten the safety of the dam

9.4.2 PMF Flood Levels for Somerset

A review of the flood levels for Wivenhoe and Somerset carried out in 2006 indicated that the Maximum Flood Level for the Probable Maximum Flood is estimated to be EL110.9m AHD. This is above the estimate limit for structural stability determined by the review of the stability analyses by Commerce (2004).

It should be noted therefore that during flood operations Somerset Dam is still subject overtopping risks.

9.4.3 Impacts on Kilcoy

A brief assessment of the flood impacts on the area upstream of Somerset Dam has been carried out. Lake levels above EL102.4 will start to impact on the D'aguilar Highway. It is anticipated that Kilcoy will be impacted by Lake Levels above EL105m AHD.

Deleted:
Formatted: Font: 10 pt
Formatted: Bullets and Num

10. EMERGENCY FLOOD OPERATIONS

10.1 INTRODUCTION

While every care has been exercised in the design and construction of the dams, there still remains a low risk that the dams may develop an emergency condition either through flood events or other causes. Experience elsewhere in the world suggests that vigilance is required to recognise emergency flood conditions such as:

- Occurrence of a much larger flood than the discharge capacity of the dam;
- Occurrence of a series of large storms in a short period;
- Failure of one or more gates during a flood.
- Development of a piping failure through the embankment of Wivenhoe Dam;
- Damage to the dams by earthquake;
- Damage to the dams as an act of war or terrorism;
- Other uncommon mechanisms.

Responses to these and other conditions are included in separate Emergency Action Plans.

10.2 OVERTOPPING OF DAMS

Whatever the circumstances, every endeavour must be made to prevent overtopping of Wivenhoe Dam by the progressive opening of operative spillway gates. The probability of overtopping of Wivenhoe Dam has been significantly reduced following the completion of the auxiliary spillway.

Deleted: will be

In the event that the probability of overtopping of Wivenhoe Dam is unacceptably high, then as an absolute last resort the saddle dams may be breached. Such actions must only be initiated with the agreement of the Chief Executive.

It should be noted that the upgrade works carried out in 2005 have

Somerset Dam should, if possible, not be overtopped by flood water but, if Wivenhoe Dam is threatened by overtopping, the release of water from Somerset Dam is to be reduced by the use of its sluice gates, even at the risk of overtopping Somerset Dam in order to prevent, if possible, the overtopping of Wivenhoe Dam.

Deleted: ¶
Deleted: , for example
Deleted: spillway

As noted previously, lowering the sector gates back into the flow at storage levels greater than EL107 is to be avoided.

Formatted: Font: Bold

Deleted:
Formatted: Font: 10 pt

10.3 COMMUNICATIONS FAILURE

In the event of normal communications being lost between the Flood Operations Engineer and either Wivenhoe Dam or Somerset Dam, the dam supervisor at that dam is to maintain contact with the dam supervisor at the other dam, to receive instructions through the remaining communications link.

In the event of normal communications being lost between the Flood Operations Engineer and both Wivenhoe Dam and Somerset Dam, the dam supervisors at each dam are to adopt the procedures set out below during flood events, and are to maintain contact with each other, where possible.

If all communications are lost between the Flood Operations Engineer, Wivenhoe Dam and Somerset Dam, the officers in charge at each dam are to adopt the procedures set out below.

10.3.1 Wivenhoe Dam Emergency Procedure

In the event of total communication failure, the minimum gate openings related to lake levels up to EL 74 are set out in the Table 10.1 are to be maintained for both opening and closing operations. Once the lake level exceeds EL 74 the gates are to be raised at the rate of 1 metre per 10 minutes till the water level peaks or the gates are fully open.

Table 10-1 - Minimum Gate Openings Wivenhoe Dam

Lake Level m AHD	Gate 3 Opening (m)	Gates 2 & 4 Opening (m)	Gates 1 & 5 Opening (m)	Total Discharge m^3/sec
67.0		-	-	0
67.5	0.5	-	-	50
68.0	1.5	-	-	155
68.5	2.5	-	-	260
69.0	3.5	0.5	-	470
69.5	4.0	1.0	-	640
70.0	4.0	1.5	0.5	875
70.5	4.0	2.0	1.0	1115
71.0	4.0	2.5	1.5	1365
71.5	4.5	2.5	2.0	1560
72.0	4.5	3.0	2.5	1820
72.5	5.0	4.0	3.0	2250
73.0	5.0	5.0	5.0	2960
73.5	6.5	6.5	6.5	3850
74.0	8.0	8.0	8.0	4750
>74.0	Gates are to be raised at the rate of 1 metre per 10 minutes till the water level peaks or gates are fully open			
75.7	Gates are to be fully open before the first fuse plug triggers at this level.			

Deleted:

Formatted: Font: 10 pt

If one or more gates become inoperable, then by reference to Table E-2 the gate openings of operable gates are to be increased in order that the discharges for the lake levels shown in Table 10.1 are achieved.

If, because of compliance with the provisions of Section 8.3 and the high inflow rate, the minimum gate openings cannot be maintained, the time intervals between successive openings shown in Table 8.2 are to be halved.

If the actual gate openings fall more than three settings below the cumulative number of minimum settings of Table 10.1, then successive gate operations are to be carried out as rapidly as possible until the minimum settings are achieved. Under these circumstances, it may be necessary to operate more than one gate at any one time.

10.3.2 Somerset Dam Emergency Procedure

In the event of total communication failure, the spillway gates are to be kept raised to allow uncontrolled discharge. The regulators and sluices are to be kept closed until either:

(i) the level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

The level in Wivenhoe Dam can be determined locally by the Dam Supervisor at Somerset Dam from the tailwater gauge located just downstream of Somerset Dam.

In the case of (i) above, the opening of the regulators and sluices is not to increase the level in Wivenhoe Dam above the peak level already attained. Section 9.3 on regulator and gate operation interval is to be observed.

In the case of (ii) above, the regulators and sluices are to be operated such that the relative flood storage between the flood level in Wivenhoe Dam and EL 80 is the same as the relative flood storage between the flood level in Somerset Dam and the non-spillway crest level in Somerset Dam (EL 107.46). Table 10.2 gives the water level correlations. The low level outlets in Somerset Dam are not to be opened if the water level in Wivenhoe Dam exceeds the level set out below for given water levels in Somerset Dam.

Deleted: free-board

Deleted: 77

Deleted: free-board

Table 10-2 - Water Level Correlation Targets

Somerset Lake Level m AHD	Wivenhoe Lake Level m AHD
102.5	72.0
103.5	73.6
104.5	75.2
105.5	76.8
106.5	78.5
107.46	80.0

Deleted: 72

Deleted: ¶ 73

Deleted: ¶ 74

Deleted: ¶ 75

Deleted: ¶ 76

Deleted: ¶ 77

The constraints applicable to case (i) operation above do not apply to case (ii) operation.

Deleted:

Formatted: Font: 10 pt

10.4 EQUIPMENT FAILURE

In the event of equipment failure the action to be taken is indicated in Appendix G for Wivenhoe Dam and Appendix H for Somerset Dam.

Deleted:

Formatted: Font: 10 pt

Formatted: Bullets and Num

APPENDIX A. EXTRACT FROM WATER ACT 2000

Division 2 – Flood Mitigation

Owners of certain dams must prepare flood mitigation manual

496.(1) A regulation may nominate an owner of a dam as an owner who must prepare a manual (a “flood mitigation manual”) of operational procedures for flood mitigation for the dam.

(2) The regulation must nominate the time by which the owner must comply with section 497(1).

Approving flood mitigation manual

497.(1) The owner must give the chief executive a copy of the flood mitigation manual for the chief executive’s approval.

(2) The chief executive may, by gazette notice, approve the manual.

(3) The approval may be for a period of not more than 5 years.

(4) The chief executive may get advice from an advisory council before approving the manual.

Amending flood mitigation manual

498.(1) The chief executive may require the owner, by notice, to amend the flood mitigation manual.

(2) The owner must comply with the chief executive’s request under subsection (1).

(3) The chief executive must, by gazette notice, approve the manual as amended.

(4) The approval of the manual as amended must be for-

(a) the balance of the period of the approval for the manual before amendment; or

(b) a period of not more than 5 years from the day the manual as amended was approved.

(5) The chief executive may get advice from an advisory council before approving the manual as amended.

Regular reviews of flood mitigation manual

499. Before the approval for the flood mitigation manual expires, the owner must-

(a) review, and if necessary, update the manual; and

Deleted: ¶

(b) give a copy of it to the chief executive under section 497.

Deleted: ¶

Protection from liability for complying with flood mitigation manual

500.(1) The chief executive or a member of the council does not incur civil liability for an act done, or omission made, honestly and without negligence under this division.

(2) An owner who observes the operational procedures in a flood mitigation manual approved by the chief executive 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” includes-

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

b) an employee of the owner or operator of the dam; or

c) an agent of the owner or operator of the dam

Deleted:

Formatted: Font: 10 pt

APPENDIX B. AGENCIES HOLDING DOCUMENTS

AGENCIES HOLDING CONTROLLED DOCUMENTS

OF

MANUAL OF OPERATIONAL PROCEDURES

FOR FLOOD MITIGATION FOR

WIVENHOE DAM AND SOMERSET DAM

Flood Management Role	Organisation
Dam Owner	South East Queensland Water Corporation
Emergency Services	Department of Emergency Services, Disaster Management Service Brisbane City Counter Disaster Committee Esk Shire Counter Disaster Committee Ipswich City Counter Disaster Committee Kilcoy Shire Counter Disaster Committee
Severe Weather Warning Authority	Bureau of Meteorology
Primary Response Authorities	Brisbane City Council Esk Shire Council Ipswich City Council Kilcoy Shire Council
Regulator of Dam Safety	Department of Natural Resources and Water
Dams Operator	SunWater

Deleted: ,

Deleted: ,

Deleted: and Mines

Deleted: & Energy

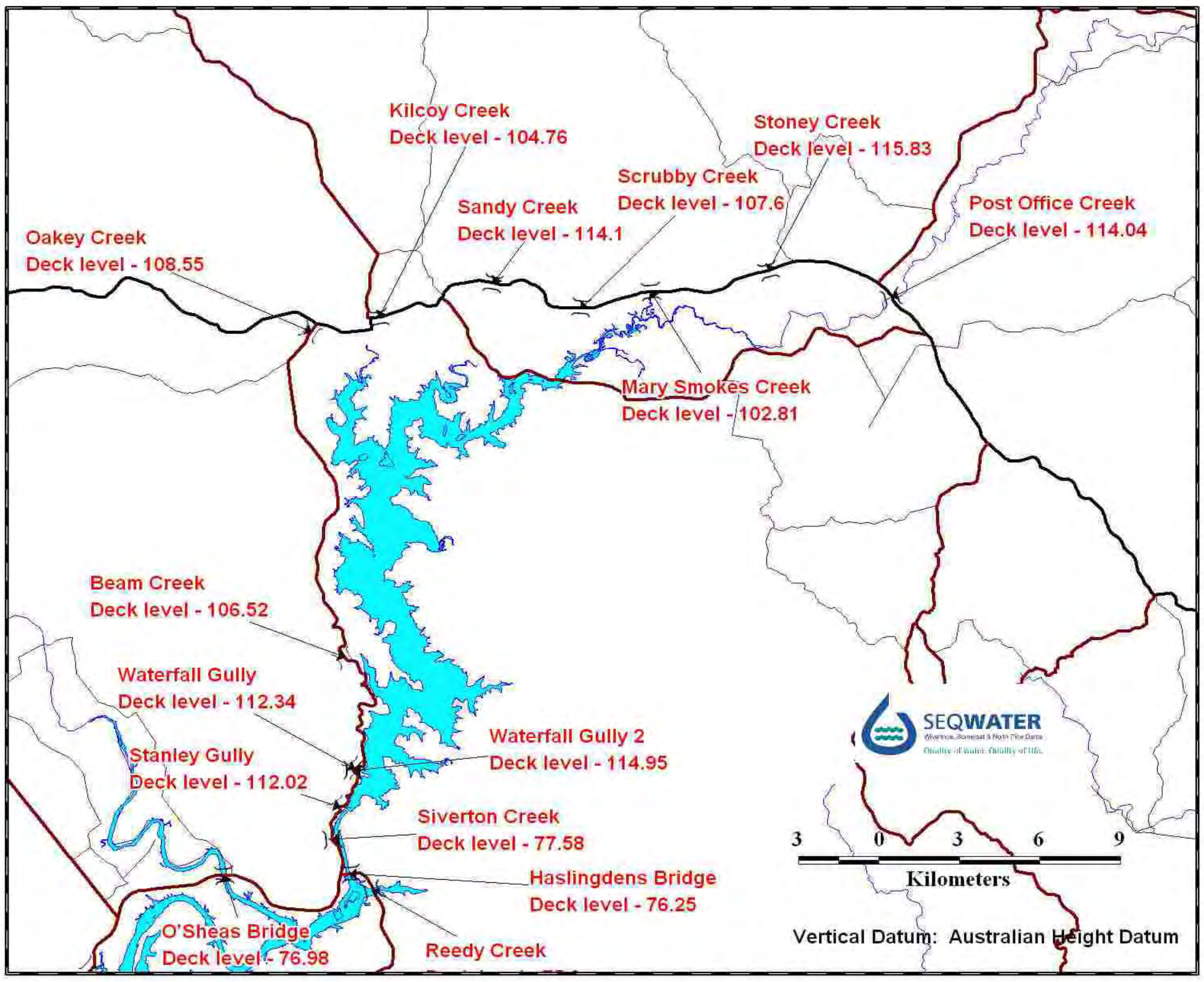
The Corporation must keep a register of contact persons of holders of controlled documents (Section 1.9 refers).

Deleted:

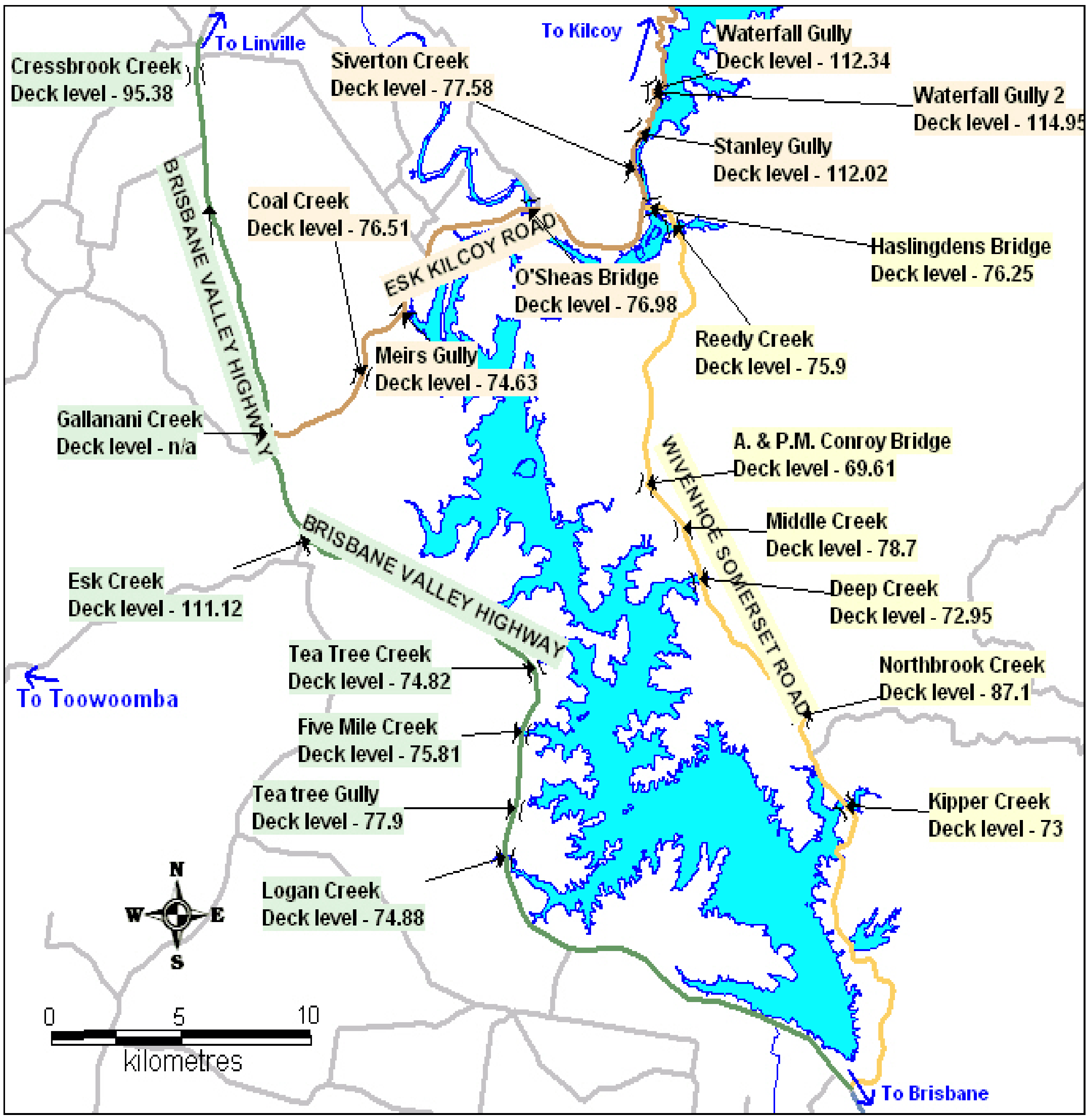
Formatted: Font: 10 pt

APPENDIX C. BRIDGE DECK LEVELS

Roads Upstream of Somerset Dam



Roads Surrounding Wivenhoe Dam

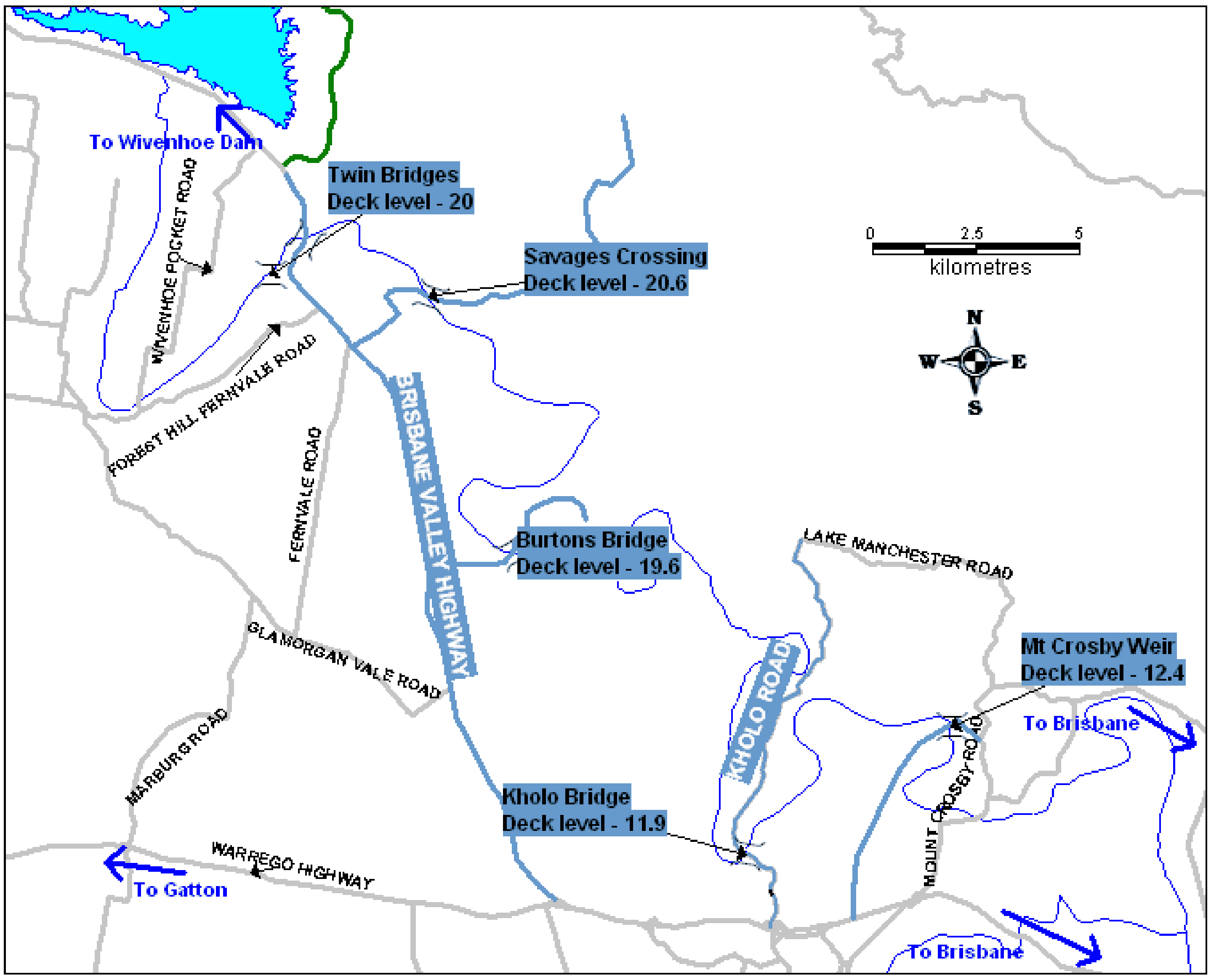


SEQWATER
Wivenhoe, Somerset & North Pine Dams

Deleted:

Formatted: Font: 10 pt

Bridges Downstream of Wivenhoe Dam



SEQWATER
Wivenhoe, Somerset & North Pine Dams

Deleted:

Formatted: Font: 10 pt

APPENDIX D. GAUGES AND BRIDGES

Table D.1. KEY REFERENCE GAUGES

Location	GZ	1974 Gauge Height	Minor		Moderate		Major	
			Gauge Height	Flow	Gauge Height	Flow	Gauge Height	Flow
			m	m³/s	m	m³/s	m	m³/s
Stanley R at Somerset Dam*	0.00 AHD	-	103.0		105.0		106.0	
Brisbane R at Lowood	23.68 AHD	22.02	8.0		15.0		20.0	
Brisbane R at Lowood*	22.74 SD	-	8.6	1000	15.9	3300	21.2	6000
Brisbane R at Savages Crossing*	18.43 AHD	23.79	9.0		16.0		21.0	
Brisbane R at Mt Crosby*	0.00 AHD	26.74	11.0		13.0		21.0	
Bremer R at Ipswich*	0.00 AHD	20.70	7.0		9.0		11.7	
Brisbane R at Moggill*	0.00 AHD	19.95	10.0		13.0		15.5	
Brisbane R at Jindalee Br*	0.00 AHD	14.10	6.0	4000	8.0	5000	10.0	6500
Brisbane R at City Gauge*	0.00 AHD	5.45	1.7		2.6		3.5	

* Indicates an automatic gauge

Flows are approximate only and gauge heights are tide dependent in the lower reaches.

A complete list of the latest river heights can be found at http://www.bom.gov.au

Formatted: Legal 3

Deleted:

Formatted: Font: 10 pt

Table D.2. SUBMERGENCE FLOWS FOR BRIDGES

AMTD	Bridge Name	Location	Estimated Submergence Flow m^3/sec
140	Twin Bridges	Wivenhoe Pocket Road, Fernvale	50
132	Savage's Crossing	Banks Creek Road, Fernvale	130
87	College's Crossing	Mt Crosby Rd, Karana Downs	175-200*
120	Burton's Bridge	E Summerville Road, Borallon	430
100	Kholo Bridge	Kholo Rd, Ipswich	550
91	Mt.Crosby Weir Bridge	Allawah Rd, Mt Crosby	1900
136	Fernvale Bridge	Brisbane Valley Hwy, Fernvale	2000

* Affected by tides.

Deleted:

Formatted: Font: 10 pt

APPENDIX E. WIVENHOE DAM TECHNICAL DATA

Formatted: Legal 3

TABLE E1 STORAGE AND UNCONTROLLED GATE DISCHARGES

Lake level m AHD	Storage Capacity 10^6 m^3	***Flood Capacity 10^6 m^3	**Net Inflow per 1mm rise per hour m^3/sec	*Discharge per Regulator m^3/sec	*Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
57.0	414	-	11.10	24.9	0	50
57.5	453	-	12.04	25.2	4	69
58.0	466	-	12.97	25.4	15	128
58.5	494	-	13.90	25.7	32	211
59.0	523	-	14.84	25.9	53	316
59.5	553	-	15.77	26.2	77	439
60.0	584	-	16.71	26.4	105	579
60.5	616	-	17.64	26.6	136	735
61.0	649	-	18.58	26.9	170	905
61.5	683	-	19.51	27.1	207	1 090
62.0	719	-	20.45	27.3	246	1 290
62.5	756	-	21.38	27.5	288	1 495
63.0	795	-	22.32	27.8	333	1 720
63.5	835	-	23.25	28.0	379	1 950
64.0	877	-	24.19	28.2	428	2 195
64.5	920	-	25.12	28.4	479	2 450
65.0	965	-	26.06	28.7	532	2 720
65.5	1 012	-	26.99	28.9	587	2 995
66.0	1 061	-	27.92	29.1	645	3 280
66.5	1 112	-	28.86	29.3	704	3 580
67.0	1 165	0	29.79	29.5	765	3 885
67.5	1 220	56	30.73	29.7	828	4 200
68.0	1 276	112	31.66	29.9	893	4 525
68.5	1 334	171	32.60	30.1	959	4 860
69.0	1 393	230	33.53	30.3	1 028	5 200
69.5	1 454	290	34.47	30.5	1 098	5 550
70.0	1 517	350	35.40	30.7	1 170	5 910
70.5	1 581	418	36.33	30.9	1 244	6 280
71.0	1 647	485	37.27	31.1	1 319	6 660
71.5	1 714	550	38.20	31.3	1 396	7 040
72.0	1 783	615	39.14	31.5	1 474	7 430
72.5	1 854	683	40.07	31.7	1 554	7 840

Deleted:
Formatted: Font: 10 pt

73.0	1 926	750	41.01	31.9	1 636	8 240
73.5	2 000	830	41.94	32.1	1 719	8 660
74.0	2 076	910	42.87	32.3	1 804	9 080
74.5	2 153	995	43.81	32.5	1 890	9 520
75.0	2 232	1 080	44.74	32.7	1 978	9 960
75.5	2 313	1 160	45.68	32.9	2 067	10 400
76.0 ****	2 395	1 240	46.61	33.1	2 158	10 860
76.5	2 480	1 258	47.55	33.3	2 250	11 320
77.0	2 566	1 420	48.48	33.4	2 343	11 780
77.5	2 655	1 500	49.41	36.6	2 438	12 260
78.0	2 746	1 580	50.35	33.8	2 535	12 740
78.5	2 839	1 680	51.28	34.0	2 632	13 230
79.0	2 934	1 780	51.28	34.2	2 731	13 730
79.5	3 032	1 867	52.22	34.4	2 832	14 230
80.0	3 132	1 966	52.22	34.5	2 891	14 455

Deleted: 52.22

* This is the maximum discharge of an individual spillway bay or regulator. Total discharge is calculated by adding the contributions of each gate or regulator. There are two (2) regulators to five (5) spillway bays.

** This assumes that all gates and sluices are closed. Discharges through the spillway have to be added to the above figures to calculate the actual inflow into the reservoir.

*** The temporary storage above normal Full Supply Level of EL 67.0.

**** The first fuse plug is designed to trigger at EL75.7. Above this level, fuse plug flows from Table E.3 need to be added to give the full outflow.

Deleted:
Deleted: outfl

TABLE E2 CONTROLLED GATE DISCHARGES

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5
67.0	0	49	98	146	194	240	285	329	372	413	453	492	530	567	603	639	675	709	744	765												
67.2	0	49	99	148	196	243	288	333	376	418	458	498	537	574	611	648	684	720	755	790												
67.4	0	50	100	149	198	245	291	336	380	422	464	504	543	582	619	657	693	730	766	802	815											
67.6	0	50	101	151	200	248	294	340	384	427	469	510	550	589	627	665	702	740	777	814	841											
67.8	0	51	102	152	202	250	297	343	388	432	474	515	556	596	635	673	712	750	787	825	863	867										
68.0	0	51	103	154	204	253	300	347	392	436	479	521	562	603	642	682	721	759	798	837	876	893										
68.2	0	52	104	155	206	255	303	350	396	441	484	527	569	610	650	690	729	769	808	848	888	919								UNCONTROLLED		
68.4	0	52	105	156	207	257	306	354	400	445	489	532	575	616	657	698	738	778	818	859	899	940	946							DISCHARGE		
68.6	0	53	105	158	209	260	309	357	404	450	494	538	581	623	665	706	747	788	829	870	911	953	973									
68.8	0	53	106	159	211	262	312	360	408	454	499	543	587	630	672	714	755	797	838	880	923	965	1000									
69.0	0	54	107	160	213	264	315	364	412	458	504	549	593	636	679	722	764	806	848	891	934	977	1022	1028								
69.2	0	54	108	162	215	267	317	367	415	463	509	554	599	643	686	729	772	815	858	901	945	989	1035	1056								
69.4	0	54	109	163	217	269	320	370	419	467	514	560	605	649	693	737	780	824	868	912	956	1001	1047	1084								
69.6	0	55	110	164	218	271	323	373	423	471	518	565	611	656	700	744	789	833	877	922	967	1013	1060	1107	1112							
69.8	0	55	111	166	220	273	326	377	427	475	523	570	616	662	707	752	797	842	887	932	978	1025	1072	1121	1141							

70.0	0	56	112	167	222	276	328	380	430	479	528	575	622	668	714	759	805	850	896	942	989	1036	1085	1134	1170				
70.2	0	56	112	168	224	278	331	383	434	484	532	580	628	674	721	767	813	859	905	952	1000	1048	1097	1147	1198	1199			
70.4	0	56	113	170	225	280	334	386	437	488	537	586	633	680	727	774	821	867	914	962	1010	1059	1109	1160	1212	1229			
70.6	0	57	114	171	227	282	336	389	441	492	542	591	639	687	734	781	828	876	923	972	1020	1070	1121	1173	1226	1258			
70.8	0	57	115	172	229	284	339	392	445	496	546	596	644	693	741	788	836	884	932	981	1031	1081	1133	1185	1239	1289			
71.0	0	58	116	173	230	286	341	395	448	500	551	601	650	699	747	795	844	892	941	991	1041	1092	1144	1198	1252	1309	1319		
71.2	0	58	117	175	232	289	344	398	452	504	555	605	655	705	754	802	851	900	950	1000	1051	1103	1156	1210	1266	1323	1349		
71.4	0	58	117	176	234	291	347	401	455	508	559	610	661	710	760	809	859	908	959	1009	1061	1114	1167	1222	1279	1337	1380		
71.6	0	59	118	177	235	293	349	404	458	512	564	615	666	716	766	816	866	916	967	1019	1071	1124	1179	1234	1292	1350	1410	1411	
71.8	0	59	119	178	237	295	352	407	462	515	568	620	671	722	773	823	874	924	976	1028	1081	1135	1190	1246	1304	1364	1425	1443	
72.0	0	60	120	180	239	297	354	410	465	519	572	625	676	728	779	830	881	932	984	1037	1091	1145	1201	1258	1317	1377	1439	1474	
72.2	0	60	121	181	240	299	357	413	469	523	577	629	682	733	785	837	888	940	993	1046	1100	1156	1212	1270	1330	1391	1454	1506	
72.4	0	60	121	182	242	301	359	416	472	527	581	634	687	739	791	843	895	948	1001	1055	1110	1166	1223	1282	1342	1404	1468	1533	1538
72.6	0	61	122	183	243	303	361	419	475	531	585	639	692	745	797	850	903	956	1009	1064	1119	1176	1234	1293	1354	1417	1482	1548	1570
72.8	0	61	123	184	245	305	364	422	478	534	589	643	697	750	803	856	910	963	1018	1073	1129	1186	1245	1305	1367	1430	1496	1563	1603

TABLE E2 CONTROLLED GATE DISCHARGES (continued)

Wivenhoe Dam - Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
73.0	0	62	124	185	247	307	366	425	482	538	593	648	702	756	809	863	917	971	1026	1081	1138	1196	1255	1316	1379	1443	1509	1577	1636						
73.2	2	62	124	187	248	309	369	427	485	542	597	653	707	761	815	869	924	978	1034	1090	1147	1206	1266	1327	1391	1456	1523	1592	1663	1669		UNCONTROLLED			
73.4	6	62	125	188	250	311	371	430	488	545	602	657	712	767	821	876	931	986	1042	1099	1156	1216	1276	1339	1403	1469	1536	1606	1678	1702			DISCHARGE		
73.6	11	64	126	189	251	313	373	433	491	549	606	662	717	772	827	882	937	993	1050	1107	1166	1225	1287	1350	1414	1481	1550	1620	1693	1736					
73.8	17	69	127	190	253	315	376	436	495	553	610	666	722	778	833	888	944	1001	1058	1116	1175	1235	1297	1361	1426	1494	1563	1635	1708	1770					
74.0	23	74	129	191	254	317	378	438	498	556	614	671	727	783	839	895	951	1008	1065	1124	1184	1245	1307	1372	1438	1506	1576	1648	1723	1800	1804				
74.2	31	80	133	192	256	319	380	441	501	560	618	675	732	788	845	901	958	1015	1073	1132	1192	1254	1317	1382	1449	1518	1589	1662	1738	1815	1838				
74.4	39	87	139	195	257	321	383	444	504	563	622	679	737	793	850	907	964	1022	1081	1140	1201	1264	1327	1393	1461	1530	1602	1676	1752	1831	1873				
74.6	47	94	145	200	259	322	385	447	507	567	626	684	741	799	856	913	971	1029	1089	1149	1210	1273	1337	1404	1472	1542	1615	1690	1767	1846	1908				
74.8	56	103	153	206	262	324	387	449	510	570	629	688	746	804	862	919	978	1036	1096	1157	1219	1282	1347	1414	1483	1554	1628	1703	1781	1861	1943				
7 5.0	66	112	161	213	267	326	390	452	513	574	633	692	751	809	867	926	984	1044	1104	1165	1227	1291	1357	1425	1494	1566	1640	1717	1795	1876	1960	1978			
75.2	76	121	169	220	274	330	392	455	516	577	637	697	756	814	873	932	991	1051	1111	1173	1236	1301	1367	1435	1506	1578	1653	1730	1809	1891	1976	2013			
75.4	87	131	178	229	281	336	394	457	519	581	641	701	760	819	878	938	997	1057	1119	1181	1245	1310	1377	1446	1517	1590	1665	1743	1823	1906	1992	2049			
75.6	98	141	188	237	289	343	399	460	522	584	645	705	765	824	884	944	1004	1064	1126	1189	1253	1319	1386	1456	1527	1601	1678	1756	1837	1921	2007	2085			
75.8	109	152	198	247	298	350	405	463	525	587	649	709	769	829	889	949	1010	1071	1133	1197	1261	1328	1396	1466	1538	1613	1690	1769	1851	1936	2023	2112	2121		

OVERTOPPING of GATE

76.0	121	164	209	257	307	359	412	468	528	591	652	713	774	834	895	955	1016	1078	1141	1205	1270	1337	1405	1476	1549	1624	1702	1782	1865	1950	2038	2129	2158		
76.2	133	175	220	268	317	368	421	475	532	594	656	718	779	839	900	961	1023	1085	1148	1212	1278	1346	1415	1486	1560	1636	1714	1795	1878	1965	2053	2145	2194		
76.4	146	187	232	279	327	378	429	483	539	597	660	722	783	844	906	967	1029	1092	1155	1220	1286	1354	1424	1496	1570	1647	1726	1808	1892	1979	2069	2161	2231		
76.6	159	200	244	290	338	388	439	492	546	603	664	726	788	849	911	973	1035	1098	1162	1228	1295	1363	1434	1506	1581	1658	1738	1820	1905	1993	2084	2177	2268		
76.8	173	213	257	302	350	399	449	501	554	610	668	730	792	854	916	978	1041	1105	1170	1235	1303	1372	1443	1516	1591	1669	1750	1833	1919	2007	2099	2193	2289	2306	
			OVERTOPPING of GATE																																
77.0	186	226	270	315	362	410	460	511	564	618	674	734	797	859	921	984	1047	1112	1177	1243	1311	1380	1452	1526	1602	1680	1762	1845	1932	2021	2113	2208	2306	2343	
77.2	200	240	283	328	374	422	471	522	574	627	682	739	801	864	927	990	1054	1118	1184	1250	1319	1389	1461	1536	1612	1691	1773	1858	1945	2035	2128	2224	2322	2381	
77.4	215	254	297	341	387	435	483	533	584	637	691	747	806	869	932	996	1060	1125	1191	1258	1327	1398	1470	1545	1622	1702	1785	1870	1958	2049	2143	2239	2339	2419	
77.6	230	269	311	355	400	447	496	545	595	647	700	756	813	873	937	1001	1066	1131	1198	1265	1335	1406	1479	1555	1633	1713	1796	1882	1971	2063	2157	2255	2355	2457	
77.8	245	283	325	369	414	461	508	557	607	658	711	765	821	880	942	1007	1072	1138	1205	1273	1343	1414	1488	1564	1643	1724	1808	1894	1984	2076	2172	2270	2371	2475	2496
78.0	260	299	340	383	428	474	522	570	619	670	722	775	831	888	948	1012	1078	1144	1211	1280	1351	1423	1497	1574	1653	1735	1819	1907	1997	2090	2186	2285	2387	2492	2535

TABLE E2 CONTROLLED GATE DISCHARGES (continued)

Wivenhoe Dam Gate Opening (m of Tangential Travel)

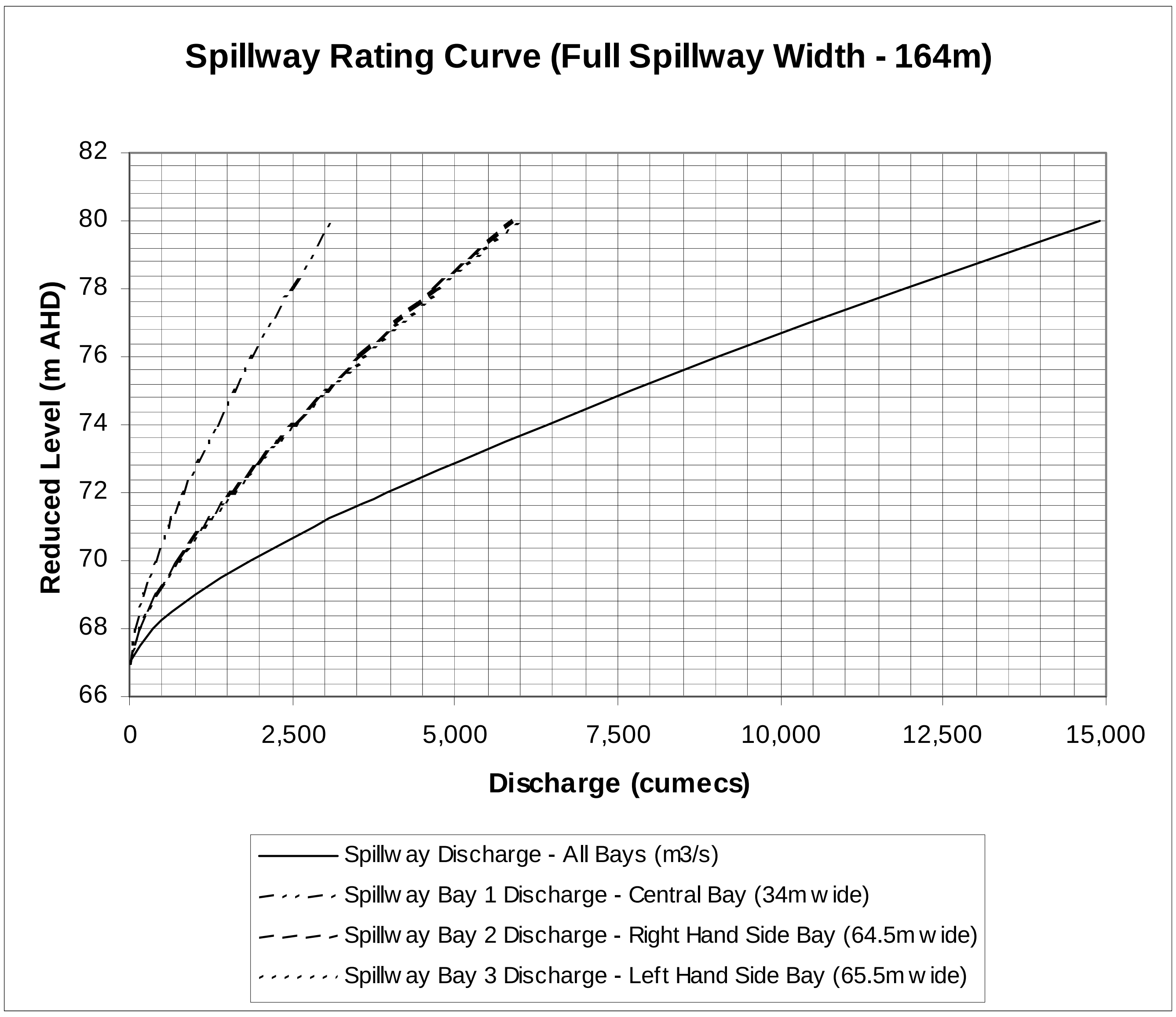
Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
											OVERTOPPING of GATE																								
79.0	342	379	419	460	504	548	594	640	688	736	786	837	889	943	999	1057	1117	1180	1246	1316	1389	1464	1541	1620	1703	1787	1875	1966	2060	2156	2257	2360	2466	2575	2687
																	OVERTOPPING of GATE																		
80.0	431	466	505	545	587	630	675	720	766	813	861	910	961	1013	1068	1124	1182	1243	1306	1372	1441	1513	1589	1668	1751	1838	1929	2023	2121	2221	2325	2432	2542	2655	2772

(The table needs cells reformatted) – Rob Ayre

Formatted: Legal 3

TABLE E.3 – WIVENHOE DAM AUXILIARY SPILLWAY RATING TABLE

Storage Level (m AHD)	Spillway Discharge - All Bays (m3/s)	Discharge Central Bay (34m wide)	Discharge Right Side Bay (64.5m wide)	Discharge Left Side Bay (65.5m wide)
67	0	0	0	0
68	361	75	142	144
69	1,020	212	401	408
70	1,858	385	731	742
71	2,847	590	1,120	1,137
72	3,961	821	1,558	1,582
74	6,409	1,329	2,521	2,560
76	9,033	1,873	3,553	3,608
78	11,907	2,468	4,683	4,755
80	14,913	3,092	5,865	5,956



APPENDIX F. SOMERSET DAM TECHNICAL DATA

Formatted: Legal 3

Table F-I - STORAGE AND DISCHARGE FOR SOMERSET DAM

Lake level m AHD	Reservoir Capacity 10^6 m^3	Temporary Flood Storage 10^6 m^3	Net Inflow per 1mm rise per hour m^3/sec	Discharge per Regulator m^3/sec	Discharge per Sluice m^3/sec	Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
90.0	120.3	-	5.29	57	163	-	1 529
90.5	129.5	-	5.50	58	165	-	1 550
91.0	139.3	-	4.88	58	167	-	1 572
91.5	149.6	-	5.28	59	170	-	1 593
92.0	160.5	-	5.68	60	172	-	1 614
92.5	172.0	-	6.09	60	174	-	1 635
93.0	184.1	-	6.79	61	176	-	1 655
93.5	196.7	-	7.10	62	179	-	1 676
94.0	210.0	-	7.43	62	181	-	1 695
94.5	224.0	-	7.78	63	183	-	1 715
95.0	238.5	-	8.15	64	185	-	1 735
95.5	253.6	-	8.54	64	187	-	1 754
96.0	269.3	-	8.95	65	189	-	1 773
96.5	285.6	-	9.37	66	191	-	1 792
97.0	302.7	-	9.81	66	193	-	1 810
97.5	320.7	-	10.28	67	195	-	1 829
98.0	339.5	-	10.76	67	197	-	1 847
98.5	359.2	-	11.25	68	199	-	1 865
99.0	379.8	0.0	11.77	69	201	-	1 883
99.5	401.4	21.5	12.31	69	203	-	1 901
100.0	428.9	49.0	13.28	70	205	-	1 918
100.5	447.5	67.6	13.83	70	207	0	1 937
101.0	472.2	92.3	14.39	71	209	4	1 989
101.5	498.0	118.1	14.95	72	211	13	2 076
102.0	524.9	145.1	15.53	72	212	25	2 189
102.5	553.1	173.3	16.11	73	214	40	2 325
103.0	582.6	202.7	16.70	73	216	58	2 482
103.5	613.2	233.4	17.30	74	218	78	2 659
104.0	645.1	265.3	17.90	74	220	100	2 854
104.5	678.3	298.4	18.52	75	221	125	3 067
105.0	712.7	332.8	19.14	75	223	151	3 296
105.5	748.3	368.4	19.78	76	225	180	3 542
106.0	785.2	405.4	20.42	76	226	211	3 803
106.5	823.4	443.6	21.07	77	228	243	4 079
107.0	863.1	483.2	21.73	78	230	278	4 370

107.5	904.0	524.2	22.39	78	232	314	4 675

* This is the maximum discharge of an individual gate or regulator. Total discharge is calculated by adding the contributions of each gate or regulator.

Regulator - Discharge regulator valve of which there are four (4).

Sluice - Sluice gate of which there are eight (8).

Spillway - Overflow section of dam controlled by eight (8) radial gates.

Temporary Flood- The temporary storage above the normal full supply level of El 99 m (AHD) Storage

APPENDIX G. WIVENHOE DAM GATE OPERATION CONSIDERATIONS

Full size plans of Wivenhoe Dam, and Operations and Maintenance Manuals for Wivenhoe Dam are held by the Corporation and the Headworks Operator and are available at the site. Operations and Maintenance Manuals relevant to the flood operation of the gates are:

(a) "Master Manual and Drawings."

(b) "Radial and Penstock Gate Hoists and Drawings."

G.1. SPILLWAY OPERATION PRINCIPLES

The radial gates are sequentially numbered from 1 to 5 from left to right looking in the downstream direction. Appendix I shows the general arrangement of the spillway area.

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions, or when gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool, which has been excavated into erodible sandstone rock, and cause non-predictable erosion. Upstream migration of this erosion is to be avoided. The wing walls adjacent to the flip bucket deflect the discharge away from the walls of the plunge pool when gates 1 and 5 are operated.

Therefore in operating the spillway, the principles to be observed are, in order of priority:

(i) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

(ii) The flow in the spillway is to be symmetrical.

The main purpose of gating the spillway is to exercise maximum control over the flow in the Brisbane River insofar as river flows in excess of 4 000 m^3/sec cause damage to urban areas downstream. The gates also allow the routing of much larger floods with substantial flood mitigation being achieved.

G.2. RADIAL GATE OPERATING PRINCIPLE

Each radial gate consists of a cylindrical upstream skinplate segment that is attached to the radial arms. The cylindrical axis is horizontal. Each gate rotates about two spherical trunnion bearings that are on this axis.

The position of the gate is controlled by hydraulically driven winches that are located on the piers beside the gates. Wire ropes are attached to the downstream face of the skin plate through a pulley system. The hydraulic motors work off a common pressure manifold and under perfectly matched conditions, will give an equal lifting force to each side of the gate. This system does not sense rope travel and will take up slack rope. It cannot prevent or

Formatted: Font: No

Formatted: Legal 2

correct skewing of the skin plate segment between the piers. If skewing occurs, skids will come into contact with the side seal plates to limit movement.

It is not possible to operate a winch independently of the other winch attached to the gate.

When the hydraulic motors are not energised, the gates are held in position by spring loaded friction brakes on the winches. There are two brake bands per winch and each band is capable of supporting half the weight of the gate. One winch can support the total weight of a gate on both its brake bands but not on one.

G.3. RADIAL GATES OPERATING LIMITATIONS

Formatted: Legal 2

G.3.1. Opening and Closing Rate

The aperture opening rate of each gate is limited to 500 mm/minute.

Aperture movement is limited by a programmable timer that stops gate movement after a set period of time.

G.3.2. Alternate Consecutive Operation

To maintain symmetry of discharge in the spillway, either gates 1 and 5 or gates 2 and 4 are to be operated in alternate consecutive increments. The power for gate operation comes from two independent electric hydraulic pumps, each of which is capable of operating one gate at a time.

The normal hydraulic pressure source for each gate is as follows:

GATES	POWER SOURCE
Radial Gates 1 & 2, and Penstock Gate Hoist	Electric hydraulic pump 1
Radial Gates 3, 4 & 5	Electric hydraulic pump 2

Deleted: ¶

In the event that an electric hydraulic pump fails, hydraulic pressure can be redirected from the other power source, but concurrent operation of more than one gate from a single power source is not possible.

G.3.3. Overtopping

While the radial gates have been designed to withstand overtopping, it should be avoided if possible. The reservoir levels and the structural state of the radial gates when in the closed position are as follows:

Reservoir Level m AHD	Condition	Radial Gate Stress Condition with Gate Closed
73	Top of closed gate	Normal
77	Design Flood Level	33% Overstress
80	Crest Level	Critical

Deleted: 79

Deleted: ¶

Once overtopped, the gates become inoperable when the lifting tackle is fouled by debris from the overflow. The gates remain structurally secure until the reservoir level exceeds EL 77. The ability to control floods however may be lost.

G.3.4. Gate Dropping

Under no circumstances are the gates to be dropped. The lower skin plate sections are overstressed if a freefall of 60 mm is arrested by the seal plate on the spillway.

If a gate becomes stuck in an open position, it is to be freed by applying positive lifting forces. Under no circumstances are the winches to be unloaded and the direct weight of the gates used to yield the obstruction.

G.3.5. Operation in High Wind

Other than in periods of mitigation of medium and major floods, the gates are not to be raised or lowered when clear of water, during periods of high winds. The gates can however, be held on the brakes in any position in the presence of high wind.

The term "high wind" means any wind that causes twisting or movement of the gate. While a precise figure cannot be placed on these velocities, further experience over time may allow a figure to be determined.

This limitation is required to prevent the gate from twisting from skew on one side to skew on the other side. While the gate is being raised or lowered, skewing cannot be prevented by the hydraulic lifting system and any impact forces encountered may damage the gate.

G.3.6. Maintenance

No more than one gate is to be inoperable at any one time for maintenance. The maintenance is to be scheduled so that the spillway bay can be cleared of obstructions in a reasonable time to allow its use in the event of major flooding.

Formatted: Legal 2

G.4. BULKHEAD GATE OPERATING LIMITATIONS

The bulkhead gate can be used to control discharge in an emergency situation where a radial gate is inoperable. It is transported to, and lowered upstream of the inoperable radial gate by means of the gantry crane. The following conditions apply:

(a) The bulkhead gate can always be lowered with any type of underflow; and

(b) It is not possible to raise the bulkhead gate once it has been lowered past certain levels depending on upstream conditions without there being a pool of water between it and the radial gate. (Department of Primary Industries Wivenhoe Dam Design Report, September 1995 refers).

It is thus possible to preserve storage by effectively closing the spillway even with one radial gate inoperable. It will not be possible to raise the bulkhead gate until the radial gate behind has been repaired and is again storing water between the bulkhead gate and itself.

The bulkhead gate is not to be used for flood regulation until the reservoir level is falling and not likely to rise within the period needed to repair the inoperable radial gate.

G.4.1. Opening and Closing Rates

The spillway gantry crane is to be used to raise and lower the bulkhead gate. The crane operates at two speeds, 1.5 and 3.0 m/min. When within the bulkhead gate guides, the bulkhead gate is to be moved only at 1.5 m/min.

G.4.2. Overtopping

In the event that the bulkhead gate is overtopped (reservoir level exceeds EL 69 when bulkhead gate is closed), it cannot be removed unless a pool of water fills the space between it and the radial gate behind. The closed bulkhead becomes critically stressed when the reservoir level overtops it to EL 71.4.

It is not possible to engage the lifting tackle while overtopping is occurring. While there is any risk that the bulkhead gate may be overtopped, the lifting gear is to be left engaged so that the gate can be raised once the downstream radial gate becomes operable.

G.4.3. Discharge Regulation

In the event that a radial gate is inoperable in a partially open position, the bulkhead gate can be used for flow regulation provided that the lower lip of the radial gate is clear of the underflow jet.

Where a pool exists between the bulkhead gate and a radial gate under flow conditions, the bulkhead gate will be subjected to additional pull-down and possibly subjected to vortex-induced vibrations. When this condition occurs, the bulkhead gate is to be lowered to dewater the pool. The bulkhead gate can then be adjusted to regulate the flow provided the underflow jet remains below the lower lip of the radial gate.

G.5. RADIAL GATE OPERATING PROCEDURES

Formatted: Font: No

Formatted: Legal 2

G.5.1. Normal Operating Procedure

This procedure is specified in Section 8.3

G.5.2. One Gate Inoperable

Under certain abnormal conditions, it may not be possible to operate one gate. The following procedures are to be adopted.

(a) Gate 3 Inoperable

If bay 3 is blocked for any reason, gates 2 and 4 are to be used to regulate flood discharges, until the discharge impinges on the walls of the plunge pool. Gates 1 and 5 are then to be opened sufficiently to deflect the discharge into the plunge pool.

The bottoms of gates 1 and 5 are to be maintained at or below those of gates 2 and 4 respectively.

(b) Either Gate 2 or 4 Inoperable

If either bay 2 or 4 is blocked for any reason during a flood, normal gate operating procedures are to be adopted, except that only the operable gate 2 or 4 is available for flood regulation beyond 500 m^3/sec and not both.

(c) Either Gate 1 or 5 Inoperable

If either bay 1 or 5 is blocked for any reason during a flood, normal gate operating procedures are to be adopted until the discharge impinges on the walls of the plunge pool. Thereafter the operable gate 1 or 5 is to be used in lieu of using the radial gate adjacent to the inoperable gate. The other radial gates are to be used in the normal way to control discharge.

In the event of a major flood, where the full discharge capacity of the four operable radial gates is required, these gates are to be used to their full capacity to protect the embankment from overtopping.

Formatted: Legal 2

G.6. EQUIPMENT MALFUNCTION

Normal gate operation is by means of two electric hydraulic pumps supplied by external mains supply electric power, with pump number 1 connected to gates 1 and 2 and the penstock gate, while pump number 2 is connected to gates 3, 4 and 5.

Normal gate operation may not be possible in the event of equipment malfunctions during the passing of a flood. The procedures to be followed under various possible events are outlined below.

G.6.1. Blackout - Failure of External Electric Power

A diesel electric generator automatically starts up. It supplies enough power to the two electric hydraulic pumps to operate the gates normally.

In the event that the diesel electric generator fails, the radial gates can still be operated by means of the emergency diesel hydraulic pump as described in G.6.3 below.

G.6.2. Failure of One Electric Hydraulic Pump

In the event that one electric hydraulic pump fails, the connecting valves between pumps are to be switched such that both sets of hydraulic lines are connected to the operable pump, thus permitting operation of all 5 gates, one gate at a time.

G.6.3. Failure of Two Electric Hydraulic Pumps

In the event that both electric hydraulic pumps fail, the emergency diesel hydraulic pump is to be used to operate the gates, one gate at a time.

G.6.4. Rupture of Hydraulic Lines

Hydraulic power is delivered from the sets of hydraulic lines beneath the gantry service bridge deck to each winch via a single hydraulic line. There is no bypass circuit. In the event that one of these lines is ruptured, the associated radial gate becomes inoperable via this system. Any ruptures in the hydraulic lines are to be repaired immediately. A trailer mounted hydraulic system is available to connect to auxiliary hydraulic lines on the service bridge deck, that can operate one gate at a time.

G.6.5. Contamination of Winch Brakes

The gates are not to be raised if the brake bands on the winch drums are contaminated with oil or other low friction contaminant.

When the hydraulic power is off the gates are held only by the winch brakes. Oil contamination will reduce their holding capacity and possibly allow the gate to fall.

The brake bands are to be inspected regularly and cleaned immediately if any contamination is observed.

G.6.6. Mechanical Failure of Winch

In the event that a winch fails, the radial gate affected becomes inoperable.

(i) Loss of hydraulic power to the winches results in the spring loaded friction brakes holding the gate in its current position.

(ii) Loss of lift from one winch jams the gate between the piers until the uplift is equalised on each side of the gate again. If the gate is in a raised position, this event causes the side skids to come into contact with the pier sides.

(iii) Without hydraulic power applied, the winch drums are restrained by brakes. If both brakes fail, the gate falls. A free fall of more than 60 mm causes structural damage to the gate. In the event that one brake fails, the gate jams between the piers.

G.6.7. Fouling of Lifting Tackle

The lifting tackle consists of blocks, wire ropes and winch drums. If the gate is overtopped, debris may be collected on the wire ropes that may in turn foul the blocks or the winch drums. This may result in jamming of the wire rope or in uneven lifting, both of which may cause the gate to jam.

The preventative measure is not to allow the gate to be overtopped.

G.6.8. Fouling of Side Skids

The side skids have been designed to limit the side-sway and skew of the radial gates during operation. Under ideal conditions, the skids should not be in contact with the side seal plates.

If the winches are lifting the gates unevenly or in a skewed position, the lifting gear should be adjusted if possible.

G.6. FLUG EARLY INITIATION

The fuse plug embankments are sloping core earth and rockfill embankments which are designed to erode once overtopped. The trigger section for each of the three embankments at Wivenhoe includes finer rockfill in the downstream

Formatted: Normal

supporting shell to promote rapid erosion of the trigger section and allow side cutting of the rest of the embankment materials.

As with all embankment dams there is a risk of piping of the core material leading to premature initiation of the fuse plug embankment during a flood event. The fuse plug embankment includes several features to minimise this risk including:-

- Downstream filters complying with modern design criteria
- Upstream filter material to provide crack filler in the event of a crack forming in the sloping clay core
- Rockfill supporting shells grade to protect the filters.

While the risk of the piping failure is considered extremely remote the fuse plug embankments should be monitored regularly throughout the flood event, particularly as this will constitute a first filling situation for the embankments.

If a fuse plug initiated prior to the storage level reaching the trigger level the dam supervisor should notify the flood control centre. The Senior Flood Operations Engineer should operate the primary spillway radial gates to achieve the required releases from both spillways.

G.6.1 FUSE PLUG EROSION RATES

It is anticipated from published data and model testing of the original design prototypes by the USBR that the fuse plug embankments will erode at a rate of approximately 100m/hour. The anticipated erosion rates for the three embankments are presented below.

Fuse Plug	Width	Approximate Time to Erode
1	34	20 minutes
2	64.5	40 minutes
3	65.5	40 minutes

Formatted Table

APPENDIX H. SOMERSET DAM AUXILIARY EQUIPMENT

H.1. DISCHARGE REGULATION

The normal operating procedure for Somerset Dam in the event of a flood requires the spillway gates to be raised to provide an uncontrolled spillway followed by opening of the low level outlets some time later.

Sketches of the spillway and low level outlets are shown in Appendix J. Somerset Dam is equipped with spillway gates, sluice gates and regulators to control the discharge from the dam. Because the dam is a combined water supply and flood control dam, the spillway is above the FSL and the sluice gates and regulators are 6-10 metres above stream-bed level. It is crucial to the water supply function of the dam that the low level outlets be able to be shut down after their flood release function is completed to ensure that storage is not lost.

Failure of any spillway gate lifting machinery could restrict the discharge capacity of the spillway with resultant risk of overtopping of the dam.

H.2. EMERGENCY POWER SUPPLY

In the event of a power failure at Somerset Dam, the emergency diesel alternator is to be started. The alternator can supply power to the gantry crane, and all gate machinery. If the emergency diesel alternator cannot be started or breaks down during a power failure, the spillway gates and sluice gates are to be operated using the electric motor drive facilities on the winches and a mobile generator.

H.3. FAILURE OF SPILLWAY GATES MACHINERY

If a spillway gate cannot be raised due to failure of the lifting machinery, the gantry crane may be attached to the gate and the gate raised using the gantry crane.

H.4. FAILURE OF SLUICE GATE MACHINERY

In the event of a sluice gate being jammed in the open position or the lifting machinery failing, the coaster gate is to be lowered over the inlet to the sluice to preserve the water supply storage.

If a sluice gate cannot be raised due to failure of the lifting machinery, repairs are to be carried out immediately.

H.5. FAILURE OF REGULATOR MACHINERY

If the regulator gate cannot be lowered and the regulator cones cannot be closed, the regulator coaster gate is to be lowered over the inlet to the regulator. Some damage may be caused to the seals on the coaster gate in this instance, but the resultant leakage will not result in the loss of the water supply storage.

APPENDIX I. HYDROLOGIC INVESTIGATIONS

I.1. INTRODUCTION

This appendix describes hydrologic analyses performed as part of the review of design flood hydrology Corporation's dams. This study included an examination of the existing operating procedures for Wivenhoe Dam and Somerset Dam and it includes the use of the latest techniques in design rainfall estimation.

The analyses were carried out using the most appropriate data available in 2001 and it is recommended that they be revised after the occurrence of a large flood or after the adoption of more advanced methods of hydrologic analysis. The work is summarised in a report entitled, 'Brisbane River – Revision of Flood Hydrology', (DNRM, 2001).

The work summarised here supersedes previous work including that completed during the design stages of Wivenhoe Dam, details of which are contained in the design report on Wivenhoe Dam and the Brisbane River and Pine River Flood Study reports. Revision of the estimates of Probable Maximum Precipitation in 2003, by the Bureau of Meterology, has increased the design flood inflows into the dams. The determination of the Probable Maximum Flood and the impacts on Wivenhoe Dam are included in reports entitled, "Preferred Solution Report" – (Wivenhoe Alliance, 2003). The increase in spillway capacity for Wivenhoe Dam and the resulting effects downstream are included in a report entitled "Design Discharges and Downstream Impacts of the Wivenhoe Dam Upgrade" – (Wivenhoe Alliance, 2004).

Deleted: in 2003

Deleted: ve

Deleted: these figure

I.2 METHOD

There are three components in the hydrologic analyses:

(i) a rainfall analysis to determine both rainfall frequency and Probable Maximum Precipitation (PMP) and also large and rare rainfall events using the CRC-FORGE methodology

(ii) a model of the catchment rainfall runoff process; and

(iii) a model of the flood operations of the two dams.

The Bureau of Meteorology completed several studies of the Probable Maximum Precipitation. The Revised Generalised Tropical Storm Method, (BOM, 2003), which is applicable to areas subject to storms of tropical origin, such as cyclones, was used to determine rainfalls for durations up to seven days. The Probable Maximum Precipitation was estimated for the whole of the Brisbane River catchment, as well as for various sub-catchments. Concurrent rainfall estimates were provided for the remainder of the catchment outside the sub-catchment for which the Probable Maximum Precipitation was provided. The Probable Maximum Precipitation temporal patterns provided by the Bureau of Meteorology were used for all rainfalls.

Deleted: Australian g method

Deleted: for

Deleted: and

Deleted: were estim

The estimation of design rainfalls within the large to rare flood range was performed using the CRC-FORGE methodology as described in Book VI of Australian Rainfall and Runoff (1998). The CRC-FORGE method uses the concept of an expanding region focussed at the site of interest. Design rainfall for frequent events (eg 1 in 50 AEP) are based upon pooled data from a few gauges around the focal point, while design rainfall estimates at the AEP of the limit extrapolation are based upon pooled rainfall data from up to several hundred gauges. Before the data from different sites can be pooled, maximum annual rainfalls from each site need to be standardised by dividing by an "index variable".

The rainfall runoff models based on a non-linear runoff routing method were used to estimate the floods. The models were calibrated on recorded storm and flood data. The model calibrations were completed in 1993, (DNRM, 1993) and were not modified for the latest re-assessment.

Models to simulate the flood operation of Somerset and Wivenhoe Dams developed during the mid-eighties were modified to incorporate the new structure of the hydrologic models and to more accurately reflect the operational procedures of the dams. These models were then used to calculate dam discharges for a range of design floods generated using the rainfall estimates and the runoff routing models.

I.3. RAINFALL ANALYSIS RESULTS

The rainfall analysis was performed in two parts, the Probable Maximum Precipitation estimate by the Bureau of Meteorology and the estimation of large to rare events using the CRC-FORGE method. These were used both for design studies for the dam and to test the effects of flood operation procedures.

The estimates of rainfall frequency are listed in Tables I-1 and I-2.

Table I-1 - Catchment Rainfall (mm) on Wivenhoe Dam Catchment

Formatted: Legal 3,

Annual Exceedance Probability %	24 Hours	48 Hours	72 Hours
1	199	274	319
0.1	276	393	464
0.01	379	550	659
0.001	712	962	1160
PMP (0.007042)	800	1060	1280

Table I-2 - Catchment Rainfall (mm) on Somerset Dam Catchment

Formatted: Legal 3,

Annual Exceedance Probability %	24 Hours	48 Hours	72 Hours
1	302	430	507
0.1	432	649	775
0.01	554	920	1117

0.001	747	1204	1483

I.4. RUNOFF ROUTING MODEL CALIBRATION

Ten floods were used for calibration: July 1965, March 1967, June 1967, January 1968, December 1971, January 1974, January 1976, June 1983, Early April 1989 and Late April 1989. The gauging stations used for model calibration are listed in Table I-3.

The runoff routing model was calibrated for the nineteen major sub-catchments listed in Table I-4. Each of these models was calibrated for as many sites as possible for each of the ten floods.

Data were missing for some of the stations for some of the floods. The estimated model parameters are given in Table I-4. In all cases relative delay time parameter (k) used in the model is related to reach length.

Formatted: Legal 3,

Table I-3 - Gauging Stations used for Model Calibration

Stream	Site	Number	AMTD (km)	Catchment Area (km^2)
Stanley River	Somerset Dam		7.2	1 335
Cooyar Creek	Damsite	143015	12.2	960
Brisbane River	Linville	143007	282.4	2 005
Emu Creek	Boat Mountain	143010	10.1	920
Brisbane River	Gregor's Creek	143009	251.7	3 885
Cressbrook Creek	Damsite	143013	58.6	325
Brisbane River	Middle Creek	143008	187.2	6 710
Brisbane River	Wivenhoe Dam		150.2	7 020
Brisbane River	Savage's Crossing	143001	130.8	10 180
Bremer River	Walloon	143107	37.2	620
Warrill Creek	Amberley	143108	8.7	920
Lockyer Creek	Lyon's Bridge	143210	27.2	2 540
Brisbane River	City		22.7	13 260

Formatted: Legal 3, Left: 0 pt

Table I-4 - Estimated Model Parameters

Sub-Catchment Name	Model Parameters	
	k	m
Cooyar Creek	43.6	0.8
Brisbane River at Linville	20.6	0.8
Emu Creek at Boat Mountain	37.2	0.8
Brisbane River at Gregors Creek	20.1	0.8
Cressbrook Creek at Cressbrook Dam	34.3	0.8
Stanley River at Somerset Dam	80.7	0.8
Brisbane River at Wivenhoe Dam	108.5	0.8
Lockyer Creek at Helidon	15.0	0.8
Tenthill Creek at Tenthill	19.0	0.8
Lockyer Creek at Lyons Bridge	75.0	0.8
Brisbane River at Savages Crossing	40.0	0.8
Brisbane River at Mount Crosby	47.0	0.8
Bremer River at Walloon	44.0	0.8
Warrill Creek at Kalbar	34.0	0.8
Warrill Creek at Amberley	35.0	0.8
Purga Creek at Loamside	49.0	0.8
Bremer River at Ipswich	15.7	0.8
Brisbane River at Jindalee	20.8	0.8
Brisbane River at Port Office	19.3	0.8

Deleted: M

I.5. WIVENHOE DAM FLOODS

Wivenhoe Dam floods were estimated using the rainfalls and runoff routing model already discussed. Inflows to Wivenhoe Dam, assuming the dam to be in existence and full, were calculated, as well as flow at the dam-site without the dam in the catchment. Two-day storms were found to have the critical storm duration for most cases, though the long duration Probable Maximum Precipitations produced very large flood volumes. Table I-5 lists results for the two-day duration storms.

Table I-5 - Wivenhoe Dam Floods - Design Inflows and Outflows for Existing, Stage 1 and Stage 2 Upgrades

Formatted: Legal 3,

Event (1in X)	Peak Inflow (m^3/s)	Peak Outflow (m^3/s)		
		Existing	Stage 1	Stage 2
200	8,300	2,800	2,800	2,800
500	10,500	3,800	3,800	3,800
1,000	12,100	5,300	5,300	5,300
2,000	14,000	6,600	6,600	6,600
5,000	17,200	8,900	10,500 [c]	10,500 [c]

10,000	20,800	11,700	12,500	12,500
22,000 [a]	25,700	12,400 [a]	17,600	17,600
50,000	34,900	- [b]	24,600	24,600
100,000	43,300	- [b]	28,100 [a]	34,900
PMF	49,000	- [b]	- [b]	37,400 [a]

[a] Dam Crest Flood

[b] Overtops dam wall

[c] Increases due to changes to Procedure 4.

I.6. SOMERSET DAM FLOODS

Somerset Dam floods were estimated using the rainfalls and runoff routing model already discussed. Inflows to Somerset Dam, assuming the dam to be in existence and full, were calculated, as well as flow at the site without the dam in the catchment. The forty-eight hour PMP storm event was found to be critical, though the long duration PMP's produced very large flood volumes. Table I-6 lists results for the forty-eight hour duration storms.

Table I-6 - Somerset Dam Floods - (for two-day storm duration)[+]

Formatted: Legal 3,

AEP %	Peak Inflow (m^3/sec)	Peak Outflow (m^3/sec)	Flood Volume (ML)	Peak Lake Level (m AHD)
1	3,500	1,700	421,000	103.5
0.1	4,500	2,600	690,000	104.5
0.01	6,800	4,700	1,042,000	107.5
0.001	9,200	6,300	1,412,000	109.3
PMF*	16,000	9,600	1,952,800	112.0

+ - NB. This duration does NOT give the maximum Peak Inflow for a given AEP

* - Overtopped, estimated flow based on no dam failure

I.7 FLOOD CONTROL OPERATION MODEL

Floods in the Brisbane River catchment above Wivenhoe Dam can originate in either the Stanley River or upper Brisbane River catchment or both. Both of the dams are capable of being operated in a number of ways, each of which will reduce the flow downstream. However, in order to achieve maximum reduction of flooding downstream of Wivenhoe Dam, it was necessary to review the operations at Somerset and Wivenhoe Dams using a flood operations simulation model.

The most recent flood studies have reviewed the basic hydrologic algorithms in the operational models used in the earlier study and modified them to incorporate additional features relating to gate openings and closings. The revised design flood hydrology and operational model algorithms were then used to re-examine the original five possible operational procedures for each of Somerset Dam and Wivenhoe Dam, giving twenty-five possible combinations to be re-considered. The procedures previously developed for Wivenhoe Dam were designed so that initial release operations did not adversely affect later operations in the event of later rainfall causing the magnitude of the flood to exceed the original estimate.

The procedures previously developed were also designed to restrict flooding in the lower catchment to the lowest level of the following categories where practicable:

(i) low level bridges submerged, Fernvale bridge open;

(ii) all bridges except Mt. Crosby Weir and to Fernvale bridges submerged;

(iii) all bridges submerged, no damage to urban areas;

(iv) damage to urban areas due to peak flow from downstream catchment, no releases from Wivenhoe Dam contributing to peak flow;

(v) extensive damage to urban areas due to combined Wivenhoe Dam releases and downstream flow, Wivenhoe Dam release component of peak flow minimum practicable.

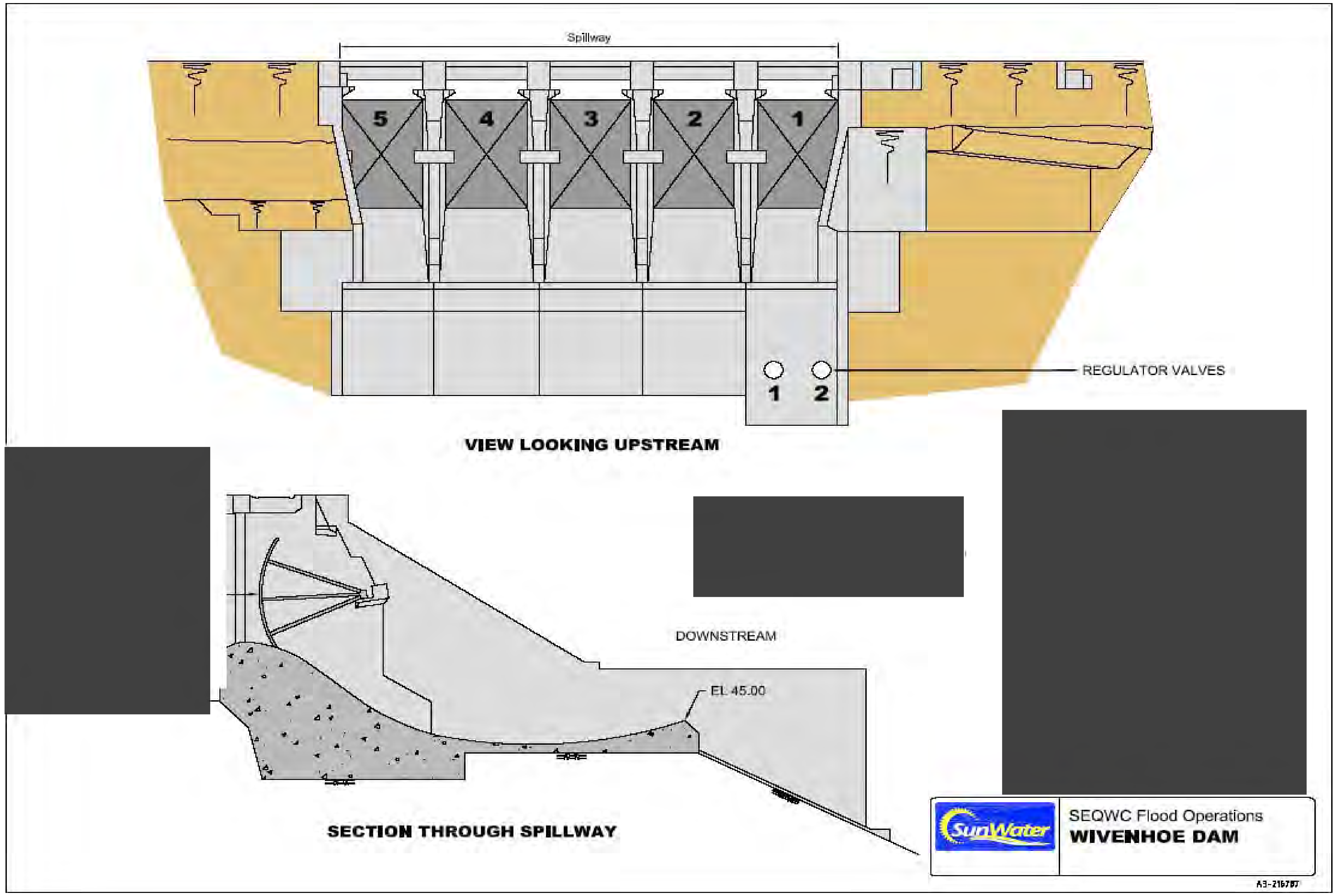
The previous flood studies recommended that one procedure be selected for the operation at Somerset Dam. This procedure had two advantages over the other procedures tested. Firstly, it was feasible for all magnitudes of Stanley River floods tested and, secondly, it was the simplest procedure to carry out. The re-analysis confirmed this conclusion.

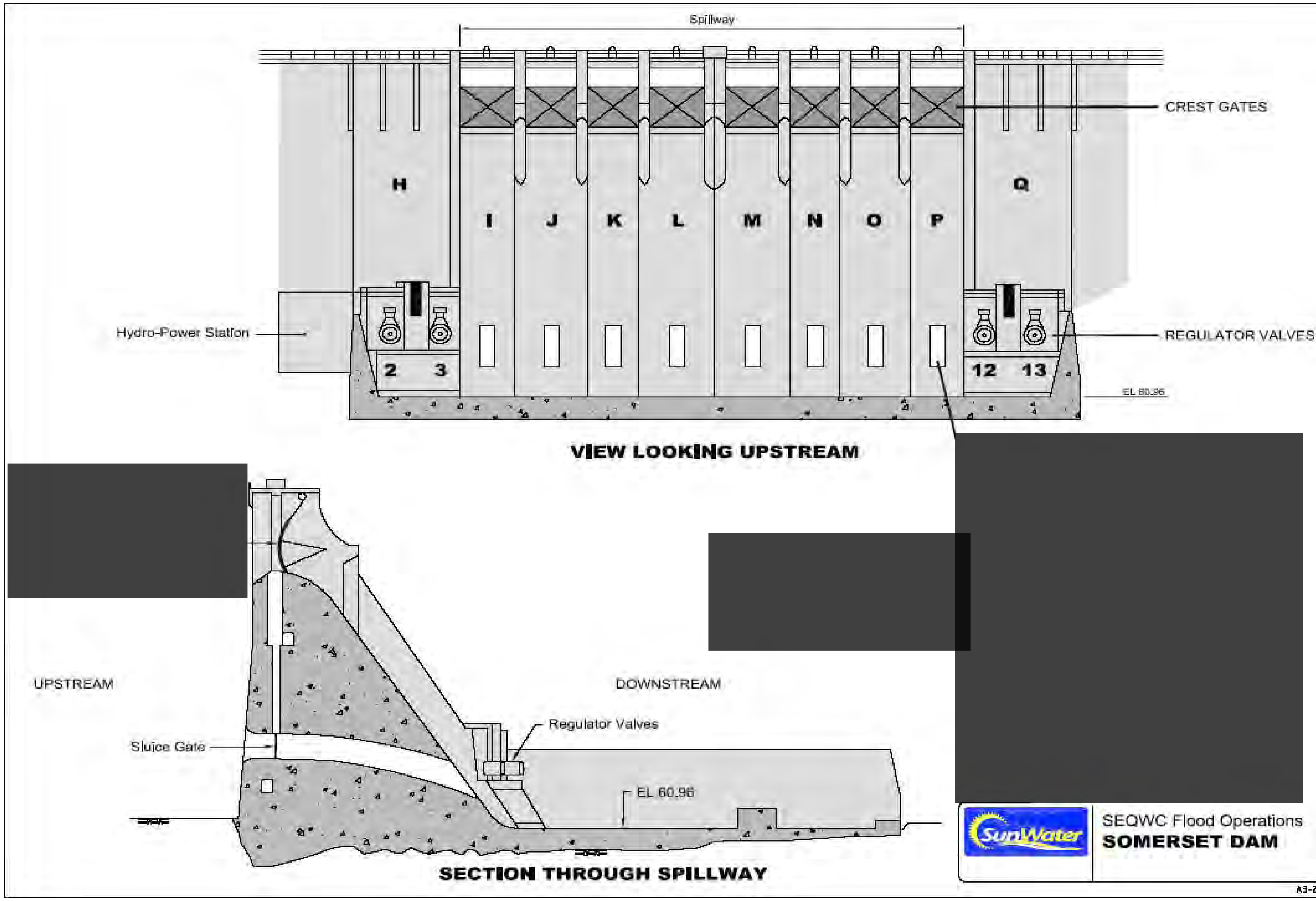
The previous flood studies concluded that procedures for Wivenhoe Dam be reduced to four by combining two procedures into one. The resulting four procedures formed a hierarchy and the procedure to be adopted advances to the next procedure as the flood magnitude increases. The re-analysis confirmed this conclusion.

A Real Time Flood Operations Model for Somerset and Wivenhoe has been developed as part of the “Brisbane River and Pine River Flood Studies”. This model incorporates the revised operational algorithms.

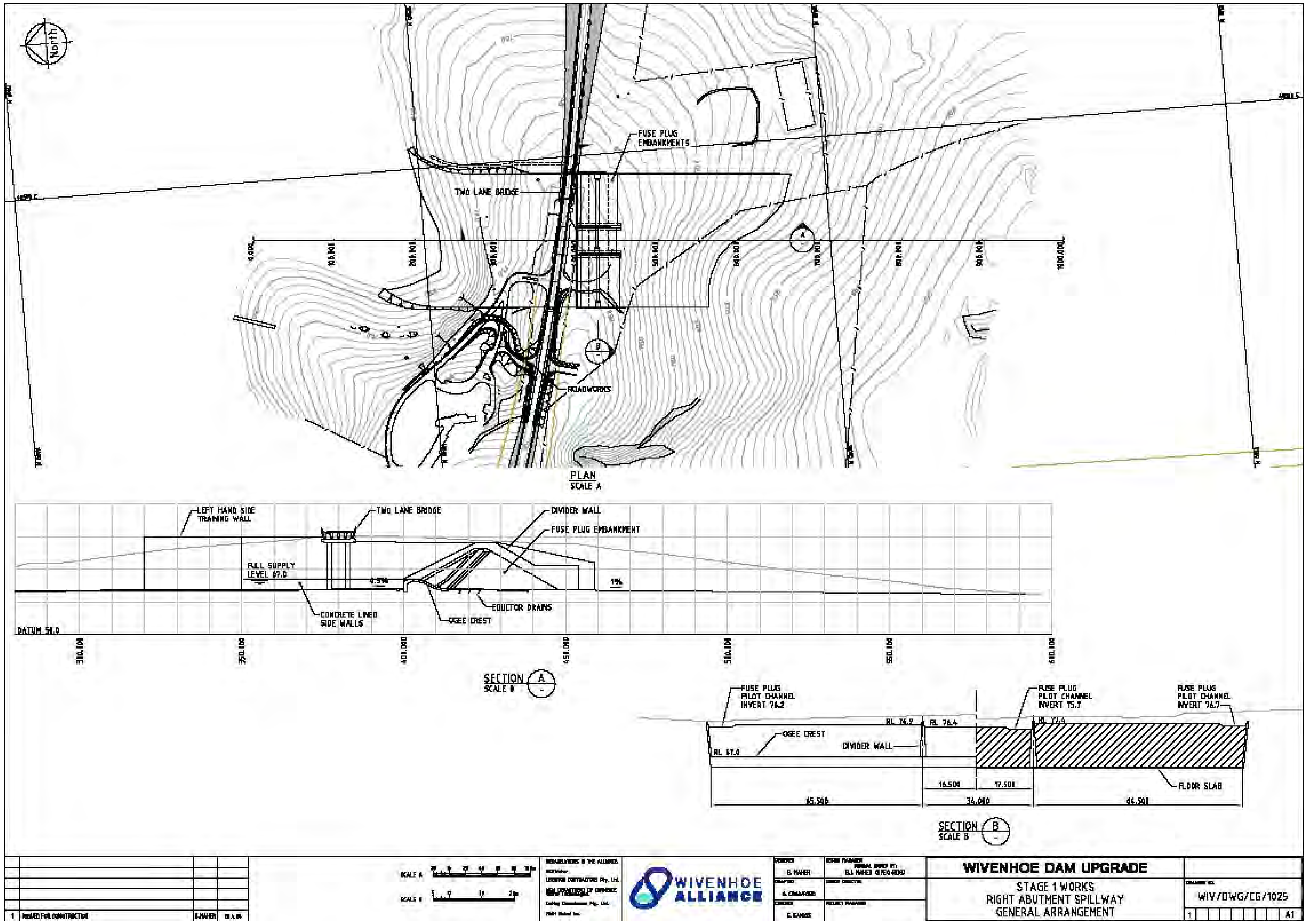
* Assume no failure of Wivenhoe Dam or Somerset Dam

APPENDIX J. DRAWINGS

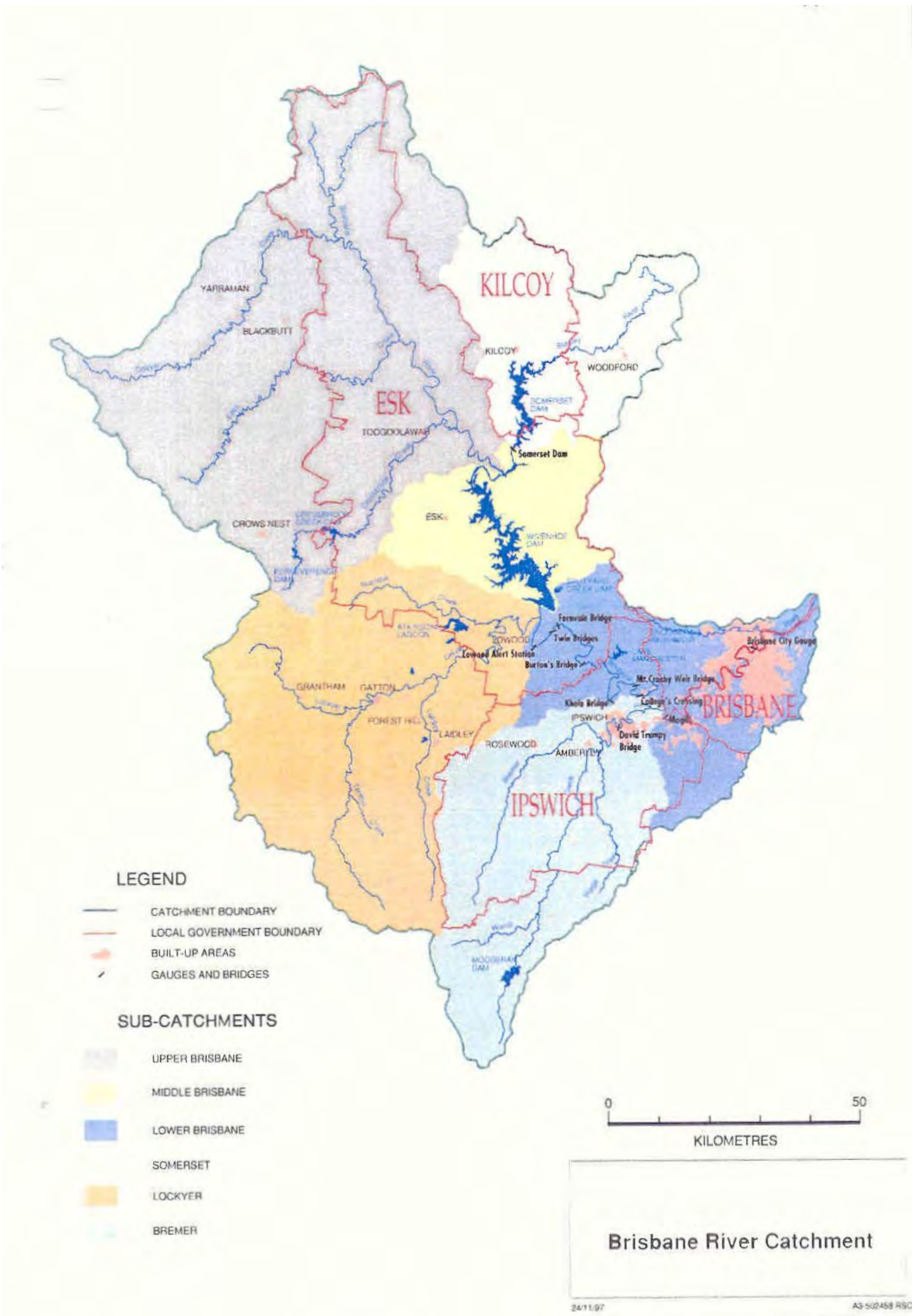




Spillway
CREST GATES
H
I
J
K
L
M
N
O
P
Q
Hydro-Power Station
REGULATOR VALVES
2
3
12
13
EL 60.96
VIEW LOOKING UPSTREAM
[redacted]
UPSTREAM
DOWNSTREAM
Regulator Valves
Sluice Gate
EL 60.96
SECTION THROUGH SPILLWAY
SEQWC Flood Operations
SOMERSET DAM


North
FUSE PLUG EMBANKMENTS
TWO LANE BRIDGE
ROADWORKS
PLAN
SCALE A
LEFT HAND SIDE TRAINING WALL
TWO LANE BRIDGE
DIVIDER WALL
FUSE PLUG EMBANKMENT
FULL SUPPLY LEVEL 67.0
1%
EDUCTOR DRAINS
CONCRETE LINED SIDE WALLS
OGEE CREST
DATUM 54.0
SECTION A
SCALE B
FUSE PLUG PILOT CHANNEL INVERT 76.2
FUSE PLUG PILOT CHANNEL INVERT 75.7
FUSE PLUG PILOT CHANNEL INVERT 76.7
RL 76.9
RL 76.4
RL 77.4
OGEE CREST
DIVIDER WALL
RL 67.0
16.500
17.500
FLOOR SLAB
45.500
34.000
46.500
SECTION B
SCALE B
1 ISSUED FOR CONSTRUCTION
SCALE A
SCALE B
WIVENHOE ALLIANCE
B. MAHER
WIVENHOE DAM UPGRADE
STAGE 1 WORKS
RIGHT ABUTMENT SPILLWAY
GENERAL ARRANGEMENT
WIV/DWG/CG/1025
A1

APPENDIX K. BRISBANE RIVER CATCHMENT



Page 36: [1] Deleted ayrer 28/11/2005 12:19:00 PM

ADDITIONAL PROVISIONS DURING CONSTRUCTION WORKS 2004/05

Auxiliary Spillway Area

The embankment forming the temporary road diversion that acts as a coffer dam is to be retained in place until the construction of the fuse plug has proceeded past EL 74, and then its removal is only to proceed once the written approval of a Senior Flood Operations Engineer has been obtained.

Gated Spillway Area

The following provisions will apply for works undertaken within the gated spillway:

The opening of spillway gates to discharge floodwaters is at the sole discretion of the Senior Flood Operations Engineer;

There is to be no obstruction of any spillway bay without the written approval of the Senior Flood Operations Engineer;

All gates are to be capable of being operated at short notice during a flood if required. To ensure this capability is maintained Table 8.6 specifies limitations that apply to the number of bays in which works may be occurring at any time. This table also nominates a target notice period to be provided by the Senior Flood Operations Engineer for the removal of construction material from the spillway bays prior to their use for releases. However the Senior Flood Operations Engineer is not constrained to provide this length of notice before operating any particular gate if its earlier operation is considered necessary.

Table 8.6 – Gated Spillway Area Works Restrictions

Dam Level	Season	Maximum number of bays that may be occupied at any time	Comments
Below EL 64.0	Winter (May to September)	3	12 hours notice to clear spillway
Below EL 64.0	Summer (October to April)	2	12 hours notice to clear spillway
Above EL 64.0	Winter (May to September)	2	12 hours notice to clear spillway
Above EL 64.0	Summer (October to April)	2	12 hours notice to clear spillway
Above EL 66.0	Flood Season (January to April)	1	Preferably not gate 1 or 5, 6 hours notice to clear spillway

A maximum of one gate may be treated as inoperable and remain closed if a flood will severely damage works if it is opened, and the expected flood magnitude can be catered for with 4 gates. The other gates are to be operated in accordance with the existing flood operational procedures but to compensate for the loss of flow in the closed gate. As the flood rises to the top of the closed gate at an EL 73 m AHD, the gate is incrementally raised to prevent it from being overtopped. It is noted that a large flood is required for the lake level to reach EL 73 m AHD.

The Corporation must prepare a Standing Operating Procedure for the conduct of works in the gated spillway whereby the above provisions are met such the capacity to achieve the dam’s operational objectives is maintained.

Guppy Ron

From: Guppy Ron
Sent: Thursday, 13 September 2007 2:42 PM
To: Allen Peter
Subject: FW: Flood Manuals for SEQWater
Attachments: WD-SD Flood Ops manual - Response to Ron Guppy's Comments

Peter

I've had a look at the Wivenhoe and Somerset Manual. I am not really happy with the correlation targets set in the Somerset Dam Procedure. The targets are the same as in the draft circulated in April of last year when the comment and response in the attached message were made. I believe Rob Ayre's suggestion there is more in line with what should be set though I would have the initial points as Wivenhoe EL74 and Somerset EL105 – Kilcoy first affected (or alternatively EL 102.5 – Mary Smokes Creek bridge level). Also the comment about limited difference between the last two Somerset lake levels needs to be considered further.

If we were to get this changed (the existing manual is approved till early 2010 so there is no real hurry with this one), I've put together a few other suggestions/ things I've noticed.

- Reword the last paragraph of section 3.2.1
- Page 26, 4th last line – reference should be to Sect 8.5 not 8.4
- The conflict found during the new Wivenhoe FSL investigation needs to be sorted out. Table 8.4 and the text referring to Procedure 1E has the maximum release rate at 1900 m3/s whereas Table 8.5 has 1500 m3/s
- Sect 8.6 (c) should refer to Sect 8.5
- I would like the instruction in sect 9.4.1 about not closing the sector gate when water level is above EL107 to be included in Sect 9.3 as well.
- Table 9.4.2 has the PMF peak level at EL110.9. In Appendix I Table I-6 has EL112.0

Ron Guppy
Principal Engineer (Dam Safety), Water Industry Regulation
Telephone [redacted] **Facsimile** [redacted]
Email: [redacted]
www.nrw.qld.gov.au
Department of Natural Resources and Water
ANZ Building, 324 Queen Street, Brisbane Q 4000
GPO Box 2454, Brisbane Q 4001

From: Barton Maher [redacted]
Sent: Wednesday, 5 September 2007 4:22 PM
To: Allen Peter
Cc: Guppy Ron
Subject: Flood Manuals for SEQWater

Hi Peter,

Please find attached:

- A copy of the cover letter for the revision of the flood manual for SEQWater
- Revision 4 for the North Pine Flood Manual and
- Revision 7 of the Wivenhoe - Somerset Flood Manual

These are submitted for your approval and gazetting. The original of the letter and hard copies of the manuals have been sent through in the post today.

Regards,

Barton Maher
Operations Engineer

SEQWater
Wivenhoe Dam, Brisbane Valley Highway
PO Box 37, Fernvale, Qld 4306
Ph [redacted] | Fax [redacted] | E [redacted]

[redacted]

From: Guppy Ron
Sent: Thursday, 8 October 2009 12:58 PM
To: Allen Peter
Subject: Flood Operations Manual - some thoughts

Attachments: Document1.doc

Document1.doc

1. Section 8.4 talks about the strategy being chosen based on predictions, maximums and peaks as below:

   The strategy chosen at any point in time will depend on the following predictions which are to be made using the best forecast rainfall and stream flow information available at the time:

   - *Maximum storage levels in Wivenhoe and Somerset Dams.*
   - *Peak flow rate at the Lowood Gauge (excluding Wivenhoe Dam releases).*
   - *Peak flow rate at the Moggill Gauge (excluding Wivenhoe Dam releases).*

   My concept is that actual values are used with some variations allowed for based on forecasts.

2. The flow chart on Page 23 needs to be looked at, particularly the use of 'likely'. There are a few W1s that need to be removed.

3. All W strategies should refer to actual levels and flows and not the predicted levels and flows. Then W4A and W4B can be differentiated based on Predicted Maximum Lake Level.

4. Strategy W2

   I still have some difficulty in distinguishing between W2 and W3. Does the shift happen if it becomes impossible to restrict flows at Lowood to less than 3500 m^3/s.

   I think there needs to be another criterion of not less than 1900 m^3/s given for the target maximum flows. Otherwise if for example the natural peak flow at Lowood excluding Wivenhoe releases was only 1000 m^3/s that becomes the target maximum flow there.

   I think it would be useful to have some 'guidance' for the SFOE in determining the actual outflow in particular circumstances such as when the water level is expected to peak at below EL 74.

5. Gate Operation Sequences – Section 8.6

   - For outflows >4000 m^3/s – says 'no restrictions on gate operating intervals' but W4A says openings to occur 'at the minimum intervals'.

   - The large Table in section 8.6 is not helpful and likely to be confusing.

     Under normal circumstances, gate operation is not dependent on storage level until EL 74 is exceeded. It is solely based on a discharge. The Table suggests otherwise.

Even after EL 74 is reached the strategy is to open gates at minimum intervals until the water level begins to fall. That also is inconsistent with the Table.

All that is needed is the order of gate operation.

The same Table in section 10 has merit but only up to EL 74 when 'open gates at minimum intervals until the water level begins to fall' is the requirement.

A few other pretty insignificant suggestions

- The Definitions section has Dam Supervisor but the emergency procedures sections refer to 'officer in charge'
- 'Flood Operations Centre' could be added to the Definitions section
- Section 2.4 last paragraph – there is an 'and' which should be 'an'
- Section 3 – All objectives apart from be at Full Supply Level at the conclusion of the event have a sub-section.
- Section 3.3 Extreme and Closely Spaced Floods is a bit out of place. Maybe renumber it as 3.2.?
- Table in 6.2. page 15 - for BOM – if we now have a 'flood event' that should be the trigger for providing information.
- In the title of the figure on page 40 'Strategy S2' should be removed - it applies to S3 as well.
- Page 44 dot point 2 refers to Somerset Dam. It should be Wivenhoe Dam.

Guppy Ron

Subject: FW: Wivenhoe Flood Mitigation Manual..

From: Nguyen Khanh
Sent: Tuesday, 13 October 2009 3:13 PM
To: Allen Peter
Cc: Guppy Ron
Subject: RE: Wivenhoe Flood Mitigation Manual..

Peter,

I've checked the LossCom spreadsheet and it seems to work ok for the case you're testing.

The rating curve for WD should start at EL 57.... Just a cosmetic change as it has no effect on the calculation...

The rating curve for SD.... I assumed it's for 1 gate, 1 sluice & 1 regulator...

Regards
Khanh (Ken) Nguyen

From: Allen Peter
Sent: Tuesday, 13 October 2009 11:55 AM
To: Tibaldi John [redacted] Terry Malone
Cc: Guppy Ron; Nguyen Khanh; Ruffini John; Ayre, Rob
Subject: Wivenhoe Flood Mitigation Manual

John/Terry,

I have had a further play with the 'Loss of Communications' spreadsheet.
<< File: GateOPs-100k Adjusted 2 time step.xls >>
I have put a variable time step in so that decisions are made when the next gate operation is possible. It seems a bit more robust and to operate as it should?

I have also attached a collated list of the comments that Ron, Ken and I have put together on the latest version of the Flood Manual (WD-SD-Rev 7 -05 TMJT.doc) for your consideration.

<< File: Wivenhoe Flood Manual comments.doc >>

Peter Allen
Director Dam Safety (Water Supply)
Office of the Water Supply Regulator
Telephone [redacted] **Mobile** [redacted] **Facsimile** [redacted]
Email [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
3rd Floor 41 George Street, Brisbane Q 4000
GPO Box 2454, Brisbane Q 4001

1. Section 3.2 last para: The statements for the AEP of the Somerset floods only apply for the overall Wivenhoe catchment floods. What are the AEPs for the Somerset catchment floods?

2. Section 3.3 middle para: Is the reference to Section 2.6 correct? Shouldn't it refer to Section 2.8 and the use of reasonable discretion?

3. Section 8.4 talks about the strategy being chosen based on predictions, maximums and peaks as below:

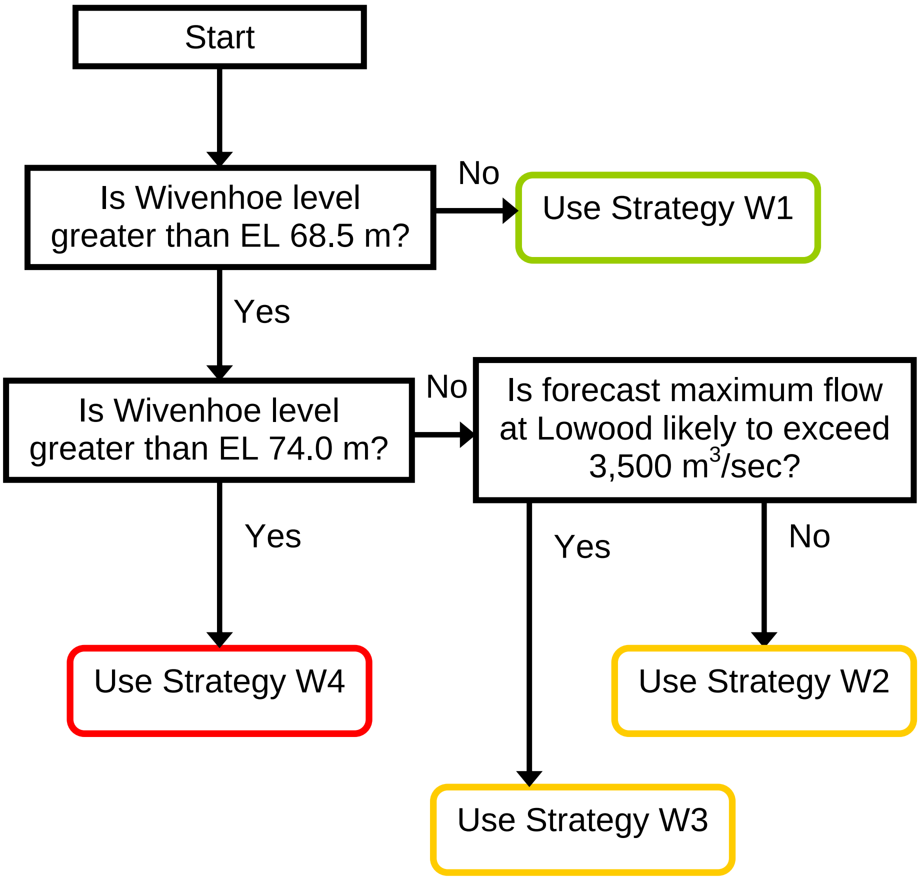
   The strategy chosen at any point in time will depend on the following predictions which are to be made using the best forecast rainfall and stream flow information available at the time:

   - *Maximum storage levels in Wivenhoe and Somerset Dams.*
   - *Peak flow rate at the Lowood Gauge (excluding Wivenhoe Dam releases).*
   - *Peak flow rate at the Moggill Gauge (excluding Wivenhoe Dam releases).*

   Our understanding is that the actual values are used to select W1 to W4 with some variations allowed for based on forecasts. e.g. You transition form W1 to W2 or W3 once the water level in Wivenhoe exceeds EL 68.5m. The choice between W2 and W3 is made on the forecast of the peaks depending on whether the Lowood or the Moggill flows control.

4. From this perspective, it may be better to change the figure on page 27 to something along the following lines.

Wivenhoe Flood Strategy Flow Chart



5. All W strategies should refer to actual levels and flows and not the predicted levels and flows. Then W4A and W4B can be differentiated based on Predicted Maximum Lake Level.

   I think there needs to be another criterion under Procedures W2 and W3 of not less than 1900 m^3/s given for the target maximum flows. Otherwise if for example the natural peak flow at Lowood excluding Wivenhoe releases was only 1000 m^3/s that becomes the target maximum flow there.

   It may also be useful to specify that the peak outflow should not exceed the peak inflow (i.e the total inflow into Wivenhoe including Somerset outflows).

6. Section 8.5 Gate Closing Strategies … Should you be trying to clear the flood storage above EL 67.0 rather than 67.5?

7. Gate Operation Sequences – Section 8.6

   - The final para of Strategy W4 (before strategy 4A) indicates ‘there are no restrictions on gate opening increments or gate opening frequency once the storage level exceeds 74.0 AHD …’ but W4A says openings to occur ‘at the minimum intervals’.

- The inclusion of the large Table in section 8.6 is not necessarily helpful and likely to be confusing. It is only really applicable for the loss of communications strategies. I am happy with the target of getting all the gates open before the first fuse plug triggers but while there are communications with the Flood Operations Centre, the gate opening rates are set by the Flood Operations Engineer.

  Under normal circumstances, gate operation is not dependent on storage level until EL 74 is exceeded. It is solely based on a discharge. The Table suggests otherwise.

  Even after EL 74 is reached the strategy is to open gates at minimum intervals until the water level begins to fall. That also is inconsistent with the Table.

  All that is needed in Section 8.6 is the order of gate operation.

- Strategy S3 for Somerset – When should it be applied? Should it only apply above say EL 102.25? What are the differences between S2 and S3?

- Appendix B Key Reference Gauges – The gauge zero for Lowood is above the 1974 Gauge Height. Is this the case?

- The rating table for Wivenhoe in Appendix C… An annotation needs to be added to identify that part of the data for which the gate will be overtopped (this is to be avoided). You also need to indicate that these are discharges per gate. Also indicate in the Auxiliary Spillway ratings that they only apply once the fuse plugs are triggered.

- You need to make it clear that Case S1 (page 47) applies before each sluice is opened. Ie. If say there are two sluices open with a Somerset headwater above 99.31, an extra sluice is only opened if Wivenhoe is still falling at 10mm/hr. If it is rising, I would expect a sluice to be closed. You then wait the minimum interval before making the next decision.

A few other pretty insignificant suggestions

- The Definitions section has Dam Supervisor but the emergency procedures sections refer to ‘officer in charge’
- ‘Flood Operations Centre’ could be added to the Definitions section
- Section 2.4 last paragraph – 2nd line - there is an ‘and’ which should be ‘an’
- Section 3 – All objectives apart from be at Full Supply Level at the conclusion of the event have a sub-section. Perhaps, to be consistent, we should include an objective to ‘drain the flood storage within seven days of the peak headwater level occurring in the dam … i.e. Drain Wivenhoe flood storage within seven days of the headwater level peaking in Wivenhoe and drain the Somerset flood storage within seven days of the headwater level peaking in Somerset. One option might be to include it as a sub-set of the first objective to ‘ensure the structural safety of the dams’.

- Section 3.3 Extreme and Closely Spaced Floods is a bit out of place. – see discussion above.
- In the title of the figure on page 40 ‘Strategy S2’ should be removed - it applies to S3 as well.
- Page 44 dot point 2 refers to Somerset Dam. It should be Wivenhoe Dam.

[redacted]

Subject: FW: Gazettal of Approval of Flood Mitigation Manual

Attachments: Request for gazettal Jan10.doc; Att 2.pdf; Att 1.doc; DERM Request form for gazettal only.doc

---

From: Guppy Ron
Sent: Friday, 15 January 2010 12:09 PM
To: Mckenna John
Subject: FW: Gazettal of Approval of Flood Mitigation Manual

John,

To formalise approval of the Flood Mitigation Manual for Wivenhoe and Somerset Dam that Peter Allen signed off on 22nd December we need to have notice published in the Government Gazette

I have drafted a request for the gazettal to occur. If you are happy with it, can you send it (with attachments) to Executive Council Team.

Request for gazettal Jan10.doc.. | Att 2.pdf | Att 1.doc

Ron Guppy
Principal Engineer (Dam Safety)

Office of the Water Supply Regulator
Telephone [redacted] **Facsimile** [redacted]
Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

From: Faaniniva Toe
Sent: Tuesday, 12 January 2010 11:49 AM
To: Guppy Ron
Subject: RE: Gazettal of Approval of Flood Mitigation Manual

Hi Ron

Can you please complete the attached request template form - for the gazettal of approval of Flood Mitigation Manual as per your email below.

Once complete and emailed through to me I will then process the paperwork onto our database in preparation for next week's Gazette.

DERM Request form for gazettal...

Kind regards

Toe Faaniniva
A/Project Officer
Executive Council Team (Cabinet and Parliamentary Services)
Governance & Strategy
Department of Environment and Resource Management (DERM)
Level 3, 400 George Street, Brisbane

Phone: [redacted]

Email: [redacted]
Website: www.derm.qld.gov.au

From: Guppy Ron
Sent: Monday, 11 January 2010 12:32 PM
To: Executive Council Team
Subject: Gazettal of Approval of Flood Mitigation Manual

On 22nd December 2009 Peter Allen, Director, Dam Safety (Water Supply) decided approval was to be given for a Flood Mitigation Manual for Wivenhoe and Somerset Dams as per the attached pdf.

The Water Supply (Safety & Reliability) Act 2008 (section 371) requires a gazette notice to formalise that approval. I am also attaching a draft of a notice that might be used based on the most recent similar gazette notice prepared in 2007.

<< File: Flood Mitigation Manual, Wivenhoe & Somerset Dams.pdf >> << File: gazette notice wiv fmm jan10.doc >>
Can you please arrange for a suitable notice to be included in an upcoming gazette. The relevant cost code is UDURKEEA06.

If anything else is required please advise.

Ron Guppy
Principal Engineer (Dam Safety)

Office of the Water Supply Regulator
Telephone [redacted] **Facsimile** [redacted]
Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000

GPO Box 2454, Brisbane Q 4001

Department of **Environment** and **Resource Management**

Request for Publication in the Gazette

Your ref:		**Our ref:**	DAM/130/000(377), DAM/130/000(354)
Author:	Ron Guppy	**Phone:**	[redacted]
		Fax:	[redacted]

Date: 15 January 2010

From: John McKenna, A/Director, Dam Safety (Water Supply)

To: Senior Project Officer, Executive Council Team, Cabinet and Parliamentary Services

Attn Kerri Pratt

Subject: **Publishing of a notice in the gazette – Approval of Flood Mitigation Manual**

BACKGROUND

Seqwater has sought approval for a Flood Mitigation Manual for Somerset and Wivenhoe Dams. Section 371(2) of the *Water Supply (Safety and Reliability) Act 2008* provides that approval of a Flood Mitigation Manual is by notice in the Government Gazette. The decision to give approval to the Flood Mitigation Manual was made on 22nd December 2009 as per attachment.

I certify that the attached:

a) draft gazette notice in relation to the approval of the Flood Mitigation Manual for Wivenhoe Dam and Somerset Dam, and

b) copy of Departmental Briefing Note approval

in relation to the approval of the Flood Mitigation Manual, are correct.

The Costing Code to be charged for publishing the Gazette Notice is UDURKEEA06

Please forward for publishing in the Queensland Government Gazette.

John McKenna

A/Director, Dam Safety (Water Supply)

Office of Water Supply Regulator

Att (2)

ECT USE ONLY

ANTICIPATED DATE OF GAZETTAL	/ /		
ECT Reference No.			
ECT documentation Prepared	/ /	Proof Checked	/ /

This request has been authorised by publication in the Government Gazette of / /

ECT Enquires - **Phone** [redacted] Email to: [redacted]

Water Supply Act 2008

APPROVAL OF FLOOD MITIGATION MANUAL NOTICE (No 01) 2010

Short title

1. This notice may be cited as the *Approval of Flood Mitigation Manual Notice (No 01) 2010.*

Approval of flood mitigation manual [s.371 of the Act]

2. Notice is hereby given that the Chief Executive on 22 December 2009 approved the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam Revision 7, November 2009 as a flood mitigation manual.

3. This approval is for a period of 5 years.

ENDNOTES

1. Published in the Gazette on 28 September 2007
2. Not required to be laid before the Legislative Assembly.
3. The administering agency is the Department of Environment and Natural Resources.

Deleted: *0*

Deleted: 07

Deleted: *07*

Deleted: 497

Deleted: 13

Deleted: September

Deleted: 7

Deleted: Releases from North Pine Dam

Deleted: 4

Formatted: Highlight

Deleted: Natural Resources and Water

File # 377 #354

Department of Environment and Resource Management
NOTE to FILE

SUBJECT: Flood Mitigation Manual, Wivenhoe and Somerset Dams

TIMEFRAME

- The previous manual is due to expire on 25th February 2010.

DECISION

I decided 22nd December 2009 to approve the *Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam Revision 7 November 2009* for a period of five years and to approve this to be gazetted in early 2010.

BACKGROUND

- The approval of the previous version of the Wivenhoe and Somerset Dam Flood Mitigation Manual was published in the Gazette under the provisions of the *Water Act 2000* on 25th February 2005 and this approval was for a period of 5 years.
- Under *s.371* of the *Water Supply (Safety and Reliability) Act 2008*, the chief executive may, by gazette notice, approve a flood mitigation manual for a period of up to five years.
- There has been extensive, ongoing consultation between officers of the Dam Safety group (Peter Allen, Ron Guppy, Ken Nguyen), officers of Seqwater (John Tibaldi, Terry Malone, Rob Drury) and the dam Flood Operations engineers (Rob Ayre and John Ruffini).
- Under the *Water Supply (Chief Executive) Delegation (No.1) 2009*, a flood mitigation manual can be approved by Director Dam Safety (Water Supply).

CURRENT ISSUES

- While the new flood mitigation manual has been upgraded/updated in a number of areas to reflect the current arrangement of Wivenhoe and Somerset Dams and the change in ownership, there are only relatively minor variations in the overall flood operation procedures. A summary of these amendments as provided by Seqwater is attached.
- The most significant change is the variation in the 'target point' for the operation of Somerset Dam. This was amended because testing of the operational procedures demonstrated that the flood immunity of Somerset Dam could be significantly improved if more water was released earlier from Somerset and this resulted in only minor increases in the levels in Wivenhoe Dam.
- The opportunity has also been taken to simplify the 'loss of communication' procedures for Somerset and Wivenhoe. This should make flood operations for both dams far more robust when communications is lost between the Flood Operations Centre and the dam operators.
- The flood immunity of the downstream crossings is largely unaffected by the upgrade operational rules.

RESOURCE/IMPLEMENTATION IMPLICATIONS

- There are no resourcing implications for the Department although the Manual does indemnify the dam owner for civil liability arising from flood operations so long as they are done in accordance with the Manual.

PROPOSED ACTION

- The approval of the Manual will be finalised once it is published in one of the first editions of the Gazette in 2010.

DOCUMENT REGISTERED BY DERM
File No. DAM/130/000(037.7)S...
File Location. WIC ACTIVE
22 DEC 2009
Action By. WIC P. ALLEN
Registered Y/N RU09/05096
Doc. Code

[redacted]

Peter Allen
Director Dam Safety (Water Supply)
22nd December 2009

Author	Cleared by	Cleared by	Recommended
Name: Peter Allen Position:D DS(WS) Tel No [redacted] Date:21/12/2009	Name: Position: Name: Position:	Name: Position: Name: Position:	Name: Position: Tel No: Date:

File Ref:

Guppy Ron

Subject: FW: Gazettal of Approval of Flood Mitigation Manual

Attachments: Request for gazettal Jan10.doc; Att 2.pdf; Att 1.doc; DERM Request form for gazettal only.doc

---

From: Mckenna John
Sent: Friday, 15 January 2010 4:37 PM
To: Faaniniva Toe
Cc: Guppy Ron
Subject: FW: Gazettal of Approval of Flood Mitigation Manual

G'day Toe,

Please refer to Ron Guppy's email below. I've approved the request for gazettal of the flood migigation manuals and made some edits to Attachment 1 which is in 'Tracked Changes'. It would be appreciated if you would progress this matter in preparation for gazettal. Please contact me if you have any queries.

Regards
John

John McKenna
A/Director, Dam Safety (Water Supply)
Office of the Water Supply Regulator
Telephone: [redacted] **Facsimile:** [redacted] **Mobile** [redacted]
Email: [redacted]
http://www.derm.qld.gov.au/
Department of Environment and Resource Management
Lvl 3, Mineral House, 41 George Street, Brisbane Q 4000
GPO Box 2454, Brisbane Q 4001

From: Guppy Ron
Sent: Friday, 15 January 2010 12:09 PM
To: Mckenna John
Subject: FW: Gazettal of Approval of Flood Mitigation Manual

John,

To formalise approval of the Flood Mitigation Manual for Wivenhoe and Somerset Dam that Peter Allen signed off on 22nd December we need to have notice published in the Government Gazette

I have drafted a request for the gazettal to occur. If you are happy with it, can you send it (with attachments) to Executive Council Team.

Ron Guppy

Request for gazettal Jan10.doc..

Principal Engineer (Dam Safety

Att 2.pdf (57 KB)

Office of the Water Supply Re ulator

Att 1.doc (42 KB)

Telephone [redacted] **Facsimile** [redacted]
Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

From: Faaniniva Toe
Sent: Tuesday, 12 January 2010 11:49 AM
To: Guppy Ron
Subject: RE: Gazettal of Approval of Flood Mitigation Manual

Hi Ron

Can you please complete the attached request template form - for the gazettal of approval of Flood Mitigation Manual as per your email below.

Once complete and emailed through to me I will then process the paperwork onto our database in preparation for next week's Gazette.

Kind regards

Toe Faaniniva
A/Project Officer
Executive Council Team (Cabinet and Parliamentary Services)
Governance & Strategy

DERM Request form for gazettal...

Department of Environment and Resource Man gement (DERM)
Level 3, 400 George Street, Brisbane

Phone: [redacted]
Extension: [redacted]

Email: [redacted]
Website: www.derm.qld.gov.au

From: Guppy Ron
Sent: Monday, 11 January 2010 12:32 PM
To: Executive Council Team
Subject: Gazettal of Approval of Flood Mitigation Manual

On 22nd December 2009 Peter Allen, Director, Dam Safety (Water Supply) decided approval was to be given for a Flood Mitigation Manual for Wivenhoe and Somerset Dams as per the attached pdf.

The Water Supply (Safety & Reliability) Act 2008 (section 371) requires a gazette notice to formalise that approval. I am also attaching a draft of a notice that might be used based on the most recent similar gazette notice prepared in 2007.

<< File: Flood Mitigation Manual, Wivenhoe & Somerset Dams.pdf >> << File: gazette notice wiv fmm jan10.doc >>
Can you please arrange for a suitable notice to be included in an upcoming gazette. The relevant cost code is UDURKEEA06.

If anything else is required please advise.

Ron Guppy
Principal Engineer (Dam Safety)

Office of the Water Supply Regulator
Telephone [redacted] **Facsimile** [redacted]
Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

Department of **Environment** and **Resource Management**

Request for Publication in the Gazette

Your ref:

Our ref: DAM/130/000(377), DAM/130/000(354)

Author: Ron Guppy

Phone: [redacted]

Fax: [redacted]

Date: 15 January 2010

From: John McKenna, A/Director, Dam Safety (Water Supply)

To: Senior Project Officer, Executive Council Team, Cabinet and Parliamentary Services

Attn Kerri Pratt

Subject: **Publishing of a notice in the gazette – Approval of Flood Mitigation Manual**

BACKGROUND

Seqwater has sought approval for a Flood Mitigation Manual for Somerset and Wivenhoe Dams. Section 371(2) of the *Water Supply (Safety and Reliability) Act 2008* provides that approval of a Flood Mitigation Manual is by notice in the Government Gazette. The decision to give approval to the Flood Mitigation Manual was made on 22nd December 2009 as per attachment.

I certify that the attached:

a) draft gazette notice in relation to the approval of the Flood Mitigation Manual for Wivenhoe Dam and Somerset Dam, and

b) copy of Departmental Briefing Note approval

in relation to the approval of the Flood Mitigation Manual, are correct.

The Costing Code to be charged for publishing the Gazette Notice is UDURKEEA06

Please forward for publishing in the Queensland Government Gazette.

John McKenna

A/Director, Dam Safety (Water Supply)

Office of Water Supply Regulator

Att (2)

ECT USE ONLY			
ANTICIPATED DATE OF GAZETTAL	/ /		
ECT Reference No.			
ECT documentation Prepared	/ /	Proof Checked	/ /

This request has been authorised by publication in the Government Gazette of / /

ECT Enquires - **Phone** [redacted] Email to: [redacted]

File # 377 #354

Department of Environment and Resource Management

NOTE to FILE

SUBJECT: Flood Mitigation Manual, Wivenhoe and Somerset Dams

TIMEFRAME

- The previous manual is due to expire on 25th February 2010.

DECISION

I decided 22nd December 2009 to approve the *Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam Revision 7 November 2009* for a period of five years and to approve this to be gazetted in early 2010.

BACKGROUND

- The approval of the previous version of the Wivenhoe and Somerset Dam Flood Mitigation Manual was published in the Gazette under the provisions of the *Water Act 2000* on 25th February 2005 and this approval was for a period of 5 years.
- Under *s.371* of the *Water Supply (Safety and Reliability) Act 2008*, the chief executive may, by gazette notice, approve a flood mitigation manual for a period of up to five years.
- There has been extensive, ongoing consultation between officers of the Dam Safety group (Peter Allen, Ron Guppy, Ken Nguyen), officers of Seqwater (John Tibaldi, Terry Malone, Rob Drury) and the dam Flood Operations engineers (Rob Ayre and John Ruffini).
- Under the *Water Supply (Chief Executive) Delegation (No.1) 2009*, a flood mitigation manual can be approved by Director Dam Safety (Water Supply).

CURRENT ISSUES

- While the new flood mitigation manual has been upgraded/updated in a number of areas to reflect the current arrangement of Wivenhoe and Somerset Dams and the change in ownership, there are only relatively minor variations in the overall flood operation procedures. A summary of these amendments as provided by Seqwater is attached.
- The most significant change is the variation in the 'target point' for the operation of Somerset Dam. This was amended because testing of the operational procedures demonstrated that the flood immunity of Somerset Dam could be significantly improved if more water was released earlier from Somerset and this resulted in only minor increases in the levels in Wivenhoe Dam.
- The opportunity has also been taken to simplify the 'loss of communication' procedures for Somerset and Wivenhoe. This should make flood operations for both dams far more robust when communications is lost between the Flood Operations Centre and the dam operators.
- The flood immunity of the downstream crossings is largely unaffected by the upgrade operational rules.

RESOURCE/IMPLEMENTATION IMPLICATIONS

- There are no resourcing implications for the Department although the Manual does indemnify the dam owner for civil liability arising from flood operations so long as they are done in accordance with the Manual.

PROPOSED ACTION

- The approval of the Manual will be finalised once it is published in one of the first editions of the Gazette in 2010.

DOCUMENT REGISTERED BY DERM
File No. DAM/130/000(9377)5
File Location. WIC ACTIVE
22 DEC 2009
Action By. WIC DDSS P. ALLEN
Registered Y/N RU09/05096
Doc. Code

[redacted]

Peter Allen
Director Dam Safety (Water Supply)
22nd December 2009

Author	Cleared by	Cleared by	Recommended
Name: Peter Allen Position: D DS(WS) Tel No [redacted] Date:21/12/2009	Name: Position: Name: Position:	Name: Position: Name: Position:	Name: Position: Tel No: Date:

File Ref:

Water Supply (Safety and Reliability) Act 2008

APPROVAL OF FLOOD MITIGATION MANUAL NOTICE (No 01) 2010

Short title

1. This notice may be cited as the *Approval of Flood Mitigation Manual Notice (No 01) 2010*.

Approval of flood mitigation manual [s.371 of the Act]

2. Notice is hereby given that the Chief Executive on 22 December 2009 approved the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam, Revision 7, November 2009 as a flood mitigation manual.

3. This approval is for a period of 5 years.

ENDNOTES

1. Published in the Gazette on XXX XXXX 2010
2. Not required to be laid before the Legislative Assembly.
3. The administering agency is the Department of Environment and Resource Management.

Deleted: *0*

Deleted: 07

Deleted: *07*

Deleted: 497

Deleted: 13

Deleted: September

Deleted: 7

Deleted: Releases from North Pine Dam

Deleted: 4

Formatted: Highlight

Deleted: 28 September 2007

Formatted: Highlight

Deleted: Natural Resources

Deleted: Natural Resources and Water

Guppy Ron

Subject: FW: Flood Mitigation Manual Approval

Attachments: GG Extracts 220110.doc

From: Guppy Ron
Sent: Friday, 22 January 2010 2:42 PM
To: 'John Tibaldi'
Subject: Flood Mitigation Manual Approval

John,

Here is a copy of the gazette notice.

I'll send a formal letter to your CEO within the next couple of weeks.

GG Extracts
20110.doc (44 KB).

Ron Guppy
Principal Engineer (Dam Safety)

Office of the Water Supply Regulator
Telephone [redacted] **Facsimile** [redacted]

Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

Water Supply (Safety and Reliability)Act 2008

APPROVAL OF FLOOD MITIGATION MANUAL NOTICE (No 01) 2010

Short title

1. This notice may be cited as the *Approval of Flood Mitigation Manual Notice (No 01) 2010.*

Approval of flood mitigation manual [s.371 of the Act]

2. Notice is hereby given that the Chief Executive on 22 December 2009 approved the Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam, Revision 7, November 2009 as a flood mitigation manual.

3. This approval is for a period of 5 years.

ENDNOTES

1. Published in the Gazette on 22 January 2010
2. Not required to be laid before the Legislative Assembly.
3. The administering agency is the Department of Environment and Resource Management.

Gov. Gaz., 22 January 2010, No. 15 page 127

Government Printer, Brisbane

File / Ref number: DAM/130/000(0377), DAM/130/000(0354)

28 January 2000

Peter Borrows
Chief Executive Officer
Queensland Bulk Water Supply Authority
PO Box 16146
CITY EAST, QLD, 4002

Dear Sir

Flood Mitigation Manual, Wivenhoe and Somerset Dams

Your letter of 3 December 2009 requesting approval of the updated flood mitigation manual submitted for Wivenhoe and Somerset Dams refers.

By publication of a notice in the Gazette the 'Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam, Revision 7' has been approved as a Flood Mitigation Manual. The approval is for five years from 22 December 2009.

I enclose a copy of the gazette notice for your records.

Controlled copies of the updated manual will need to be distributed to the agencies listed in Appendix B of the manual

Should you have any further enquiries, please do not hesitate to contact Mr Ron Guppy, Principal Engineer, Dam Safety of the department on telephone [redacted]

Yours sincerely

John McKenna
A/Director, Dam Safety (Water Supply)

Postal Address
GPO Box 2454
Brisbane Qld 4001

Telephone + [redacted]
Facsimile +

Website
www.derm.qld.gov.au
ABN 83 705 537 586

From Guppy Ron **Date** Tuesday, 7 December 2010 9:10:10 AM
To Executive Council Team
Cc Allen Peter
Subject Gazettal of Flood Mitigation Manual Approval Notice

gazettal request dec 6.pdf (35 KB HTML)
approval decision notice dec 6.pdf (166 KB HTML) **draft NPD Dec10 gazette notice.doc** (45 KB HT

Attached is a request for gazettal of a notice approving a flood mitigation manual for North Pine Dam and two attachments that go with the notice.

As per the request for publication can you arrange publication please. As indicated on the scanned copy of the Decision Notice the Director, Dam Safety (Water Supply) is a delegated officer for such decisions about Flood Mitigation Manuals.

Though the draft notice has been prepared as if gazettal will occur this year it is not critical that this occur.

<<gazettal request dec 6.pdf>> <<approval decision notice dec 6.pdf>> <<draft NPD Dec10 gazette notice.doc>>

Ron Guppy
Principal Engineer (Dam Safety)
Office of the Water Supply Regulator [redacted]
Telephone [redacted] **Facsimile** [redacted]
Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

Department of Environment and Resource Management

Request for Publication in the Gazette

Your ref:		Our ref:	DAM/130/000(344)
Author:	Ron Guppy	Phone:	(07) 3224 7215
		Fax:	(07) 3224 7999

Date: 6 December 2010

From: Peter Allen, Director, Dam Safety, Office of Water Supply Regulator

To: Executive Council Team, Cabinet and Parliamentary Services

Subject: Publishing of a notice in the gazette – Approval of Flood Mitigation Manual

BACKGROUND

Seqwater has sought approval of a Flood Mitigation Manual for North Pine Dam. Section 371(2) of the *Water Supply (Safety and Reliability) Act 2008* provides that approval of a Flood Mitigation Manual is by notice in the Government Gazette. The decision to give approval to the Flood Mitigation Manual was made on 6th December 2010 as per attachment.

I certify that the attached:

a) draft gazette notice in relation to the approval of the Flood Mitigation Manual for North Pine Dam, and

b) copy of Decision Notice approving the Flood Mitigation Manual for 5 years

in relation to the approval of the Flood Mitigation Manual, are correct.

The Costing Code to be charged for publishing the Gazette Notice is WGBANEEA06

Please forward for publishing in the Queensland Government Gazette.

[redacted]

Peter Allen

Director, Dam Safety

Office of Water Supply Regulator

Att (2)

ECT USE ONLY			
ANTICIPATED DATE OF GAZETTAL	/ /		
ECT Reference No.			
ECT documentation Prepared	/ /	Proof Checked	/ /

This request has been authorised by publication in the Government Gazette of / /

ECT Enquires - **Phone** [redacted] Email to: [redacted]

FLOOD MITIGATION MANUAL
ASSESSMENT AND DECISION FORM

General Information

Name of dam	North Pine Dam
Reference number (from Referable Dam Register)	# 334
Dam owner contact details	John Tibaldi
Date dam owner requested approval of flood mitigation manual	13th August 2010
Manual for which approval is requested	Manual of Operational Procedures for Flood Mitigation at North Pine Dam, Revision 5, August 2010
DERM file details	CBD/024083
Name / position of action officer	Ron Guppy
Name / position of decision maker	Peter Allen, Director Dam Safety (Water Supply)
Due date for completion of review	

FLOOD MITIGATION MANUAL CHECKLIST

	Issue	Y or N or a rating from 0-5 where 0 = lowest and 5 = highest, as appropriate	Comments
Direction of operations			
1.	Does the manual include the following		
	• Operational arrangements to unambiguously define flood release operations for the dam during flood events	5	Yes – Details in Manual
	• Designation and responsibilities of those responsible for Flood Operations including qualifications and experience.	5	Yes – Details in Manual
2.	Does the manual cover training for relevant personnel	5	Yes
3.	Does the manual detail the follow reporting requirements		
	• Training	5	Yes
	• Flood preparedness	5	Yes
	• Flood event reporting	5	Yes
Flood Mitigation Objectives			
4.	Does the manual cover the following objectives and assign priorities to each objective:-		
	• Structural safety of dam/s	5	Yes – Details in Manual
	• Protection of urbanised areas from inundation	5	Yes – Details in Manual
	• Minimise disruption to downstream rural communities (if applicable)	5	Yes – Details in Manual – North Pine has very limited flood mitigation capability There is sufficient 'discretion' during the closing phase to minimise disruption to Young's Crossing.
	• Minimise impact on flora and fauna	5	Yes – Details in Manual – Primarily of concern during the final closing of the gates at the end of a release.
Flood monitoring and forecasting			
5.	Does the manual detail the provision of real time flood data to BOM for the issuing of flood warnings and any necessary flood modelling?	5	Yes – Details in Manual

	Issue	Y or N or a rating from 0-5 where 0 = lowest and 5 = highest, as appropriate	Comments
6.	Have details of the operation of the overall operating system been included	5	Yes – Details in Manual
7.	Does the manual detail an appropriate flood monitoring and forecasting system?	5 .	Yes – Details in Manual
Communications			
8.	Does the manual cover communications with the following:		
	• Stakeholder agencies (e.g. Bureau of Meteorology, DERM, relevant councils affected by the dam)	5	Yes – Details in Manual
	• Operational staff employed by the dam owner	5	Yes – Details in Manual
	• Public	5	Yes but covered more completely in Flood Protocol
Review			
9.	Does the manual allow for variation to the document when technical and physical conditions relating to the dam change.	5	Yes – The mechanism for change would normally be triggered by a Flood Event Report produced after each flood event involving flood releases.
10.	If no other changes are required (as per No. 9 above) does the manual include details of the mandatory review that is required within the time frame set by the chief executive? **Note: the manual should include details such as** • **how detailed the review should be** • **things to be considered during the review.** **A review may or may not result in a change to the manual.**	5	Yes these details are covered
Operation during flood events			
11.	Does the manual include details of:		
12.	• infrastructure for flood releases (this may include diagrammatic representations)	5	Yes – Schematics provided to identify gate numbering.

	Issue	Y or N or a rating from 0-5 where 0 = lowest and 5 = highest, as appropriate	Comments
	• details of structures to be considered during flood operations	5	Yes
	• Discharge rating information for gates, spillways and auxiliary spillways	5	Yes
	• Initial flood control action	5	Yes
	• Flood operation strategies	5	Yes – Primarily requires a nominated gate opening for given headwater levels
	• Gate closing strategies	5	Yes
	• Gate operation sequences	5	Yes
Emergency flood operations			
13.	Does the manual include information on emergency flood operations	5	Yes – Loss of communications procedures
14.	Are flood operations consistent with the Emergency Action Plan (EAP)?	5	Yes
Amendments since previous manual			
15.	Does the manual provide a summary of changes and why they are necessary?		No but there was an attached summary detailing the changes.
Consultation			
16.	Are any stakeholders adversely affected by the changes? If so, has the dam owner consulted with relevant stakeholders?	No	The changes primarily relate to the shut down phase at the end of the event. Road users of Young's Crossing are expected to be largely unaffected by the changes.
17.	Have concerns/issues raised by stakeholders been raised by stakeholders? If so, have the concerns been addressed in the manual?		Not applicable

Comment on the results of the detailed assessment of the manual. In particular comment on the overall extent and significance of any non-compliance with the issues in the checklist or any failures to address the above issues adequately or in sufficient detail

There are no outstanding issues. The manual is compliant with DERM requirements

Recommendation and decision

Action officer's recommendation to decision maker (tick appropriate box/es and delete those not needed)

☐ Approve the Flood Mitigation Manual

Reasons for recommendation to approve the manual

<< Comment on the consequences of approving the flood mitigation manual>>

☐ Reject the Flood Mitigation Manual

Reasons for recommendation to reject the manual

<<insert reasons for recommendation to reject manual>>

☐ Require additional information about the flood mitigation manual

Details of additional information required

<<insert details of additional information>>

Suggest a reasonable time frame for the information to be provided to the chief executive

<<insert timeframe>>

Evidence for the findings

Note: Documents, information, Acts, standards and guidelines that were considered in the course of carrying out this assessment and making this recommendation. List all contacts with the dam owner, information given to the dam owner and information received or used in making the recommendation.

- *Water Supply (Safety and Reliability) Act 2008*;
- Work practice DS 5.1 Assessing a flood mitigation manual for a dam (WIR/2009/3991 in the policy register);
- Work practice OWSR 2.2 Guidelines for Decision Making (WIR/2005/2053 in Policy Register)
- DERM file CBD/024083
- The decision maker's own experience in flood operations at North Pine Dam

Findings on material facts

Note: That is, the results of the flood mitigation manual checklist.

- The owner of the dam prepared a flood mitigation manual for North Pine Dam and submitted it to the department for approval on 13 August 2010.
- The manual incorporates all necessary components to be effective.

Reasons for the recommendation

Note: These are the real reasons for the conclusion, in this part you assess the evidence and say how it was applied; you give a logical explanation for the recommendation.

- The manual incorporates all necessary components to be an effective Flood Mitigation Manual.

Certification and signature of action officer

I have complied with the procedure for flood mitigation manuals for a dam when making this recommendation. I have taken the material described above, the requirements of the *Water Supply (Safety and Reliability) Act 2008*, relevant guidelines, the matters outlined in the procedure for processing a flood mitigation manual and departmental training I have received, into account when making this recommendation.

Signature of action officer ______________________

Date recommendation made <<Insert Date>>

Decision maker's decision (tick appropriate box/es and delete those not needed)

Authority to make decision

Water Supply (Chief Executive) Delegation No. 1 2010

☑ Approve the flood mitigation manual

Duration for which approval is given: 5 years

Certification and signature of decision maker

I have complied with the procedure for flood mitigation manual for a dam when making this decision. I have taken the action officer's recommendation and the documents and information described above into account when making this decision.

Signature of decision maker [redacted]

Date of decision 6th December 2010

Water Supply (Safety and Reliability)Act 2008

APPROVAL OF FLOOD MITIGATION MANUAL NOTICE (No 02) 2010

Short title

1. This notice may be cited as the *Approval of Flood Mitigation Manual Notice (No 02) 2010.*

Approval of flood mitigation manual [s.371 of the Act]

2. Notice is hereby given that the Chief Executive on 6 December 2010 approved the Manual of Operational Procedures for Flood Mitigation at North Pine Dam, Revision 5, August 2010 as a flood mitigation manual.

3. This approval is for a period of 5 years.

ENDNOTES

1. Published in the Gazette on ???????? 2010
2. Not required to be laid before the Legislative Assembly.
3. The administering agency is the Department of Environment and Resource Management.

Gov. Gaz., 22 January 2010, No. 15 page 127

Government Printer, Brisbane

From Guppy Ron **Date** Friday, 17 December 2010 11:23:59 AM
To 'John Tibaldi'
Cc Allen Peter
Subject North Pine Dam Flood Mitigation Manual

FMM Gazettal_16_12_10.pdf (94 KB HTML)

John

The approval notice (copy attached) for the latest revision of the North Pine Dam Manual appears in today's gazette. I'll get a formal letter to Seqwater away within the next week.

<<FMM Gazettal_16_12_10.pdf>>

Ron Guppy
Principal Engineer (Dam Safety)
Office of the Water Supply Regulator
Telephone [redacted] **Facsimile** [redacted]
Mobile [redacted] **Email:** [redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
Level 3, 41 George Street, Brisbane QLD 4000
GPO Box 2454, Brisbane Q 4001

Queensland Government

Department of
Environment and Resource Management

File / Ref number: DAM/130/000(0334)

21 December 2010

Peter Borrows
Chief Executive Officer
Queensland Bulk Water Supply Authority
PO Box 16146
CITY EAST, QLD, 4002

Dear Sir

Flood Mitigation Manual, North Pine Dam

Your letter of 13 August 2010 requesting approval of the updated flood mitigation manual submitted for North Pine Dam refers.

By publication of a notice in the Gazette the 'Manual of Operational Procedures for Flood Mitigation at North Pine Dam, Revision 5, August 2010' has been approved as a Flood Mitigation Manual. The approval is for five years from 6 December 2010.

I enclose a copy of the gazette notice for your records.

Controlled copies of the updated manual will need to be distributed to the agencies listed in Appendix B of the manual.

Should you have any further enquiries, please do not hesitate to contact Mr Ron Guppy, Principal Engineer, Dam Safety of the department on telephone [redacted]

Yours sincerely

[redacted]

Peter Allen
Director, Dam Safety (Water Supply)

Postal Address
GPO Box 2454
Brisbane Qld 4001

Telephone + 61 7 3224 7215
Facsimile + 61 7 3224 7999

Website
www.derm.qld.gov.au

ABN 83 705 537 586

Water Supply (Safety and Reliability) Act 2008

APPROVAL OF FLOOD MITIGATION MANUAL NOTICE (No 02) 2010

Short title

1. This notice may be cited as the *Approval of Flood Mitigation Manual Notice (No 02) 2010*.

Approval of flood mitigation manual [s.371 of the Act]

2. Notice is hereby given that the Chief Executive on 6 December 2010 approved the Manual of Operational Procedures for Flood Mitigation at North Pine Dam, Revision 5, August 2010 as a flood mitigation manual.

3. This approval is for a period of 5 years.

ENDNOTES

1. Published in the Gazette on 17 December 2010.
2. Not required to be laid before the Legislative Assembly.
3. The administering agency is the Oepartment of Environment and Resource Management.

Gov. Gaz., 17 December 2010, No. 114 page 1102

Government Printer, Brisbane

File / Ref number: DAM/130/000(0377), DAM/130/000(0354)

28 January 2000

Peter Borrows
Chief Executive Officer
Queensland Bulk Water Supply Authority
PO Box 16146
CITY EAST, QLD, 4002

Dear Sir

Flood Mitigation Manual, Wivenhoe and Somerset Dams

Your letter of 3 December 2009 requesting appr oval of the updated floo d mitigation manual submitted for Wivenhoe and Somerset Dams refers.

By publication of a notice in the Gazette the 'Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam, Revision 7' has been approved as a Flood Mitigation Manual. The approval is for five years from 22 December 2009.

I enclose a copy of the gazette notice for your records.

Controlled copies of the updated manual will need to be di stributed to the agencie s listed in Appendix B of the manual

Should you have an y f urther enquiries, please do not hesitate to contact Mr Ron Guppy, Principal Engineer, Dam Safety of the department on telephone [redacted]

Yours sincerely

John McKenna
A/Director, Dam Safety (Water Supply)

Postal Address
GPO Box 2454
Brisbane Qld 4001

Telephone + [redacted]
Facsimile +

Website
www.derm.qld.gov.au

ABN 83 705 537 586

South East Queensland
WATER CORPORATION
LIMITED

MANUAL

OF

OPERATIONAL PROCEDURES

FOR FLOOD MITIGATION

FOR

WIVENHOE DAM

AND SOMERSET DAM

Revision No.	Date of Approval	Amendment Details
0	27 October 1968	Original Issue
1	6 October 1992	Complete revision and re-issue
2	13 November 1997	Complete revision and re-issue
3	24 August 1998	Change to page 23
4	6 September 2002	Complete revision and re-issue

TABLE OF CONTENTS

APPENDICES

1 INTRODUCTION

1.1 Preface

Given their size and location, it is imperative that Wivenhoe and Somerset Dams be operated during flood events in accordance with clearly defined procedures to minimise hazard to life and property.

Recognising this, the South East Queensland Water Board Act required that the South East Queensland Water Corporation's Technical Advisory Committee cause to be prepared a manual of operational procedures for the dam during floods. With changes to the controlling legislation, the manual became an approved flood mitigation manual under *Water Act 2000* (extract in Appendix A).

This Manual is the result of a review of the 1998 revision of the Manual. The Corporation is required to review, update the Manual if necessary, and submit it to the Chief Executive for approval prior to its expiry. Any amendments to the basic operating procedures need to be treated similarly.

Deleted: ¶
Recognising this, the *Water Act 2000* (Extract in Appendix A) required that the South East Queensland Water Corporation's Technical Advisory Committee cause to be prepared a combined manual of operational procedures for Wivenhoe and Somerset Dams for the purpose of flood mitigation.¶
¶

Deleted: The Corporation is required to submit the Manual to the Minister charged with administration of the Act for approval.

An expanded flood monitoring and warning radio telemetry network (ALERT) has been installed in the Brisbane River Catchment. Additionally, a computerised flood operational model that allows for rainfall and river modelling in real time based on data from the ALERT system has been developed, implemented and fully commissioned. The accuracy and reliability of the system during a flood event has been proven.

The primary objectives have not varied from those defined in the previous manual of ensuring safety of the dams, their ability to deal with extreme and closely spaced floods, and protection of urban areas. The basic operational procedures have also remained the same. Wivenhoe Dam and Somerset Dam are operated in conjunction so as to maximise the flood mitigation capabilities of the two dams. The procedures outlined in this Manual are based on the operation of the dams in tandem.

Changes from the previous revision (1998) have mostly arisen from the refinement of gate opening and closing sequences based upon experience obtained during flood events whilst using the real time flood operations model. Other changes have been necessary to fit in with the new regulatory regime provided by the commencement of *Water Act 2000.*

1.2 Meaning of Terms

In this Manual, save where a contrary definition appears -

"Act"
means the *Water Act 2000*;

"Agency"
includes a person, a local government and a department of state government within the meaning of the Acts Interpretation Act 1954;

"AHD"
means Australian Height Datum;

"Bureau of Meteorology"
means the Commonwealth Bureau of Meteorology;

"Chairperson"
means the Chairperson of the South East Queensland Water Corporation;

"Chief Executive"
means the Chief Executive or Director General of the Department of Natural Resources and Mines;

"Controlled Document"
means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

"Dams"
means dams to which this Manual applies, that is Wivenhoe Dam and Somerset Dam;

"Dam Supervisor"
means the senior on-site officer at Wivenhoe or Somerset Dam as the case may be;

"EL"
means elevation in metres from Australian Height Datum;

"Flood Operations Engineer"
means the person designated at the time to direct the operations of Wivenhoe Dam and Somerset Dam under the general direction of the Senior Flood Operations Engineer and in accordance with the procedures in this Manual;

"FSL"[1] or "FULL SUPPLY LEVEL"
means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

"Gauge"
when referred to in (m) means river level referenced to AHD, and
when referred to in (m^3/sec) means flow rate in cubic metres per second;

Deleted: "AFC"[1] or¶
"Acceptable Flood Capacity (AFC)¶
means for a specific dam the overall flood capacity, including freeboard as relevant, which provides an appropriate level of safety against a flood initiated dam failure to protect the community and environment to acceptable risk levels, within the total context of overall dam safety from all causes.¶
¶

Deleted: ¶
"South East Queensland Water Corporation"¶
means the body corporate constituted by that name pursuant to Part III of the South East Queensland Water Board Act 1979. The Board became a government owned corporation in 2000;¶

Deleted: "DCF"[1] or¶
"Dam Crest Flood"¶
means the flood event which, when routed through the reservoir, results in a still water level in the reservoir, excluding wave effects which for an embankment is the lowset point of the embankment crest.¶
¶

Deleted: Page Break
A

Deleted: ≅

Deleted:
"EDF"[1] or "Evaluation Design Flood"¶
means the flood used for the design of a Dam at the time of design as defined by the 1986 ANCOLD Guidelines on Design Floods for Dams;¶
¶

"Headworks Operator"

for the purposes of this manual the Headworks Operator is the South-East Queensland Water Corporation:

"Manual" or "Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam"

means the current version of this Manual;

"Power Station"

means the Wivenhoe pumped storage hydro-electric power station associated with Wivenhoe Dam and Split-Yard Creek Dam;

"Senior Flood Operations Engineer"

means the senior person designated at the time pursuant to Section 2.1 of this Manual under whose general direction the procedures in this Manual must be carried out;

"South East Queensland Water Corporation"

means the body corporate constituted by that name pursuant to Part III of the South East Queensland Water Board Act 1979. The Board became a government owned corporation in 2000;

"Technical Advisory Committee"

means the Technical Advisory Committee established pursuant to Section 21 of the South East Queensland Water Board Act 1979, as constituted at the material time.

Deleted: means the agency with which the Corporation has entered into a contract or arrangement with respect to the operation and maintenance of the dams, for the purpose of flood mitigation;

Deleted: "IFF"[1] or "Imminent Failure Flood"¶
means the flood which if exceeded would cause failure of a dam as defined in the 1986 ANCOLD Guidelines on Design Floods for Dams;¶
¶
"Manager Dam Safety " or¶
"Director Dam Safety"¶
means the suitably qualified and experienced person fulfilling the function of an advisory committee on referable dams pursuant to Part 6 of the *Water Act 2000*;¶
¶

Deleted: "Minister"¶
means the Minister of the Crown who at the material time is charged with the administration of the Act;¶
¶

Deleted:

Deleted:

Deleted: -

Deleted: ¶
"RDF"[1] or¶
"Recommended Design Flood"¶
means the flood which a dam should be designed for in accordance with accepted practices as defined in the 1986 ANCOLD Guidelines on Design floods for Dams;¶

Deleted: shall

1.3 Purpose of Manual

The purpose of this Manual is to define procedures for the operation of Wivenhoe Dam and Somerset Dam to reduce, so far as practicable, the effects of flooding, by the proper control and regulation in time of headworks under the control of the Corporation, with due regard to the safety of the structures comprising those headworks.

For the purpose of this Manual, the Corporation adopts the policy that the community is to be protected to the maximum extent possible against flood hazards recognising the limitations on being able to:

- identify all potential flood hazards and their likelihood,
- remove or reduce community vulnerability to flood hazards,
- effectively respond to flooding, and
- provide resources in a cost effective manner.

1.4 Legal Authority

This manual has been prepared as a Flood Mitigation Manual in accordance with the provisions of Part 6 Division 2 of the Act.

1.5 Application and Effect

The procedures in this Manual apply to the operation of Wivenhoe Dam and Somerset Dam for the purpose of flood mitigation, and operation in accordance with the manual shall give the protection from liability provided by Section 500 of *Water Act 2000*.

1.6 Date of Effect

The procedures in this Manual shall have effect on and from the date on which the Manual is approved by gazette notice.

1.7 Observance of Manual

This Manual contains the operational procedures for Wivenhoe Dam and Somerset Dam for the purposes of flood mitigation, and must be applied by the Headworks Operator for the operation of the dams.

1.8 Provision for Variations to Manual

If the Corporation is of the opinion that the procedures in this Manual should be amended, altered or varied, it must submit for approval as soon as practical a request, which is in accordance with the flood mitigation provisions of the *Water Act 2000*, to the Chief Executive setting out the circumstances and the exact nature of the amendment, alteration or variation sought. The Chief Executive may require the Corporation amend the Manual by written notice.

1.9 Distribution of Manual

Deleted: shall

Deleted: , and operation in accordance with the manual shall be deemed to meet the relevant dam safety requirements of the *Water Act 2000* for the purpose of flood mitigation.

Deleted: approved by

Deleted: the Minister

Deleted: shall

Deleted: ¶
If any one of the Chief Executive, the Headworks Operator, or the South East Queensland Water Corporation (including its Technical Advisory Committee) is of the opinion that this Manual requires amendment, it shall make a submission to the South East Queensland Water Corporation setting forth those circumstances and the exact nature of the amendment, alteration or variation sought.¶
¶
If the Corporation is of the opinion that the procedures in this Manual should be amended, altered or varied, it shall submit for approval as soon as practical a recommendation, which is in accordance with the dam safety provisions of the *Water Act 2000*, to the Minister setting out the circumstances and the exact nature of the amendment, alteration or variation sought.¶

The Corporation must regard the manual as a Controlled Document and ensure that only controlled manuals are used in the direction of flood mitigation activities. Agencies having copies of Controlled Documents are listed in Appendix B. The Corporation must maintain a Register of Contact Persons for Controlled Documents and ensure that each issued document is updated whenever amendments or changes are approved.

Deleted: shall

Deleted: shall

Before using this Manual for the direction of flood control, the Headworks Operator must ensure that it is the current version of the Controlled Document.

1.10 Authority to Use Discretion

Where it is reasonable to expect that the safety of either dam will not be reduced, temporary deviations from the procedures detailed in this manual may be made in accordance with Section 2.8.

2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

Pursuant to the provisions of the Act, the Corporation is responsible for and has the duty for operation and maintenance of Wivenhoe Dam and Somerset Dam, and while it may enter into contracts for the purpose of discharging these responsibilities, for the purposes of this manual the Headworks Operator is the Corporation.

2.1.1 Designation of Senior Flood Operations Engineer

The Headworks Operator must ensure that the procedures set out in this Manual are carried out under the general direction of a suitably qualified and experienced person who shall be referred to hereafter as the Senior Flood Operations Engineer. Only a person authorised in the Schedule of Authorities can give the general direction for carrying out procedures set out in this Manual.

2.1.2 Designation of Flood Operations Engineer

The Headworks Operator must have available or on standby at all times a suitably qualified and experienced Flood Operations Engineer to direct the operation of the dams during floods in accordance with the general strategy determined by the Senior Flood Operations Engineer.

The Headworks Operator must ensure that flood control of the dams is under the direction of a Flood Operations Engineer at all times. Only a person authorised in the Schedule of Authorities can direct the flood operation of the dams.

The Headworks Operator must also employ an adequate number of suitably qualified and experienced persons to assist the Flood Operations Engineer in the operation of the dams during floods.

2.2 Qualifications and Experience of Engineers

2.2.1 Qualifications

All engineers referred to in Section 2.1 must meet all applicable requirements of registration or certification under any relevant State Act, and must hold appropriate engineering qualifications to the satisfaction of the Chief Executive.

2.2.2 Experience

All engineers referred to in Section 2.1 must, to the satisfaction of the Chief Executive, have:

Deleted: and may enter into contracts for the purpose of discharging these responsibilities.

Deleted: ¶
All instruments of delegation and contract made in accordance with the Act shall be recorded in the Schedule of Authorities attached to the Manual as Appendix C. Changes to instruments of delegation and contract shall be made in accordance with the Act and incorporated in the Schedule as amendments to the Schedule.¶

Deleted: shall

Deleted: , as may be required under the provisions of the *Water Act 2000*,

Deleted: shall

Deleted: shall

Deleted: shall

Deleted: shall

Deleted: shall

Deleted: shall

(1) Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and

(2) At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:

  (a) Investigation, design or construction of major dams;

  (b) Operation and maintenance of major dams;

  (c) Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;

  (d) Applied hydrology with particular reference to flood forecasting and flood warning systems.

2.3 Schedule of Authorities

For the purpose of directing operation of the dams during floods, a list of suitably qualified and experienced Senior Flood Operations Engineers and Flood Operations Engineers must be maintained in the Schedule of Authorities (Appendix C).

Deleted: shall

The Headworks Operator shall, as the need arises, nominate suitably qualified and experienced engineers for registration in the Schedule of Authorities as Senior Flood Operations Engineers and Flood Operations Engineers. Each new nomination must include a copy of any certificate required under Section 2.2 and a validated statement of qualifications and experience.

Deleted: shall

The Headworks Operator must obtain the approval for all nominations from the Chief Executive prior to their inclusion in the Schedule of Authorities.

Deleted: ¶
The Headworks Operator shall forward all nominations to the Chief Executive who shall review nominations and make recommendations to the Minister for approval for inclusion in the Schedule of Authorities.¶

If, in the event of unforseen and emergency situations, no Senior Flood Operations Engineer or no Flood Operations Engineer is available from the Schedule of Authorities, the Headworks Operator must temporarily appoint a suitable person or persons and immediately seek ratification from the Chief Executive.

Deleted: shall

2.4 Training

The Headworks Operator must ensure that operational personnel required for flood control operations receive adequate training in the various activities involved in flood control operation.

Deleted: shall

2.5 Dam Operation Arrangements

For the purposes of operation of the dams during times of flood, the Headworks Operator must ensure that:

Deleted: shall

(a) the operation be carried out under the general direction of the Senior Flood Operations Engineer, and

(b) in the direction of operations which may knowingly endanger life or property, the Senior Flood Operations Engineer must where practical liaise with the Chairperson of the Corporation and the Chief Executive or nominated delegate.

Deleted: shall

2.6 Responsibilities of the Senior Flood Operations Engineer

The Senior Flood Operations Engineer is responsible for the overall direction of flood operations.

Except insofar as reasonable discretion is provided for in Section 2.8 of this Manual, the Senior Flood Operations Engineer must ensure that the operational procedures for the dam shall be in accordance with this Manual.

Deleted: shall

2.7 Responsibilities of the Flood Operations Engineer

The Flood Operations Engineer must apply the operational procedures in accordance with this manual and the direction set for flood operations. In so doing, account must be taken of prevailing weather conditions, the probability of follow up storms and the ability of the dam to discharge excess flood waters in the period between rainfall events or in the period from the time of detection of conditions associated with the development storm cells to the likely time of occurrence of the rainfall.

Deleted: shall

Deleted: shall

2.8 Reasonable Discretion

If in the opinion of the Senior Flood Operations Engineer, based on available information and professional experience, it is necessary to depart from the procedures set out in this manual, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary to meet the situation, provided that the Senior Flood Operations Engineer observes the flood mitigation objectives set out in Section 3 of this Manual when exercising such reasonable discretion.

Deleted: shall

Before exercising discretion under this Section of the Manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must consult with such of the following persons as are available at the time that the discretion has to be exercised:

Deleted: objectives

Deleted: shall

the Chairperson of the Corporation, and

the Chief Executive or nominated delegate.

If not able to contact any of the above within a reasonable time, the Senior Flood Operations Engineer may proceed with such other procedures considered as necessary to meet the situation and report such action at the earliest opportunity to the above persons.

Deleted: shall

2.9 Report

The Senior Flood Operations Engineer must prepare a report to the Headworks Operator after each event that requires flood operation of the dams and the report must contain details of the procedures used, the reasons therefore and other pertinent information. The Headworks Operator must forward the report to the Chief Executive together with any comments within six weeks of the completion of the event referred to.

Deleted: shall

Deleted: shall

Deleted: shall

Deleted: Corporation

3 FLOOD MITIGATION OBJECTIVES

3.1 General

To meet the purpose of the flood operational procedures in this Manual, the following objectives, listed in descending order of importance, are as follows:

(a) Ensure the structural safety of the dams;

(b) Provide optimum protection of urbanised areas from inundation;

(c) Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers and their major tributaries;

(d) Minimise disruption and impact upon Wivenhoe Power Station;

(e) Minimise disruption to navigation in the Brisbane River.

3.2 Structural Safety of Dams

The structural safety of the dams must be the first consideration in the operation of the dams for the purpose of flood mitigation.

3.2.1 Wivenhoe

The structural safety of Wivenhoe Dam is of paramount importance. Structural failure of Wivenhoe Dam would have catastrophic consequences.

Wivenhoe Dam is predominantly a central core rockfill dam. Such dams are not resistant to overtopping and are susceptible to breaching should such an event occur. Overtopping is considered the major threat to the security of Wivenhoe Dam.

3.2.2 Somerset Dam

The structural safety of Somerset Dam also is of paramount importance. Failure of Somerset Dam could have catastrophic consequences.

Whilst Wivenhoe Dam has the capacity to mitigate the flood effects of such a failure in the absence of any other flooding, if the failure were to occur during major flooding, Wivenhoe Dam could be overtopped and destroyed also.

Somerset Dam is a mass concrete dam. Such dams can withstand limited overtopping without damage. Failure of such structures is rare but when they do occur, they occur suddenly without warning, creating very severe and destructive flood waves.

3.3 Extreme Floods and Closely Spaced Large Floods

Techniques for estimating extreme floods indicate that floods are possible which would overtop both dams. In the case of Wivenhoe Dam such an overtopping would most likely result in the destruction of the dam itself. Such events however require several days of intense rainfall to produce the necessary runoff. Pre release or accelerated release of storage at damaging flood levels could reduce, but not eliminate the risk of overtopping. Such a measure should be taken only after careful consideration of the reliability of precipitation forecasts and of perceived antecedent conditions.

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.

In order to be prepared to meet such a situation, the stored flood-waters from one storm should be discharged from the dams after a flood as quickly as would be consistent with the other major operating principles. Typically the Flood Operations Engineer should aim to empty stored flood-waters within seven days after the flood peak has passed through the lower reaches of the Brisbane River. In a very large flood, this time frame may not be achievable because of downstream flood conditions and it may be necessary to extend the emptying period by several days.

The discharges should be regulated so as to have little impact on the urban reaches of the Brisbane River taking into account inflows into the river downstream of the dams. However they may result in submergence of some low level bridges. The level of flooding as a result of emptying stored flood-waters after the peak has passed is to be less than the flood peak unless accelerated release is necessary to reduce the risk of overtopping.

3.4 Inundation of Urban Areas

The prime purpose of incorporating flood mitigation measures into Wivenhoe Dam and Somerset Dam is to reduce flooding in the urban areas on the flood plains below Wivenhoe Dam. The peak flows of floods emanating from the upper catchments of Brisbane and Stanley Rivers can be reduced by using the flood-gates to control releases from the dams, taking into account flooding derived from the lower Brisbane River catchments.

3.5 Disruption to Rural Areas

While the dams are being used for flood mitigation purposes, some low level bridges and areas upstream of the dams may be temporarily inundated. Downstream of the dam, bridges and lower river terraces will be submerged. The operation of the dams should not prolong this inundation unnecessarily.

3.6 Provision of Pumping Pool for Power Station

The power station is not affected by the reservoir level in Wivenhoe Dam during floods other than the impacts high tail water levels have on the efficiency of the power station. The power station does however require a pumping pool for operation. The loss of storage by dam failure would render the power station inoperative.

3.7 Disruption to Navigation

The disruption to navigation in the Brisbane River has been given the lower priority. The effect of flood flows upon navigation in the river varies widely.

Large ships can be manoeuvred in the river at considerable flood flows. On the other hand, barges and dredges are affected by low flows which lower salinity thus decreasing the density of the water which in turn causes craft to sit lower in the water, sometimes bottoming. The Moggill Ferry is also affected by low flood flows.

A short emptying period for the flood storage compartment of the dams is consistent with Objectives (c) and (e) of Section 3.1, which are closely related.

4 FLOOD CLASSIFICATION

For the reference purposes of this Manual, five magnitudes of flooding are classified as follows:

Fresh
This causes only very low-level bridges to be submerged.

Minor Flooding
This causes inconvenience such as closing minor roads and the submergence of low-level bridges. Some urban properties are affected.

Moderate Flooding
This causes inundation of low-lying areas and may require the evacuation of some houses and/or business premises. Traffic bridges may be closed.

Major Flooding
This causes flooding of appreciable urban Ares. Properties may become isolated. Major disruption occurs to traffic. Evacuation of many houses and business premises may be required.

Extreme Flooding
This causes flooding well in excess of floods in living memory and general evacuation of whole areas are likely to be required.

Usually a flood does not cause the same category of flooding along its entire length and the relevant agencies shall have regard to this when flooding is predicted.

(The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia)

5 FLOOD MONITORING AND WARNING SYSTEM

5.1 General

A real time flood monitoring and warning system is established in the Brisbane Valley. This system is based upon an event reporting protocol. A radio telemetry system (ALERT) is used to collect, transmit and receive rainfall and streamflow information. The system consists of more than 50 field stations that automatically record rainfall and/or river heights at selected locations in the Stanley and Brisbane River catchments. Some of the field stations are owned by the Corporation with the remainder belonging to other agencies.

The rainfall and river height data is transmitted by radio telemetry, via repeater stations, to base stations at the head office of the Headworks Operator (and the Corporation). There the data is processed in real time by computer programs to assess what is occurring in the catchments in terms of flood flows and what could occur if weather conditions continued, or changed.

Other agencies with their own base stations can, and do, receive data transmissions direct, and so collect and are able to process rainfall and streamflow information appropriate to their needs.

The real time flood model (RTFM) is a suite of hydrologic and hydraulic computer programs that utilise the real time ALERT data to assist in the operation of the dams during flood events.

5.2 Operation

The Headworks Operator is responsible for operating the computer model provided by the Corporation for flood monitoring and forecasting during flood events to optimise flood gate operations and minimise the impacts of flooding.

It is the responsibility of the Corporation to maintain and keep calibrated its own equipment; and to enter into such arrangements with other agencies or to provide such further equipment as the Corporation deems necessary for the Headworks Operator to properly operate the computer model for flood monitoring and forecasting.

A system such as this is expected to improve over time due to:

- improved operation and reliability with experience,
- improved calibration as further data becomes available,
- software upgrades, and
- the number, type and locations of sensors being varied.

A regular process of internal audit and management review must be maintained to achieve this.

Deleted: shall

A log of the performance of all field equipment necessary to properly operate the computer model must be kept by the Corporation. The log is to also include all revised field

Deleted: shall

calibrations and changes to the number, type and locations of gauges. Entries onto the log are to be notified to the Headworks Operator without delay in writing.

A log of the performance of the system (ALERT and RTFM) must be kept by the Senior Flood Operations Engineer. Any faults to the computer hardware or software, and any faults to field equipment which the Corporation has not advised the Headworks Operator of, are to be notified to the Corporation without delay in writing. The Corporation must promptly attend to the matters under its control and refer other matters to the appropriate agencies.

Deleted: shall

Deleted: shall

Whenever the Senior Flood Operations Engineer considers that the performance and functionality of the system can be improved, by whatever means, a recommendation must be made to the Headworks Operator accordingly. The Headworks Operator must promptly consider, act on, or refer such recommendations to the Corporation as it considers appropriate.

Deleted: shall

Deleted: shall

5.3 Storage of Documentation

The performance of any flood monitoring and warning system is reliant on accurate historical data over a long period of time. The Senior Flood Operations Engineer must ensure that all available data and other documentation is appropriately collected and catalogued as approved by the Corporation, for future use.

Deleted: shall

5.4 Key Reference Gauges

Key field station locations have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to relocate field stations from these locations, or vary flood classification levels, agreement must first be obtained between the Corporation, Headworks Operator, Bureau of Meteorology and the Local Governments within whose boundaries the locations are situated. The locations and gauge readings at which the various classifications of flooding occur are contained in Appendix D.

Deleted: shall

Gauge boards that can be read manually must be maintained as part of the equipment of each key field station. The Corporation must have procedures to ensure such gauge boards are read in the event of failure of field stations to operate.

Deleted: shall

Deleted: shall

5.5 Reference Gauge Values

Other agencies such as the Bureau of Meteorology, Ipswich City Council and the Brisbane City Council have direct access to the information from field stations for flood assessment purposes. The consultation between agencies is a very important part of the assessment and prediction of flood flows and heights.

The Corporation must ensure that information relative to the calibration of the Corporation's field stations is shared with such agencies.

Deleted: shall

6 COMMUNICATIONS

6.1 Communications between Staff

The Corporation is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams.

The Headworks Operator is responsible for ensuring that adequate communication exists at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams. Where equipment deficiencies are detected during normal operations, such deficiencies are to be reported within one week to the Corporation for timely corrective action.

6.2 Dissemination of Information

Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public. These agencies shall include agencies holding Controlled Documents (Appendix B), and the persons listed in the Schedule of Authorities (Appendix C). For this purpose, the Corporation must maintain a Register of Contact Persons for Information, their means of contact and the type of information to be supplied to each. The Corporation must ensure that each agency receives a copy of the updated Register of Contact Persons for Information whenever amendments are made, but at least every 6 months.

The Flood Operations Engineer must supply information (refer 6.3) to each of these contact persons during dam releases.

All enquiries other than provided for in the Register of Contact Persons for Information, either to the Headworks Operator, the Senior Flood Operations Engineer, the Flood Operations Engineer or dam site staff must be referred to the Corporation. The Corporation must provide a mechanism to receive these enquiries from the time it is advised that releases from the dams are likely until flood release operations are completed.

Some agencies have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public. The Corporation, Headworks Operator, Senior Flood Operations Engineer and Flood Operations Engineer must liaise and consult with those agencies with a view to ensuring all information relative to the flood event is consistent, and used and disseminated in accordance with agreed responsibilities.

6.3 Nature of Information

When, in the opinion of the Flood Operations Engineer, a flood situation is imminent and gate operations are likely, and is of a magnitude that it is likely to cause flows to exceed 2,000 m^3/sec at Lowood, the Flood Operations Engineer must advise those listed in the Register of Contact Persons for Information of :

Deleted: and agencies

Deleted: shall

Deleted: shall

Deleted: shall

Deleted: shall

Deleted: shall

Deleted: shall

Deleted: shall

(a) the current and proposed releases from the dams, and

(b) the estimated flow rates and water heights at the key reference gauges listed in Appendix D.

This information is to be updated at intervals as better and more accurate information becomes available.

6.4 Release of Information to the Public

The Corporation is responsible for the issue of information regarding storage conditions and current and proposed releases from the dams to the public and the media.

The Bureau of Meteorology has responsibility for issuing flood warnings.

The Emergency Services Response Authorities, under the State Counter Disaster Organisation Act 1975, have responsibility for the preparation of a local counter disaster plan hence the interpretation of flood forecast information for inclusion in their local flood warnings prepared under the flood sub plan of the counter disaster plan.

7 REVIEW

7.1 Introduction

This review of the Manual has addressed the mechanisms of delegation and control of the dams in periods of operation of the dams for flood mitigation. It is known overtopping of the dams can result should floods occur which are derived from lesser rainfall than the probable maximum precipitation storm or from the combination of two lesser storms in close proximity. The dams may also overtop in the eventuality that the flood-gate control systems fail to operate or partially malfunction during the passage of a major flood or combination of floods.

Procedures and systems have been developed since the last revision that should enable lower risk operation of the dams for flood mitigation purposes. This technology is intended to provide longer warning times and the capability of examining options to optimise the safety of the dams and minimise the hazard potential and risk to the community.

With the passage of time neither the technical assumptions nor the physical conditions on which this Manual is based may remain unchanged. It is also recognised that the relevance of the Manual may change with changing circumstances.

It is important, therefore, that the Manual contain operational procedures which in themselves cause the Manual's procedures, and the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

The checking and reviewing process must involve the Headworks Operator and all associated operations personnel in order that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based.

Variations to the Manual may be made in accordance with provisions in Section 1.8.

7.2 Personnel Training

The Headworks Operator must report to the Corporation by 30th September each year on the training and state of preparedness of operations personnel. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources and Mines.

Deleted: shall

7.3 Monitoring and Warning System and Communication Networks

The Headworks Operator must provide a report to the Corporation by the 1st May and 1st November of each year; and after each flood event. The report must assess in terms of hardware, software and personnel, the :

Deleted: shall

Deleted: shall

- adequacy of the communication and data gathering facilities,
- reliability of the system over the previous period,
- reliability of the system under prolonged flood conditions,
- accuracy of forecasting flood flows and heights, and

Formatted: Bullets and Numbering

- the overall state of preparedness of the system.

The Corporation must review the report, and taking into account its own log of the performance of the field equipment, take any action considered necessary for the proper functioning and improvement of the system. . A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources and Mines.

7.4 Operational Review

After each significant flood event, the Corporation must review the effectiveness of the operational procedures contained in this manual. The Headworks Operator is required to prepare a report for submission to the Corporation within six weeks of any flood event that requires mobilisation of the Flood Control Centre.

7.5 Five Yearly Review

The Corporation, at intervals of no greater than five years must review the Manual pursuant to Section 6 Division 2 of the Act. The review is to take into account the continued suitability of the communication network, and the flood monitoring and warning system as well as hydrological and hydraulic engineering assessments of the operational procedures. The hydrologic investigations performed for the purpose of this manual are discussed in Appendix I.

Deleted: The Headworks Operator by the 1st November of each year, after every event that results in flood operation of the dams and at other times as appropriate, shall review the adequacy of the communication and data gathering facilities and make recommendations to the Corporation regarding improving reliability.¶
¶

Deleted: shall

Deleted: shall

8 WIVENHOE DAM

8.1 Introduction

Wivenhoe Dam is capable of being operated in a number of ways to reduce flooding in the Brisbane River downstream of the dam, depending on the part of the catchment in which the flood originates and depending also on the magnitude of the flood.

A general plan and cross-section of Wivenhoe Dam, and relevant elevations are included in Appendix J.

Storage and discharge data are included in Appendix E.

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

Spiltyard Creek Dam is part of the overall Wivenhoe Area Project and it forms the upper pumped storage of the peak power generation scheme. Splityard Creek Dam impounds a volume of 28 700 ML at its normal full supply level (El 166.5). The contents of Splityard Creek Dam can be emptied into Lake Wivenhoe within 12 hours by releasing water through the power station conduits. This volume of water can affect the level in Wivenhoe Dam by up to 300mm when Wivenhoe Dam is close to FSL. The operational level of Splityard Creek Dam should be considered when assessing the various trigger levels of Wivenhoe Dam.

The Corporation has acquired land above FSL to a level of EL 75.0 to provide temporary flood storage. Reasonable care must be exercised to confine the flood rises to below this level. This requirement should be ignored in the case of extreme floods that threaten the safety of the dams.

Deleted: shall

8.2 Initial Action

When indications are received of an imminent flood, the flood control operation of the dam must commence with the storing of all inflow of the Brisbane River in Wivenhoe Dam, whilst an assessment is made of the origin and magnitude of the flood. The spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding EL 67.25.

Deleted: shall

8.3 Regulator and Gate Operation Procedures

Rapid opening of outlets (spillway gates and regulators) can cause hydraulic surges and other effects in the Brisbane River that can endanger life and property and may sometimes have other adverse effects. Under normal gate operations, the gates and regulators are therefore to be operated one at a time at intervals that will minimise adverse impacts on the river system.

Rapid closure of the gates can affect river-bank stability. Rapid closure of more than one gate at a time should only be used when time is critical and there is a requirement to correct a malfunction to preserve storage or to reduce downstream flooding rapidly. For flood operations where time is not critical, longer closure intervals should be used. The minimum closure intervals specified below are based on experience from the 1974 flood.

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a gate by the immediate opening of a regulator valve (or the reverse operation). This allows for greater control of low flows and enables a smooth transition and closure as slow as possible to prevent the stranding of fish downstream of Wivenhoe Dam.

Except as provided for in procedure 4 of Section 8.4 and as indicated above, the gate opening and closing intervals as tabled below are the most rapid permitted for flood mitigation purposes.

Table 8.1
WIVENHOE DAM
MINIMUM INTERVALS for Normal Operation

500 mm Incremental gate openings	10 minutes
500 mm Incremental gate closures	20 minutes
Full regulator opening or closures	30 minutes

Gates are numbered 1 to 5 from the left bank looking downstream.

Under normal operation, only one gate is to be opened at any one time and the following procedures are to be adopted:

Approximate Discharge Range	Gate opening sequence	Comments
(a) Up to 330 m^3/sec	1. Open Gate 3 up to 3.5 metres	• Gates 1, 2, 4 & 5 remain closed
(b) 330 m^3/sec to 575 m^3/sec	2. Gate 3 at 3.5 metres 3. Open Gates 2 & 4 alternately to 0.5 metre 4. Open Gate 3 to 4.0 metre 5. Open Gates 2 & 4 alternately to 1.0 metre	• Gates 1 & 5 remain closed unless discharge from Gates 2 & 4 impinges on side wall of plunge pool proceed to (c)
(c) 575 m^3/sec to 1160 m^3/sec	6. Gate 3 kept at 4.0 metres 7. Open Gates 1 & 5 alternately one increment followed by Gates 2 & 4 alternately one increment 8. Repeat Step 7 until at the end of the sequence Gates 1 & 5 are open 1.5 metres and Gates 2 & 4 are open 2.5 metres	• Flow in spillway to be as symmetrical as possible • Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5

(d)	$1160\ m^3/sec$ to $1385\ m^3/sec$	9. Open Gate 3 to 4.0 metres 10. Open Gates 1 & 5 alternately to 2.0 metres followed by opening Gates 2 & 4 alternately to 3.0 metres	• Flow in spillway to be as symmetrical as possible • Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5
(e)	$1385\ m^3/sec$ to $2290\ m^3/sec$	11. Open ALL gates to 5.0 metre openings	• Flow in spillway to be as symmetrical as possible • Gates 2 & 4 are to have openings not less than Gates 1 & 5 or not more than 1.0 metre more than Gates 1 & 5 • Gate 3 is to have an opening not less than Gates 2 & 4 or not more than 1.0 metre more than Gates 2 & 4.
(f)	Greater than $2290\ m^3/sec$	12. Open ALL gates to incrementally in the sequence 3, 2, 4, 1, 5	• Flow in spillway to be as symmetrical as possible • Gate 3 to have the largest opening • Gates 2 & 4 are to have openings greater than Gates 1 & 5

Gate operating procedures in the event of equipment failure are contained in Appendix G. If one or more gates are inoperable during the course of the flood event, the gate openings of the remaining gates are to be adjusted to compensate. These adjustments should ensure that:

- The flow in the spillway is as symmetrical as practicable.
- The impact of the flow on the sidewalls of the plunge pool should be minimised.

In general, gate closing is to occur in the reverse order. The final gate closure should occur when the lake level has returned to Full Supply Level.

8.4 Flood Control Procedures

When the preliminary estimation of the degree of expected flooding has been made, the operating procedures set out hereunder shall be used at Wivenhoe Dam.

As the magnitude of the expected flood increases, the procedures to be adopted commence with Procedure 1 and extend to Procedure 4 as set out in the following table in response to current and predicted inflows both into the dams, and into the Brisbane River from tributaries downstream of the dams. This table provides indicative limits of application for each procedure for the initial filling of Wivenhoe Dam. Once Wivenhoe Dam has peaked and the drainage phase has commenced the indicative limits will not apply.

Provision is made for the releases to be regulated so as to lessen the impact when peak flows from Lockyer Creek, Bremer River and other tributaries enter the Brisbane River. This may result in the releases being decreased for a time even though lake levels are rising.

Provision is also made for the releases from Wivenhoe Dam to be regulated in the early procedures so as not to unduly submerge bridges. The relevant bridges and their estimated submergence flows are included in Appendix D.

Wivenhoe Dam - Normal Gate Operating Procedures: Initial Filling Phase

Procedure	Current Reservoir Level	Applicable Limits		
0	**EL ≤ 67.25**	$Q_{Wivenhoe} = 0$ m^3/sec ... i.e No Releases		$Q_{Moggill} < 4000$ m^3/sec
1A	**67.25 < EL ≤ 67.50**	$Q_{Wivenhoe} < 110$ m^3/sec	$Q_{Colleges\ Crossing} < 175$ m^3/sec with care taken not to submerge Twin Bridges prematurely	
1B	**67.50 < EL ≤ 67.75**	$Q_{Wivenhoe} < 380$ m^3/sec	$Q_{Burtons/Noogoorah} < 430$ m^3/sec with care taken not to submerge Colleges Crossing prematurely	
1C	**67.75 < EL ≤ 68.00**	$Q_{Wivenhoe} < 500$ m^3/sec	$Q_{Kholo} < 550$ m^3/sec with care taken not to submerge Burtons/Noogoorah prematurely	
1D	**68.00 < EL ≤ 68.25**	$Q_{Wivenhoe} < 900$ m^3/sec	$Q_{MtCrosby} < 1900$m^3/sec with care taken not to submerge Kholo prematurely	
1E	**68.25 < EL ≤ 68.50**	$Q_{Wivenhoe} < 1500$ m^3/sec	$Q_{MtCrosby} < 1900$m^3/sec with care taken not to submerge Kholo prematurely	
2	**68.50 < EL < 74.00**	$Q_{Lowood} < 3500$ m^3/sec	Q_{Lowood} < peak of Lockyer <u>and</u> Q_{Lowood} < peak of Bremer	Gates are <u>NOT</u> to be overtopped
3	**68.50 < EL < 74.00**	$Q_{Lowood} < 3500$ m^3/sec	$Q_{Moggill} < 4000$ m^3/sec	
4	**EL ≥ 74.00 or dam safety may be compromised**	Gates are to be opened until reservoir level begins to fall	Gate opening interval restrictions NO LONGER apply	

The gate opening sequences specified are to be overridden when the gates will be overtopped during normal operation.

In procedure 2, if there is little or no flow in Lockyer Creek, the release from Wivenhoe Dam should be limited to between 1900 m^3/sec and 2000 m^3/sec with care taken not to submerge Mt Crosby Weir Bridge or Fernvale Bridge prematurely. If the flood storage compartments of Wivenhoe Dam and Somerset Dam cannot be emptied within the prescribed time of seven days, the release from Wivenhoe Dam should be limited to between 1900 m^3/sec and 3500 m^3/sec. In such circumstances, the release from the dam should be less than the peak inflow into the lake.

8.5 Closing Procedures

If at the time the lake level in Wivenhoe Dam begins to fall, the combined flow at Lowood is in excess of 3500 m^3/sec, then the combined flow at Lowood is to be reduced to 3500 m^3/sec as quickly as practicable having regard to Section 3.3, and is to remain at this rate until final gate closure procedures can commence.

Gate closing procedures should be initiated having regard to the following requirements:

(a) Early release of stored water to regain flood-mitigating ability for any subsequent flood inflows as described in Section 3.3.

(b) Gate operation procedures as described in Section 8.3.

(c) Downstream impact of the discharges. To prevent the stranding of fish downstream of the dam, closures below flows of 275 m^3/sec should be undertaken as slow as practicable and if possible such closures should occur during daylight hours on a weekday so that personnel are available for fish rescue.

(d) Establishment of storage at FSL at completion of flood events.

9 SOMERSET DAM

9.1 Introduction

Somerset Dam is capable of being operated in a number of ways to regulate Stanley River floods and optimise the flood mitigation capacity of Wivenhoe Dam.

A general plan and cross-section of Somerset Dam, and relevant dam operating levels are included in Appendix J.

The discharge capacities for various storage levels of Somerset Dam are listed in Appendix F.

9.2 Initial Action

Upon indications being received of a significant inflow, the flood control operation of the dam shall commence with the raising of any closed gates and the closure of all low level regulators and sluices, whilst an assessment is made of the origin and magnitude of the flood.

9.3 Regulator and Gate Operation Procedures

The following minimum intervals must be observed whilst opening and closing regulators, sluices and crest gates at Somerset Dam for flood mitigation purposes:

Deleted: shall

Table 9.1
SOMERSET DAM
MINIMUM INTERNALS FOR NORMAL OPERATIONS

	OPENING	CLOSING
Regulators	30 minutes	60 minutes
Sluice Gates	120 minutes	180 minutes
Crest Gates	Gates are normally open	

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a sluice gate by the immediate opening of one or more regulator valves (or the reverse operation). This allows for greater control of low flows and enables a smooth transition on opening and closing sequences.

9.4 Flood Control Procedure

It is essential that the operating procedures adopted should not endanger the safety of Wivenhoe Dam. Within this constraint, the Senior Flood Operations Engineer must adopt a procedure for the operation of Somerset Dam such that:

Deleted: shall

(a) the structural safety of Somerset Dam is not endangered;

(b) the Upper Brisbane River flood flow plus Somerset Dam releases does not cause Wivenhoe Dam to be overtopped.

The normal operating procedure to be used for Somerset Dam is as follows.

The crest gates are raised to enable uncontrolled discharge. The low level regulators and sluices are to be kept closed until either:

(i) the lake level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

In the case of (i) above the opening of the regulators and sluices is not to increase the inflow to Wivenhoe Dam above the peak inflow from the Brisbane River just passed or, if possible, not to cause the Wivenhoe Dam lake level to exceed EL 74.

In the case of (ii) above, the Senior Flood Operations Engineer must direct the operation of the low-level regulators and sluices to ensure the safety of Somerset Dam. It should also be recognised that the D'Aguilar Highway at Mary Smokes Creek becomes inundated when Lake Somerset exceeds EL 102.2.

Deleted: shall

If the flood event emanates from the Stanley River catchment only, without significant runoff in the Upper Brisbane River catchment, the operation of Somerset Dam will proceed on the basis that Wivenhoe Dam has peaked as per (i) above.

10 EMERGENCY

10.1 Introduction

While every care has been exercised in the design and construction of the dams, there still remains a low risk that the dams may develop an emergency condition either through flood events or other causes. Experience elsewhere in the world suggests that vigilance is required to recognise emergency flood conditions such as:

- Occurrence of a much larger flood than the discharge capacity of the dam;
- Occurrence of a series of large storms in a short period;
- Failure of one or more gates during a flood.
- Development of a piping failure through the embankment of Wivenhoe Dam;
- Damage to the dams by earthquake;
- Damage to the dams as an act of war or terrorism;
- Other uncommon mechanisms.

Responses to these and other conditions are included in separate Emergency Action Plans.

10.2 Overtopping of Dams

Whatever the circumstances, every endeavour must be made to prevent overtopping of Wivenhoe Dam by the progressive opening of operative spillway gates.

In the event that the probability of overtopping of Wivenhoe Dam is unacceptably high, then as an absolute last resort the saddle dams may be breached. Such actions must only be initiated with the approval of the Chief Executive.

Deleted: shall

Somerset Dam should, if possible, not be overtopped by flood water but, if Wivenhoe Dam is threatened by overtopping, the release of water from Somerset Dam is to be reduced, for example by the use of its spillway gates, even at the risk of overtopping Somerset Dam in order to prevent, if possible, the overtopping of Wivenhoe Dam.

10.3 Communications Failure

In the event of normal communications being lost between the Flood Operations Engineer and either Wivenhoe Dam or Somerset Dam, the dam supervisor at that dam is to maintain contact with the dam supervisor at the other dam, to receive instructions through the remaining communications link.

In the event of normal communications being lost between the Flood Operations Engineer and both Wivenhoe Dam and Somerset Dam, the dam supervisors at each dam are to adopt the procedures set out below during flood events, and are to maintain contact with each other, where possible.

If all communications are lost between the Engineer, Wivenhoe Dam and Somerset Dam, the officers in charge at each dam are to adopt the procedures set out below.

10.4 Wivenhoe Dam Emergency Procedure

In the event of total communication failure, the minimum gate openings related to lake level set out in the table below are to be maintained for both opening and closing operations.

Table 10.4 Minimum Gate Openings Wivenhoe Dam

Lake Level m AHD	**Gate 3 Opening (m)**	**Gates 2 & 4 Opening (m)**	**Gates 1 & 5 Opening (m)**	**Discharge m^3/sec**
67.0		-	-	0
67.5	0.5	-	-	50
68.0	1.5	-	-	155
68.5	2.5	-	-	260
69.0	3.5	0.5	-	470
69.5	4.0	1.0	-	640
70.0	4.0	1.5	0.5	875
70.5	4.0	2.0	1.0	1115
71.0	4.0	2.5	1.5	1365
71.5	4.5	2.5	2.0	1560
72.0	4.5	3.0	2.5	1820
72.5	5.0	4.0	3.0	2250
73.0	5.0	5.0	5.0	2960
73.5	6.5	6.5	6.5	3850
74.0	8.0	8.0	8.0	4750
74.5	10.0	10.0	10.0	6030
75.0	12.5	12.5	12.5	7830
75.5	14.0	14.0	14.0	9150
76.0	Fully Open	Fully Open	Fully Open	10790
76.5	Fully Open	Fully Open	Fully Open	11250
77.0	Fully Open	Fully Open	Fully Open	11720

If one or more gates become inoperable, then by reference to Table E-2 the gate openings of operable gates are to be increased in order that the discharges for the lake levels shown in Table 10.4 are achieved.

If, because of compliance with the provisions of Section 8.3 and the high inflow rate, the minimum gate openings cannot be maintained, the time intervals between successive openings shown in Table 8.1 are to be halved.

If the actual gate openings fall more than three settings below the cumulative number of minimum settings of Table 10.4, then successive gate operations are to be carried out as rapidly as possible until the minimum settings are achieved. Under these circumstances, it may be necessary to operate more than one gate at any one time.

10.5 Somerset Dam Emergency Procedure

In the event of total communication failure, the spillway gates are to be kept raised to allow uncontrolled discharge. The regulators and sluices are to be kept closed until either:

(i) the level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

The level in Wivenhoe Dam can be determined locally by the Dam Supervisor at Somerset Dam from the tailwater gauge located just downstream of Somerset Dam.

In the case of (i) above, the opening of the regulators and sluices is not to increase the level in Wivenhoe Dam above the peak level already attained. Section 9.3 on regulator and gate operation interval is to be observed.

In the case of (ii) above, the regulators and sluices are to be operated such that the free-board between the flood level in Wivenhoe Dam and EL 77 is the same as the free-board between the flood level in Somerset Dam and the non-spillway crest level in Somerset Dam (EL 107.46). The low level outlets in Somerset Dam are not to be opened if the water level in Wivenhoe Dam exceeds the level set out below for given water levels in Somerset Dam.

Somerset Lake Level m AHD	**Wivenhoe Lake Level m AHD**
102.5	72
103.5	73
104.5	74
105.5	75
106.5	76
107.46	77

The constraints applicable to case (i) operation above do not apply to case (ii) operation.

10.6 Equipment Failure

In the event of equipment failure the action to be taken is indicated in Appendix G for Wivenhoe Dam and Appendix H for Somerset Dam.

APPENDIX A EXTRACT FROM ACT

EXTRACT FROM WATER ACT 2000

Division 2 – Flood Mitigation

Owners of certain dams must prepare flood mitigation manual

496.(1) A regulation may nominate an owner of a dam as an owner who must prepare a manual (a "flood mitigation manual") of operational procedures for flood mitigation for the dam.

(2) The regulation must nominate the time by which the owner must comply with section 497(1).

Approving flood mitigation manual

497.(1) The owner must give the chief executive a copy of the flood mitigation manual for the chief executive's approval.

(2) The chief executive may, by gazette notice, approve the manual.

(3) The approval may be for a period of not more than 5 years.

(4) The chief executive may get advice from an advisory council before approving the manual.

Amending flood mitigation manual

498.(1) The chief executive may require the owner, by notice, to amend the flood mitigation manual.

(2) The owner must comply with the chief executive's request under subsection (1).

(3) The chief executive must, by gazette notice, approve the manual as amended.

(4) The approval of the manual as amended must be for-

(a) the balance of the period of the approval for the manual before amendment; or

(b) a period of not more than 5 years from the day the manual as amended was approved.

(5) The chief executive may get advice from an advisory council before approving the manual as amended.

Regular reviews of flood mitigation manual

499. Before the approval for the flood mitigation manual expires, the owner must-

(a) review, and if necessary, update the manual; and

(b) give a copy of it to the chief executive under section 497.

Protection from liability for complying with flood mitigation manual

500.(1) The chief executive or a member of the council does not incur civil liability for an act done, or omission made, honestly and without negligence under this division.

(2) An owner who observes the operational procedures in a flood mitigation manual approved by the chief executive 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**" includes-

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

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

(c) an agent of the owner or operator of the dam

APPENDIX B AGENCIES HOLDING DOCUMENTS

AGENCIES HOLDING CONTROLLED DOCUMENTS
OF
MANUAL OF OPERATIONAL PROCEDURES
FOR FLOOD MITIGATION
FOR
WIVENHOE DAM AND SOMERSET DAM

Dam Owner	South East Queensland Water Corporation
Emergency Services	Department of Emergency Services, Disaster Management Service Brisbane City Counter Disaster Committee Esk Shire Counter Disaster Committee Ipswich City Counter Disaster Committee Kilcoy Shire Counter Disaster Committee
Severe Weather Warning Authority	Bureau of Meteorology
Primary Response Authorities	Brisbane City Council Esk Shire Council Ipswich City Council Kilcoy Shire Council
Regulator of Dam Safety	Department of Natural Resources and Mines
Schedule of Authorities, Appendix C	Agencies and persons listed in Appendix C

The Corporation must keep a register of contact persons of holders of controlled documents (Section 1.9 refers).

Deleted: shall

APPENDIX C SCHEDULE OF AUTHORITIES

AUTHORITY	AGENCY/PERSON	APPROVED BY	APPROVAL DATE	REFERENCE
Senior Flood Operations Engineer	Robert Arnold Ayre SunWater	Chief Executive	Date of approval of this manual	
	John Lawrence Ruffini Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	
Flood Operations Engineer	Peter Hugh Allen Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	
	Robert Arnold Ayre SunWater	Chief Executive	Date of approval of this manual	
	John Lawrence Ruffini Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	
	Toby Leonard McGrath SunWater	Chief Executive	Date of approval of this manual	
	Donald James Cock Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	

APPENDIX D GAUGES AND BRIDGES

D.1. KEY REFERENCE GAUGES

BRISBANE CITY

	FLOOD CLASSIFICATION			
Gauge	Minor	Moderate	Major	1974 Flood
Moggill	10.0	13.0	15.5	19.9
Jindalee	6.0	8.0	10.0	14.1
Brisbane City Gauge (B.C.G)	1.7	2.6	3.5	5.5

(Reference: Brisbane City Disaster Management Plan, Flood Management Special Plan 30 July, 1996)

IPSWICH CITY

	FLOOD CLASSIFICATION			
Gauge	Minor	Moderate	Major	1974 Flood
David Trumpy Bridge	7.0	9.0	11.7	20.7
Mt Crosby Weir	11.0	13.0	21.0	26.7
Moggill	10.0	13.0	15.5	19.9

ESK SHIRE

	FLOOD CLASSIFICATION		
Gauge	Minor	Moderate	Major
Lowood Alert Station	8.6	15.9	21.2

KILCOY SHIRE

	FLOOD CLASSIFICATION		
Gauge	Minor	Moderate	Major
Somerset Dam Reservoir Level	103.0	105.0	106.0

Values are in metres AHD

APPENDIX D

D.2. SUBMERGENCE FLOWS FOR BRIDGES

AMTD	Bridge Name	Estimated Submergence Flow m^3/sec
140	Twin Bridges	50
132	Savage’s Crossing	130
87	College's Crossing	175-200*
120	Burton's Bridge	430
100	Kholo Bridge	550
91	Mt.Crosby Weir Bridge	1900
136	Fernvale Bridge	2000

* Affected by tides.

Twin Bridges, Wivenhoe Pocket Road, Fernvale
Savage’s Crossing, Banks Creek Road, Fernvale
College’s Crossing, Mt Crosby Rd, Karana Downs
Burton’s Bridge, E Summerville Rd, Borallon
Kholo Bridge, Kholo Rd, Ipswich
Mt Crosby Weir Bridge, Allawah Rd, Mt Crosby
Fernvale Bridge, Brisbane Valley Highway, north of Fernvale

APPENDIX E WIVENHOE DAM TECHNICAL DATA
TABLE E1 STORAGE AND UNCONTROLLED DISCHARGES

Lake level m AHD	Storage Capacity 10^6 m^3	*** Flood Capacity 10^6 m^3	** Net Inflow per 1mm rise per hour m^3/sec	* Discharge per Regulator m^3/sec	* Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
57.0	414	-	11.10	24.9	0	50
57.5	453	-	12.04	25.2	4	69
58.0	466	-	12.97	25.4	15	128
58.5	494	-	13.90	25.7	32	211
59.0	523	-	14.84	25.9	53	316
59.5	553	-	15.77	26.2	77	439
60.0	584	-	16.71	26.4	105	579
60.5	616	-	17.64	26.6	136	735
61.0	649	-	18.58	26.9	170	905
61.5	683	-	19.51	27.1	207	1 090
62.0	719	-	20.45	27.3	246	1 290
62.5	756	-	21.38	27.5	288	1 495
63.0	795	-	22.32	27.8	333	1 720
63.5	835	-	23.25	28.0	379	1 950
64.0	877	-	24.19	28.2	428	2 195
64.5	920	-	25.12	28.4	479	2 450
65.0	965	-	26.06	28.7	532	2 720
65.5	1 012	-	26.99	28.9	587	2 995
66.0	1 061	-	27.92	29.1	645	3 280
66.5	1 112	-	28.86	29.3	704	3 580
67.0	1 165	0	29.79	29.5	765	3 885
67.5	1 220	56	30.73	29.7	828	4 200
68.0	1 276	112	31.66	29.9	893	4 525
68.5	1 334	171	32.60	30.1	959	4 860
69.0	1 393	230	33.53	30.3	1 028	5 200
69.5	1 454	290	34.47	30.5	1 098	5 550
70.0	1 517	350	35.40	30.7	1 170	5 910
70.5	1 581	418	36.33	30.9	1 244	6 280
71.0	1 647	485	37.27	31.1	1 319	6 660
71.5	1 714	550	38.20	31.3	1 396	7 040
72.0	1 783	615	39.14	31.5	1 474	7 430
72.5	1 854	683	40.07	31.7	1 554	7 840
73.0	1 926	750	41.01	31.9	1 636	8 240
73.5	2 000	830	41.94	32.1	1 719	8 660
74.0	2 076	910	42.87	32.3	1 804	9 080
74.5	2 153	995	43.81	32.5	1 890	9 520
75.0	2 232	1 080	44.74	32.7	1 978	9 960
75.5	2 313	1 160	45.68	32.9	2 067	10 400
76.0	2 395	1 240	46.61	33.1	2 158	10 860
76.5	2 480	1 258	47.55	33.3	2 250	11 320
77.0	2 566	1 420	48.48	33.4	2 343	11 780
77.5	2 655	1 500	49.41	36.6	2 438	12 260
78.0	2 746	1 580	50.35	33.8	2 535	12 740
78.5	2 839	1 680	51.28	34.0	2 632	13 230
79.0	2 934	1 780	52.22	34.2	2 731	13 730

* This is the maximum discharge of an individual spillway bay or regulator. Total discharge is calculated by adding the contributions of each gate or regulator. There are two (2) regulators to five (5) spillway bays.

** This assumes that all gates and sluices are closed. Discharges through the spillway have to be added to the above figures to calculate the actual inflow into the reservoir.

*** The temporary storage above normal Full Supply Level of EL 67.0.

TABLE E2 CONTROLLED GATE DISCHARGES

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
67.0	0	49	98	146	194	240	285	329	372	413	453	492	530	567	603	639	675	709	744	765															
67.2	0	49	99	148	196	243	288	333	376	418	458	498	537	574	611	648	684	720	755	790															
67.4	0	50	100	149	198	245	291	336	380	422	464	504	543	582	619	657	693	730	766	802	815														
67.6	0	50	101	151	200	248	294	340	384	427	469	510	550	589	627	665	702	740	777	814	841														
67.8	0	51	102	152	202	250	297	343	388	432	474	515	556	596	635	673	712	750	787	825	863	867													
68.0	0	51	103	154	204	253	300	347	392	436	479	521	562	603	642	682	721	759	798	837	876	893													
68.2	0	52	104	155	206	255	303	350	396	441	484	527	569	610	650	690	729	769	808	848	888	919													
68.4	0	52	105	156	207	257	306	354	400	445	489	532	575	616	657	698	738	778	818	859	899	940	946												
68.6	0	53	105	158	209	260	309	357	404	450	494	538	581	623	665	706	747	788	829	870	911	953	973												
68.8	0	53	106	159	211	262	312	360	408	454	499	543	587	630	672	714	755	797	838	880	923	965	1000												
69.0	0	54	107	160	213	264	315	364	412	458	504	549	593	636	679	722	764	806	848	891	934	977	1022	1028											
69.2	0	54	108	162	215	267	317	367	415	463	509	554	599	643	686	729	772	815	858	901	945	989	1035	1056											
69.4	0	54	109	163	217	269	320	370	419	467	514	560	605	649	693	737	780	824	868	912	956	1001	1047	1084											
69.6	0	55	110	164	218	271	323	373	423	471	518	565	611	656	700	744	789	833	877	922	967	1013	1060	1107	1112										
69.8	0	55	111	166	220	273	326	377	427	475	523	570	616	662	707	752	797	842	887	932	978	1025	1072	1121	1141										
70.0	0	56	112	167	222	276	328	380	430	479	528	575	622	668	714	759	805	850	896	942	989	1036	1085	1134	1170										
70.2	0	56	112	168	224	278	331	383	434	484	532	580	628	674	721	767	813	859	905	952	1000	1048	1097	1147	1198	1199									
70.4	0	56	113	170	225	280	334	386	437	488	537	586	633	680	727	774	821	867	914	962	1010	1059	1109	1160	1212	1229									
70.6	0	57	114	171	227	282	336	389	441	492	542	591	639	687	734	781	828	876	923	972	1020	1070	1121	1173	1226	1258									
70.8	0	57	115	172	229	284	339	392	445	496	546	596	644	693	741	788	836	884	932	981	1031	1081	1133	1185	1239	1289									
71.0	0	58	116	173	230	286	341	395	448	500	551	601	650	699	747	795	844	892	941	991	1041	1092	1144	1198	1252	1309	1319								
71.2	0	58	117	175	232	289	344	398	452	504	555	605	655	705	754	802	851	900	950	1000	1051	1103	1156	1210	1266	1323	1349								
71.4	0	58	117	176	234	291	347	401	455	508	559	610	661	710	760	809	859	908	959	1009	1061	1114	1167	1222	1279	1337	1380								
71.6	0	59	118	177	235	293	349	404	458	512	564	615	666	716	766	816	866	916	967	1019	1071	1124	1179	1234	1292	1350	1410	1411							
71.8	0	59	119	178	237	295	352	407	462	515	568	620	671	722	773	823	874	924	976	1028	1081	1135	1190	1246	1304	1364	1425	1443							
72.0	0	60	120	180	239	297	354	410	465	519	572	625	676	728	779	830	881	932	984	1037	1091	1145	1201	1258	1317	1377	1439	1474							
72.2	0	60	121	181	240	299	357	413	469	523	577	629	682	733	785	837	888	940	993	1046	1100	1156	1212	1270	1330	1391	1454	1506							
72.4	0	60	121	182	242	301	359	416	472	527	581	634	687	739	791	843	895	948	1001	1055	1110	1166	1223	1282	1342	1404	1468	1533	1538						
72.6	0	61	122	183	243	303	361	419	475	531	585	639	692	745	797	850	903	956	1009	1064	1119	1176	1234	1293	1354	1417	1482	1548	1570						
72.8	0	61	123	184	245	305	364	422	478	534	589	643	697	750	803	856	910	963	1018	1073	1129	1186	1245	1305	1367	1430	1496	1563	1603						

UNCONTROLLED DISCHARGE

TABLE E2 CONTROLLED GATE DISCHARGES

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
73.0	0	62	124	185	247	307	366	425	482	538	593	648	702	756	809	863	917	971	1026	1081	1138	1196	1255	1316	1379	1443	1509	1577	1636						
73.2	2	62	124	187	248	309	369	427	485	542	597	653	707	761	815	869	924	978	1034	1090	1147	1206	1266	1327	1391	1456	1523	1592	1663	1669		UNCONTROLLED			
73.4	6	62	125	188	250	311	371	430	488	545	602	657	712	767	821	876	931	986	1042	1099	1156	1216	1276	1339	1403	1469	1536	1606	1678	1702			DISCHARGE		
73.6	11	64	126	189	251	313	373	433	491	549	606	662	717	772	827	882	937	993	1050	1107	1166	1225	1287	1350	1414	1481	1550	1620	1693	1736					
73.8	17	69	127	190	253	315	376	436	495	553	610	666	722	778	833	888	944	1001	1058	1116	1175	1235	1297	1361	1426	1494	1563	1635	1708	1770					
74.0	23	74	129	191	254	317	378	438	498	556	614	671	727	783	839	895	951	1008	1065	1124	1184	1245	1307	1372	1438	1506	1576	1648	1723	1800	1804				
74.2	31	80	133	192	256	319	380	441	501	560	618	675	732	788	845	901	958	1015	1073	1132	1192	1254	1317	1382	1449	1518	1589	1662	1738	1815	1838				
74.4	39	87	139	195	257	321	383	444	504	563	622	679	737	793	850	907	964	1022	1081	1140	1201	1264	1327	1393	1461	1530	1602	1676	1752	1831	1873				
74.6	47	94	145	200	259	322	385	447	507	567	626	684	741	799	856	913	971	1029	1089	1149	1210	1273	1337	1404	1472	1542	1615	1690	1767	1846	1908				
74.8	56	103	153	206	262	324	387	449	510	570	629	688	746	804	862	919	978	1036	1096	1157	1219	1282	1347	1414	1483	1554	1628	1703	1781	1861	1943				
7 5.0	66	112	161	213	267	326	390	452	513	574	633	692	751	809	867	926	984	1044	1104	1165	1227	1291	1357	1425	1494	1566	1640	1717	1795	1876	1960	1978			
75.2	76	121	169	220	274	330	392	455	516	577	637	697	756	814	873	932	991	1051	1111	1173	1236	1301	1367	1435	1506	1578	1653	1730	1809	1891	1976	2013			
75.4	87	131	178	229	281	336	394	457	519	581	641	701	760	819	878	938	997	1057	1119	1181	1245	1310	1377	1446	1517	1590	1665	1743	1823	1906	1992	2049			
75.6	98	141	188	237	289	343	399	460	522	584	645	705	765	824	884	944	1004	1064	1126	1189	1253	1319	1386	1456	1527	1601	1678	1756	1837	1921	2007	2085			
75.8	109	152	198	247	298	350	405	463	525	587	649	709	769	829	889	949	1010	1071	1133	1197	1261	1328	1396	1466	1538	1613	1690	1769	1851	1936	2023	2112	2121		
				OVERTOPPING of GATE																															
76.0	121	164	209	257	307	359	412	468	528	591	652	713	774	834	895	955	1016	1078	1141	1205	1270	1337	1405	1476	1549	1624	1702	1782	1865	1950	2038	2129	2158		
76.2	133	175	220	268	317	368	421	475	532	594	656	718	779	839	900	961	1023	1085	1148	1212	1278	1346	1415	1486	1560	1636	1714	1795	1878	1965	2053	2145	2194		
76.4	146	187	232	279	327	378	429	483	539	597	660	722	783	844	906	967	1029	1092	1155	1220	1286	1354	1424	1496	1570	1647	1726	1808	1892	1979	2069	2161	2231		
76.6	159	200	244	290	338	388	439	492	546	603	664	726	788	849	911	973	1035	1098	1162	1228	1295	1363	1434	1506	1581	1658	1738	1820	1905	1993	2084	2177	2268		
76.8	173	213	257	302	350	399	449	501	554	610	668	730	792	854	916	978	1041	1105	1170	1235	1303	1372	1443	1516	1591	1669	1750	1833	1919	2007	2099	2193	2289	2306	
				OVERTOPPING of GATE																															
77.0	186	226	270	315	362	410	460	511	564	618	674	734	797	859	921	984	1047	1112	1177	1243	1311	1380	1452	1526	1602	1680	1762	1845	1932	2021	2113	2208	2306	2343	
77.2	200	240	283	328	374	422	471	522	574	627	682	739	801	864	927	990	1054	1118	1184	1250	1319	1389	1461	1536	1612	1691	1773	1858	1945	2035	2128	2224	2322	2381	
77.4	215	254	297	341	387	435	483	533	584	637	691	747	806	869	932	996	1060	1125	1191	1258	1327	1398	1470	1545	1622	1702	1785	1870	1958	2049	2143	2239	2339	2419	
77.6	230	269	311	355	400	447	496	545	595	647	700	756	813	873	937	1001	1066	1131	1198	1265	1335	1406	1479	1555	1633	1713	1796	1882	1971	2063	2157	2255	2355	2457	
77.8	245	283	325	369	414	461	508	557	607	658	711	765	821	880	942	1007	1072	1138	1205	1273	1343	1414	1488	1564	1643	1724	1808	1894	1984	2076	2172	2270	2371	2475	2496
78.0	260	299	340	383	428	474	522	570	619	670	722	775	831	888	948	1012	1078	1144	1211	1280	1351	1423	1497	1574	1653	1735	1819	1907	1997	2090	2186	2285	2387	2492	2535

APPENDIX F SOMERSET DAM TECHNICAL DATA

Table F-l
STORAGE AND DISCHARGE FOR SOMERSET DAM

Lake level M AHD	Reservoir Capacity 10^6 m^3	Temporary Flood Storage 10^6 m^3	Net Inflow per 1mm rise per hour m^3/sec	* Discharge per Regulator m^3/sec	* Discharge per Sluice m^3/sec	* Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
90.0	120.3	-	5.29	57	163	-	1 529
90.5	129.5	-	5.50	58	165	-	1 550
91.0	139.3	-	4.88	58	167	-	1 572
91.5	149.6	-	5.28	59	170	-	1 593
92.0	160.5	-	5.68	60	172	-	1 614
92.5	172.0	-	6.09	60	174	-	1 635
93.0	184.1	-	6.79	61	176	-	1 655
93.5	196.7	-	7.10	62	179	-	1 676
94.0	210.0	-	7.43	62	181	-	1 695
94.5	224.0	-	7.78	63	183	-	1 715
95.0	238.5	-	8.15	64	185	-	1 735
95.5	253.6	-	8.54	64	187	-	1 754
96.0	269.3	-	8.95	65	189	-	1 773
96.5	285.6	-	9.37	66	191	-	1 792
97.0	302.7	-	9.81	66	193	-	1 810
97.5	320.7	-	10.28	67	195	-	1 829
98.0	339.5	-	10.76	67	197	-	1 847
98.5	359.2	-	11.25	68	199	-	1 865
99.0	379.8	0.0	11.77	69	201	-	1 883
99.5	401.4	21.5	12.31	69	203	-	1 901
100.0	428.9	49.0	13.28	70	205	-	1 918
100.5	447.5	67.6	13.83	70	207	0	1 937
101.0	472.2	92.3	14.39	71	209	4	1 989
101.5	498.0	118.1	14.95	72	211	13	2 076
102.0	524.9	145.1	15.53	72	212	25	2 189
102.5	553.1	173.3	16.11	73	214	40	2 325
103.0	582.6	202.7	16.70	73	216	58	2 482
103.5	613.2	233.4	17.30	74	218	78	2 659
104.0	645.1	265.3	17.90	74	220	100	2 854
104.5	678.3	298.4	18.52	75	221	125	3 067
105.0	712.7	332.8	19.14	75	223	151	3 296
105.5	748.3	368.4	19.78	76	225	180	3 542
106.0	785.2	405.4	20.42	76	226	211	3 803
106.5	823.4	443.6	21.07	77	228	243	4 079
107.0	863.1	483.2	21.73	78	230	278	4 370
107.5	904.0	524.2	22.39	78	232	314	4 675

* This is the maximum discharge of an individual gate or regulator. Total discharge is calculated by adding the contributions of each gate or regulator.

Regulator - Discharge regulator valve of which there are four (4).
Sluice - Sluice gate of which there are eight (8).
Spillway - Overflow section of dam controlled by eight (8) radial gates.
Temporary Flood Storage - The temporary storage above the normal full supply level of El 99 m (AHD)

APPENDIX G WIVENHOE DAM GATE OPERATION CONSIDERATIONS

Full size plans of Wivenhoe Dam, and Operations and Maintenance Manuals for Wivenhoe Dam are held by the Corporation and the Headworks Operator and are available at the site. Operations and Maintenance Manuals relevant to the flood operation of the gates are:

(a) "Master Manual and Drawings."

(b) "Radial and Penstock Gate Hoists and Drawings."

G.1. SPILLWAY OPERATION PRINCIPLES

The radial gates are sequentially numbered from 1 to 5 from left to right looking in the downstream direction. Appendix I shows the general arrangement of the spillway area.

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions, or when gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool, which has been excavated into erodible sandstone rock, and cause non-predictable erosion. Upstream migration of this erosion is to be avoided. The wing walls adjacent to the flip bucket deflect the discharge away from the walls of the plunge pool when gates 1 and 5 are operated.

Therefore in operating the spillway, the principles to be observed are, in order of priority:

(i) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

(ii) The flow in the spillway is to be symmetrical.

The main purpose of gating the spillway is to exercise maximum control over the flow in the Brisbane River insofar as river flows in excess of 4 000 m^3/sec cause damage to urban areas downstream. The gates also allow the routing of much larger floods with substantial flood mitigation being achieved.

G.2. RADIAL GATE OPERATING PRINCIPLE

Each radial gate consists of a cylindrical upstream skinplate segment that is attached to the radial arms. The cylindrical axis is horizontal. Each gate rotates about two spherical trunnion bearings that are on this axis.

The position of the gate is controlled by hydraulically driven winches that are located on the piers beside the gates. Wire ropes are attached to the downstream face of the skin plate through a pulley system. The hydraulic motors work off a common pressure manifold and under perfectly matched conditions, will give an equal lifting force to each side of the gate. This system does not sense rope travel and will take up slack rope. It cannot prevent or correct skewing of the skin plate segment between the piers. If skewing occurs, skids will come into contact with the side seal plates to limit movement.

It is not possible to operate a winch independently of the other winch attached to the gate.

When the hydraulic motors are not energised, the gates are held in position by spring loaded friction brakes on the winches. There are two brake bands per winch and each band is capable of supporting half the weight of the gate. One winch can support the total weight of a gate on both its brake bands but not on one.

G.3. RADIAL GATES OPERATING LIMITATIONS

G.3.1. Opening and Closing Rate

The aperture opening rate of each gate is limited to 500 mm/minute.

Aperture movement is limited by a programmable timer that stops gate movement after a set period of time.

G.3.2. Alternate Consecutive Operation

To maintain symmetry of discharge in the spillway, either gates 1 and 5 or gates 2 and 4 are to be operated in alternate consecutive increments. The power for gate operation comes from two independent electric hydraulic pumps, each of which is capable of operating one gate at a time.

The normal hydraulic pressure source for each gate is as follows:

GATES	POWER SOURCE
Radial Gates 1 & 2, and Penstock Gate Hoist	Electric hydraulic pump 1
Radial Gates 3, 4 & 5	Electric hydraulic pump 2

In the event that an electric hydraulic pump fails, hydraulic pressure can be redirected from the other power source, but concurrent operation of more than one gate from a single power source is not possible.

G.3.3. Overtopping

While the radial gates have been designed to withstand overtopping, it should be avoided if possible. The reservoir levels and the structural state of the radial gates when in the closed position are as follows:

Reservoir Level m AHD	Condition	Radial Gate Stress Condition with Gate Closed
73	Top of closed gate	Normal
77	Design Flood Level	33% Overstress
79	Crest Level	Critical

Once overtopped, the gates become inoperable when the lifting tackle is fouled by debris from the overflow. The gates remain structurally secure until the reservoir level exceeds EL 77. The ability to control floods however may be lost.

G.3.4. Gate Dropping

Under no circumstances are the gates to be dropped. The lower skin plate sections are overstressed if a freefall of 60 mm is arrested by the seal plate on the spillway.

If a gate becomes stuck in an open position, it is to be freed by applying positive lifting forces. Under no circumstances are the winches to be unloaded and the direct weight of the gates used to yield the obstruction.

G.3.5. Operation in High Wind

Other than in periods of mitigation of medium and major floods, the gates are not to be raised or lowered when clear of water, during periods of high winds. The gates can however, be held on the brakes in any position in the presence of high wind.

The term "high wind" means any wind that causes twisting or movement of the gate. While a precise figure cannot be placed on these velocities, further experience over time may allow a figure to be determined.

This limitation is required to prevent the gate from twisting from skew on one side to skew on the other side. While the gate is being raised or lowered, skewing cannot be prevented by the hydraulic lifting system and any impact forces encountered may damage the gate.

G.3.6. Maintenance

No more than one gate is to be inoperable at any one time for maintenance. The maintenance is to be scheduled so that the spillway bay can be cleared of obstructions in a reasonable time to allow its use in the event of major flooding.

G.4. BULKHEAD GATE OPERATING LIMITATIONS

The bulkhead gate can be used to control discharge in an emergency situation where a radial gate is inoperable. It is transported to, and lowered upstream of the inoperable radial gate by means of the gantry crane. The following conditions apply:

(a) The bulkhead gate can always be lowered with any type of underflow; and

(b) It is not possible to raise the bulkhead gate once it has been lowered past certain levels depending on upstream conditions without there being a pool of water between it and the radial gate. (Department of Primary Industries Wivenhoe Dam Design Report, September 1995 refers).

It is thus possible to preserve storage by effectively closing the spillway even with one radial gate inoperable. It will not be possible to raise the bulkhead gate until the radial gate behind has been repaired and is again storing water between the bulkhead gate and itself.

The bulkhead gate is not to be used for flood regulation until the reservoir level is falling and not likely to rise within the period needed to repair the inoperable radial gate.

G.4.1. Opening and Closing Rates

The spillway gantry crane is to be used to raise and lower the bulkhead gate. The crane operates at two speeds, 1.5 and 3.0 m/min. When within the bulkhead gate guides, the bulkhead gate is to be moved only at 1.5 m/min.

G.4.2. Overtopping

In the event that the bulkhead gate is overtopped (reservoir level exceeds EL 69 when bulkhead gate is closed), it cannot be removed unless a pool of water fills the space between it and the radial gate behind. The closed bulkhead becomes critically stressed when the reservoir level overtops it to EL 71.4.

It is not possible to engage the lifting tackle while overtopping is occurring. While there is any risk that the bulkhead gate may be overtopped, the lifting gear is to be left engaged so that the gate can be raised once the downstream radial gate becomes operable.

G.4.3. Discharge Regulation

In the event that a radial gate is inoperable in a partially open position, the bulkhead gate can be used for flow regulation provided that the lower lip of the radial gate is clear of the underflow jet.

Where a pool exists between the bulkhead gate and a radial gate under flow conditions, the bulkhead gate will be subjected to additional pull-down and possibly subjected to vortex-induced vibrations. When this condition occurs, the bulkhead gate is to be lowered to dewater the pool. The bulkhead gate can then be adjusted to regulate the flow provided the underflow jet remains below the lower lip of the radial gate.

G.5. RADIAL GATE OPERATING PROCEDURES

G.5.1. Normal Operating Procedure

This procedure is specified in Section 8.3

G.5.2. One Gate Inoperable

Under certain abnormal conditions, it may not be possible to operate one gate. The following procedures are to be adopted.

(a) Gate 3 Inoperable

If bay 3 is blocked for any reason, gates 2 and 4 are to be used to regulate flood discharges, until the discharge impinges on the walls of the plunge pool. Gates 1 and 5 are then to be opened sufficiently to deflect the discharge into the plunge pool.

The bottoms of gates 1 and 5 are to be maintained at or below those of gates 2 and 4 respectively.

(b) Either Gate 2 or 4 Inoperable

If either bay 2 or 4 is blocked for any reason during a flood, normal gate operating procedures are to be adopted, except that only the operable gate 2 or 4 is available for flood regulation beyond 500 m^3/sec and not both.

(c) Either Gate 1 or 5 Inoperable

If either bay 1 or 5 is blocked for any reason during a flood, normal gate operating procedures are to be adopted until the discharge impinges on the walls of the plunge pool. Thereafter the operable gate 1 or 5 is to be used in lieu of using the radial gate adjacent to the inoperable gate. The other radial gates are to be used in the normal way to control discharge.

In the event of a major flood, where the full discharge capacity of the four operable radial gates is required, these gates are to be used to their full capacity to protect the embankment from overtopping.

G.6. EQUIPMENT MALFUNCTION

Normal gate operation is by means of two electric hydraulic pumps supplied by external mains supply electric power, with pump number 1 connected to gates 1 and 2 and the penstock gate, while pump number 2 is connected to gates 3, 4 and 5.

Normal gate operation may not be possible in the event of equipment malfunctions during the passing of a flood. The procedures to be followed under various possible events are outlined below.

G.6.1. Blackout - Failure of External Electric Power

A diesel electric generator automatically starts up. It supplies enough power to the two electric hydraulic pumps to operate the gates normally.

In the event that the diesel electric generator fails, the radial gates can still be operated by means of the emergency diesel hydraulic pump as described in G.6.3 below.

G.6.2. Failure of One Electric Hydraulic Pump

In the event that one electric hydraulic pump fails, the connecting valves between pumps are to be switched such that both sets of hydraulic lines are connected to the operable pump, thus permitting operation of all 5 gates, one gate at a time.

G.6.3. Failure of Two Electric Hydraulic Pumps

In the event that both electric hydraulic pumps fail, the emergency diesel hydraulic pump is to be used to operate the gates, one gate at a time.

G.6.4. Rupture of Hydraulic Lines

The only source of power to the radial gate winches is via the hydraulic lines.

Hydraulic power is delivered from the sets of hydraulic lines beneath the gantry service bridge deck to each winch via a single hydraulic line. There is no bypass circuit. In the event that one of these lines is ruptured, the associated radial gate becomes inoperable and cannot be raised or lowered. Any ruptures in the hydraulic lines are to be repaired immediately.

G.6.5. Contamination of Winch Brakes

The gates are not to be raised if the brake bands on the winch drums are contaminated with oil or other low friction contaminant.

When the hydraulic power is off the gates are held only by the winch brakes. Oil contamination will reduce their holding capacity and possibly allow the gate to fall.

The brake bands are to be inspected regularly and cleaned immediately if any contamination is observed.

G.6.6. Mechanical Failure of Winch

In the event that a winch fails, the radial gate affected becomes inoperable.

(i) Loss of hydraulic power to the winches results in the spring loaded friction brakes holding the gate in its current position.

(ii) Loss of lift from one winch jams the gate between the piers until the uplift is equalised on each side of the gate again. If the gate is in a raised position, this event causes the side skids to come into contact with the pier sides.

(iii) Without hydraulic power applied, the winch drums are restrained by brakes. If both brakes fail, the gate falls. A free fall of more than 60 mm causes structural damage to the gate. In the event that one brake fails, the gate jams between the piers.

G.6.7. Fouling of Lifting Tackle

The lifting tackle consists of blocks, wire ropes and winch drums. If the gate is overtopped, debris may be collected on the wire ropes that may in turn foul the blocks or the winch drums. This may result in jamming of the wire rope or in uneven lifting, both of which may cause the gate to jam.

The preventative measure is not to allow the gate to be overtopped.

G.6.8. Fouling of Side Skids

The side skids have been designed to limit the side-sway and skew of the radial gates during operation. Under ideal conditions, the skids should not be in contact with the side seal plates.

If the winches are lifting the gates unevenly or in a skewed position, the lifting gear should be adjusted if possible.

APPENDIX H SOMERSET DAM AUXILIARY EQUIPMENT

H.1. DISCHARGE REGULATION

The normal operating procedure for Somerset Dam in the event of a flood requires the spillway gates to be raised to provide an uncontrolled spillway followed by opening of the low level outlets some time later.

Sketches of the spillway and low level outlets are shown in Appendix J. Somerset Dam is equipped with spillway gates, sluice gates and regulators to control the discharge from the dam. Because the dam is a combined water supply and flood control dam, the spillway is above the FSL and the sluice gates and regulators are 6-10 metres above stream-bed level. It is crucial to the water supply function of the dam that the low level outlets be able to be shut down after their flood release function is completed to ensure that storage is not lost.

Failure of any spillway gate lifting machinery could restrict the discharge capacity of the spillway with resultant risk of overtopping of the dam.

H.2. EMERGENCY POWER SUPPLY

In the event of a power failure at Somerset Dam, the emergency diesel alternator is to be started. The alternator can supply power to the gantry crane, and all gate machinery. If the emergency diesel alternator cannot be started or breaks down during a power failure, the spillway gates and sluice gates are to be operated using the electric motor drive facilities on the winches and a mobile generator.

H.3. FAILURE OF SPILLWAY GATES MACHINERY

If a spillway gate cannot be raised due to failure of the lifting machinery, the gantry crane may be attached to the gate and the gate raised using the gantry crane.

H.4. FAILURE OF SLUICE GATE MACHINERY

In the event of a sluice gate being jammed in the open position or the lifting machinery failing, the coaster gate is to be lowered over the inlet to the sluice to preserve the water supply storage.

If a sluice gate cannot be raised due to failure of the lifting machinery, repairs are to be carried out immediately.

H.5. FAILURE OF REGULATOR MACHINERY

If the regulator gate cannot be lowered and the regulator cones cannot be closed, the regulator coaster gate is to be lowered over the inlet to the regulator. Some damage may be caused to the seals on the coaster gate in this instance, but the resultant leakage will not result in the loss of the water supply storage.

APPENDIX I HYDROLOGIC INVESTIGATIONS

I.1. INTRODUCTION

This appendix describes hydrologic analyses performed as part of the review of design flood hydrology Corporation's dams. This study included an examination of the existing operating procedures for Wivenhoe Dam and Somerset Dam and it includes the use of the latest techniques in design rainfall estimation.

The analyses were carried out using the most appropriate data available in 2001 and it is recommended that they be revised after the occurrence of a large flood or after the adoption of more advanced methods of hydrologic analysis. The work is summarised in a report entitled, 'Brisbane River – Revision of Flood Hydrology', (DNRM, 2001). The work summarised here supersedes previous work including that completed during the design stages of Wivenhoe Dam, details of which are contained in the design report on Wivenhoe Dam and the Brisbane River and Pine River Flood Study reports.

I.2. METHOD

There are three components in the hydrologic analyses:

(i) a rainfall analysis to determine both rainfall frequency and Probable Maximum Precipitation (PMP) and also large and rare rainfall events using the CRC-FORGE methodology

(ii) a model of the catchment rainfall runoff process; and

(iii) a model of the flood operations of the two dams.

The Bureau of Meteorology completed several studies of the Probable Maximum Precipitation. The Australian generalised method for areas subject to tropical cyclones was used and rainfalls for durations up to seven days were estimated. The Probable Maximum Precipitation was estimated for the whole of the Brisbane River catchment, as well as for various sub-catchments. Concurrent rainfall estimates were provided for the remainder of the catchment outside the sub-catchment for which the Probable Maximum Precipitation was provided. The Probable Maximum Precipitation temporal patterns provided by the Bureau of Meteorology were used for all rainfalls.

The estimation of design rainfalls within the large to rare flood range was performed using the CRC-FORGE methodology as described in Book VI of Australian Rainfall and Runoff (1998). The CRC-FORGE method uses the concept of an expanding region focussed at the site of interest. Design rainfall for frequent events (eg 1 in 50 AEP) are based upon pooled data from a few gauges around the focal point, while design rainfall estimates at the AEP of the limit extrapolation are based upon pooled rainfall data from up to several hundred gauges. Before the data from different sites can be poled, maximum annual rainfalls from each site need to be standardised by dividing by an "index variable".

The rainfall runoff models based on a non-linear runoff routing method were used to estimate the floods. The models were calibrated on recorded storm and flood data. The model calibrations were completed in 1993 and were not modified for the latest re-assessment.

Models to simulate the flood operation of Somerset and Wivenhoe Dams developed during the mid-eighties were modified to incorporate the new structure of the hydrologic models and to more accurately reflect the operational procedures of the dams. These models were then used to calculate dam discharges for a range of design floods generated using the rainfall estimates and the runoff routing models.

I.3. RAINFALL ANALYSIS RESULTS

The rainfall analysis was performed in two parts, the Probable Maximum Precipitation estimate by the Bureau of Meteorology and the estimation of large to rare events using the CRC-FORGE method. These were used both for design studies for the dam and to test the effects of flood operation procedures.

The estimates of Probable Maximum Precipitation are listed in Table I-1.

Table I-1
Probable Maximum Precipitation (mm)

Duration (days)	Somerset Dam	Wivenhoe Dam	Brisbane Catchment
1	900	670	530
2	1420	870	680
3	1770	1080	830
4	2090	1250	1010
5	2170	1300	1050
6	2220	1330	1070
7	2410	1480	1160

The estimates of rainfall frequency are listed in tables I-2. These estimates are based upon the CRC-FORGE methodology as recommended in Book VI of Australian Rainfall and Runoff, (1998).

Table I-2

Catchment Rainfall (mm) on Wivenhoe Dam Catchment

Annual Exceedence Probability %	24 Hours	48 Hours	72 Hours
1	199	274	319
0.1	276	393	464
0.01	379	550	659

Catchment Rainfall (mm) on Somerset Dam Catchment

Annual Exceedence Probability %	24 Hours	48 Hours	72 Hours
1	302	430	507
0.1	432	649	775
0.01	554	920	1117
0.001	747	1204	1483

I.4. RUNOFF ROUTING MODEL CALIBRATION

Ten floods were used for calibration: July 1965, March 1967, June 1967, January 1968, December 1971, January 1974, January 1976, June 1983, Early April 1989 and Late April 1989. The gauging stations used for model calibration are listed in Table I-3.

The runoff routing model was calibrated for the nineteen major sub-catchments listed in Table I-4. Each of these models was calibrated for as many sites as possible for each of the ten floods. Data were missing for some of the stations for some of the floods. The estimated model parameters are given in Table I-4. In all cases relative delay time parameter (k) used in the model is related to reach length.

Table I-3

Gauging Stations used for Model Calibration

Stream	Site	Number	AMTD (km)	Catchment Area (km^2)
Stanley River	Somerset Dam		7.2	1 335
Cooyar Creek	Damsite	143015	12.2	960
Brisbane River	Linville	143007	282.4	2 005
Emu Creek	Boat Mountain	143010	10.1	920
Brisbane River	Gregor's Creek	143009	251.7	3 885
Cressbrook Creek	Damsite	143013	58.6	325
Brisbane River	Middle Creek	143008	187.2	6 710
Brisbane River	Wivenhoe Dam		150.2	7 020
Brisbane River	Savage's Crossing	143001	130.8	10 180
Bremer River	Walloon	143107	37.2	620
Warrill Creek	Amberley	143108	8.7	920
Lockyer Creek	Lyon's Bridge	143210	27.2	2 540
Brisbane River	City		22.7	13 260

Table I-4

Estimated Model Parameters

Sub-Catchment Name	Model Parmeters (k)	(m)
(1) Cooyar Creek	43.6	0.8
(2) Brisbane River at Linville	20.6	0.8
(3) Emu Creek at Boat Mountain	37.2	0.8
(4) Brisbane River at Gregors Creek	20.1	0.8
(5) Cressbrook Creek at Cressbrook Dam	34.3	0.8
(6) Stanley River at Somerset Dam	80.7	0.8
(7) Brisbane River at Wivenhoe Dam	108.5	0.8
(8) Lockyer Creek at Helidon	15.0	0.8
(9) Tenthill Creek at Tenthill	19.0	0.8
(10) Lockyer Creek at Lyons Bridge	75.0	0.8
(11) Brisbane River at Savages Crossing	40.0	0.8
(12) Brisbane River at Mount Crosby	47.0	0.8
(13) Bremer River at Walloon	44.0	0.8
(14) Warrill Creek at Kalbar	34.0	0.8
(15) Warrill Creek at Amberley	35.0	0.8
(16) Purga Creek at Loamside	49.0	0.8
(17) Bremer River at Ipswich	15.7	0.8
(18) Brisbane River at Jindalee	20.8	0.8
(19) Brisbane River at Port Office	19.3	0.8

I.5. WIVENHOE DAM FLOODS

Wivenhoe Dam floods were estimated using the rainfalls and runoff routing model already discussed. Inflows to Wivenhoe Dam, assuming the dam to be in existence and full, were calculated, as well as flow at the dam-site without the dam in the catchment. Two-day storms were found to have the critical storm duration for most cases, though the long duration Probable Maximum Precipitations produced very large flood volumes. Table I-6 lists results for the two-day duration storms.

Table I-5
Wivenhoe Dam Floods
(for two-day storm duration)

AEP %	Peak Inflow (m^3/sec)	Peak Outflow (m^3/sec)	Flood Volume (ML)	Peak Lake Level (m AHD)
1	5,400	1,890	1,170,000	73.4
0.1	9,380	6,760	1,710,000	74.9
0.01	15,000	11,300	2,980,000	76.8
PMF	28,600 *****	25,800 *****	5,270,000 *****	81.7 *****

+ - NB. This duration does NOT give the maximum Peak Inflow for a given AEP
*** - Overtopped, estimated flow based on no dam failure**

This assessment assumes certain operational procedures and assumes that the Dam would fail once the embankment crest level of 79.15 was reached.

I.6. SOMERSET DAM FLOODS

Somerset Dam floods were estimated using the rainfalls and runoff routing model already discussed. Inflows to Somerset Dam, assuming the dam to be in existence and full, were calculated, as well as flow at the site without the dam in the catchment. The forty-eight hour PMP storm event was found to be critical, though the long duration PMP's produced very large flood volumes. Table I-6 lists results for the forty-eight hour duration storms.

Table I-6
Somerset Dam Floods
(for two-day storm duration)

AEP %	Peak Inflow (m^3/sec)	Peak Outflow (m^3/sec)	Flood Volume (ML)	Peak Lake Level (m AHD)
1	3,500	1,700	421,000	103.5
0.1	4,500	2,600	690,000	104.5
0.01	6,800	4,700	1,042,000	107.5
0.001	9,200	6,300	1,412,000	109.3
PMF	11,100 *	7,500 *	1,694,000 *	110.3 *

+ - NB. This duration does NOT give the maximum Peak Inflow for a given AEP
*** - Overtopped, estimated flow based on no dam failure**

Studies conducted by structural engineers indicate that Somerset could withstandovertopping to EL 111.7 mAHD.

I.7 FLOOD CONTROL OPERATION MODEL

Floods in the Brisbane River catchment above Wivenhoe Dam can originate in either the Stanley River or upper Brisbane River catchment or both. Both of the dams are capable of being operated in a number of ways, each of which will reduce the flow downstream. However, in order to achieve maximum reduction of flooding downstream of Wivenhoe Dam, it was necessary to review the operations at Somerset and Wivenhoe Dams using a flood operations simulation model.

The most recent flood studies have reviewed the basic hydrologic algorithms in the operational models used in the earlier study and modified them to incorporate additional features relating to gate openings and closings. The revised design flood hydrology and operational model algorithms were then used to re-examine the original five possible operational procedures for each of Somerset Dam and Wivenhoe Dam, giving twenty-five possible combinations to be re-considered. The procedures previously developed for Wivenhoe Dam were designed so that initial release operations did not adversely affect later operations in the event of later rainfall causing the magnitude of the flood to exceed the original estimate.

The procedures previously developed were also designed to restrict flooding in the lower catchment to the lowest level of the following categories where practicable:

(i) low level bridges submerged, Fernvale bridge open;

(ii) all bridges except Mt. Crosby Weir and to Fernvale bridges submerged;

(iii) all bridges submerged, no damage to urban areas;

(iv) damage to urban areas due to peak flow from downstream catchment, no releases from Wivenhoe Dam contributing to peak flow;

(v) extensive damage to urban areas due to combined Wivenhoe Dam releases and downstream flow, Wivenhoe Dam release component of peak flow minimum practicable.

The previous flood studies recommended that one procedure be selected for the operation at Somerset Dam. This procedure had two advantages over the other procedures tested. Firstly, it was feasible for all magnitudes of Stanley River floods tested and, secondly, it was the simplest procedure to carry out. The re-analysis confirmed this conclusion.

The previous flood studies concluded that procedures for Wivenhoe Dam be reduced to four by combining two procedures into one. The resulting four procedures formed a hierarchy and the procedure to be adopted advances to the next procedure as the flood magnitude increases. The re-analysis confirmed this conclusion.

A Real Time Flood Operations Model for Somerset and Wivenhoe has been developed as part of the "Brisbane River and Pine River Flood Studies". This model incorporates the revised operational algorithms.

* Assume no failure of Wivenhoe Dam or Somerset Dam

APPENDIX J DRAWINGS

APPENDIX K BRISBANE RIVER CATCHMENT

Page iii: [1] Deleted	guppy	22/05/2002 10:07:00 AM

DEPARTMENT OF NATURAL RESOURCES & MINES
OFFICE MEMO

Your Ref.: **Our Ref.:** RRD/130/000(377), RRD/130/000(354)
Author: Ron Guppy **Telephone:** [redacted] **Facsimile:** [redacted]

DATE: 26 October 2004

FROM: Principal Engineer, Dam Safety

TO: Director, Dam Safety (Water Supply)

SUBJECT: Flood Mitigation Manual, Wivenhoe and Somerset Dams

Background

The South East Queensland Water Board Act 1979 set a requirement for Flood Mitigation Manuals to be prepared for Wivenhoe Dam and for Somerset Dam. The requirement for Flood Mitigation Manuals for the dams has been retained through the subsequent legislation changes. It currently exists within Water Act 2000.

The then South East Queensland Water Board elected to prepare a combined Manual for the two dams because of the potential effect of Somerset Dam flood operations on Wivenhoe Dam operations. The Manual defines standard procedures for the operation of both Somerset and Wivenhoe Dams during flood periods. Revision 4 of the Manual is the currently approved version. It was approved in September 2002 for a five year period.

The South East Queensland Water Corporation is currently upgrading Wivenhoe Dam to improve its security against failure. This is being done in response to revised flood estimates indicating an increased likelihood of the dam overtopping and failing. The principal component of the new works will be construction of an auxiliary spillway in the form of a fuse plug at the right abutment. Other works are to occur at the main embankment and existing spillway area so that the dam is secure for water levels up to embankment crest level. Throughout the design process for these upgrade works, regular briefings of progress were provided to the local community and other interested parties. In particular representatives of Natural Resources & Mines, SunWater, Brisbane City Council, Ipswich City Council, Esk Shire Council, and Bureau of Meteorology provided a reference group.

The addition of these new works has implications for the operation of Wivenhoe Dam during floods, and to a very limited extent to Somerset Dam. Operation of the dams to prevent unnecessary triggering of a fuse plug also becomes a consideration.

Flood Mitigation Manual Revision

This revision of the Manual has been prepared for the construction period during which upgrading of Wivenhoe Dam is occurring. During this time the maximum flood level will be lowered for construction of the fuse plugs and post-tensioning works will be occurring in the main spillway area. During the construction period, the lowest point of the embankment will be EL 77.0 – the level of the diversion road/coffer dam.

A further request for revision of the manual is anticipated when the auxiliary spillway is fully functional about the end of 2005. A safety review of Somerset Dam should also be complete by

[redacted]

that time. Additional modelling of floods passing through the dams under the new conditions will be available at this time.

The SEQWC's intention to seek revision of the flood mitigation manual was flagged during the design process for the dam upgrading and an initial document containing revised operating procedures was circulated to the reference group of Natural Resources & Mines (WIC – Dam Safety), Sun Water (operator of the dams), Brisbane City Council, Ipswich City Council, Esk Shire Council, and Bureau of Meteorology representatives in May 2004. David Gill of SEQWC also contacted Kilcoy Shire Council regarding the manual revisions. Subsequently where possible the SEQWC has attempted to incorporate the wishes of all parties regarding the operating procedures into the document.

The Corporation has now submitted the document as an updated manual under <u>s499 – Regular reviews of flood mitigation manual</u> of *Water Act 2000* for the chief executive's approval. A copy of the updated manual they are now seeking approval for is attached

The procedures for Somerset Dam remain unchanged from the currently approved manual.

The procedures for Wivenhoe Dam remain generally unchanged for lake levels up to EL 74.0 providing the same downstream flood mitigation effects up to this level. Above this level, the gates may be opened at a quicker rate than previously to minimise the likelihood of the coffer dam being overtopped. Additional provisions are also included for the conduct of works in the main spillway area to ensure full use can be made of the radial gates.

Approval of Manual

Approval of the attached document as a flood mitigation manual would continue to provide the dam owner and operators with protection from civil liability while the procedures are observed (s.500 of *Water Act 2000*).

The *Water Act 2000* provides that the chief executive may get advice from an advisory council before approving a flood mitigation manual. In this instance I recommend that the option to get advice from such an advisory council be waived – those who would make up the advisory council have already been given the opportunity to comment as agency representatives.

Flood mitigation manuals can be approved for periods not exceeding five years. It would seem reasonable to approve this manual for a five year period.

Recommendation

That the *Manual of Operational Procedures for Flood Mitigation for Wivenhoe and Somerset Dam (Revision 5)* submitted by the South East Queensland Water Corporation be approved for five years as a Flood Mitigation Manual under section 497 of *Water Act 2000*. A gazette notice is required to formalise the approval.

Ron Guppy
PRINCIPAL ENGINEER, DAM SAFETY

[redacted]

MANUAL

OF

OPERATIONAL PROCEDURES

FOR FLOOD MITIGATION

FOR

WIVENHOE DAM

AND SOMERSET DAM

Revision No.	Date of Approval	Amendment Details
0	27 October 1968	Original Issue
1	6 October 1992	Complete revision and re-issue
2	13 November 1997	Complete revision and re-issue
3	24 August 1998	Change to page 23
4	6 September 2002	Complete revision and re-issue
5	May 2004	Revision for PMF Works

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

TABLE OF CONTENTS

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

APPENDICES

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

1 INTRODUCTION

1.1 Preface

Given their size and location, it is imperative that Wivenhoe and Somerset Dams be operated during flood events in accordance with clearly defined procedures to minimise hazard to life and property.

Recognising this, the South East Queensland Water Board Act required that the South East Queensland Water Corporation's Technical Advisory Committee cause to be prepared a manual of operational procedures for the dam during floods. With changes to the controlling legislation, the manual became an approved flood mitigation manual under *Water Act 2000* (extract in Appendix A).

This Manual is the result of a review of the 2002 revision of the Manual. The Corporation is required to review, update the Manual if necessary, and submit it to the Chief Executive for approval prior to its expiry. Any amendments to the basic operating procedures need to be treated similarly.

Prior to the 1998 version of the manual, an expanded flood monitoring and warning radio telemetry network (ALERT) was installed in the Brisbane River Catchment. Additionally, a computerised flood operational model that allows for rainfall and river modelling in real time based on data from the ALERT system was developed, implemented and fully commissioned. The accuracy and reliability of the system during a flood event has now been proven.

The primary objectives have not varied from those defined in the previous manual of ensuring safety of the dams, their ability to deal with extreme and closely spaced floods, and protection of urban areas. The basic operational procedures have also remained the same. Wivenhoe Dam and Somerset Dam are operated in conjunction so as to maximise the flood mitigation capabilities of the two dams. The procedures outlined in this Manual are based on the operation of the dams in tandem.

The changes to the 2002 version of the manual have arisen out of the spillway upgrade process for Wivenhoe Dam with the addition of the three bay right abutment fuse plug spillway. The changes enable Wivenhoe Dam to pass a 1:100,000 AEP flood event. The manual covers the provisions introduced to cover flood operations of the dams during the construction period for the spillway upgrade and for flood operations after theses provisions become operational.

Deleted: 1998

Deleted: A

Deleted: has been

Deleted: has been

Deleted: Changes from the previous revision (1998) have mostly arisen from the refinement of gate opening and closing sequences based upon experience obtained during flood events whilst using the real time flood operations model. Other changes have been necessary to fit in with the new regulatory regime provided by the commencement of *Water Act 2000*.

Deleted: which is approximately ??% of the Probable Maximum Flood event

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

1.2 Meaning of Terms

In this Manual, save where a contrary definition appears -

"Act"

means the *Water Act 2000*;

"AEP"

means annual exceedance probability, the probability of a specified event being exceeded in any year.

"Agency"

includes a person, a local government and a department of state government within the meaning of the Acts Interpretation Act 1954;

"AHD"

means Australian Height Datum;

"Bureau of Meteorology"

means the Commonwealth Bureau of Meteorology;

"Chairperson"

means the Chairperson of the South East Queensland Water Corporation;

"Chief Executive"

means the Chief Executive or Director General of the Department of Natural Resources, Mines & Energy;

Deleted: and

"Controlled Document"

means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

"Dams"

means dams to which this Manual applies, that is Wivenhoe Dam and Somerset Dam;

"Dam Supervisor"

means the senior on-site officer at Wivenhoe or Somerset Dam as the case may be;

"EL"

means elevation in metres from Australian Height Datum;

"Flood Operations Engineer"

means the person designated at the time to direct the operations of Wivenhoe Dam and Somerset Dam under the general direction of the Senior Flood Operations Engineer and in accordance with the procedures in this Manual;

"FSL"[1] or "FULL SUPPLY LEVEL"

means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

"Gauge"

when referred to in (m) means river level referenced to AHD, and
when referred to in (m^3/sec) means flow rate in cubic metres per second;

"Headworks Operator"

for the purposes of this manual the Headworks Operator is the South-East Queensland Water Corporation:

Comment [r1]: Page: 7
There is a need to better distinguish between the Headworks Operator and the Corporation.

"Manual" or "Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam"

means the current version of this Manual;

"Power Station"

means the Wivenhoe pumped storage hydro-electric power station associated with Wivenhoe Dam and Split-Yard Creek Dam;

"Senior Flood Operations Engineer"

means the senior person designated at the time pursuant to Section 2.1 of this Manual under whose general direction the procedures in this Manual must be carried out;

"South East Queensland Water Corporation"

means the body corporate constituted by that name pursuant to Part III of the South East Queensland Water Board Act 1979. The Board became a government owned corporation in 2000;

Deleted: "Technical Advisory Committee"¶
means the South East Queensland Water Corporation Limited (ACN 088 729 765), an unlisted public company which owns and operates Wivenhoe Dam, Somerset Dam and North Pine Dam.¶

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

1.3 Purpose of Manual

The purpose of this Manual is to define procedures for the operation of Wivenhoe Dam and Somerset Dam to reduce, so far as practicable, the effects of flooding, by the proper control and regulation in time of headworks under the control of the Corporation, with due regard to the safety of the structures comprising those headworks.

For the purpose of this Manual, the Corporation adopts the policy that the community is to be protected to the maximum extent possible against flood hazards recognising the limitations on being able to:

- identify all potential flood hazards and their likelihood,
- remove or reduce community vulnerability to flood hazards,
- effectively respond to flooding, and
- provide resources in a cost effective manner.

1.4 Legal Authority

This manual has been prepared as a Flood Mitigation Manual in accordance with the provisions of Part 6 Division 2 of the Act.

1.5 Application and Effect

The procedures in this Manual apply to the operation of Wivenhoe Dam and Somerset Dam for the purpose of flood mitigation, and operation in accordance with the manual shall give the protection from liability provided by Section 500 of *Water Act 2000*.

1.6 Date of Effect

The procedures in this Manual shall have effect on and from the date on which this version of the Manual is approved by gazette notice.

The Manual shall remain in force for the period of approval as determined by the chief executive. This approval may be for a period of up to five years.

Before the approval of the Manual expires, the Corporation must review and if necessary update the Manual and submit a copy to the chief executive for approval.

1.7 Observance of Manual

This Manual contains the operational procedures for Wivenhoe Dam and Somerset Dam for the purposes of flood mitigation, and must be applied by the Headworks Operator for the operation of the dams.

1.8 Provision for Variations to Manual

Deleted: The procedures in this Manual shall have effect on and from the date on which this version of

Deleted: e

Deleted: Manual is approved by gazette notice,which was ??

Deleted: 25

Deleted: th

Deleted: October

Deleted: ?? 2004

Deleted: 2

Deleted: (date to be determined).¶

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

If the Corporation is of the opinion that the procedures in this Manual should be amended, altered or varied, it must submit for approval as soon as practical a request, which is in accordance with the flood mitigation provisions of the *Water Act 2000*, to the Chief Executive setting out the circumstances and the exact nature of the amendment, alteration or variation sought. The Chief Executive may require the Corporation amend the Manual by written notice.

1.9 Distribution of Manual

Deleted: ¶
¶
¶

Formatted: Bullets and Numbering

The Corporation must regard the manual as a Controlled Document and ensure that only controlled manuals are used in the direction of flood mitigation activities. Agencies having copies of Controlled Documents are listed in Appendix B. The Corporation must maintain a Register of Contact Persons for Controlled Documents and ensure that each issued document is updated whenever amendments or changes are approved.

Before using this Manual for the direction of flood control, the Headworks Operator must ensure that it is the current version of the Controlled Document.

Comment [r2]: Page: 9
This provision is included again in section 2.8 – It should be able to be left out of here.

Deleted: **<#>Authority to Use Discretion¶**
¶
Where it is reasonable to expect that the safety of either dam will not be reduced, temporary deviations from the procedures detailed in this manual may be made in accordance with Section 2.8

Formatted: Bullets and Numbering

Deleted: .¶

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

Pursuant to the provisions of the Act, the Corporation is responsible for and has the duty for operation and maintenance of Wivenhoe Dam and Somerset Dam, and while it may enter into contracts for the purpose of discharging these responsibilities, for the purposes of this manual the Headworks Operator is the Corporation.

2.1.1 Designation of Senior Flood Operations Engineer

The Headworks Operator must ensure that the procedures set out in this Manual are carried out under the general direction of a suitably qualified and experienced person who shall be referred to hereafter as the Senior Flood Operations Engineer. Only a person authorised in the Schedule of Authorities can give the general direction for carrying out procedures set out in this Manual.

2.1.2 Designation of Flood Operations Engineer

The Headworks Operator must have available or on standby at all times a suitably qualified and experienced Flood Operations Engineer to direct the operation of the dams during floods in accordance with the general strategy determined by the Senior Flood Operations Engineer.

The Headworks Operator must ensure that flood control of the dams is under the direction of a Flood Operations Engineer at all times. Only a person authorised in the Schedule of Authorities can direct the flood operation of the dams.

The Headworks Operator must also employ an adequate number of suitably qualified and experienced persons to assist the Flood Operations Engineer in the operation of the dams during floods.

2.2 Qualifications and Experience of Engineers

2.2.1 Qualifications

All engineers referred to in Section 2.1 must meet all applicable requirements of registration or certification under any relevant State Act, and must hold appropriate engineering qualifications to the satisfaction of the Chief Executive.

2.2.2 Experience

All engineers referred to in Section 2.1 must, to the satisfaction of the Chief Executive, have:

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

(1) Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and

(2) At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:

(a) Investigation, design or construction of major dams;

(b) Operation and maintenance of major dams;

(c) Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;

(d) Applied hydrology with particular reference to flood forecasting and flood warning systems.

2.3 Schedule of Authorities

The Corporation must maintain a Schedule of Authorities containing a list of the Senior Flood Operations Engineers and Flood Operations Engineers authorised to direct flood operations at the dams during floods.

Deleted: For the purpose of directing operation of the dams during floods, a list of suitably qualified and experienced Senior Flood Operations Engineers and Flood Operations Engineers must be maintained in the Schedule of Authorities (Appendix C).

Comment [r3]: Page: 11 This takes the actual names out of the approved manual thereby facilitating the addition of more operators.

The Headworks Operator shall, as the need arises, nominate suitably qualified and experienced engineers for registration in the Schedule of Authorities as Senior Flood Operations Engineers and Flood Operations Engineers. Each new nomination must include a copy of any certificate required under Section 2.2 and a validated statement of qualifications and experience.

The Headworks Operator must obtain the approval for all nominations from the Chief Executive prior to their inclusion in the Schedule of Authorities.

If, in the event of unforseen and emergency situations, no Senior Flood Operations Engineer or no Flood Operations Engineer is available from the Schedule of Authorities, the Headworks Operator must temporarily appoint a suitable person or persons and immediately seek ratification from the Chief Executive.

2.4 Training

The Headworks Operator must ensure that operational personnel required for flood control operations receive adequate training in the various activities involved in flood control operation.

2.5 Dam Operation Arrangements

For the purposes of operation of the dams during times of flood, the Headworks Operator must ensure that:

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

(a) the operation be carried out under the general direction of the Senior Flood Operations Engineer, and

(b) in the direction of operations which may knowingly endanger life or property, the Senior Flood Operations Engineer must where practical liaise with the Chairperson of the Corporation and the Chief Executive or nominated delegate.

2.6 Responsibilities of the Senior Flood Operations Engineer

The Senior Flood Operations Engineer is responsible for the overall direction of flood operations.

Except insofar as reasonable discretion is provided for in Section 2.8 of this Manual, the Senior Flood Operations Engineer must ensure that the operational procedures for the dam shall be in accordance with this Manual.

2.7 Responsibilities of the Flood Operations Engineer

The Flood Operations Engineer must apply the operational procedures in accordance with this manual and the direction set for flood operations. In so doing, account must be taken of prevailing weather conditions, the probability of follow up storms and the ability of the dam to discharge excess flood waters in the period between rainfall events or in the period from the time of detection of conditions associated with the development storm cells to the likely time of occurrence of the rainfall.

2.8 Reasonable Discretion

If in the opinion of the Senior Flood Operations Engineer, based on available information and professional experience, it is necessary to depart from the procedures set out in this manual, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary to meet the situation, provided that the Senior Flood Operations Engineer observes the flood mitigation objectives set out in Section 3 of this Manual when exercising such reasonable discretion.

Before exercising discretion under this Section of the Manual with respect to flood mitigation operations, the Senior Flood Operations Engineer must consult with such of the following persons as are available at the time that the discretion has to be exercised:

the Chairperson of the Corporation, and

the Chief Executive or nominated delegate.

If not able to contact any of the above within a reasonable time, the Senior Flood Operations Engineer may proceed with such other procedures considered as necessary to meet the situation and report such action at the earliest opportunity to the above persons.

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

2.9 Report

The Senior Flood Operations Engineer must prepare a report to the Headworks Operator after each event that requires flood operation of the dams and the report must contain details of the procedures used, the reasons therefore and other pertinent information. The Headworks Operator must forward the report to the Chief Executive together with any comments within six weeks of the completion of the event referred to.

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

3 FLOOD MITIGATION OBJECTIVES

3.1 General

To meet the purpose of the flood operational procedures in this Manual, the following objectives, listed in descending order of importance, are as follows:

(a) Ensure the structural safety of the dams;

(b) Provide optimum protection of urbanised areas from inundation;

(c) Minimise disruption to rural life and traffic movements in the valleys of the Brisbane and Stanley Rivers;

(d) Minimise disruption and impact upon Wivenhoe Power Station;

(e) Minimise disruption to navigation in the Brisbane River.

3.2 Structural Safety of Dams

The structural safety of the dams must be the first consideration in the operation of the dams for the purpose of flood mitigation.

3.2.1 Wivenhoe Dam

The structural safety of Wivenhoe Dam is of paramount importance. Structural failure of Wivenhoe Dam would have catastrophic consequences.

Wivenhoe Dam is predominantly a central core rockfill dam. Such dams are not resistant to overtopping and are susceptible to breaching should such an event occur. Overtopping is considered a major threat to the security of Wivenhoe Dam. Works are being undertaken between May 2004 and December 2005 to build an auxiliary spillway to cope with the 1:100,000 AEP event without overtopping of the dam.

3.2.2 Somerset Dam

The structural safety of Somerset Dam also is of paramount importance. Failure of Somerset Dam could have catastrophic consequences.

Whilst Wivenhoe Dam has the capacity to mitigate the flood effects of such a failure in the absence of any other flooding, if the failure were to occur during major flooding, Wivenhoe Dam could be overtopped and destroyed also.

Somerset Dam is a mass concrete dam. Such dams can withstand limited overtopping without damage. For Somerset Dam the risk of failure increases once a water level of EL 109.7 is exceeded. Failure of such structures is rare but when they do occur, they occur suddenly without warning, creating very severe and destructive flood waves.

Extreme Floods and Closely Spaced Large Floods

Techniques for estimating extreme floods indicate that floods are possible which would overtop both dams. In the case of Wivenhoe Dam such an overtopping would most likely result in the destruction of the dam itself. Such events however require several days of intense rainfall to produce the necessary runoff.

Historical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane River system within a short time of each other. In order to be prepared to meet such a situation, the stored flood-waters from one storm should be discharged from the dams after a flood as quickly as would be consistent with the other major operating principles. Typically the Senior Flood Operations Engineer should aim to empty stored flood-waters within seven days after the flood peak has passed through the lower reaches of the Brisbane River. In a very large flood, this time frame may not be achievable because of downstream flood conditions and it may be necessary to extend the emptying period by several days.

The discharges should be regulated so as to have little impact on the urban reaches of the Brisbane River taking into account inflows into the river downstream of the dams. However they may result in submergence of some bridges. The level of flooding as a result of emptying stored flood-waters after the peak has passed is to be less than the flood peak unless accelerated release is necessary to reduce the risk of overtopping.

3.3 Inundation of Urban Areas

The prime purpose of incorporating flood mitigation measures into Wivenhoe Dam and Somerset Dam is to reduce flooding in the urban areas on the flood plains below Wivenhoe Dam. The peak flows of floods emanating from the upper catchments of Brisbane and Stanley Rivers can be reduced by using the flood-gates to control releases from the dams, taking into account flooding derived from the lower Brisbane River catchments.

The auxiliary spillway being constructed in 2004 and 2005 incorporates fuse plugs. Triggering of a fuse plug will significantly increase floods levels downstream. Where possible, and taking into account the other objectives, gate operations should be designed to prevent operation of the fuse plug in situations where .

Gates clear of the flow before the fuse plug operates.

3.4 Disruption to Rural Areas

While the dams are being used for flood mitigation purposes, bridges and areas upstream of the dams may be temporarily inundated. Downstream of the dam, bridges and lower river terraces will be submerged. The operation of the dams should not prolong this inundation unnecessarily. The deck levels of bridges potentially inundated during flood events are shown on the Drawings in Appendix D.

Formatted: Bullets and Numbering

Deleted: Pre release or accelerated release of storage at damaging flood levels could reduce, but not eliminate the risk of overtopping. Such a measure should be taken only after careful consideration of the reliability of precipitation forecasts and of perceived antecedent conditions. ¶

Deleted: ¶
¶

Comment [r4]: Page: 15
Check whether this is Senior FOP or just FOP.

Deleted: low level

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

Deleted: some low level

Comment [r5]: Page: 16
SEQWC has maps on their website suitable, though with recent road and bridge works on D'Aguilar Highway levels there may not be up to date.

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

3.5 Provision of Pumping Pool for Power Station

Formatted: Bullets and Numbering

The power station is not affected by the reservoir level in Wivenhoe Dam during floods other than the impacts high tail water levels have on the efficiency of the power station. The power station does however require a pumping pool for operation. The loss of storage by dam failure would render the power station inoperative.

3.6 Disruption to Navigation

Formatted: Bullets and Numbering

The disruption to navigation in the Brisbane River has been given the lower priority. The effect of flood flows upon navigation in the river varies widely.

Large ships can be manoeuvred in the river at considerable flood flows. On the other hand, barges and dredges are affected by low flows which lower salinity thus decreasing the density of the water which in turn causes craft to sit lower in the water, sometimes bottoming. The Moggill Ferry is also affected by low flood flows.

A short emptying period for the flood storage compartment of the dams is consistent with Objectives (c) and (e) of Section 3.1, which are closely related.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

4 FLOOD CLASSIFICATION

For the reference purposes of this Manual, five magnitudes of flooding are classified as follows:

Fresh
This causes only very low-level bridges to be submerged.

Minor Flooding
This causes inconvenience such as closing minor roads and the submergence of low-level bridges. Some urban properties are affected.

Moderate Flooding
This causes inundation of low-lying areas and may require the evacuation of some houses and/or business premises. Traffic bridges may be closed.

Major Flooding
This causes flooding of appreciable urban Areas. Properties may become isolated. Major disruption occurs to traffic. Evacuation of many houses and business premises may be required.

Extreme Flooding
This causes flooding well in excess of floods in living memory and general evacuation of whole areas are likely to be required.

Usually a flood does not cause the same category of flooding along its entire length and the relevant agencies shall have regard to this when flooding is predicted.

(The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia)

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

5 FLOOD MONITORING AND WARNING SYSTEM

5.1 General

A real time flood monitoring and warning system is established in the Brisbane Valley. This system is based upon an event reporting protocol. A radio telemetry system (ALERT) is used to collect, transmit and receive rainfall and streamflow information. The system consists of more than 50 field stations that automatically record rainfall and/or river heights at selected locations in the Stanley and Brisbane River catchments. Some of the field stations are owned by the Corporation with the remainder belonging to other agencies.

The rainfall and river height data is transmitted by radio telemetry, via repeater stations, to base stations at the head office of the Headworks Operator (and the Corporation). There the data is processed in real time by computer programs to assess what is occurring in the catchments in terms of flood flows and what could occur if weather conditions continued, or changed.

Other agencies with their own base stations can, and do, receive data transmissions direct, and so collect and are able to process rainfall and streamflow information appropriate to their needs.

The real time flood model (RTFM) is a suite of hydrologic and hydraulic computer programs that utilise the real time ALERT data to assist in the operation of the dams during flood events.

5.2 Operation

The Headworks Operator is responsible for operating the computer model provided by the Corporation for flood monitoring and forecasting during flood events to optimise flood gate operations and minimise the impacts of flooding.

It is the responsibility of the Corporation to maintain and keep calibrated its own equipment; and to enter into such arrangements with other agencies or to provide such further equipment as the Corporation deems necessary for the Headworks Operator to properly operate the computer model for flood monitoring and forecasting.

A system such as this is expected to improve over time due to:

- improved operation and reliability with experience,
- improved calibration as further data becomes available,
- software upgrades, and
- the number, type and locations of sensors being varied.

A regular process of internal audit and management review must be maintained to achieve this.

A log of the performance of all field equipment necessary to properly operate the computer model must be kept by the Corporation. The log is to also include all revised field

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

calibrations and changes to the number, type and locations of gauges. Entries onto the log are to be notified to the Headworks Operator without delay in writing.

A log of the performance of the system (ALERT and RTFM) must be kept by the Senior Flood Operations Engineer. Any faults to the computer hardware or software, and any faults to field equipment which the Corporation has not advised the Headworks Operator of, are to be notified to the Corporation without delay in writing. The Corporation must promptly attend to the matters under its control and refer other matters to the appropriate agencies.

Whenever the Senior Flood Operations Engineer considers that the performance and functionality of the system can be improved, by whatever means, a recommendation must be made to the Headworks Operator accordingly. The Headworks Operator must promptly consider, act on, or refer such recommendations to the Corporation as it considers appropriate.

5.3 Storage of Documentation

The performance of any flood monitoring and warning system is reliant on accurate historical data over a long period of time. The Senior Flood Operations Engineer must ensure that all available data and other documentation is appropriately collected and catalogued as approved by the Corporation, for future use.

5.4 Key Reference Gauges

Key field station locations have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to relocate field stations from these locations, or vary flood classification levels, agreement must first be obtained between the Corporation, Headworks Operator, Bureau of Meteorology and the Local Governments within whose boundaries the locations are situated. The locations and gauge readings at which the various classifications of flooding occur are contained in Appendix D.

Gauge boards that can be read manually must be maintained as part of the equipment of each key field station. The Corporation must have procedures to ensure such gauge boards are read in the event of failure of field stations to operate.

5.5 Reference Gauge Values

Other agencies such as the Bureau of Meteorology, Ipswich City Council and the Brisbane City Council have direct access to the information from field stations for flood assessment purposes. The consultation between agencies is a very important part of the assessment and prediction of flood flows and heights.

The Corporation must ensure that information relative to the calibration of the Corporation's field stations is shared with such agencies.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

6 COMMUNICATIONS

6.1 Communications between Staff

The Corporation is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams.

The Headworks Operator is responsible for ensuring that adequate communication exists at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams. Where equipment deficiencies are detected during normal operations, such deficiencies are to be reported within one week to the Corporation for timely corrective action.

6.2 Dissemination of Information

Some agencies have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public. The Corporation, Headworks Operator, Senior Flood Operations Engineer and Flood Operations Engineer must liaise and consult with those agencies with a view to ensuring all information relative to the flood event is consistent, and used and disseminated in accordance with agreed responsibilities.

Comment [r6]: Page: 20
This was previously the last paragraph in this section.

Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public. Agency information requirements are generally as shown in Table ???.

Deleted: These agencies shall include agencies holding Controlled Documents (Appendix B), and the persons listed in the Schedule of Authorities (Appendix C).

The Flood Operations Engineer must supply information to each of these agencies during dam releases. For this purpose, the Corporation must maintain a Register of Contact Persons for Information, their means of contact including back up systems, and the specific information to be supplied to each. The Corporation must ensure that each agency receives a copy of the updated Register of Contact Persons for Information whenever amendments are made, but at least every 6 months.

Deleted: type of

All enquiries other than provided for in the Register of Contact Persons for Information, either to the Headworks Operator, the Senior Flood Operations Engineer, the Flood Operations Engineer or dam site staff must be referred to the Corporation. The Corporation must provide a mechanism to receive these enquiries from the time it is advised that releases from the dams are likely until flood release operations are completed.

Deleted: ¶
The Flood Operations Engineer must supply information (refer 6.3) to each of these contact persons during dam releases.¶
¶

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

Agency	Interest / Activity	Information Requirement	Trigger level and frequency of reporting
Kilcoy Shire Council	Flood levels upstream of Somerset Dam	Current and predicted flood levels, Somerset Dam	Somerset Dam water level exceeds EL????
Esk Shire Council	Flood Levels upstream and downstream of Wivenhoe Dam Evacuations?	Current and predicted flood levels and discharges, Wivenhoe Dam	Initial gate operation.
Ipswich City Council			
Brisbane City Council			
NRM&E			
Bureau of Meteorology		Actual and projected discharges from Somerset Dam and Wivenhoe Dam	Initial gate operation and thereafter at 3 hourly intervals. annually

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

6.3 Release of Information to the Public

The Corporation is responsible for the issue of information regarding storage conditions and current and proposed releases from the dams to the public and the media.

The Bureau of Meteorology has responsibility for issuing flood warnings.

The Emergency Services Response Authorities, under the Disaster Management Act 2003 [??], have responsibility for the preparation of a local counter disaster plan hence the interpretation of flood forecast information for inclusion in their local flood warnings prepared under the flood sub plan of the counter disaster plan.

Deleted: Some agencies have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public. The Corporation, Headworks Operator, Senior Flood Operations Engineer and Flood Operations Engineer must liaise and consult with those agencies with a view to ensuring all information relative to the flood event is consistent, and used and disseminated in accordance with agreed responsibilities.¶
¶
<#>Nature of Information¶
¶
When, in the opinion of the Flood Operations Engineer, a flood situation is imminent and gate operations are likely, and is of a magnitude that it is likely to cause flows to exceed 2,000 m^3/sec at Lowood, the Flood Operations Engineer must advise those listed in the Register of Contact Persons for Information of : [Is the 2000 m3/sec limit reasonable?]¶
¶
(a) the current and proposed releases from the dams, and¶
¶
(b) the estimated flow rates and water heights at the key reference gauges listed in Appendix D.¶
¶
This information is to be updated at intervals as better and more accurate information becomes available.¶
¶

Formatted: Bullets and Numbering

Deleted: State Counter Disaster Organisation Act 1975

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

7 REVIEW

7.1 Introduction

This review of the Manual has addressed the mechanisms of delegation and control of the dams in periods of operation of the dams for flood mitigation. It is known overtopping of the dams can result should floods occur which are derived from lesser rainfall than the probable maximum precipitation storm or from the combination of two lesser storms in close proximity. The dams may also overtop in the eventuality that the flood-gate control systems fail to operate or partially malfunction during the passage of a major flood or combination of floods.

Procedures and systems have been developed that should enable lower risk operation of the dams for flood mitigation purposes. This technology is intended to provide longer warning times and the capability of examining options to optimise the safety of the dams and minimise the hazard potential and risk to the community.

Deleted: since the last revision

With the passage of time neither the technical assumptions nor the physical conditions on which this Manual is based may remain unchanged. It is also recognised that the relevance of the Manual may change with changing circumstances.

It is important, therefore, that the Manual contain operational procedures which in themselves cause the Manual's procedures, and the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

The checking and reviewing process must involve the Headworks Operator and all associated operations personnel in order that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based.

Variations to the Manual may be made in accordance with provisions in Section 1.8.

7.2 Personnel Training

The Headworks Operator must report to the Corporation by 30th September each year on the training and state of preparedness of operations personnel. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources, Mines & Energy within 14 days of it being received by the Corporation.

Deleted: and

7.3 Monitoring and Warning System and Communication Networks

The Headworks Operator must provide a report to the Corporation by the 1st May and 1st November of each year; and after each flood event. The report must assess in terms of hardware, software and personnel, the :

- adequacy of the communication and data gathering facilities,

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

- reliability of the system over the previous period,
- reliability of the system under prolonged flood conditions,
- accuracy of forecasting flood flows and heights, and
- the overall state of preparedness of the system.

The Corporation must review the report, and taking into account its own log of the performance of the field equipment, take any action considered necessary for the proper functioning and improvement of the system. . A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources, Mines & Energy within 14 days of it being received by the Corporation.

Deleted: and

7.4 Operational Review

After each significant flood event, the Corporation must review the effectiveness of the operational procedures contained in this manual. The Headworks Operator is required to prepare a report for submission to the Corporation within six weeks of any flood event that requires mobilisation of the Flood Control Centre. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources, Mines & Energy within 14 days of it being received by the Corporation.

7.5 Five Yearly Review

Prior to the expiry of the approval period, the Corporation must review the Manual pursuant to Section 6 Division 2 of the Act. The review is to take into account the continued suitability of the communication network, and the flood monitoring and warning system as well as hydrological and hydraulic engineering assessments of the operational procedures. The hydrologic investigations performed for the purpose of this manual are discussed in Appendix I.

Deleted: T

Deleted: , at intervals of no greater than five years

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

8 WIVENHOE DAM

8.1 Introduction

Wivenhoe Dam is capable of being operated in a number of ways to reduce flooding in the Brisbane River downstream of the dam, depending on the part of the catchment in which the flood originates and depending also on the magnitude of the flood.

A general plan and cross-section of Wivenhoe Dam, and relevant elevations are included in Appendix J.*[The suite of drawings need to be modified to reflect the new arrangement]*

Formatted

Storage and discharge data are included in Appendix E. *[The headwater discharge relationships for the fuse plug bays need to be included in Appendix E]*

Formatted

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

Spiltyard Creek Dam is part of the overall Wivenhoe Area Project and it forms the upper pumped storage of the peak power generation scheme. Splityard Creek Dam impounds a volume of 28 700 ML at its normal full supply level (El 166.5). The contents of Splityard Creek Dam can be emptied into Lake Wivenhoe within 12 hours by releasing water through the power station conduits. This volume of water can affect the level in Wivenhoe Dam by up to 300mm when Wivenhoe Dam is close to FSL. The operational level of Splityard Creek Dam should be considered when assessing the various trigger levels of Wivenhoe Dam.

The Corporation has acquired land above FSL to a level of EL 75.0 to provide temporary flood storage. Reasonable care must be exercised to confine the flood rises to below this level. This requirement should be ignored in the case of extreme floods that threaten the safety of the dams.

8.2 Initial Action

When indications are received of an imminent flood, the flood control operation of the dam must commence with the storing of all inflow of the Brisbane River in Wivenhoe Dam, whilst an assessment is made of the origin and magnitude of the flood. The spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding EL 67.25.

8.3 Regulator and Gate Operation Sequences

Deleted: Procedures

Rapid opening of outlets (spillway gates and regulators) can cause hydraulic surges and other effects in the Brisbane River that can endanger life and property and may sometimes have other adverse effects. Under normal gate operations, the gates and regulators are therefore to be operated one at a time at rates that will minimise adverse impacts on the river system.

Deleted: intervals

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

Rapid closure of the gates can affect river-bank stability. Rapid closure of more than one gate at a time should only be used when time is critical and there is a requirement to correct a malfunction to preserve storage or to reduce downstream flooding rapidly. For flood operations where time is not critical, longer closure intervals should be used. The minimum closure intervals specified below are based on experience from the 1974 flood.

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a gate by the immediate opening of a regulator valve (or the reverse operation). This allows for greater control of low flows and enables a smooth transition and closure as slow as possible to prevent the stranding of fish downstream of Wivenhoe Dam.

Except as provided for in procedure 4 of Section 8.4 where it is necessary to have the gate clear of the flow prior to the fuse plug operating and as indicated above, the gate opening and closing intervals as tabled below are the most rapid permitted for flood mitigation purposes.

Table 8.1

8.3.1 WIVENHOE DAM

MINIMUM INTERVALS for Normal Operation

500 mm Incremental gate openings	10 minutes
500 mm Incremental gate closures	20 minutes
Full regulator opening or closures	30 minutes

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions, or when gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool, which has been excavated into erodible sandstone rock, and cause non-predictable erosion. Upstream migration of this erosion is to be avoided. The wing walls adjacent to the flip bucket deflect the discharge away from the walls of the plunge pool when gates 1 and 5 are operated.

Therefore in operating the spillway, the principles to be observed are, in order of priority:

(i) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

(ii) The flow in the spillway is to be symmetrical.

Under normal operation, only one gate is to be opened at any one time and the following sequences are to be adopted:

Formatted: Bullets and Numbering

Deleted: Gates are numbered 1 to 5 from the left bank looking downstream. ¶

Comment [r7]: Page: 9 This section has come from Appendix G, section G1.

Deleted: procedures

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

Approximate Discharge Range	Gate opening sequence	Comments
(a) Up to 330 m^3/sec	1. Open Gate 3 up to 3.5 metres	• Gates 1, 2, 4 & 5 remain closed
(b) 330 m^3/sec to 575 m^3/sec	2. Gate 3 at 3.5 metres 3. Open Gates 2 & 4 alternately to 0.5 metre 4. Open Gate 3 to 4.0 metre 5. Open Gates 2 & 4 alternately to 1.0 metre	• Gates 1 & 5 remain closed unless discharge from Gates 2 & 4 impinges on side wall of plunge pool proceed to (c)
(c) 575 m^3/sec to 1160 m^3/sec	6. Gate 3 kept at 4.0 metres 7. Open Gates 1 & 5 alternately one increment followed by Gates 2 & 4 alternately one increment 8. Repeat Step 7 until at the end of the sequence Gates 1 & 5 are open 1.5 metres and Gates 2 & 4 are open 2.5 metres	• Flow in spillway to be as symmetrical as possible • Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5
(d) 1160 m^3/sec to 1385 m^3/sec	9. Open Gate 3 to 4.0 metres 10. Open Gates 1 & 5 alternately to 2.0 metres followed by opening Gates 2 & 4 alternately to 3.0 metres	• Flow in spillway to be as symmetrical as possible • Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5
(e) 1385 m^3/sec to 2290 m^3/sec	11. Open ALL gates to 5.0 metre openings	• Flow in spillway to be as symmetrical as possible • Gates 2 & 4 are to have openings not less than Gates 1 & 5 or not more than 1.0 metre more than Gates 1 & 5 • Gate 3 is to have an opening not less than Gates 2 & 4 or not more than 1.0 metre more than Gates 2 & 4.
(f) Greater than 2290 m^3/sec	12. Open ALL gates to incrementally in the sequence 3, 2, 4, 1, 5	• Flow in spillway to be as symmetrical as possible • Gate 3 to have the largest opening • Gates 2 & 4 are to have openings greater than Gates 1 & 5

Gates are numbered 1 to 5 from the left bank looking downstream.

Gate openings are occur in 500mm increments unless

Gate operating procedures in the event of equipment failure are contained in Appendix G. If one or more gates are inoperable during the course of the flood event, the gate openings of the remaining gates are to be adjusted to compensate. These adjustments should ensure that:

- The flow in the spillway is as symmetrical as practicable.

Comment [r8]: Page: 10
This doesn't seem consistent with the other discharge ranges.

Comment [r9]: Page: 10
I am not sure what more needs to be done here.

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

- The impact of the flow on the sidewalls of the plunge pool should be minimised.

In general, gate closing is to occur in the reverse order. The final gate closure should occur when the lake level has returned to Full Supply Level.

8.4 Auxiliary Spillways [I think the bulk of this should be moved to Appendix G]

Formatted: Bullets and Numbering

The auxiliary spillway works for Wivenhoe Dam will consist of a three bay fuse plug spillway on the right abutment and a one bay fuse plug spillway at Saddle Dam two. Works will also be undertaken on the main embankment to raise the maximum lake level to 80 m AHD. In setting the maximum lake level, zero freeboard is proposed. Details of the two auxiliary spillways are provided in **Error! Reference source not found.**.
It is proposed to undertake the works in two stages. The works proposed for the first stage consist of:

Formatted: Bullets and Numbering

- The three right bank fuse plug spillways separated by concrete divider walls;
- The construction of a new highway bridge;
- A concrete cut off trench along the main dam wall to intersect with the existing clay core and strengthening of the existing crash barrier to raise the maximum lake level to 80 m AHD; and
- Post tensioning the main spillway monolith to resist overturning at the new maximum lake level.

Stage 1 works increase the dam crest flood to an annual exceedance probability (AEP) of approximately 1 in 100,000. The current dam crest flood is 1 in 22,000 AEP. Pending approvals, Stage 1 works are proposed to commence early 2004 and are to be completed by the end of 2005.
Stage 2 works consist of the construction of a single bay fuse plug at saddle dam 2. It is proposed to review the Stage 2 at the next comprehensive dam safety review due in 2017

Table 8.2 Dam Water Levels at Fuse Plug Initiation Levels, Wivenhoe Dam

Auxiliary Spillway Location	Spillway Crest Control Type	Spillway Crest Width (m)	Spillway Crest Level (m AHD)	Peak Lake Level at Fuse Plug Initiation (m AHD)
Right Bank				
Fuse plug 1	Ogee	34	67	75.7
Fuse plug 2	Ogee	64.5	67	76.25
Fuse plug 3	Ogee	65.5	67	77.2
Saddle Dam 2				
Fuse plug 4	Ogee	100	67	78.3

Error! Reference source not found. shows a cross section of a typical fuse plug embankment. It is effectively a zoned earth and rock fill embankment that is constructed on a non erosive sill or weir. The embankment is designed to erode in a controlled manner when the lake water level reaches a pre-determined level. Below this level, the embankment impounds water in the same manner as a typical zoned earth and rock fill embankment. The upstream face of the embankment consists of a riprap layer to protect against wave action. Consecutive layers consist of coarse rock followed by a coarse filter and then the impermeable clay core that are laid on a similar slope to the riprap. Downstream of the

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

sloping clay core are more layers of filters that lie on compacted rock fill, which extends to the downstream slope of the embankment.

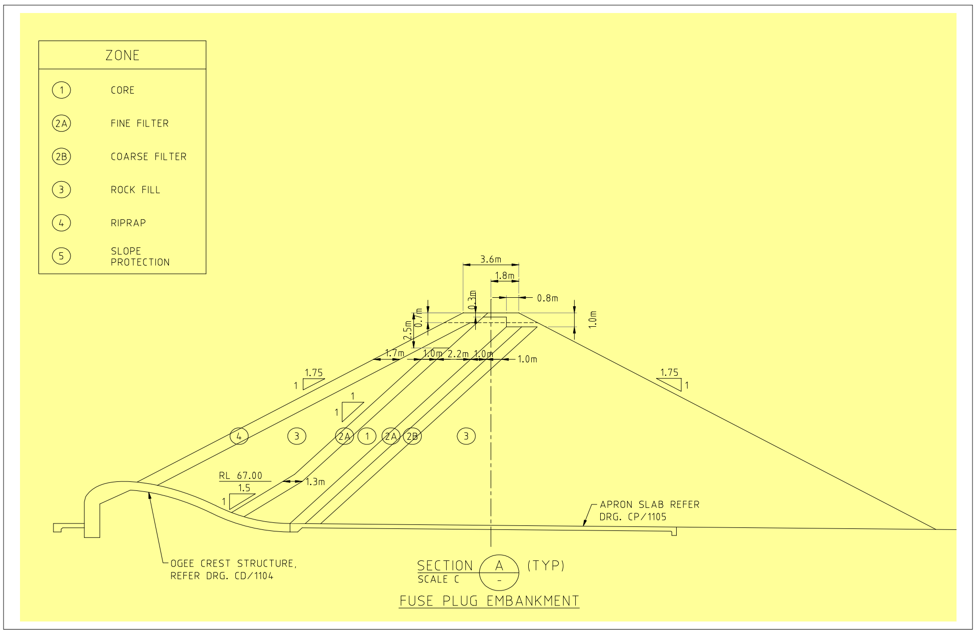
The controlled erosion is initiated at a low point, or pilot channel located in the embankment crest. A narrow vertical slot of coarse filter is located immediately downstream of the pilot channel that extends to the downstream slope of the dam and replaces the compacted rock fill. As the lake water level rises above the pilot channel crest to a depth of about 0.15 m, fast flowing water starts to erode the coarse filter in the vertical slot, which removes the material supporting the sloping clay core eventually causing it to collapse. The material adjacent to the slot is then exposed to the fast flowing water initiating lateral erosion.

Fuse plug performance is largely based on two research projects undertaken by Tinney & Hsu (1961) and Pugh (1985).

The Tinney & Hsu study was conducted as part of the design of the Oxbow Fuse plug at Snake River in the United States. In the study, scale model tests were conducted in both the laboratory and the field to investigate the behaviour and performance of fuse plug spillways. Pugh's study used laboratory models to simulate full sized fuse plugs from 3 m to 9 m high. Both studies found that the fuse plugs washed out in an orderly and predictable manner. They found that the rate of erosion is proportional to the type of material used and height of the embankment.

The NSW Public Works and Services, now the NSW Department of Commerce, extrapolated the results of these studies to design the 15 m high fuse plug embankments at Warragamba Dam in Sydney (DPWS, 1998). The analysis undertaken for Warragamba Dam has been used to select the material and estimate the lateral erosion rates for the proposed fuse plugs at Wivenhoe Dam. Based on the fuse plug material selected for Wivenhoe, lateral erosion rates of 100 m per hour are expected.

Error! Reference source not found. cross section of a typical fuse plug embankment.



Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

8.5 Flood Control Procedures

When the preliminary estimation of the degree of expected flooding has been made, the operating procedures set out hereunder shall be used at Wivenhoe Dam in line with the Flood Mitigation Objectives.

When considering the discharge to be made from both Wivenhoe Dam and Somerset Dam under particular procedures, the total discharge for each dam from all sources is to be considered when determining the appropriate openings for gates, valves and sluices.

The procedures to be adopted commence with Procedure 1 and extend through to Procedure 4 as the magnitude of the flood as predicted by the RTFM increases. Table ?? provides **indicative** limits of application for each procedure for the initial filling of Wivenhoe Dam. Once Wivenhoe Dam has peaked and the drainage phase has commenced the indicative limits will not apply.

Provision is made for the releases to be regulated so as to lessen the impact when peak flows from Lockyer Creek, Bremer River and other tributaries enter the Brisbane River. This may result in the releases being decreased for a time even though lake levels are rising.

Provision is also made for the releases from Wivenhoe Dam to be regulated in the early procedures so as not to unduly submerge bridges. The relevant bridges and their estimated submergence flows are included in Appendix D.

Formatted: Bullets and Numbering

Comment [r10]: Page: 13 This shouldn't refer to Somerset Dam.

Deleted: As the magnitude of the expected flood increases,

Deleted: t

Comment [r11]: Page: 13 Can include the section Rob Ayre has written describing the procedures.

Deleted: set out in the following table in response to current and predicted inflows both into the dams, and into the Brisbane River from tributaries downstream of the dams. This t

Formatted

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

Wivenhoe Dam - Normal Gate Operating Procedures: Initial Filling Phase

Procedure	Current Reservoir Level	Applicable Limits		
0	**EL ≤ 67.25**	$Q_{Wivenhoe}$ = 0 m³/sec ... i.e No Releases		$Q_{Moggill}$ < 4000 m³/sec
1A	**67.25 < EL ≤ 67.50**	$Q_{Wivenhoe}$ < 110 m³/sec	$Q_{Colleges\ Crossing}$ < 175 m³/sec with care taken not to submerge Twin Bridges prematurely	
1B	**67.50 < EL ≤ 67.75**	$Q_{Wivenhoe}$ < 380 m³/sec	$Q_{Burtons/Noogoorah}$ < 430 m³/sec with care taken not to submerge Colleges Crossing prematurely	
1C	**67.75 < EL ≤ 68.00**	$Q_{Wivenhoe}$ < 500 m³/sec	Q_{Kholo} < 550 m³/sec with care taken not to submerge Burtons/Noogoorah prematurely	
1D	**68.00 < EL ≤ 68.25**	$Q_{Wivenhoe}$ < 900 m³/sec	$Q_{MtCrosby}$ < 1900m³/sec with care taken not to submerge Kholo prematurely	
1E	**68.25 < EL ≤ 68.50**	$Q_{Wivenhoe}$ < 1500 m³/sec	$Q_{MtCrosby}$ < 1900m³/sec with care taken not to submerge Kholo prematurely	
2	**68.50 < EL < 74.00**	Q_{Lowood} < 3500 m³/sec	Q_{Lowood} < peak of Lockyer and Q_{Lowood} < peak of Bremer	Gates are NOT to be overtopped
3	**68.50 < EL < 74.00[1]**	Q_{Lowood} < 3500 m³/sec	$Q_{Moggill}$ < 4000 m³/sec	
4	**EL ≥ 74.00 or dam safety may be compromised**	Gates are to be opened until reservoir level begins to fall	Gate opening interval restrictions NO LONGER apply	

1 The EL 74.00 trigger level for the initiation of Procedure 4 may be varied in accordance with the provisions of Section ?.?.

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

The gate opening sequences specified are to be overridden when the gates will be overtopped during normal operation.

In procedure 2, if there is little or no flow in Lockyer Creek, the release from Wivenhoe Dam should be limited to between 1900 m^3/sec and 2000 m^3/sec with care taken not to submerge Mt Crosby Weir Bridge or Fernvale Bridge prematurely. If the flood storage compartments of Wivenhoe Dam and Somerset Dam cannot be emptied within the prescribed time of seven days, the release from Wivenhoe Dam should be limited to between 1900 m^3/sec and 3500 m^3/sec. In such circumstances, the release from the dam should be less than the peak inflow into the lake.

8.6 Closing Procedures

Formatted: Bullets and Numbering

If at the time the lake level in Wivenhoe Dam begins to fall, the combined flow at Lowood is in excess of 3500 m^3/sec, then the combined flow at Lowood is to be reduced to 3500 m^3/sec as quickly as practicable having regard to Section 3.3, and is to remain at this rate until final gate closure procedures can commence.

Gate closing procedures should be initiated having regard to the following requirements:

(a) Early release of stored water to regain flood-mitigating ability for any subsequent flood inflows as described in Section 3.3.

(b) Gate operation procedures as described in Section 8.3.

(c) Downstream impact of the discharges. To prevent the stranding of fish downstream of the dam, closures below flows of 275 m^3/sec should be undertaken as slow as practicable and if possible such closures should occur during daylight hours on a weekday so that personnel are available for fish rescue.

(d) Establishment of storage at FSL at completion of flood events.

(e) The total discharge from Wivenhoe Dam from all sources is to be considered when considering appropriate closing procedures. This includes any discharge from triggered fuse plugs.

Formatted: Bullets and Numbering

Deleted: <#>8.6 Coping with Extreme Floods¶
¶
The current procedures apply for floods with predicted levels up to EL 74 and greater but where the flood discharge is through the existing gated spillway. In order to cope with large volume floods auxillary spillways will be built where flood levels are predicted to exceed EL 75 and outflows greater than the gated spillway capacity. This will be a second spillway will be a fuse plug spillway in the right embankment, and a future third spillway in saddle dam 2¶
¶

8.7 Modification to Flood Operating Procedures to Prevent Fuse Plug Operation

Formatted: Bullets and Numbering

Where flood modelling indicates that it is possible to modify gate openings to 'just prevent a fuse plug from operating', the Senior Flood Operations Engineer is given the discretion to do so. This may be done by:

Formatted

Formatted

Formatted

Formatted

- Reducing the headwater level at which Procedure 4 initiates;

  The minimum level at which Procedure 4 is to be triggered under these circumstances is EL 73.0 m AHD. *[What studies can be done to validate this level??]*

- Varying the interval between gate operations;

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

If the flood level in Wivenhoe using the minimum gate opening intervals for normal operation specified in Section 8.3 is predicted to peak below a level of 75.5 m AHD no changes are to be made to the specified flood operating procedures.

If the flood level in Wivenhoe using the minimum gate opening intervals for normal operation is predicted to be above 75.5 m AHD, but is predicted to be below 75.5 m AHD using a 1 m in 10 minute gate opening procedure, the gates may be raised at a rate to maximise flood storage capacity but to prevent the first fuse plug from initiating. (An allowance of 0.2 m below the initiation level of the first fuse plug has been given to account for errors in predicting flood levels and possible wave run up, which may cause premature initiation of the fuse plug).

- Storing additional water in Somerset Dam;

  Somerset gates and valves can be temporarily closed to prevent a fuse plug from initiating. With respect to the safety of Somerset, SMEC (2004) estimated that the dam has an increased risk of cracking at a headwater level of 109.7 m AHD. Altering the Somerset gate operating procedures is considered safe below this level

- A combination of the above.

This discretion is given subject to:

- the safety of either Wivenhoe Dam or Somerset Dam not being compromised;
- The increase in the resultant discharges is not to be more than 50% (??) of the incremental discharge produced by the operation of the fuse plug;
- the decision to modify the flood operation procedures is only to be taken after careful consideration of the impact of forecast rainfall and inflows on headwater levels and the consultation procedure specified in Section 2.8 is to be followed;

8.8 Modification to Flood Operating Procedures with Fuse Plug Operation

The general philosophy is to maintain the existing flood storage to mitigate downstream flooding but to maximise the capacity of the existing spillway to reduce the chance of the fuse plugs initiating. A release from a fuse plug will cause significant erosion immediately downstream of the dam and will also increase downstream flood flows and flood levels within a short period. Initiation of a fuse also limits the opportunity to mitigate consecutive floods until the fuse plugs are re-constructed. A summary of the proposed changes to the gate opening procedures following the completion of the proposed upgrade works is outlined below:

- Wivenhoe gate opening procedures 1, 2 and 3 will remain unchanged. ;
- If the flood level in Wivenhoe using a 1 m in 10-minute gate opening procedure is predicted to be above 75.5 m AHD, the gates are to be raised at a rate to ensure they are out of the water before the initiation of the first fuse plug. Where practicable, the gates are to be secured in a locked position before the dam water level reaches 75.7 m AHD.

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

Deleted: This means that the proposed works will not affect outflows until the dam reaches a water level of 74 m AHD. It is noted that the 1999 flood, which had an AEP of about 1 in 100 at the dam reached a peak water level of 70.41 m AHD

Formatted: Bullets and Numbering

Deleted: T

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

- The concepts of the Wivenhoe gate closure rules will remain unchanged. However, releases from the main spillway may be reduced to recompense the releases from the auxiliary spillways to reduce the downstream flows below the non-damaging flows as quickly as possible, whilst still ensuring flood storage is available for consecutive floods within 7 days.

Formatted: Bullets and Numbering

8.9 Modification to Flood Operating Procedures if a subsequent flood event occurs prior to the reconstruction of Triggered Fuse Plugs

Formatted

Formatted: Bullets and Numbering

Where the operation of any or all of the fuse plug spillway bays has been triggered and a flood event occurs before the fuse plug can be reinstated, the flood operation procedures are to be modified such that:

- The discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;
- the gates are to be operated, to the extent possible, so that the same discharge restrictions apply as would have if the fuse plug embankment was intact.

Formatted: Bullets and Numbering

Deleted: ¶

8.10 Modification to Flood Operating Procedures during Construction of Right Abutment Auxiliary Spillway

8.10.1 Works in the Auxiliary Spillway

Formatted: Bullets and Numbering

Formatted

For the Stage 1 auxiliary spillway, it is proposed to construct a temporary road diversion on the upstream side of the works that will act as a temporary coffer dam for the first half of the project. The lowest point of the diversion road/coffer dam is 77 m AHD, which is at the height of the clay core of the existing dam. That is, there will be no loss of flood storage during the first half of the construction program. When the fuse plug has been constructed to a level of 74 m AHD and the new road bridge is built, the temporary coffer dam will be removed and the upstream spillway chute will be excavated, thereby lowering the available flood storage before a fuse plug initiates. Current assessments indicate the annual exceedance probability of the flood that reaches a lake level of 74 m AHD is about 1 in 500 at the dam. Floods exceeding this level will flow through the construction works. The fuse plug construction program for this period will be of a number of months duration programmed for winter 2005. During this period flow through the existing gated spillway should be maximised.

Deleted: T

Comment [r12]: Page: 18 This could go into safety conditions associated with the development permit.

8.10.2 Construction Works within the Gated Spillway

Formatted: Bullets and Numbering

Deleted: 8.9.2

Formatted

Formatted

The following provisions will apply for works undertaken within the gated spillway:

- The opening of spillway gates to discharge floodwaters is at the sole discretion of the Senior Flood Operations Engineer;
- There is to be no obstruction of any spillway bay without the approval of the Senior Flood Operations Engineer;
- No more than one gated spillway bay is to be obstructed at any one time;
- All construction material will be removed from the main spillway within 12 hours of being notified by the Senior Flood Operations Engineer. The bulkhead will also be

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

raised once the construction material has been removed. That is, all gates are to be capable of being operated at short notice during a flood if required;

Deleted: will

- A gate can remain closed if a flood will severely damage works if it is opened, and the expected flood magnitude can be catered for with 4 gates. The other gates are to be operated in accordance with the existing flood operational procedures but to compensate for the loss of flow in the closed gate;

Formatted: Bullets and Numbering

- As the flood rises to the top of the closed gate, at an elevation of 73 m AHD, the gate is incrementally raised to prevent it from being overtopped. It is noted that a large flood is required for the lake level to reach 73 m AHD.

Formatted: Bullets and Numbering

Table 8.1 Peak Outflows and Maximum Lake Levels at Fuse Plug Initiation, Wivenhoe Dam

Fuse Plug No. Initiated	Approx. AEP (1 in X Years)	Peak Outflow (m^3/s)			Maximum Lake Water Level (m AHD)
		Gated Spillway	Right Abutment Spillway	Saddle Dam 2 Spillway	
1	5,000	10,500	1,600	0	75.7
2	11,500	11,000	5,300	0	76.25
3	30,000	12,200	10,200	0	77.2
4	53,000	13,000	11,850	7,450	78.3

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

9 SOMERSET DAM

9.1 Introduction

Somerset Dam is capable of being operated in a number of ways to regulate Stanley River floods and optimise the flood mitigation capacity of Wivenhoe Dam.

A general plan and cross-section of Somerset Dam, and relevant dam operating levels are included in Appendix J.

The discharge capacities for various storage levels of Somerset Dam are listed in Appendix F.

9.2 Initial Action

Upon indications being received of a significant inflow, the flood control operation of the dam shall commence with the raising of any closed gates and the closure of all low level regulators and sluices, whilst an assessment is made of the origin and magnitude of the flood.

9.3 Regulator and Gate Operation Procedures

The following minimum intervals must be observed whilst opening and closing regulators, sluices and crest gates at Somerset Dam for flood mitigation purposes:

Table 9.1
SOMERSET DAM
MINIMUM INTEVNALS FOR NORMAL OPERATIONS

Deleted: R

	OPENING	CLOSING
Regulators	30 minutes	60 minutes
Sluice Gates	120 minutes	180 minutes
Crest Gates	Gates are normally open	

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a sluice gate by the immediate opening of one or more regulator valves (or the reverse operation). This allows for greater control of low flows and enables a smooth transition on opening and closing sequences.

9.4 Flood Control Procedure

It is essential that the operating procedures adopted should not endanger the safety of Wivenhoe Dam. Within this constraint, the Senior Flood Operations Engineer must adopt a procedure for the operation of Somerset Dam such that:

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

(a) the structural safety of Somerset Dam is not endangered;

As indicated in Section 8.7, Somerset gates and valves can be temporarily closed to prevent a fuse plug from initiating. With respect to the safety of Somerset, SMEC (2004) estimated that the dam has an increased risk of cracking at a headwater level of 109.7 m AHD. Altering the standard Somerset gate operating procedures is considered safe below this level

(b) the Upper Brisbane River flood flow plus Somerset Dam releases does not cause Wivenhoe Dam to be overtopped.

The normal operating procedure to be used for Somerset Dam is as follows.

The crest gates are raised to enable uncontrolled discharge. The low level regulators and sluices are to be kept closed until either:

(i) the lake level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

In the case of (i) above the opening of the regulators and sluices is not to increase the inflow to Wivenhoe Dam above the peak inflow from the Brisbane River just passed or, if possible, not to cause the Wivenhoe Dam lake level to exceed EL 74.

In the case of (ii) above, the Senior Flood Operations Engineer must direct the operation of the low-level regulators and sluices to ensure the safety of Somerset Dam. It should also be recognised that the D'Aguilar Highway at Mary Smokes Creek becomes inundated when Lake Somerset exceeds EL 102.2.

If the flood event emanates from the Stanley River catchment only, without significant runoff in the Upper Brisbane River catchment, the operation of Somerset Dam will proceed on the basis that Wivenhoe Dam has peaked as per (i) above.

Comment [r13]: Page: 20
There must be more to the procedures than this.

Deleted: Page Break

10 EMERGENCY

10.1 Introduction

While every care has been exercised in the design and construction of the dams, there still remains a low risk that the dams may develop an emergency condition either through flood events or other causes. Experience elsewhere in the world suggests that vigilance is required to recognise emergency flood conditions such as:

- Occurrence of a much larger flood than the discharge capacity of the dam;
- Occurrence of a series of large storms in a short period;
- Failure of one or more gates during a flood.
- Development of a piping failure through the embankment of Wivenhoe Dam;
- Damage to the dams by earthquake;
- Damage to the dams as an act of war or terrorism;

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

- Other uncommon mechanisms.

Responses to these and other conditions are included in separate Emergency Action Plans.

10.2 Overtopping of Dams

Whatever the circumstances, every endeavour must be made to prevent overtopping of Wivenhoe Dam by the progressive opening of operative spillway gates.

The probability of overtopping of Wivenhoe Dam will be significantly reduced following the completion of the auxiliary spillway.

Somerset Dam should, if possible, not be overtopped by flood water but, if Wivenhoe Dam is threatened by overtopping, the release of water from Somerset Dam is to be reduced, for example by the use of its spillway gates, even at the risk of overtopping Somerset Dam in order to prevent, if possible, the overtopping of Wivenhoe Dam.

Deleted: In the event that
Deleted: t
Deleted: is unacceptably high, then as an absolute last resort the saddle dams may be breached. Such actions must only be initiated with the approval of the Chief Executive
Deleted: .
Deleted: s
Deleted: ¶

10.3 Communications Failure

In the event of normal communications being lost between the Flood Operations Engineer and either Wivenhoe Dam or Somerset Dam, the dam supervisor at that dam is to maintain contact with the dam supervisor at the other dam, to receive instructions through the remaining communications link.

In the event of normal communications being lost between the Flood Operations Engineer and both Wivenhoe Dam and Somerset Dam, the dam supervisors at each dam are to adopt the procedures set out below during flood events, and are to maintain contact with each other, where possible.

If all communications are lost between the Engineer, Wivenhoe Dam and Somerset Dam, the officers in charge at each dam are to adopt the procedures set out below.

10.4 Wivenhoe Dam Emergency Procedure

In the event of total communication failure, the minimum gate openings related to lake level set out in the table below are to be maintained for both opening and closing operations.

Table 10.4 Minimum Gate Openings Wivenhoe Dam

Lake Level m AHD	Gate 3 Opening (m)	Gates 2 & 4 Opening (m)	Gates 1 & 5 Opening (m)	Total Discharge m^3/sec

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

67.0		-	-	0
67.5	0.5	-	-	50
68.0	1.5	-	-	155
68.5	2.5	-	-	260
69.0	3.5	0.5	-	470
69.5	4.0	1.0	-	640
70.0	4.0	1.5	0.5	875
70.5	4.0	2.0	1.0	1115
71.0	4.0	2.5	1.5	1365
71.5	4.5	2.5	2.0	1560
72.0	4.5	3.0	2.5	1820
72.5	5.0	4.0	3.0	2250
73.0	5.0	5.0	5.0	2960
73.5	6.5	6.5	6.5	3850
74	Raise gates at			
74.5	rate of I metre			
75	per 10 minutes			
75.5	FULLY OPEN	FULLY OPEN	FULLY OPEN	5500
76				7112
76.5				8723
77				10335
77.5				10790
78				11250
78.5				11720
79				13600
79.5				13500
80				13440

If one or more gates become inoperable, then by reference to Table E-2 the gate openings of operable gates are to be increased in order that the discharges for the lake levels shown in Table 10.4 are achieved.

If, because of compliance with the provisions of Section 8.3 and the high inflow rate, the minimum gate openings cannot be maintained, the time intervals between successive openings shown in Table 8.1 are to be halved.

If the actual gate openings fall more than three settings below the cumulative number of minimum settings of Table 10.4, then successive gate operations are to be carried out as rapidly as possible until the minimum settings are achieved. Under these circumstances, it may be necessary to operate more than one gate at any one time.

Deleted: ¶

Deleted: ¶

Deleted: ¶

Deleted: ¶

Deleted: ¶

Deleted: 74.0¶ 74.5¶ 75.0¶ 75.5¶ 76.0¶ 76.5¶ 77.0

Deleted: 8.0¶ 10.0¶ 12.5¶ 14.0¶ Fully Open¶ Fully Open¶ Fully Open

Deleted: 8.0¶ 10.0¶ 12.5¶ 14.0¶ Fully Open¶ Fully Open¶ Fully Open

Deleted: 8.0¶ 10.0¶ 12.5¶ 14.0¶ Fully Open¶ Fully Open¶ Fully Open

Deleted: 4750¶ 6030¶ 7830¶ 9150¶ 10790¶ 11250¶ 11720

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

10.5 Somerset Dam Emergency Procedure

In the event of total communication failure, the spillway gates are to be kept raised to allow uncontrolled discharge. The regulators and sluices are to be kept closed until either:

(i) the level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

The level in Wivenhoe Dam can be determined locally by the Dam Supervisor at Somerset Dam from the tailwater gauge located just downstream of Somerset Dam.

In the case of (i) above, the opening of the regulators and sluices is not to increase the level in Wivenhoe Dam above the peak level already attained. Section 9.3 on regulator and gate operation interval is to be observed.

In the case of (ii) above, the regulators and sluices are to be operated such that the free-board between the flood level in Wivenhoe Dam and EL 77 is the same as the free-board between the flood level in Somerset Dam and the non-spillway crest level in Somerset Dam (EL 107.46). The low level outlets in Somerset Dam are not to be opened if the water level in Wivenhoe Dam exceeds the level set out below for given water levels in Somerset Dam.

Somerset Lake Level m AHD	Wivenhoe Lake Level m AHD
102.5	72
103.5	73
104.5	74
105.5	75
106.5	76
107.46	77

The constraints applicable to case (i) operation above do not apply to case (ii) operation.

10.6 Equipment Failure

In the event of equipment failure the action to be taken is indicated in Appendix G for Wivenhoe Dam and Appendix H for Somerset Dam.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

APPENDIX A EXTRACT FROM ACT

EXTRACT FROM WATER ACT 2000

Division 2 – Flood Mitigation

Owners of certain dams must prepare flood mitigation manual

496.(1) A regulation may nominate an owner of a dam as an owner who must prepare a manual (a "flood mitigation manual") of operational procedures for flood mitigation for the dam.

(2) The regulation must nominate the time by which the owner must comply with section 497(1).

Approving flood mitigation manual

497.(1) The owner must give the chief executive a copy of the flood mitigation manual for the chief executive's approval.

(2) The chief executive may, by gazette notice, approve the manual.

(3) The approval may be for a period of not more than 5 years.

(4) The chief executive may get advice from an advisory council before approving the manual.

Amending flood mitigation manual

498.(1) The chief executive may require the owner, by notice, to amend the flood mitigation manual.

(2) The owner must comply with the chief executive's request under subsection (1).

(3) The chief executive must, by gazette notice, approve the manual as amended.

(4) The approval of the manual as amended must be for-

(a) the balance of the period of the approval for the manual before amendment; or

(b) a period of not more than 5 years from the day the manual as amended was approved.

(5) The chief executive may get advice from an advisory council before approving the manual as amended.

Regular reviews of flood mitigation manual

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

499. Before the approval for the flood mitigation manual expires, the owner must-

(a) review, and if necessary, update the manual; and

(b) give a copy of it to the chief executive under section 497.

Protection from liability for complying with flood mitigation manual

500.(1) The chief executive or a member of the council does not incur civil liability for an act done, or omission made, honestly and without negligence under this division.

(2) An owner who observes the operational procedures in a flood mitigation manual approved by the chief executive 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**" includes-

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

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

(c) an agent of the owner or operator of the dam

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

APPENDIX B AGENCIES HOLDING DOCUMENTS

AGENCIES HOLDING CONTROLLED DOCUMENTS
OF
MANUAL OF OPERATIONAL PROCEDURES
FOR FLOOD MITIGATION FOR
WIVENHOE DAM AND SOMERSET DAM

Dam Owner	South East Queensland Water Corporation
Emergency Services	Department of Emergency Services, Disaster Management Service Brisbane City Counter Disaster Committee Esk Shire Counter Disaster Committee Ipswich City Counter Disaster Committee Kilcoy Shire Counter Disaster Committee
Severe Weather Warning Authority	Bureau of Meteorology
Primary Response Authorities	Brisbane City Council Esk Shire Council Ipswich City Council Kilcoy Shire Council
Regulator of Dam Safety	Department of Natural Resources and Mines
Schedule of Authorities, Appendix C	Agencies and persons listed in Appendix C

The Corporation must keep a register of contact persons of holders of controlled documents (Section 1.9 refers).

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

APPENDIX C SCHEDULE OF AUTHORITIES

AUTHORITY	AGENCY/PERSON	APPROVED BY	APPROVAL DATE	REFERENCE
Senior Flood Operations Engineer	Robert Arnold Ayre SunWater	Chief Executive	Date of approval of this manual	
	John Lawrence Ruffini Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	
Flood Operations Engineer	Peter Hugh Allen Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	
	Robert Arnold Ayre SunWater	Chief Executive	Date of approval of this manual	
	John Lawrence Ruffini Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	
	Toby Leonard McGrath SunWater	Chief Executive	Date of approval of this manual	
	Donald James Cock Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

APPENDIX D GAUGES AND BRIDGES

Deleted: ¶

Formatted

D.1. KEY REFERENCE GAUGES

BRISBANE CITY

	FLOOD CLASSIFICATION			
Gauge	Minor	Moderate	Major	1974 Flood
Moggill	10.0	13.0	15.5	19.9
Jindalee	6.0	8.0	10.0	14.1
Brisbane City Gauge (B.C.G)	1.7	2.6	3.5	5.5

(Reference: Brisbane City Disaster Management Plan, Flood Management Special Plan 30 July, 1996)

IPSWICH CITY

	FLOOD CLASSIFICATION			
Gauge	Minor	Moderate	Major	1974 Flood
David Trumpy Bridge	7.0	9.0	11.7	20.7
Mt Crosby Weir	11.0	13.0	21.0	26.7
Moggill	10.0	13.0	15.5	19.9

ESK SHIRE

	FLOOD CLASSIFICATION		
Gauge	Minor	Moderate	Major
Lowood Alert Station	8.6	15.9	21.2

KILCOY SHIRE

	FLOOD CLASSIFICATION		
Gauge	Minor	Moderate	Major
Somerset Dam Reservoir Level	103.0	105.0	106.0

Values are in metres AHD

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

APPENDIX D GAUGES AND BRIDGES

Formatted

Formatted

D.2. SUBMERGENCE FLOWS FOR BRIDGES

AMTD	Bridge Name	Estimated Submergence Flow m^3/sec
140	Twin Bridges	50
132	Savage's Crossing	130
87	College's Crossing	175-200*
120	Burton's Bridge	430
100	Kholo Bridge	550
91	Mt.Crosby Weir Bridge	1900
136	Fernvale Bridge	2000

* Affected by tides.

Twin Bridges, Wivenhoe Pocket Road, Fernvale
Savage's Crossing, Banks Creek Road, Fernvale
College's Crossing, Mt Crosby Rd, Karana Downs
Burton's Bridge, E Summerville Rd, Borallon
Kholo Bridge, Kholo Rd, Ipswich
Mt Crosby Weir Bridge, Allawah Rd, Mt Crosby
Fernvale Bridge, Brisbane Valley Highway, north of Fernvale

Flood Level Increases in metres in Brisbane River due to Fuse Plug Operation

Location	Fuse Plug 1	Fuse Plug 2	Fuse Plug 3	Fuse Plug 4 (Saddle Dam 2)
Savages Crossing (Fernvale)	0.7	1.1	0.9	1.5
Moggill Gauge	0.3	0.5	0.4	0.6

APPENDIX D 3

Flood Peak Travel Time Following Fuse Plug Initiation, Brisbane River

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

Location	Flood Peak Travel Time Following Fuse Plug Initiation (hours)							
	Fuse Plug 1		Fuse Plug 2		Fuse Plug 3		Fuse Plug 4 (Saddle Dam 2)	
	Before	After	Before	After	Before	After	Before	After
Wivenhoe Dam	53.0	53.0	54.0	51.5	53.5	52.5	53.5	53.5
Savages Crossing (Fernvale)	60.0	60.5	58.0	57.5	56.5	55.5	55.5	55.0
Mt Crosby Weir	70.5	69.5	68.5	67.0	65.5	64.0	61.5	61.0
Moggill Gauge	76.5	76.0	75.5	75.0	73.0	72.5	70.0	69.0
Port Office Gauge	88.0	88.0	88.0	87.5	86.5	87.0	84.0	82.5

APPENDIX E WIVENHOE DAM TECHNICAL DATA
TABLE E1 STORAGE AND UNCONTROLLED DISCHARGES
[MODIFY TO INCLUDE FUSE PLUG DISCHARGES OR PUT IN TABLE E2]

Lake level m AHD	Storage Capacity 10^6 m^3	*** Flood Capacity 10^6 m^3	** Net Inflow per 1mm rise per hour m^3/sec	* Discharge per Regulator m^3/sec	* Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
57.0	414	-	11.10	24.9	0	50
57.5	453	-	12.04	25.2	4	69
58.0	466	-	12.97	25.4	15	128
58.5	494	-	13.90	25.7	32	211
59.0	523	-	14.84	25.9	53	316
59.5	553	-	15.77	26.2	77	439
60.0	584	-	16.71	26.4	105	579
60.5	616	-	17.64	26.6	136	735
61.0	649	-	18.58	26.9	170	905
61.5	683	-	19.51	27.1	207	1 090
62.0	719	-	20.45	27.3	246	1 290
62.5	756	-	21.38	27.5	288	1 495
63.0	795	-	22.32	27.8	333	1 720
63.5	835	-	23.25	28.0	379	1 950
64.0	877	-	24.19	28.2	428	2 195
64.5	920	-	25.12	28.4	479	2 450
65.0	965	-	26.06	28.7	532	2 720
65.5	1 012	-	26.99	28.9	587	2 995
66.0	1 061	-	27.92	29.1	645	3 280
66.5	1 112	-	28.86	29.3	704	3 580
67.0	1 165	0	29.79	29.5	765	3 885
67.5	1 220	56	30.73	29.7	828	4 200
68.0	1 276	112	31.66	29.9	893	4 525
68.5	1 334	171	32.60	30.1	959	4 860
69.0	1 393	230	33.53	30.3	1 028	5 200
69.5	1 454	290	34.47	30.5	1 098	5 550
70.0	1 517	350	35.40	30.7	1 170	5 910
70.5	1 581	418	36.33	30.9	1 244	6 280
71.0	1 647	485	37.27	31.1	1 319	6 660
71.5	1 714	550	38.20	31.3	1 396	7 040
72.0	1 783	615	39.14	31.5	1 474	7 430
72.5	1 854	683	40.07	31.7	1 554	7 840
73.0	1 926	750	41.01	31.9	1 636	8 240
73.5	2 000	830	41.94	32.1	1 719	8 660
74.0	2 076	910	42.87	32.3	1 804	9 080
74.5	2 153	995	43.81	32.5	1 890	9 520
75.0	2 232	1 080	44.74	32.7	1 978	9 960
75.5	2 313	1 160	45.68	32.9	2 067	10 400
76.0	2 395	1 240	46.61	33.1	2 158	10 860
76.5	2 480	1 258	47.55	33.3	2 250	11 320
77.0	2 566	1 420	48.48	33.4	2 343	11 780
77.5	2 655	1 500	49.41	36.6	2 438	12 260
78.0	2 746	1 580	50.35	33.8	2 535	12 740
78.5	2 839	1 680	51.28	34.0	2 632	13 230
79.0	2 934	1 780	52.22	34.2	2 731	13 730

* This is the maximum discharge of an individual spillway bay or regulator. Total discharge is calculated by adding the contributions of each gate or regulator. There are two (2) regulators to five (5) spillway bays.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

** This assumes that all gates and sluices are closed. Discharges through the spillway have to be added to the above figures to calculate the actual inflow into the reservoir.

*** The temporary storage above normal Full Supply Level of EL 67.0.

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

TABLE E2 CONTROLLED GATE DISCHARGES

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
67.0	0	49	98	146	194	240	285	329	372	413	453	492	530	567	603	639	675	709	744	765															
67.2	0	49	99	148	196	243	288	333	376	418	458	498	537	574	611	648	684	720	755	790															
67.4	0	50	100	149	198	245	291	336	380	422	464	504	543	582	619	657	693	730	766	802	815														
67.6	0	50	101	151	200	248	294	340	384	427	469	510	550	589	627	665	702	740	777	814	841														
67.8	0	51	102	152	202	250	297	343	388	432	474	515	556	596	635	673	712	750	787	825	863	867													
68.0	0	51	103	154	204	253	300	347	392	436	479	521	562	603	642	682	721	759	798	837	876	893													
68.2	0	52	104	155	206	255	303	350	396	441	484	527	569	610	650	690	729	769	808	848	888	919													
68.4	0	52	105	156	207	257	306	354	400	445	489	532	575	616	657	698	738	778	818	859	899	940	946												
68.6	0	53	105	158	209	260	309	357	404	450	494	538	581	623	665	706	747	788	829	870	911	953	973												
68.8	0	53	106	159	211	262	312	360	408	454	499	543	587	630	672	714	755	797	838	880	923	965	1000												
69.0	0	54	107	160	213	264	315	364	412	458	504	549	593	636	679	722	764	806	848	891	934	977	1022	1028											
69.2	0	54	108	162	215	267	317	367	415	463	509	554	599	643	686	729	772	815	858	901	945	989	1035	1056											
69.4	0	54	109	163	217	269	320	370	419	467	514	560	605	649	693	737	780	824	868	912	956	1001	1047	1084											
69.6	0	55	110	164	218	271	323	373	423	471	518	565	611	656	700	744	789	833	877	922	967	1013	1060	1107	1112										
69.8	0	55	111	166	220	273	326	377	427	475	523	570	616	662	707	752	797	842	887	932	978	1025	1072	1121	1141										
70.0	0	56	112	167	222	276	328	380	430	479	528	575	622	668	714	759	805	850	896	942	989	1036	1085	1134	1170										
70.2	0	56	112	168	224	278	331	383	434	484	532	580	628	674	721	767	813	859	905	952	1000	1048	1097	1147	1198	1199									
70.4	0	56	113	170	225	280	334	386	437	488	537	586	633	680	727	774	821	867	914	962	1010	1059	1109	1160	1212	1229									
70.6	0	57	114	171	227	282	336	389	441	492	542	591	639	687	734	781	828	876	923	972	1020	1070	1121	1173	1226	1258									
70.8	0	57	115	172	229	284	339	392	445	496	546	596	644	693	741	788	836	884	932	981	1031	1081	1133	1185	1239	1289									
71.0	0	58	116	173	230	286	341	395	448	500	551	601	650	699	747	795	844	892	941	991	1041	1092	1144	1198	1252	1309	1319								
71.2	0	58	117	175	232	289	344	398	452	504	555	605	655	705	754	802	851	900	950	1000	1051	1103	1156	1210	1266	1323	1349								
71.4	0	58	117	176	234	291	347	401	455	508	559	610	661	710	760	809	859	908	959	1009	1061	1114	1167	1222	1279	1337	1380								
71.6	0	59	118	177	235	293	349	404	458	512	564	615	666	716	766	816	866	916	967	1019	1071	1124	1179	1234	1292	1350	1410	1411							
71.8	0	59	119	178	237	295	352	407	462	515	568	620	671	722	773	823	874	924	976	1028	1081	1135	1190	1246	1304	1364	1425	1443							
72.0	0	60	120	180	239	297	354	410	465	519	572	625	676	728	779	830	881	932	984	1037	1091	1145	1201	1258	1317	1377	1439	1474							
72.2	0	60	121	181	240	299	357	413	469	523	577	629	682	733	785	837	888	940	993	1046	1100	1156	1212	1270	1330	1391	1454	1506							
72.4	0	60	121	182	242	301	359	416	472	527	581	634	687	739	791	843	895	948	1001	1055	1110	1166	1223	1282	1342	1404	1468	1533	1538						
72.6	0	61	122	183	243	303	361	419	475	531	585	639	692	745	797	850	903	956	1009	1064	1119	1176	1234	1293	1354	1417	1482	1548	1570						
72.8	0	61	123	184	245	305	364	422	478	534	589	643	697	750	803	856	910	963	1018	1073	1129	1186	1245	1305	1367	1430	1496	1563	1603						

UNCONTROLLED DISCHARGE

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

TABLE E2 CONTROLLED GATE DISCHARGES

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
73.0	0	62	124	185	247	307	366	425	482	538	593	648	702	756	809	863	917	971	1026	1081	1138	1196	1255	1316	1379	1443	1509	1577	1636						
73.2	2	62	124	187	248	309	369	427	485	542	597	653	707	761	815	869	924	978	1034	1090	1147	1206	1266	1327	1391	1456	1523	1592	1663	1669		UNCONTROLLED			
73.4	6	62	125	188	250	311	371	430	488	545	602	657	712	767	821	876	931	986	1042	1099	1156	1216	1276	1339	1403	1469	1536	1606	1678	1702			DISCHARGE		
73.6	11	64	126	189	251	313	373	433	491	549	606	662	717	772	827	882	937	993	1050	1107	1166	1225	1287	1350	1414	1481	1550	1620	1693	1736					
73.8	17	69	127	190	253	315	376	436	495	553	610	666	722	778	833	888	944	1001	1058	1116	1175	1235	1297	1361	1426	1494	1563	1635	1708	1770					
74.0	23	74	129	191	254	317	378	438	498	556	614	671	727	783	839	895	951	1008	1065	1124	1184	1245	1307	1372	1438	1506	1576	1648	1723	1800	1804				
74.2	31	80	133	192	256	319	380	441	501	560	618	675	732	788	845	901	958	1015	1073	1132	1192	1254	1317	1382	1449	1518	1589	1662	1738	1815	1838				
74.4	39	87	139	195	257	321	383	444	504	563	622	679	737	793	850	907	964	1022	1081	1140	1201	1264	1327	1393	1461	1530	1602	1676	1752	1831	1873				
74.6	47	94	145	200	259	322	385	447	507	567	626	684	741	799	856	913	971	1029	1089	1149	1210	1273	1337	1404	1472	1542	1615	1690	1767	1846	1908				
74.8	56	103	153	206	262	324	387	449	510	570	629	688	746	804	862	919	978	1036	1096	1157	1219	1282	1347	1414	1483	1554	1628	1703	1781	1861	1943				
7 5.0	66	112	161	213	267	326	390	452	513	574	633	692	751	809	867	926	984	1044	1104	1165	1227	1291	1357	1425	1494	1566	1640	1717	1795	1876	1960	1978			
75.2	76	121	169	220	274	330	392	455	516	577	637	697	756	814	873	932	991	1051	1111	1173	1236	1301	1367	1435	1506	1578	1653	1730	1809	1891	1976	2013			
75.4	87	131	178	229	281	336	394	457	519	581	641	701	760	819	878	938	997	1057	1119	1181	1245	1310	1377	1446	1517	1590	1665	1743	1823	1906	1992	2049			
75.6	98	141	188	237	289	343	399	460	522	584	645	705	765	824	884	944	1004	1064	1126	1189	1253	1319	1386	1456	1527	1601	1678	1756	1837	1921	2007	2085			
75.8	109	152	198	247	298	350	405	463	525	587	649	709	769	829	889	949	1010	1071	1133	1197	1261	1328	1396	1466	1538	1613	1690	1769	1851	1936	2023	2112	2121		
			OVERTOPPING of GATE																																
76.0	121	164	209	257	307	359	412	468	528	591	652	713	774	834	895	955	1016	1078	1141	1205	1270	1337	1405	1476	1549	1624	1702	1782	1865	1950	2038	2129	2158		
76.2	133	175	220	268	317	368	421	475	532	594	656	718	779	839	900	961	1023	1085	1148	1212	1278	1346	1415	1486	1560	1636	1714	1795	1878	1965	2053	2145	2194		
76.4	146	187	232	279	327	378	429	483	539	597	660	722	783	844	906	967	1029	1092	1155	1220	1286	1354	1424	1496	1570	1647	1726	1808	1892	1979	2069	2161	2231		
76.6	159	200	244	290	338	388	439	492	546	603	664	726	788	849	911	973	1035	1098	1162	1228	1295	1363	1434	1506	1581	1658	1738	1820	1905	1993	2084	2177	2268		
76.8	173	213	257	302	350	399	449	501	554	610	668	730	792	854	916	978	1041	1105	1170	1235	1303	1372	1443	1516	1591	1669	1750	1833	1919	2007	2099	2193	2289	2306	
			OVERTOPPING of GATE																																
77.0	186	226	270	315	362	410	460	511	564	618	674	734	797	859	921	984	1047	1112	1177	1243	1311	1380	1452	1526	1602	1680	1762	1845	1932	2021	2113	2208	2306	2343	
77.2	200	240	283	328	374	422	471	522	574	627	682	739	801	864	927	990	1054	1118	1184	1250	1319	1389	1461	1536	1612	1691	1773	1858	1945	2035	2128	2224	2322	2381	
77.4	215	254	297	341	387	435	483	533	584	637	691	747	806	869	932	996	1060	1125	1191	1258	1327	1398	1470	1545	1622	1702	1785	1870	1958	2049	2143	2239	2339	2419	
77.6	230	269	311	355	400	447	496	545	595	647	700	756	813	873	937	1001	1066	1131	1198	1265	1335	1406	1479	1555	1633	1713	1796	1882	1971	2063	2157	2255	2355	2457	
77.8	245	283	325	369	414	461	508	557	607	658	711	765	821	880	942	1007	1072	1138	1205	1273	1343	1414	1488	1564	1643	1724	1808	1894	1984	2076	2172	2270	2371	2475	2496
78.0	260	299	340	383	428	474	522	570	619	670	722	775	831	888	948	1012	1078	1144	1211	1280	1351	1423	1497	1574	1653	1735	1819	1907	1997	2090	2186	2285	2387	2492	2535

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

APPENDIX F SOMERSET DAM TECHNICAL DATA

Table F-l
STORAGE AND DISCHARGE FOR SOMERSET DAM

Lake level M AHD	Reservoir Capacity 10^6 m^3	Temporary Flood Storage 10^6 m^3	Net Inflow per 1mm rise per hour m^3/sec	* Discharge per Regulator m^3/sec	* Discharge per Sluice m^3/sec	* Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
90.0	120.3	-	5.29	57	163	-	1 529
90.5	129.5	-	5.50	58	165	-	1 550
91.0	139.3	-	4.88	58	167	-	1 572
91.5	149.6	-	5.28	59	170	-	1 593
92.0	160.5	-	5.68	60	172	-	1 614
92.5	172.0	-	6.09	60	174	-	1 635
93.0	184.1	-	6.79	61	176	-	1 655
93.5	196.7	-	7.10	62	179	-	1 676
94.0	210.0	-	7.43	62	181	-	1 695
94.5	224.0	-	7.78	63	183	-	1 715
95.0	238.5	-	8.15	64	185	-	1 735
95.5	253.6	-	8.54	64	187	-	1 754
96.0	269.3	-	8.95	65	189	-	1 773
96.5	285.6	-	9.37	66	191	-	1 792
97.0	302.7	-	9.81	66	193	-	1 810
97.5	320.7	-	10.28	67	195	-	1 829
98.0	339.5	-	10.76	67	197	-	1 847
98.5	359.2	-	11.25	68	199	-	1 865
99.0	379.8	0.0	11.77	69	201	-	1 883
99.5	401.4	21.5	12.31	69	203	-	1 901
100.0	428.9	49.0	13.28	70	205	-	1 918
100.5	447.5	67.6	13.83	70	207	0	1 937
101.0	472.2	92.3	14.39	71	209	4	1 989
101.5	498.0	118.1	14.95	72	211	13	2 076
102.0	524.9	145.1	15.53	72	212	25	2 189
102.5	553.1	173.3	16.11	73	214	40	2 325
103.0	582.6	202.7	16.70	73	216	58	2 482
103.5	613.2	233.4	17.30	74	218	78	2 659
104.0	645.1	265.3	17.90	74	220	100	2 854
104.5	678.3	298.4	18.52	75	221	125	3 067
105.0	712.7	332.8	19.14	75	223	151	3 296
105.5	748.3	368.4	19.78	76	225	180	3 542
106.0	785.2	405.4	20.42	76	226	211	3 803
106.5	823.4	443.6	21.07	77	228	243	4 079
107.0	863.1	483.2	21.73	78	230	278	4 370
107.5	904.0	524.2	22.39	78	232	314	4 675

* This is the maximum discharge of an individual gate or regulator. Total discharge is calculated by adding the contributions of each gate or regulator.

Regulator - Discharge regulator valve of which there are four (4).
Sluice - Sluice gate of which there are eight (8).
Spillway - Overflow section of dam controlled by eight (8) radial gates.
Temporary Flood Storage - The temporary storage above the normal full supply level of El 99 m (AHD)

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

APPENDIX G WIVENHOE DAM GATE OPERATION CONSIDERATIONS

Full size plans of Wivenhoe Dam, and Operations and Maintenance Manuals for Wivenhoe Dam are held by the Corporation and the Headworks Operator and are available at the site. Operations and Maintenance Manuals relevant to the flood operation of the gates are:

(a) "Master Manual and Drawings."

(b) "Radial and Penstock Gate Hoists and Drawings."

G.1. SPILLWAY OPERATION PRINCIPLES

The radial gates are sequentially numbered from 1 to 5 from left to right looking in the downstream direction. Appendix I shows the general arrangement of the spillway area.

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions, or when gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool, which has been excavated into erodible sandstone rock, and cause non-predictable erosion. Upstream migration of this erosion is to be avoided. The wing walls adjacent to the flip bucket deflect the discharge away from the walls of the plunge pool when gates 1 and 5 are operated.

Therefore in operating the spillway, the principles to be observed are, in order of priority:

(i) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

(ii) The flow in the spillway is to be symmetrical.

The main purpose of gating the spillway is to exercise maximum control over the flow in the Brisbane River insofar as river flows in excess of 4 000 m^3/sec cause damage to urban areas downstream. The gates also allow the routing of much larger floods with substantial flood mitigation being achieved.

G.2. RADIAL GATE OPERATING PRINCIPLE

Each radial gate consists of a cylindrical upstream skinplate segment that is attached to the radial arms. The cylindrical axis is horizontal. Each gate rotates about two spherical trunnion bearings that are on this axis.

The position of the gate is controlled by hydraulically driven winches that are located on the piers beside the gates. Wire ropes are attached to the downstream face of the skin plate through a pulley system. The hydraulic motors work off a common pressure manifold and under perfectly matched conditions, will give an equal lifting force to each side of the gate. This system does not sense rope travel and will take up slack rope. It cannot prevent or correct skewing of the skin plate segment between the piers. If skewing occurs, skids will come into contact with the side seal plates to limit movement.

It is not possible to operate a winch independently of the other winch attached to the gate.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

When the hydraulic motors are not energised, the gates are held in position by spring loaded friction brakes on the winches. There are two brake bands per winch and each band is capable of supporting half the weight of the gate. One winch can support the total weight of a gate on both its brake bands but not on one.

G.3. RADIAL GATES OPERATING LIMITATIONS

G.3.1. Opening and Closing Rate

The aperture opening rate of each gate is limited to 500 mm/minute.

Aperture movement is limited by a programmable timer that stops gate movement after a set period of time.

G.3.2. Alternate Consecutive Operation

To maintain symmetry of discharge in the spillway, either gates 1 and 5 or gates 2 and 4 are to be operated in alternate consecutive increments. The power for gate operation comes from two independent electric hydraulic pumps, each of which is capable of operating one gate at a time.

The normal hydraulic pressure source for each gate is as follows:

GATES	POWER SOURCE
Radial Gates 1 & 2, and Penstock Gate Hoist	Electric hydraulic pump 1
Radial Gates 3, 4 & 5	Electric hydraulic pump 2

In the event that an electric hydraulic pump fails, hydraulic pressure can be redirected from the other power source, but concurrent operation of more than one gate from a single power source is not possible.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

G.3.3. Overtopping

While the radial gates have been designed to withstand overtopping, it should be avoided if possible. The reservoir levels and the structural state of the radial gates when in the closed position are as follows:

Reservoir Level m AHD	Condition	Radial Gate Stress Condition with Gate Closed
73	Top of closed gate	Normal
77	Design Flood Level	33% Overstress
79	Crest Level	Critical

Once overtopped, the gates become inoperable when the lifting tackle is fouled by debris from the overflow. The gates remain structurally secure until the reservoir level exceeds EL 77. The ability to control floods however may be lost.

G.3.4. Gate Dropping

Under no circumstances are the gates to be dropped. The lower skin plate sections are overstressed if a freefall of 60 mm is arrested by the seal plate on the spillway.

If a gate becomes stuck in an open position, it is to be freed by applying positive lifting forces. Under no circumstances are the winches to be unloaded and the direct weight of the gates used to yield the obstruction.

G.3.5. Operation in High Wind

Other than in periods of mitigation of medium and major floods, the gates are not to be raised or lowered when clear of water, during periods of high winds. The gates can however, be held on the brakes in any position in the presence of high wind.

The term "high wind" means any wind that causes twisting or movement of the gate. While a precise figure cannot be placed on these velocities, further experience over time may allow a figure to be determined.

This limitation is required to prevent the gate from twisting from skew on one side to skew on the other side. While the gate is being raised or lowered, skewing cannot be prevented by the hydraulic lifting system and any impact forces encountered may damage the gate.

G.3.6. Maintenance

No more than one gate is to be inoperable at any one time for maintenance. The maintenance is to be scheduled so that the spillway bay can be cleared of obstructions in a reasonable time to allow its use in the event of major flooding.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

G.4. BULKHEAD GATE OPERATING LIMITATIONS

The bulkhead gate can be used to control discharge in an emergency situation where a radial gate is inoperable. It is transported to, and lowered upstream of the inoperable radial gate by means of the gantry crane. The following conditions apply:

(a) The bulkhead gate can always be lowered with any type of underflow; and

(b) It is not possible to raise the bulkhead gate once it has been lowered past certain levels depending on upstream conditions without there being a pool of water between it and the radial gate. (Department of Primary Industries Wivenhoe Dam Design Report, September 1995 refers).

It is thus possible to preserve storage by effectively closing the spillway even with one radial gate inoperable. It will not be possible to raise the bulkhead gate until the radial gate behind has been repaired and is again storing water between the bulkhead gate and itself.

The bulkhead gate is not to be used for flood regulation until the reservoir level is falling and not likely to rise within the period needed to repair the inoperable radial gate.

G.4.1. Opening and Closing Rates

The spillway gantry crane is to be used to raise and lower the bulkhead gate. The crane operates at two speeds, 1.5 and 3.0 m/min. When within the bulkhead gate guides, the bulkhead gate is to be moved only at 1.5 m/min.

G.4.2. Overtopping

In the event that the bulkhead gate is overtopped (reservoir level exceeds EL 69 when bulkhead gate is closed), it cannot be removed unless a pool of water fills the space between it and the radial gate behind. The closed bulkhead becomes critically stressed when the reservoir level overtops it to EL 71.4.

It is not possible to engage the lifting tackle while overtopping is occurring. While there is any risk that the bulkhead gate may be overtopped, the lifting gear is to be left engaged so that the gate can be raised once the downstream radial gate becomes operable.

G.4.3. Discharge Regulation

In the event that a radial gate is inoperable in a partially open position, the bulkhead gate can be used for flow regulation provided that the lower lip of the radial gate is clear of the underflow jet.

Where a pool exists between the bulkhead gate and a radial gate under flow conditions, the bulkhead gate will be subjected to additional pull-down and possibly subjected to vortex-induced vibrations. When this condition occurs, the bulkhead gate is to be lowered to dewater the pool. The bulkhead gate can then be adjusted to regulate the flow provided the underflow jet remains below the lower lip of the radial gate.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

G.5. RADIAL GATE OPERATING PROCEDURES

G.5.1. Normal Operating Procedure

This procedure is specified in Section 8.3

G.5.2. One Gate Inoperable

Under certain abnormal conditions, it may not be possible to operate one gate. The following procedures are to be adopted.

(a) Gate 3 Inoperable

If bay 3 is blocked for any reason, gates 2 and 4 are to be used to regulate flood discharges, until the discharge impinges on the walls of the plunge pool. Gates 1 and 5 are then to be opened sufficiently to deflect the discharge into the plunge pool.

The bottoms of gates 1 and 5 are to be maintained at or below those of gates 2 and 4 respectively.

(b) Either Gate 2 or 4 Inoperable

If either bay 2 or 4 is blocked for any reason during a flood, normal gate operating procedures are to be adopted, except that only the operable gate 2 or 4 is available for flood regulation beyond 500 m^3/sec and not both.

(c) Either Gate 1 or 5 Inoperable

If either bay 1 or 5 is blocked for any reason during a flood, normal gate operating procedures are to be adopted until the discharge impinges on the walls of the plunge pool. Thereafter the operable gate 1 or 5 is to be used in lieu of using the radial gate adjacent to the inoperable gate. The other radial gates are to be used in the normal way to control discharge.

In the event of a major flood, where the full discharge capacity of the four operable radial gates is required, these gates are to be used to their full capacity to protect the embankment from overtopping.

G.6. EQUIPMENT MALFUNCTION

Normal gate operation is by means of two electric hydraulic pumps supplied by external mains supply electric power, with pump number 1 connected to gates 1 and 2 and the penstock gate, while pump number 2 is connected to gates 3, 4 and 5.

Normal gate operation may not be possible in the event of equipment malfunctions during the passing of a flood. The procedures to be followed under various possible events are outlined below.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

G.6.1. Blackout - Failure of External Electric Power

A diesel electric generator automatically starts up. It supplies enough power to the two electric hydraulic pumps to operate the gates normally.

In the event that the diesel electric generator fails, the radial gates can still be operated by means of the emergency diesel hydraulic pump as described in G.6.3 below.

G.6.2. Failure of One Electric Hydraulic Pump

In the event that one electric hydraulic pump fails, the connecting valves between pumps are to be switched such that both sets of hydraulic lines are connected to the operable pump, thus permitting operation of all 5 gates, one gate at a time.

G.6.3. Failure of Two Electric Hydraulic Pumps

In the event that both electric hydraulic pumps fail, the emergency diesel hydraulic pump is to be used to operate the gates, one gate at a time.

G.6.4. Rupture of Hydraulic Lines

Deleted: The only source of power to the radial gate winches is via the hydraulic lines.

Hydraulic power is delivered from the sets of hydraulic lines beneath the gantry service bridge deck to each winch via a single hydraulic line. There is no bypass circuit. In the event that one of these lines is ruptured, the associated radial gate becomes inoperable via this system. Any ruptures in the hydraulic lines are to be repaired immediately. A trailer mounted hydraulic system is available to connect to auxillary hydraulic lines on the service bridge deck, that can operate one gate at a time.

Deleted: and cannot be raised or lowered

G.6.5. Contamination of Winch Brakes

The gates are not to be raised if the brake bands on the winch drums are contaminated with oil or other low friction contaminant.

When the hydraulic power is off the gates are held only by the winch brakes. Oil contamination will reduce their holding capacity and possibly allow the gate to fall.

The brake bands are to be inspected regularly and cleaned immediately if any contamination is observed.

G.6.6. Mechanical Failure of Winch

In the event that a winch fails, the radial gate affected becomes inoperable.

(i) Loss of hydraulic power to the winches results in the spring loaded friction brakes holding the gate in its current position.

(ii) Loss of lift from one winch jams the gate between the piers until the uplift is equalised on each side of the gate again. If the gate is in a raised position, this event causes the side skids to come into contact with the pier sides.

(iii) Without hydraulic power applied, the winch drums are restrained by brakes. If both brakes fail, the gate falls. A free fall of more than 60 mm causes structural damage to the gate. In the event that one brake fails, the gate jams between the piers.

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

G.6.7. Fouling of Lifting Tackle

The lifting tackle consists of blocks, wire ropes and winch drums. If the gate is overtopped, debris may be collected on the wire ropes that may in turn foul the blocks or the winch drums. This may result in jamming of the wire rope or in uneven lifting, both of which may cause the gate to jam.

The preventative measure is not to allow the gate to be overtopped.

G.6.8. Fouling of Side Skids

The side skids have been designed to limit the side-sway and skew of the radial gates during operation. Under ideal conditions, the skids should not be in contact with the side seal plates.

If the winches are lifting the gates unevenly or in a skewed position, the lifting gear should be adjusted if possible.

[Details of the fuse plugs should be moved to here]

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

APPENDIX H SOMERSET DAM AUXILIARY EQUIPMENT

H.1. DISCHARGE REGULATION

The normal operating procedure for Somerset Dam in the event of a flood requires the spillway gates to be raised to provide an uncontrolled spillway followed by opening of the low level outlets some time later.

Sketches of the spillway and low level outlets are shown in Appendix J. Somerset Dam is equipped with spillway gates, sluice gates and regulators to control the discharge from the dam. Because the dam is a combined water supply and flood control dam, the spillway is above the FSL and the sluice gates and regulators are 6-10 metres above stream-bed level. It is crucial to the water supply function of the dam that the low level outlets be able to be shut down after their flood release function is completed to ensure that storage is not lost.

Failure of any spillway gate lifting machinery could restrict the discharge capacity of the spillway with resultant risk of overtopping of the dam.

H.2. EMERGENCY POWER SUPPLY

In the event of a power failure at Somerset Dam, the emergency diesel alternator is to be started. The alternator can supply power to the gantry crane, and all gate machinery. If the emergency diesel alternator cannot be started or breaks down during a power failure, the spillway gates and sluice gates are to be operated using the electric motor drive facilities on the winches and a mobile generator.

H.3. FAILURE OF SPILLWAY GATES MACHINERY

If a spillway gate cannot be raised due to failure of the lifting machinery, the gantry crane may be attached to the gate and the gate raised using the gantry crane.

H.4. FAILURE OF SLUICE GATE MACHINERY

In the event of a sluice gate being jammed in the open position or the lifting machinery failing, the coaster gate is to be lowered over the inlet to the sluice to preserve the water supply storage.

If a sluice gate cannot be raised due to failure of the lifting machinery, repairs are to be carried out immediately.

H.5. FAILURE OF REGULATOR MACHINERY

If the regulator gate cannot be lowered and the regulator cones cannot be closed, the regulator coaster gate is to be lowered over the inlet to the regulator. Some damage may be caused to the seals on the coaster gate in this instance, but the resultant leakage will not result in the loss of the water supply storage.

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

APPENDIX I HYDROLOGIC INVESTIGATIONS

I.1. INTRODUCTION

This appendix describes hydrologic analyses performed as part of the review of design flood hydrology Corporation's dams. This study included an examination of the existing operating procedures for Wivenhoe Dam and Somerset Dam and it includes the use of the latest techniques in design rainfall estimation.

The analyses were carried out using the most appropriate data available in 2001 and it is recommended that they be revised after the occurrence of a large flood or after the adoption of more advanced methods of hydrologic analysis. The work is summarised in a report entitled, 'Brisbane River – Revision of Flood Hydrology', (DNRM, 2001). The work summarised here supersedes previous work including that completed during the design stages of Wivenhoe Dam, details of which are contained in the design report on Wivenhoe Dam and the Brisbane River and Pine River Flood Study reports.

Revision of the estimates of Probable Maximum Precipitation by the Bureau of Meterology in 2003 have increased these figures. The determination of the Probable Maximum Flood and the impacts on Wivenhoe Dam are included in reports entitled, "Preferred Solution Report" – Wivenhoe Alliance 2003.

The increase in spillway capacity for Wivenhoe Dam and the resulting effects downstream are included in a report entitled "Design Discharges and Downstream Impacts of the Wivenhoe Dam Upgrade" – Wivenhoe Alliance 2004.

I.2. METHOD

There are three components in the hydrologic analyses:

(i) a rainfall analysis to determine both rainfall frequency and Probable Maximum Precipitation (PMP) and also large and rare rainfall events using the CRC-FORGE methodology

(ii) a model of the catchment rainfall runoff process; and

(iii) a model of the flood operations of the two dams.

The Bureau of Meteorology completed several studies of the Probable Maximum Precipitation. The Australian generalised method for areas subject to tropical cyclones was used and rainfalls for durations up to seven days were estimated. The Probable Maximum Precipitation was estimated for the whole of the Brisbane River catchment, as well as for various sub-catchments. Concurrent rainfall estimates were provided for the remainder of the catchment outside the sub-catchment for which the Probable Maximum Precipitation was provided. The Probable Maximum Precipitation temporal patterns provided by the Bureau of Meteorology were used for all rainfalls.

The estimation of design rainfalls within the large to rare flood range was performed using the CRC-FORGE methodology as described in Book VI of Australian Rainfall and Runoff (1998). The CRC-FORGE method uses the concept of an expanding region focussed at the site of interest. Design rainfall for frequent events (eg 1 in 50 AEP) are based upon pooled data from a few gauges around the focal point, while design rainfall estimates at the AEP of the limit extrapolation are based upon pooled rainfall data from up to several hundred gauges. Before the data from different sites can be poled, maximum annual rainfalls from each site need to be standardised by dividing by an "index variable".

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

The rainfall runoff models based on a non-linear runoff routing method were used to estimate the floods. The models were calibrated on recorded storm and flood data. The model calibrations were completed in 1993 and were not modified for the latest re-assessment.

Models to simulate the flood operation of Somerset and Wivenhoe Dams developed during the mid-eighties were modified to incorporate the new structure of the hydrologic models and to more accurately reflect the operational procedures of the dams. These models were then used to calculate dam discharges for a range of design floods generated using the rainfall estimates and the runoff routing models.

I.3. RAINFALL ANALYSIS RESULTS

The rainfall analysis was performed in two parts, the Probable Maximum Precipitation estimate by the Bureau of Meteorology and the estimation of large to rare events using the CRC-FORGE method. These were used both for design studies for the dam and to test the effects of flood operation procedures.

The estimates of Probable Maximum Precipitation are listed in Table I-1.

Table I-1
Probable Maximum Precipitation (mm)

Deleted: ¶
¶
Duration¶
(days) ... [1]

(new table to come)

The estimates of rainfall frequency are listed in tables I-2. These estimates are based upon the CRC-FORGE methodology as recommended in Book VI of Australian Rainfall and Runoff, (1998).

Table I-2

Catchment Rainfall (mm) on Wivenhoe Dam Catchment

Annual Exceedence Probability %	24 Hours	48 Hours	72 Hours
1	199	274	319
0.1	276	393	464
0.01	379	550	659

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

Catchment Rainfall (mm) on Somerset Dam Catchment

Deleted: ¶
Page Break

Annual Exceedence Probability %	24 Hours	48 Hours	72 Hours
1	302	430	507
0.1	432	649	775
0.01	554	920	1117
0.001	747	1204	1483

I.4. RUNOFF ROUTING MODEL CALIBRATION

Ten floods were used for calibration: July 1965, March 1967, June 1967, January 1968, December 1971, January 1974, January 1976, June 1983, Early April 1989 and Late April 1989. The gauging stations used for model calibration are listed in Table I-3.

The runoff routing model was calibrated for the nineteen major sub-catchments listed in Table I-4. Each of these models was calibrated for as many sites as possible for each of the ten floods. Data were missing for some of the stations for some of the floods. The estimated model parameters are given in Table I-4. In all cases relative delay time parameter (k) used in the model is related to reach length.

Table I-3

Gauging Stations used for Model Calibration

Stream	Site	Number	AMTD (km)	Catchment Area (km^2)
Stanley River	Somerset Dam		7.2	1 335
Cooyar Creek	Damsite	143015	12.2	960
Brisbane River	Linville	143007	282.4	2 005
Emu Creek	Boat Mountain	143010	10.1	920
Brisbane River	Gregor's Creek	143009	251.7	3 885
Cressbrook Creek	Damsite	143013	58.6	325
Brisbane River	Middle Creek	143008	187.2	6 710
Brisbane River	Wivenhoe Dam		150.2	7 020
Brisbane River	Savage's Crossing	143001	130.8	10 180
Bremer River	Walloon	143107	37.2	620
Warrill Creek	Amberley	143108	8.7	920
Lockyer Creek	Lyon's Bridge	143210	27.2	2 540
Brisbane River	City		22.7	13 260

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

Table I-4

10.6.1 Estimated Model Parameters

Formatted: Bullets and Numbering

10.6.2 Sub-Catchment Name	Model Parmeters	
	(k)	(m)
(1) Cooyar Creek	43.6	0.8
(2) Brisbane River at Linville	20.6	0.8
(3) Emu Creek at Boat Mountain	37.2	0.8
(4) Brisbane River at Gregors Creek	20.1	0.8
(5) Cressbrook Creek at Cressbrook Dam	34.3	0.8
(6) Stanley River at Somerset Dam	80.7	0.8
(7) Brisbane River at Wivenhoe Dam	108.5	0.8
(8) Lockyer Creek at Helidon	15.0	0.8
(9) Tenthill Creek at Tenthill	19.0	0.8
(10) Lockyer Creek at Lyons Bridge	75.0	0.8
(11) Brisbane River at Savages Crossing	40.0	0.8
(12) Brisbane River at Mount Crosby	47.0	0.8
(13) Bremer River at Walloon	44.0	0.8
(14) Warrill Creek at Kalbar	34.0	0.8
(15) Warrill Creek at Amberley	35.0	0.8
(16) Purga Creek at Loamside	49.0	0.8
(17) Bremer River at Ipswich	15.7	0.8
(18) Brisbane River at Jindalee	20.8	0.8
(19) Brisbane River at Port Office	19.3	0.8

Formatted: Bullets and Numbering

I.5. WIVENHOE DAM FLOODS

Wivenhoe Dam floods were estimated using the rainfalls and runoff routing model already discussed. Inflows to Wivenhoe Dam, assuming the dam to be in existence and full, were calculated, as well as flow at the dam-site without the dam in the catchment. Two-day storms were found to have the critical storm duration for most cases, though the long duration Probable Maximum Precipitations produced very large flood volumes. Table I-6 lists results for the two-day duration storms.

Table I-5
Wivenhoe Dam Floods

Deleted: **(for two-day storm duration)¶**
¶
AEP % ... [2]

Deleted: This assessment assumes certain operational procedures and assumes that the Dam would fail once the embankment crest level of 79.15 was reached.

Design Inflows and Outflows for Existing, Stage 1 and Stage 2 Upgrades, Wivenhoe Dam.

Event (1in X)	Peak Inflow (m^3/s)	Peak Outflow (m^3/s) Existing	Stage 1	Stage 2
200	8,300	2,800	2,800	2,800
500	10,500	3,800	3,800	3,800
1,000	12,100	5,300	5,300	5,300

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

2,000	14,000	6,600	6,600	6,600
5,000	17,200	8,900	10,500 [c]	10,500 [c]
10,000	20,800	11,700	12,500	12,500
22,000 [a]	25,700	12,400 [a]	17,600	17,600
50,000	34,900	- [b]	24,600	24,600
100,000	43,300	- [b]	28,100 [a]	34,900
PMF	49,000	- [b]	- [b]	37,400 [a]

[a] Dam Crest Flood [b] Overtops dam wall [c] Increases due to changes to Procedure 4.

I.6. SOMERSET DAM FLOODS

Somerset Dam floods were estimated using the rainfalls and runoff routing model already discussed. Inflows to Somerset Dam, assuming the dam to be in existence and full, were calculated, as well as flow at the site without the dam in the catchment. The forty-eight hour PMP storm event was found to be critical, though the long duration PMP's produced very large flood volumes. Table I-6 lists results for the forty-eight hour duration storms.

Table I-6
Somerset Dam Floods
(for two-day storm duration)

AEP %	Peak Inflow (m^3/sec)	Peak Outflow (m^3/sec)	Flood Volume (ML)	Peak Lake Level (m AHD)
1	3,500	1,700	421,000	103.5
0.1	4,500	2,600	690,000	104.5
0.01	6,800	4,700	1,042,000	107.5
0.001	9,200	6,300	1,412,000	109.3
PMF				

+ - NB. This duration does NOT give the maximum Peak Inflow for a given AEP
*** - Overtopped, estimated flow based on no dam failure**

Studies conducted by structural engineers indicate that Somerset could withstand overtopping to EL 111.7 mAHD. *[Is tis still the case with the recent SMEC studies??]*

I.7 FLOOD CONTROL OPERATION MODEL

Floods in the Brisbane River catchment above Wivenhoe Dam can originate in either the Stanley River or upper Brisbane River catchment or both. Both of the dams are capable of being operated in a number of ways, each of which will reduce the flow downstream. However, in order to achieve maximum reduction of flooding downstream of Wivenhoe Dam, it was necessary to review the operations at Somerset and Wivenhoe Dams using a flood operations simulation model.

Deleted: ¶
Deleted: PMF
Deleted: 11,100 *
Deleted: 7,500 *
Deleted: 1,694,000 *
Deleted: 110.3 *
Formatted
Comment [r14]: Page: 58 This may no longer be totally up to date.
Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

The most recent flood studies have reviewed the basic hydrologic algorithms in the operational models used in the earlier study and modified them to incorporate additional features relating to gate openings and closings. The revised design flood hydrology and operational model algorithms were then used to re-examine the original five possible operational procedures for each of Somerset Dam and Wivenhoe Dam, giving twenty-five possible combinations to be re-considered. The procedures previously developed for Wivenhoe Dam were designed so that initial release operations did not adversely affect later operations in the event of later rainfall causing the magnitude of the flood to exceed the original estimate.

The procedures previously developed were also designed to restrict flooding in the lower catchment to the lowest level of the following categories where practicable:

(i) low level bridges submerged, Fernvale bridge open;

(ii) all bridges except Mt. Crosby Weir and to Fernvale bridges submerged;

(iii) all bridges submerged, no damage to urban areas;

(iv) damage to urban areas due to peak flow from downstream catchment, no releases from Wivenhoe Dam contributing to peak flow;

(v) extensive damage to urban areas due to combined Wivenhoe Dam releases and downstream flow, Wivenhoe Dam release component of peak flow minimum practicable.

The previous flood studies recommended that one procedure be selected for the operation at Somerset Dam. This procedure had two advantages over the other procedures tested. Firstly, it was feasible for all magnitudes of Stanley River floods tested and, secondly, it was the simplest procedure to carry out. The re-analysis confirmed this conclusion.

The previous flood studies concluded that procedures for Wivenhoe Dam be reduced to four by combining two procedures into one. The resulting four procedures formed a hierarchy and the procedure to be adopted advances to the next procedure as the flood magnitude increases. The re-analysis confirmed this conclusion.

A Real Time Flood Operations Model for Somerset and Wivenhoe has been developed as part of the "Brisbane River and Pine River Flood Studies". This model incorporates the revised operational algorithms.

* Assume no failure of Wivenhoe Dam or Somerset Dam

Deleted:

Deleted: 4

Deleted: 6/09/02

Deleted:

APPENDIX J DRAWINGS

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

APPENDIX K BRISBANE RIVER CATCHMENT

Deleted:
Deleted: 4
Deleted: 6/09/02
Deleted:

Page 53: [1] Deleted	Authorised User	15/05/2004 10:20:00 AM

Duration (days)	Somerset Dam	Wivenhoe Dam	Brisbane Catchment
1	900	670	530
2	1420	870	680
3	1770	1080	830
4	2090	1250	1010
5	2170	1300	1050
6	2220	1330	1070
7	2410	1480	1160

Page 55: [2] Deleted	Authorised User	15/05/2004 10:25:00 AM

(for two-day storm duration)

AEP %	Peak Inflow (m^3/sec)	Peak Outflow (m^3/sec)	Flood Volume (ML)	Peak Lake Level (m AHD)
1	5,400	1,890	1,170,000	73.4
0.1	9,380	6,760	1,710,000	74.9
0.01	15,000	11,300	2,980,000	76.8
PMF	28,600 *	25,800 *	5,270,000 *	81.7 *

+ - NB. This duration does NOT give the maximum Peak Inflow for a given AEP
*** - Overtopped, estimated flow based on no dam failure**

DEPARTMENT OF NATURAL RESOURCES & MINES
OFFICE MEMO

Your Ref.: **Our Ref.:** RRD/130/000(377), RRD/130/000(354)
Author: Ron Guppy **Telephone:** [redacted] **Facsimile:** [redacted]

DATE: 24 January 2005

FROM: Principal Engineer, Dam Safety

TO: Director, Dam Safety (Water Supply)

SUBJECT: **Approval of Flood Mitigation Manual, Wivenhoe and Somerset Dams**

Background

The South East Queensland Water Board Act 1979 set a requirement for Flood Mitigation Manuals to be prepared for Wivenhoe Dam and for Somerset Dam. The requirement for Flood Mitigation Manuals for the dams has been retained through the subsequent legislation changes. It currently exists within Water Act 2000.

The then South East Queensland Water Board elected to prepare a combined Manual for the two dams because of the potential effect of Somerset Dam flood operations on Wivenhoe Dam operations. The Manual defines standard procedures for the operation of both Somerset and Wivenhoe Dams during flood periods. Revision 5 of the Manual, approved in October 2004 for five years is the current version. It was prepared specifically for use during the period of construction of the first auxiliary spillway at Wivenhoe Dam.

Flood Mitigation Manual Revision

The South East Queensland Water Corporation has now requested through their letter of 10 January 2005 some further revisions to the manual.

The key revision is to reflect that SEQWater may contract another organisation to discharge the responsibilities of the Headworks Operator, as it has done with SunWater. Other minor errors or discrepancies are also corrected. The actual operational procedures for the gates at the dams remain unchanged from the currently approved manual.

The complete document submitted for approval is attached.

Approval of Manual

Approval of the attached document as a flood mitigation manual would continue to provide the dam owner and operators with protection from civil liability while the procedures are observed (s.500 of *Water Act 2000*).

The *Water Act 2000* provides that the chief executive may get advice from an advisory council before approving a flood mitigation manual. In this instance I recommend that the option to get advice from such an advisory council be waived – the changes do not warrant use of such a council.

[redacted]

Flood mitigation manuals can be approved for periods not exceeding five years. It would seem reasonable to approve this manual for a five year period.

Recommendation

That the *Manual of Operational Procedures for Flood Mitigation for Wivenhoe and Somerset Dam (Revision 6)* submitted by the South East Queensland Water Corporation be approved for five years as a Flood Mitigation Manual under section 497 of *Water Act 2000*. A gazette notice is required to formalise the approval.

Ron Guppy
PRINCIPAL ENGINEER, DAM SAFETY

[redacted]

MANUAL

OF

OPERATIONAL PROCEDURES

FOR FLOOD RELEASES

FROM

NORTH PINE DAM

Revision No.	Date of Approval	Amendment Details
0	10 December 1986	Original Issue
1	6 October 1992	Complete revision and re-issue
2	13 November 1997	Complete revision and re-issue
3	26 July 2002	Complete revision and re-issue

Deleted: 17 April 2002

Deleted: 17

Deleted: 4

TABLE OF CONTENTS

Deleted: 17/04/02

Deleted:

Deleted: 17

Deleted: 4

1 INTRODUCTION

1.1 Preface

Given its size and location, it is imperative that North Pine Dam be operated during flood events in accordance with clearly defined procedures to minimise hazard to life and property.

Recognising this, the South East Queensland Water Board Act required that the South East Queensland Water Corporation's Technical Advisory Committee cause to be prepared a manual of operational procedures for the dam during floods. With changes to the controlling legislation, the manual became an approved flood mitigation manual under *Water Act 2000* (extract in Appendix A).

Formatted

This manual is the result of a review of the 1997 revision of the Manual. The Corporation is required to review, update the Manual if necessary, and submit it to the Chief Executive for approval prior to its expiry. Any amendments to the basic operating procedures need to be treated similarly.

An expanded flood monitoring and warning radio telemetry network (ALERT) has been installed in the Pine River catchment. Additionally a computerised flood operational model, which allows for rainfall and river modelling in real time based on data from the ALERT network has been developed, implemented and fully commissioned. The small flood storage capacity of the dam and the relatively short response time between flood producing rains and the occurrence of flooding means that prescribed operating procedures must be followed. However the ALERT and flood modelling system allows earlier warning of an imminent flood event.

The operational effectiveness of the system has led to some flexibility in the operating procedures being identified. Some minor changes to the procedures have been incorporated in this current review as a consequence.

The review has not included a formal risk management assessment process. It is intended this shall form part of a broader assessment regarding dam and flood management and then be incorporated in this manual.

Flood studies undertaken since the last review in 1997 supported the basic procedures for operation of the dam and these have not been varied. Neither have the primary objectives of ensuring safety of the dam, its ability to deal with extreme and closely spaced floods, and protection of urban areas from those defined in the original manual.

Changes from the previous revision have mostly arisen from the refinement of gate opening and closing sequences based upon experience obtained during flood events whilst using the real time flood operations model. Other changes have been necessary to fit in with the new regulatory regime provided by the commencement of *Water Act 2000*.

Deleted: 17/04/02

1.2 Meaning of Terms

In this Manual, save where a contrary definition appears -

"Act"
means the *Water Act 2000*;

Agency≅
includes a person, a local government and a department of state government within the meaning of the Acts Interpretation Act 1954;

"AHD"
means Australian Height Datum;

"Bureau of Meteorology"
means the Commonwealth Bureau of Meteorology;

"Chairperson"
means the Chairperson of the South East Queensland Water Corporation;

"Chief Executive"
means the Chief Executive or Director General of the Department of Natural Resources and Mines;

"Controlled Document"
means a document subject to managerial control over its contents, distribution and storage. It may have legal and contractual implications;

"Dam"
means the dam to which this Manual applies, that is North Pine Dam;

"Dam Supervisor"
means the senior on-site officer at North Pine Dam;

"EL"
means elevation in metres from Australian Height Datum;

"Flood Operations Engineer"
means the person designated at the time to direct the operations of the dam under the general direction of the Senior Flood Operations Engineer and in accordance with the procedures in this manual

Deleted: "AFC"[1] or¶
"Acceptable Flood Capacity (AFC)¶
means for a specific dam the overall flood capacity, including freeboard as relevant, which provides an appropriate level of safety against a flood initiated dam failure to protect the community and environment to acceptable risk levels, within the total context of overall dam safety from all causes.¶
¶

Deleted: ¶
"South East Queensland Water Corporation"¶
means the body corporate constituted by that name pursuant to Part III of the South East Queensland Water Board Act 1979. The Board became a government owned corporation in 2000;¶

Deleted: ¶
"DCF"[1] or¶
"Dam Crest Flood"¶
means the flood event which, when routed through the reservoir, results in a still water level in the reservoir, excluding wave effects which for an embankment is the lowset point of the embankment crest.¶
¶
Page Break

Deleted: ;¶

Deleted: 17/04/02

"FSL"[1] or
"FULL SUPPLY LEVEL"

means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

"Gauge"

when referred to in (m) means river level referenced to AHD
when referred to in (m^3/sec) means flow rate in cubic metres per second;

"Headworks Operator"

for the purposes of this manual the Headworks Operator is the South-East Queensland Water Corporation.

"Manual" or "Manual of Operational Procedures for Flood Releases from North Pine Dam"

means the current version of this Manual;

"Senior Flood Operations Engineer"

means the person designated at the time pursuant to Section 2.1.1 of this Manual under whose direction the procedures in this Manual shall be carried out;

"South East Queensland Water Corporation"

means the body corporate constituted by that name pursuant to Part III of the South East Queensland Water Board Act 1979. The Board became a government owned corporation in 2000;

Deleted: means the agency with which the

Deleted: has entered into a contract or arrangement with respect to the operation and maintenance of the dams, for the purpose of flood mitigation;

Deleted: "IFF"[1] or¶
"Imminent Failure Flood"¶
means the flood which if exceeded would cause failure of a dam. As defined in the 1986 ANCOLD Guidelines on Design Floods for Dams;¶
¶

Deleted: "RDF"[1] or¶
"Recommended Design Flood"¶
means the flood which a dam should be designed for in accordance with accepted practices. As defined in the 1986 ANCOLD Guidelines on Design Floods for Dams;¶
¶

[1] For reference, these terms are described in "Guideliines on Selection of Acceptable Flood Capacity for Dams" March 2000 by the Australian National Committee on Large Dams (ANCOLD)

Deleted: 17/04/02

1.3 Purpose of Manual

The purpose of this Manual is to define standard procedures for the operation of North Pine Dam during flood periods.

1.4 Legal Authority

This manual has been prepared in accordance with the provisions of Chapter 3 Part 6 Division 2 of the Act.

1.5 Application and Effect

The procedures in this Manual shall apply to the operation of North Pine Dam for the purpose of flood releases, and operation in accordance with the manual shall give the protection from liability provided by Section 500 of *Water Act 2000*.

1.6 Date of Effect

The procedures in this Manual shall have effect on and from the date on which the Manual is approved by gazette notice.

1.7 Observance of Manual

This Manual contains the operational procedures for North Pine Dam for the purposes of flood releases, and must be applied by the Headworks Operator for the operation of the dam.

1.8 Provision for Variations to Manual

If the Corporation is of the opinion that the procedures in this Manual should be amended, altered or varied, it must submit for approval as soon as practical a request, which is in accordance with the flood mitigation provisions of the *Water Act 2000*, to the Chief Executive setting out the circumstances and the exact nature of the amendment, alteration or variation sought. The Chief Executive may require the Corporation amend the Manual by written notice.

1.9 Distribution of Manual

The Corporation must regard the manual as a Controlled Document and ensure that only controlled manuals are used in the direction of flood release activities. Agencies having copies of Controlled Documents are listed in Appendix B. The Corporation must maintain a Register of Contact Persons for Controlled Documents and ensure that each issued document is updated whenever amendments are approved.

Before using this Manual for the direction of flood releases, the Headworks Operator must ensure that it is the current version of the Controlled Document.

Deleted: 17/04/02

1.10 Authority to Use Discretion

Where it is reasonable to expect that the safety of the dam will not be reduced, temporary deviations from the procedures detailed in this manual may be made in accordance with Section 2.8.

2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

The Corporation is responsible for and has the duty for operation and maintenance of North Pine Dam, and while it may enter into contracts for the purpose of discharging these responsibilities, for the purposes of this manual the Headworks Operator is the Corporation.

2.1.1 Designation of Senior Flood Operations Engineer

The Headworks Operator must ensure that the procedures set out in this Manual are carried out under the general direction of a suitably qualified and experienced person who shall be referred to hereafter as the Senior Flood Operations Engineer. Only a person authorised in the Schedule of Authorities can give the general direction for carrying out procedures set out in this manual.

Deleted: All instruments of delegation and contract made in accordance with the Act must be recorded in the Schedule of Authorities attached to the Manual as Appendix C. Changes to instruments of delegation and contract must be made in accordance with the Act and incorporated in the Schedule as amendments to the Schedule.¶
¶

2.1.2 Designation of Flood Operations Engineers

The Headworks Operator must have available or on standby at all times a suitably qualified and experienced Flood Operations Engineer to direct the operation of the dam during floods in accordance with the general strategy determined by the Senior Flood Operations Engineer.

The Headworks Operator must ensure that flood control of the dam is under the direction of a Flood Operations Engineer at all times. Only a person authorised in the Schedule of Authorities can direct the flood operation of the dam.

The Headworks Operator must also employ an adequate number of suitably qualified and experienced persons to assist the Flood Operations Engineer in the operation of the dam during floods.

2.2 Qualifications and Experience of Engineers

2.2.1 Qualifications

All engineers referred to in Section 2.1 must meet all applicable requirements of registration or certification under any relevant State Act, and must hold appropriate engineering qualifications to the satisfaction of the Chief Executive.

Deleted: 17/04/02

2.2.2 Experience

All engineers referred to in Section 2.1 must, to the satisfaction of the Chief Executive, have:

(1) Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and

(2) At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:

  (a) Investigation, design or construction of major dams;

  (b) Operation and maintenance of major dams;

  (c) Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;

  (d) Applied hydrology with particular reference to flood forecasting and flood warning systems.

2.3 Schedule of Authorities

For the purpose of directing operation of the dam during floods, a list of suitably qualified and experienced Senior Flood Operations Engineers and Flood Operations Engineers must be maintained in a Schedule of Authorities (Appendix C).

The Headworks Operator must, as the need arises, nominate suitably qualified and experienced engineers for registration in the Schedule of Authorities as Senior Flood Operations Engineers and Flood Operations Engineers. Each new nomination must include a copy of any certificate required under Section 2.2 and a validated statement of qualifications and experience.

The Headworks Operator must obtain the approval for all nominations from the Chief Executive prior to their inclusion in the Schedule of Authorities.

If, in the event of unforseen and emergency situations, no Senior Flood Operations Engineer or no Flood Operations Engineer is available from the Schedule of Authorities, the Headworks Operator must temporarily appoint suitable persons and immediately seek ratification from the Chief Executive.

2.4 Training

The Headworks Operator must ensure that operational personnel required for flood control operations receive adequate training in the various activities involved in flood control operation.

2.5 Dam Operation Arrangements

For the purposes of operation of the dam during times of flood, the Headworks Operator must ensure that:

(a) the operation be carried out under the general direction of the Senior Flood Operations Engineer; and

(b) in the direction of operations which may knowingly endanger life or property, the Senior Flood Operations Engineer must where practical liaise with the Chairperson of the Corporation and the Chief Executive or nominated delegate.

2.6 Responsibilities of the Senior Flood Operations Engineer

The Senior Flood Operations Engineer is responsible for the overall direction of flood operations.

Except insofar as reasonable discretion is provided for in Section 2.8 of this Manual, the Senior Flood Operations Engineer must ensure that the operational procedures for the dam shall be in accordance with this Manual.

2.7 Responsibilities of the Flood Operations Engineer

The Flood Operations Engineer must apply the operational procedures in accordance with this manual and the direction set for flood operations. In so doing, account must be taken of prevailing weather conditions, the probability of follow up storms and the ability of the dam to discharge excess flood waters in the period between rainfall events or in the period from the time of detection of conditions associated with the development of storm cells to the likely time of occurrence of the rainfall.

2.8 Reasonable Discretion

If in the opinion of the Senior Flood Operations Engineer, based on available information and professional experience, it is necessary to depart from the procedures set out in this manual, the Senior Flood Operations Engineer is authorised to adopt such other procedures as considered necessary to meet the situation, provided that the Senior Flood Operations Engineer observes the flood release objectives set out in Section 3 of this Manual when exercising such reasonable discretion.

Deleted: must

Deleted:

Before exercising discretion under this Section of the Manual with respect to flood release operations, the Senior Flood Operations Engineer must consult with such of the following persons as are available at the time that the discretion has to be exercised:

Deleted: objectives

the Chairperson of the Corporation, and

the Chief Executive or nominated delegate.

Deleted: 17/04/02

If not able to contact any of the above within a reasonable time, the Senior Flood Operations Engineer may proceed with such other procedures considered as necessary to meet the situation and report such action at the earliest opportunity to the above persons.

Deleted: must

2.9 Report

The Senior Flood Operations Engineer must prepare a report to the Headworks Operator after each event that requires flood operation of the dam and the report must contain details of the procedures used, the reasons therefore and other pertinent information. The Headworks Operator shall forward a copy of the report to the Chief Executive within six weeks of the event referred to.

Deleted: Corporation

Deleted: 17/04/02

3 FLOOD RELEASE OBJECTIVES

3.1 General

To meet the purpose of the flood operation procedures in this Manual, the flood release objectives, listed in descending order of importance, are as follows:

Deleted: al

(a) Ensure the structural safety of the dam;

(b) Minimise disruption to urban and rural life in the valleys of the North Pine River and its major tributaries; and

(c) Retain storage at the full supply level.

3.2 Structural Safety of Dam

The structural safety of North Pine Dam must be the first consideration in flood release operations. Failure could have catastrophic consequences due to the magnitude of flood damage that would be caused downstream, and also due to the loss of a water supply source.

The most likely cause of damage is overtopping. North Pine Dam consists of a mass concrete section, and earthen embankment sections. Concrete sections can withstand limited overtopping without damage. Failure of such sections is rare but when they do occur, they occur suddenly without warning, creating very severe and destructive flood waves. Embankment sections on the other hand will washout rapidly if overtopped and cause failure of the dam, resulting in severe flooding downstream. The prevention of overtopping is thus of paramount importance.

The safety of the dam therefore depends primarily on the proper operation of the spillway gates, which are used to control maximum flood levels. Such operation in turn relies on the proper functioning of the mechanical hoist mechanisms and their electric power supply and controls. This equipment is located just above full supply level and can become inundated. Once inundated, the electric winches will not work and backup systems which themselves may not be able to respond quickly enough to handle large flows will be needed to adjust gate positions.

The critical levels for the operation of the dam and the consequence of their exceedance are as follows:

Description	AHD (m)	Possible Consequence
Embankment Crest	43.28	Breach of embankment by erosion
Radial Gate Switch Gear	41.66	Electric motors submerged, backup opening system required
Above Full Supply Level at Start of Storm	39.60	Reduced capacity to handle large floods

Deleted: 17/04/02

3.3 Extreme Floods and Closely Spaced Large Floods

The spillway of North Pine Dam has adequate capacity with gates operating correctly to handle current maximum estimates of runoff from precipitation. Techniques for estimating extreme floods have in the past had a tendency to increase flood magnitudes as more has become known about possible flooding. There is still a very remote possibility that floods are possible which would overtop the dam. Such events however require intense rainfall to produce the necessary runoff. Pre-release of storage at flood producing levels could reduce the risk of overtopping but this may result in discharges exceeding inflows. Such a measure should be taken only after careful consideration of the reliability of precipitation forecasts and of perceived antecedent conditions.

Anticipated reservoir levels for various magnitude inflows under normal gate operations and with one gate inoperable in the closed position are as follows:

Deleted: resevoir

NORTH PINE DAM
ESTIMATED PEAK LAKE LEVELS

Average Recurrence Interval of Inflows (Years)	Normal Gate Operations (m AHD)	One Gate Inoperable (m AHD)
2	39.88	39.86
5	40.02	39.97
10	40.10	40.04
20	40.19	40.12
50	40.32	40.23
100	40.42	40.34
200	40.44	40.53
500	40.59	40.68
1 000	40.73	40.77
10 000	41.06	41.32
100 000	41.47	42.23
PMF	42.38	43.22

Source: Pine River System Hydraulic Model - Interim Report on North Pine Dam Dambreak Analysis, April 1993
Crest of embankment is EL 43.28.

Historical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane area within a short time of each other.

In order to be prepared to meet such a situation the stored flood waters from one storm should be discharged from the dam after a flood as quickly as would be consistent with the other major operating principles.

Deleted: 17/04/02

3.4 Maintenance of Full Supply Level

North Pine Dam provides water for the cities of Brisbane and Redcliffe and for the Shires of Caboolture and Pine Rivers. For this reason the storage level after a flood release must be near full supply level. Failure to achieve this objective may place the water supply to these areas at unnecessary risk.

3.5 Disruption to Downstream Areas

Under normal flood situations, community disruption will be limited to inundation of bridges and low-lying paddocks.

In the case of major floods, several houses immediately downstream of the dam may be subject to partial inundation.

In the case of dam break, floods can be generated which are well in excess of natural floods. Dam break floods or the detection of situations that may result in dam break shall be grounds for the emergency evacuation of threatened areas by the appropriate counter disaster agencies.

Deleted: 17/04/02

4 FLOOD CLASSIFICATION

For the reference purposes of this Manual, four magnitudes of flooding are classified as follows:

Minor Flooding
This causes inconvenience such as closing minor roads and the submergence of low-level bridges. Some urban properties are affected.

Deleted: effected

Moderate Flooding
This causes inundation of low-lying areas and may require the evacuation of some houses and/or business premises. Traffic bridges may be closed.

Major Flooding
This causes flooding of appreciable urban Areas. Properties may become isolated. Major disruption occurs to traffic. Evacuation of many houses and business premises may be required.

Extreme Flooding
This causes flooding well in excess of floods in living memory and general evacuation of whole areas are likely to be required.

Usually a flood does not cause the same category of flooding along its entire length and the relevant agencies must have regard to this when flooding is predicted.

(The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia)

Deleted: 17/04/02

5 FLOOD MONITORING AND WARNING SYSTEM

5.1 General

A real time flood monitoring and warning system is established in the Pine River catchment. This system is an event reporting radio telemetry system, (ALERT), used to collect, transmit and receive rainfall and streamflow information. The system consists of field stations which automatically record rainfall and/or river heights at selected locations in the catchments.

The rainfall and river height data is transmitted by radio telemetry, via repeater stations, to base stations at the head office of the Headworks Operator (and the Corporation). There the data is processed in real time by computer programs to assess what is occurring in the catchments in terms of flood flows and what could occur if weather conditions continued, or changed.

Other agencies with their own base stations can, and do, receive data transmissions direct, and so collect and are able to process rainfall and streamflow information appropriate to their needs.

The real time flood model (RTFM) is a suite of hydrologic and hydraulic computer programs that utilise the real time ALERT data to assist in the operation of the dams during flood events.

5.2 Operation

The Headworks Operator is responsible for operating the computer model provided by the Corporation for flood monitoring and forecasting during flood events to optimise flood gate operations and minimise the impacts of flooding.

It is the responsibility of the Corporation to maintain and keep calibrated its own equipment; and to enter into such arrangements with other agencies or to provide such further equipment as the Corporation deems necessary for the Headworks Operator to properly operate the computer model for flood monitoring and forecasting.

A system such as this is expected to improve over time due to:

- improved operation and reliability with experience,
- improved calibration as further data becomes available,
- software upgrades, and
- the number, type and locations of sensors being varied.

A regular process of internal audit and management review must be maintained to achieve this.

A log of the performance of all field equipment necessary to properly operate the real time flood operations model must be kept by the Corporation. The log is to also include all revised field calibrations and changes to the number, type and locations of gauges. Entries onto the log are to be notified to the Headworks Operator without delay in writing.

Deleted: 17/04/02

A log of the performance of the system (ALERT and RTFM) shall be kept by the Senior Flood Operations Engineer. Any faults to the computer hardware or software, and any faults to field equipment which the Corporation has not advised the Headworks Operator of, are to be notified to the Corporation without delay in writing. The Corporation must promptly attend to the faults.

Whenever the Senior Flood Operations Engineer considers that the performance and functionality of the system can be improved, by whatever means, a recommendation must be made to the Headworks Operator accordingly. The Headworks Operator must promptly consider, act on, or refer such recommendations to the Corporation as it considers appropriate.

5.3 Storage of Documentation

The performance of any flood monitoring and warning system is reliant on accurate historical data over a long period of time. The Senior Flood Operations Engineer must ensure that all available data and other documentation is appropriately collected and catalogued as approved by the Corporation, for future use.

5.4 Key Reference Locations

Key field locations have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to alter these locations or vary flood classification levels, agreement must first be obtained between the Corporation, Headworks Operator and the Local Governments within whose boundaries the locations are situated. The locations and gauge readings at which the various classifications of flooding occur are contained in Appendix D.

Gauge boards which can be read manually must be maintained as part of the ALERT stations installed at any key reference location. The Corporation must have procedures to ensure such gauge boards are read in the event of failure of a field station to operate.

5.5 Reference Gauge Values

Other agencies such as the Bureau of Meteorology, the Pine Rivers Shire Council and the Brisbane City Council have direct access to the information from field stations for flood assessment purposes. The consultation between agencies is a very important part of the assessment and prediction of flood flows and heights.

The Corporation must ensure that information relative to the calibration of the Corporations field stations is shared with such agencies.

Deleted: 17/04/02

6 COMMUNICATIONS

6.1 Communications between Staff

The Corporation is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Flood Operations Engineer and site staff at North Pine Dam.

The Headworks Operator is responsible for ensuring that adequate communication exists at all times between the Flood Operations Engineer and site staff at North Pine Dam. Where equipment deficiencies are detected during normal operations, such deficiencies are to be reported within one week to the Corporation for timely corrective action.

6.2 Dissemination of Information

Adequate and timely information is to be supplied to agencies responsible for the operation of facilities affected by flooding and for providing warnings and information to the public. These agencies shall include agencies holding Controlled Documents (Appendix B), and the persons listed in the Schedule of Authorities (Appendix C). For this purpose, the Corporation must maintain a Register of Contact Persons for Information, their means of contact and the type of information to be supplied to each. The Corporation must ensure that each agency receives a copy of the updated Register of Contact Persons for Information whenever amendments are made, but at least every 6 months.

Deleted: and agencies

The Flood Operations Engineer must supply information (refer Section 6.3) to each of these contact persons during dam releases.

All enquiries other than provided for in the Register of Contact Persons for Information, either to the Headworks Operator, the Senior Flood Operations Engineer, the Flood Operations Engineer or dam site staff must be referred to the Corporation. The Corporation must provide a mechanism to receive these enquiries from the time it is advised that releases from the dam is likely until flood release operations are completed.

Some agencies have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public. The Corporation, Headworks Operator, Senior Flood Operations Engineer and Flood Operations Engineer must liaise and consult with those agencies with a view to ensuring all information relative to the flood event is consistent, and used and disseminated in accordance with agreed responsibilities.

6.3 Nature of Information

When, in the opinion of the Flood Operations Engineer, a flood situation is imminent and gate operations are likely, the Flood Operations Engineer must advise those listed in the Register of Contact Persons for Information of :

(a) the current and proposed releases from the dam, and
(b) the estimated flow rates and water heights at the key reference locations listed below:

- Grant Street at Whiteside

Deleted: 17/04/02

- Railway Bridge on North Pine River at Wylie Park, Petrie
- Railway Bridge on South Pine River at Bald Hills

This information is to be updated at intervals as better and more accurate information becomes available.

6.4 Release of Information to the Public

The Corporation is responsible for the issue of information regarding storage conditions and current and proposed releases from the dam to the public and the media.

The Bureau of Meteorology has responsibility for issuing severe weather warnings.

The Emergency Services Response Authorities, under the State Counter Disaster Organisation Act 1975, have responsibility for the preparation of a local counter disaster plan hence the interpretation of dam release information for inclusion in their local flood warnings prepared under the flood sub plan of the counter disaster plan.

7 REVIEW

7.1 Introduction

This review of the Manual has addressed the mechanisms of delegation and control of the dam in periods of operation of the dam for flood releases. The dam may overtop in the eventuality that the flood-gate control systems fail to operate or partially malfunction during the passage of a major flood or combination of floods.

Procedures and systems have been developed since the last revision that should enable lower risk operation of the dam for flood release purposes. This technology is intended to provide longer warning times and the capability of examining options to optimise the safety of the dams and minimise the hazard potential and risk to the community.

With the passage of time neither the technical assumptions nor the physical conditions on which this Manual is based may remain unchanged. It is also recognised that the relevance of the Manual may change with changing circumstances.

It is important, therefore, that the Manual contain operational procedures which in themselves cause the Manual's procedures, and the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

The checking and reviewing process must involve the Headworks Operator and all associated operations personnel in order that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based.

Variations to the Manual may be made in accordance with provisions in Section 1.8.

7.2 Personnel Training

The Headworks Operator must prepare a report by 30th September each year on the training and state of preparedness of operations personnel. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources and Mines.

7.3 Monitoring and Warning System and Communication Networks

The Headworks Operator must prepare a report by the 1st May and 1st November of each year; and after each flood event. The report must assess in terms of hardware, software and personnel, the :

- adequacy of the communication and data gathering facilities,
- reliability of the system over the previous period,
- reliability of the system under prolonged flood conditions,
- accuracy of forecasting flood flows and heights, and
- the overall state of preparedness of the system.

Formatted: Bullets and Numbering

Deleted: 17/04/02

The Corporation must review the report, and taking into account its own log of the performance of the field equipment, take any action considered necessary for the proper functioning and improvement of the system. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources and Mines.

7.4 Operational Review

After each significant flood event, the Corporation must review the effectiveness of the operational procedures contained in this manual. The Headworks Operator is required to prepare a report for submission to the Corporation within six weeks of any flood event that requires mobilisation of the Flood Control Centre.

Deleted: The Headworks Operator by the 30 September of each year, after every event that results in flood operation of the dam and at other times as appropriate, must review the adequacy of the communication and data gathering facilities and make recommendations to the Corporation regarding improving reliability and performance.¶
¶

7.5 Five Yearly Review

Prior to expiry of approval of the Manual, the Corporation must review and if necessary update the Manual and provide a copy to the chief executive for approval pursuant to Section 499 of the Act. The review is to take into account the continued suitability of the communication network, and the flood monitoring and warning system as well as hydrological and hydraulic engineering assessments of the operational procedures.

Deleted: 17/04/02

8 FLOOD RELEASE OPERATION

8.1 Introduction

North Pine dam is a water supply dam with only a small flood storage compartment above full supply level. It effectively has no provision for flood mitigation. The peak inflow from critical storms may occur approximately two to four hours after the commencement of heavy rain. Because of this, operation of the dam during flood periods is restricted to satisfying the flood release objectives and the rapid response of the catchment to flood rains. Once the dam is full, floods will pass through the reservoir with little mitigation.

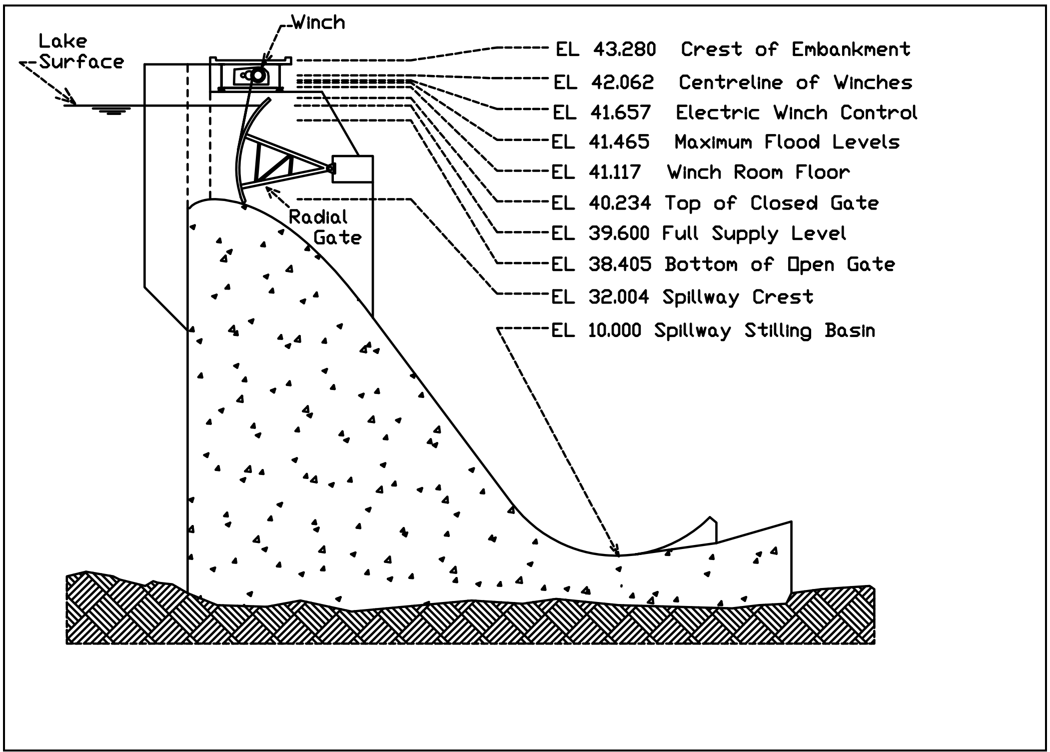


Figure 8.1 Section of North Pine Dam Spillway

Deleted: 17/04/02

8.2 Initial Action

With the onset of heavy rain, initial runoff is to be stored until the lake level exceeds FSL by 50mm, whereafter the spillway gates must be used to control lake level in accordance with the procedures laid out herein. This action is to keep Young's Crossing open for as long as possible.

The Dam Supervisor must ensure that the gates on the road approaches to the Grant Street causeway are also closed before flood releases occur.

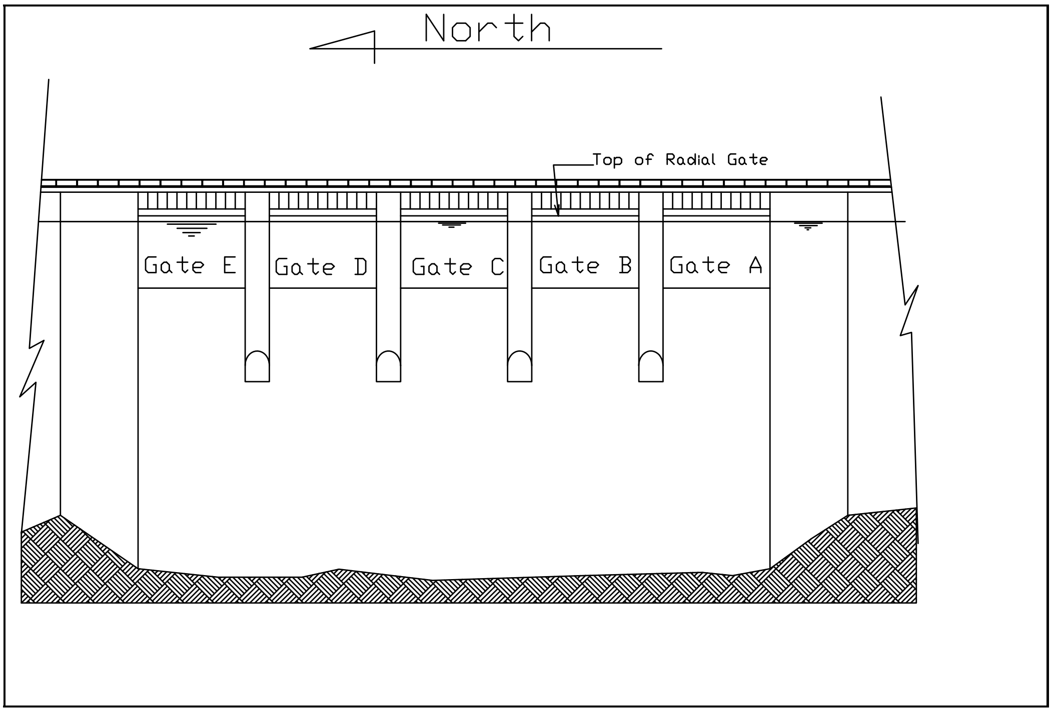


Figure 8.2 View of spillway looking downstream.

8.3 Gate Operation

To minimise potential damage to the dissipator and the river-bed and banks downstream, the gates must be opened incrementally in accordance with the cyclic sequences shown in Figure 8.3. There is to be no more than one increment between any two operable spillway gates.

Deleted: Figure 8.3

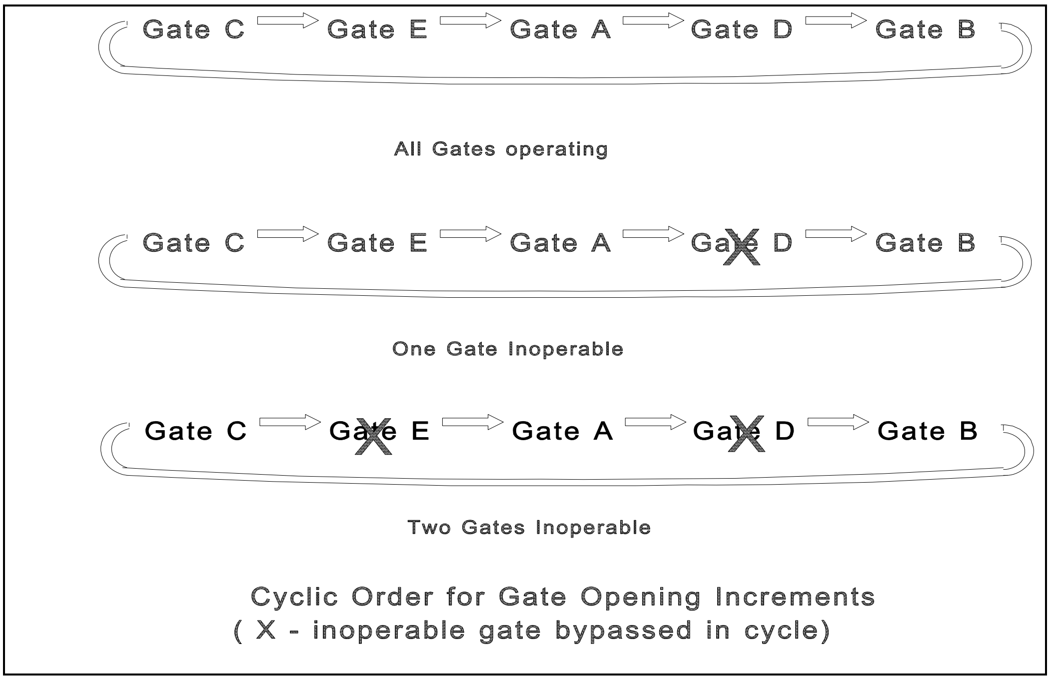


Figure 8.3 Gate Operation Sequence

The operating rule involves assigning gate positions to corresponding lake levels in the reservoir, as detailed in Appendix E.

As the lake level rises, the gates are to be opened in cyclic sequence to positions assigned for the current lake level. A gate opening increment is required for each water level rise of 15 mm, except for the initial two increments that involve water level rises of 50 mm.

As the lake level falls, the gates are to be closed in the reverse of the order shown in Figure 8.3. During small, long duration flood events, extra gate openings may be used on the falling limb of the storage levels to minimise the duration of gate operation. Such openings should not result in discharges that are higher than the peak discharge encountered on the rising limb of the flood event. Gate opening sequences should be in accordance with Figure 8.3 and minimum gate opening and closing intervals should be observed at all times during this operation.

Where one or more gates are inoperable, the same sequencing applies except that the inoperable gates must be ignored in the cycle and their increments passed on to the next gate in the sequence. The cumulative number of increments taken by all gates at any particular lake level thus remains unaltered save that the total number of available gate increments has been reduced

Deleted: 17/04/02

by inoperable gates. The process is illustrated in Figure 8.3 where inoperable gates have been crossed out.

Appendix E contains tables of gate position settings against lake levels for the situations where all gates are operating and where one gate is inoperable.

The minimum time interval between increments of gates in the spillway must be determined by prevailing circumstances. Short time intervals between successive increments of the gates can cause surging of the river downstream of the dam. This is undesirable as it may damage banks or put at risk near-stream population and property. The adoption of long periods between increments could result in excessive maximum flood levels within the dam. The higher maximum flood levels are associated with higher probabilities of damage or failure of the dam.

It is therefore necessary to consider two situations for the operation of the gates:

(1) Gradually varying lake levels where long intervals between gate increments are sufficient to control the lake level; and

(2) Rapidly varying lake levels where high inflows are causing the lake level to rise rapidly.

In the case of gradually varying lake levels, the minimum time interval between successive operations of any spillway gate must be determined by the lake level as shown below:

Lake Level	Opening Interval	Closing Interval
Below EL 39.9 m	15 min	15 min
EL 39.9 to 40.5 m	10 min	10 min
Above EL 40.5 m	5 min	5 min

8.4 Operating Procedure

Spillway gates are to be opened to successive settings in the order specified in Appendix E subject to the provisions of Section 8.3 above.

If, because of compliance with the provisions of Section 8.3 and the high inflow rate, the minimum gate settings of Appendix E cannot be maintained, the time intervals between successive openings are to be halved.

If the actual gate settings fall more than three settings below the cumulative number of minimum settings of Table E.1, then successive gate operations are to be carried out as rapidly as possible until the minimum settings are achieved.

As soon as the lake level begins to fall, the gates are to be closed in the order specified in Appendix E. At no time are the gate settings to be less than those specified in Appendix E. As noted in Section 8.3 for small floods of long duration, additional gate openings may be

Deleted: 17/04/02

used to reduce the duration of gate operation. Such openings should not result in discharges that are higher than the peak discharge encountered on the rising limb of the flood event. Gate opening sequences should be in accordance with Figure 3 and minimum gate opening and closing intervals should be observed at all times during this operation.

To prevent the stranding of fish downstream of North Pine Dam after flood events final closure should be as slow as practicable and whenever practicable, closure should be on a weekend so that volunteer rescuers can be mobilised.

The last gate closing is to take place when the lake level falls to EL 39.550.

9 EMERGENCY

9.1 Introduction

While every care has been exercised in the design and construction of the dam, there still remains a low risk that the dam may develop an emergency condition either through flood events or other causes. Experience elsewhere in the world suggests that vigilance is required to recognise emergency flood conditions such as:

- Occurrence of a much larger flood than discharge capacity of the dam;
- Occurrence of a series of large storms in a short period;
- Failure of one or more gates during a flood;
- Development of a piping failure through the embankment;
- Damage to the dam by earthquake;
- Damage to the dam as an act of war or terrorism;
- Other rarer mechanisms.

Deleted: e

Responses to these and other conditions are included in separate Emergency Action Plans.

9.2 Communications Failure

In the event of normal communications being lost between the Flood Operations Engineer and North Pine dam, the Dam Supervisor is to adopt the procedure set out in Section 8.3 above.

9.3 Spillway Gate/Gates Out of Service

In the event of one or more spillway gates being out of service, the remaining operable gates are to be opened in the cyclic order as shown in Figure 8.3.

The provisions of Section 8.3 are to be applied in this case also.

9.4 Equipment Failure

In the event of an electrical failure of the gate lifting machinery, the gates are to be operated using the auxiliary compressed air drive mechanism.

Further details of the auxiliary equipment are contained in Appendix F.

Deleted: 17/04/02

APPENDIX A EXTRACT FROM ACT

EXTRACT FROM WATER ACT 2000

Division 2 – Flood Mitigation

Owners of certain dams must prepare flood mitigation manual

496.(1) A regulation may nominate an owner of a dam as an owner who must prepare a manual (a "flood mitigation manual") of operational procedures for flood mitigation for the dam.

(2) The regulation must nominate the time by which the owner must comply with section 497(1).

Approving flood mitigation manual

497.(1) The owner must give the chief executive a copy of the flood mitigation manual for the chief executive's approval.

(2) The chief executive may, by gazette notice, approve the manual.

(3) The approval may be for a period of not more than 5 years.

(4) The chief executive may get advice from an advisory council before approving the manual.

Amending flood mitigation manual

498.(1) The chief executive may require the owner, by notice, to amend the flood mitigation manual.

(2) The owner must comply with the chief executive's request under subsection (1).

(3) The chief executive must, by gazette notice, approve the manual as amended.

(4) The approval of the manual as amended must be for-

(a) the balance of the period of the approval for the manual before amendment; or

(b) a period of not more than 5 years from the day the manual as amended was approved.

(5) The chief executive may get advice from an advisory council before approving the manual as amended.

Regular reviews of flood mitigation manual

499. Before the approval for the flood mitigation manual expires, the owner must-

(a) review, and if necessary, update the manual; and

Deleted: 17/04/02

(b) give a copy of it to the chief executive under section 497.

Protection from liability for complying with flood mitigation manual

500.(1) The chief executive or a member of the council does not incur civil liability for an act done, or omission made, honestly and without negligence under this division.

(2) An owner who observes the operational procedures in a flood mitigation manual approved by the chief executive 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**" includes-

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

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

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

Deleted: 17/04/02

APPENDIX B AGENCIES HOLDING DOCUMENTS

AGENCIES HOLDING CONTROLLED DOCUMENTS
OF
MANUAL OF OPERATIONAL PROCEDURES
FOR FLOOD RELEASES
FROM
NORTH PINE DAM

Dam Owner	South East Queensland Water Corporation
Emergency Services	Department of Emergency Services, Disaster Management Service Brisbane City Counter Disaster Committee Pine Rivers Shire Counter Disaster Committee
Severe Weather Warning Authority	Bureau of Meteorology
Primary Response Authorities	Brisbane City Council Pine Rivers Shire Council
Regulator	Department of Natural Resources and Mines
Schedule of Authorities, Appendix C	Persons listed in Appendix C

The Corporation must keep a register of contact persons for controlled documents (Section 1.9 refers).

Deleted: 17/04/02

APPENDIX C SCHEDULE OF AUTHORITIES

AUTHORITY	AGENCY/ PERSON	APPROVED BY	APPROVAL DATE	REFERENCE
Senior Flood Operations Engineer	Robert Arnold Ayre SunWater	Chief Executive	Date of approval of this Manual	
	John Lawrence Ruffini Department of Natural Resources and Mines	Chief Executive	Date of approval of this Manual	
Flood Operations Engineer	Peter Hugh Allen Department of Natural Resources and Mines	Chief Executive	Date of approval of this Manual	
	Robert Arnold Ayre SunWater	Chief Executive	Date of approval of this Manual	
	John Lawrence Ruffini Department of Natural Resources and Mines	Chief Executive	Date of approval of this Manual	
	Donald James Cock Department of Natural Resources and Mines	Chief Executive	Date of approval of this Manual	
	Toby Leonard McGrath SunWater	Chief Executive	Date of Approval of this Manual	

APPENDIX D KEY REFERENCE LOCATIONS

Deleted: D

PINE RIVERS SHIRE

	FLOOD CLASSIFICATION			
Gauge	**Minor**	**Moderate**	**Major**	**1974 Flood**
Grant Street, Whiteside	any release from dam			
Railway Bridge, Wyllie Park, Petrie	4.0	5.0	6.0	5.1
Railway Bridge, South Pine River, Bald Hills		3.5	6.0	5.18

Values are in metres AHD
Dam Supervisor to close gates on road approaches to the Grant Street causeway before releases occur (Section 8.2 refers).

Deleted: 17/04/02

APPENDIX E TABLES OF GATE SETTINGS

Deleted: E

Object of Tables:

To provide the target gate settings for any particular lake level in situations when all gates are operational or when one gate is inoperable.

Method of Use:

For rising lake level:

As the lake surface reaches each level shown in the left column, one gate has to be opened to the next setting. This continues until the limit of movement of the gates (setting 23) is reached.

For falling lake level:

As the lake surface falls below each level shown in the left column, one gate has to be closed to the next setting.

Cautionary Notes:

(1) The discharges shown in the right hand columns of Tables E are estimates only and may be revised when actual measurements can be taken.

(2) The actual openings of the gates are set by electro-mechanical controls. As no direct measurement of gate position is available and these settings could drift with time, the actual openings may vary slightly from those originally determined. The discharges indicated are estimated on the basis of the design openings.

Gate Setting	Gate Opening (m)	Top of Gate (EL)	Gate Setting	Gate Opening (m)	Top of Gate (EL)
1	0.152	40.362	13	3.810	41.885
2	0.457	40.547	14	4.115	41.940
3	0.762	40.720	15	4.420	41.984
4	1.067	40.886	16	4.724	42.016
5	1.372	41.041	17	5.029	42.037
6	1.676	41.185	18	5.334	42.047
7	1.981	41.316	19	5.639	42.047
8	2.286	41.349	20	5.944	42.047
9	2.591	41.549	21	6.248	42.047
10	2.896	41.650	22	6.553	42.047
11	3.200	41.740	23	6.858	42.047
12	3.505	41.817			

Design Spillway Gate Settings

Deleted: 17/04/02

Table E.1 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM
(All gates are operational)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
39.600	closed	closed	closed	closed	closed	0
39.650	closed	closed	1	closed	closed	19
39.700	closed	closed	1	closed	1	38
39.715	1	closed	1	closed	1	57
39.730	1	closed	1	1	1	77
39.745	1	1	1	1	1	96
39.760	1	1	2	1	1	130
39.775	1	1	2	1	2	164
39.790	2	1	2	1	2	198
39.805	2	1	2	2	2	233
39.820	2	2	2	2	2	267
39.835	2	2	3	2	2	298
39.850	2	2	3	2	3	329
39.865	3	2	3	2	3	360
39.880	3	2	3	3	3	391
39.895	3	3	3	3	3	423
39.910	3	3	4	3	3	452
39.925	3	3	4	3	4	481
39.940	4	3	4	3	4	511
39.955	4	3	4	4	4	540
39.970	4	4	4	4	4	570
39.985	4	4	5	4	4	599
40.000	4	4	5	4	5	628
40.015	5	4	5	4	5	657
40.030	5	4	5	5	5	686
40.045	5	5	5	5	5	716
40.060	5	5	6	5	5	745
40.075	5	5	6	5	6	775
40.090	6	5	6	5	6	805
40.105	6	5	6	6	6	835
40.120	6	6	6	6	6	866
40.135	6	6	7	6	6	896
40.150	6	6	7	6	7	927
40.165	7	6	7	6	7	957
40.180	7	6	7	7	7	988
40.195	7	7	7	7	7	1019
40.210	7	7	8	7	7	1048
40.225	7	7	8	7	8	1078
40.240	8	7	8	7	8	1108
40.255	8	7	8	8	8	1137
40.270	8	8	8	8	8	1167
40.285	8	8	9	8	8	1198
40.300	8	8	9	8	9	1229
40.315	9	8	9	8	9	1259
40.330	9	8	9	9	9	1290
40.345	9	9	9	9	9	1321
40.360	9	9	10	9	9	1352
40.375	9	9	10	9	10	1383
40.390	10	9	10	9	10	1413
40.405	10	9	10	10	10	1444
40.420	10	10	10	10	10	1475

Deleted: 17/04/02

Table E.1 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(All gates are operational)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
40.435	10	10	11	10	10	1507
40.450	10	10	11	10	11	1538
40.465	11	10	11	10	11	1570
40.480	11	10	11	11	11	1602
40.495	11	11	11	11	11	1633
40.510	11	11	12	11	11	1663
40.525	11	11	12	11	12	1692
40.540	12	11	12	11	12	1721
40.555	12	11	12	12	12	1751
40.570	12	12	12	12	12	1781
40.585	12	12	13	12	12	1808
40.600	12	12	13	12	13	1836
40.615	13	12	13	12	13	1864
40.630	13	12	13	13	13	1892
40.645	13	13	13	13	13	1920
40.660	13	13	14	13	13	1947
40.675	13	13	14	13	14	1975
40.690	14	13	14	13	14	2002
40.705	14	13	14	14	14	2030
40.720	14	14	14	14	14	2057
40.735	14	14	15	14	14	2084
40.750	14	14	15	14	15	2111
40.765	15	14	15	14	15	2138
40.780	15	14	15	15	15	2165
40.795	15	15	15	15	15	2192
40.810	15	15	16	15	15	2218
40.825	15	15	16	15	16	2244
40.840	16	15	16	15	16	2270
40.855	16	15	16	16	16	2297
40.870	16	16	16	16	16	2323
40.885	16	16	17	16	16	2349
40.900	16	16	17	16	17	2375
40.915	17	16	17	16	17	2400
40.930	17	16	17	17	17	2426
40.945	17	17	17	17	17	2452
40.960	17	17	18	17	17	2477
40.975	17	17	18	17	18	2503
40.990	18	17	18	17	18	2528
41.005	18	17	18	18	18	2553
41.020	18	18	18	18	18	2579
41.035	18	18	19	18	18	2603
41.050	18	18	19	18	19	2628
41.065	19	18	19	18	19	2653
41.080	19	18	19	19	19	2677
41.095	19	19	19	19	19	2702
41.110	19	19	20	19	19	2895
41.125	19	19	20	19	20	3090
41.140	20	19	20	19	20	3288
41.155	20	19	20	20	20	3489
41.170	20	20	20	20	20	3692

Deleted: 17/04/02

Table E.1 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(All gates are operational)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
41.185	20	20	21	20	20	3702
41.200	20	20	21	20	21	3712
41.215	21	20	21	20	21	3366
41.230	21	20	21	21	21	3553
41.245	21	21	21	21	21	3742
41.260	21	21	22	21	21	3752
41.275	21	21	22	21	22	3762
41.290	22	21	22	21	22	3772
41.305	22	21	22	22	22	3782
41.320	22	22	22	22	22	3792
41.335	22	22	23	22	22	3802
41.350	22	22	23	22	23	3812
41.365	23	22	23	22	23	3822
41.380	23	22	23	23	23	3832
41.395	23	23	23	23	23	3842

Deleted: 17/04/02

Table E.2 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM
(GATE A STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
39.600	inoperable	closed	closed	closed	closed	0
39.650	inoperable	closed	1	closed	closed	19
39.700	inoperable	closed	1	closed	1	38
39.715	inoperable	0	1	1	1	57
39.730	inoperable	1	1	1	1	77
39.750	inoperable	1	2	1	1	111
39.765	inoperable	1	2	1	2	145
39.780	inoperable	1	2	2	2	179
39.795	inoperable	2	2	2	2	213
39.810	inoperable	2	3	2	2	244
39.825	inoperable	2	3	2	3	275
39.840	inoperable	2	3	3	3	306
39.855	inoperable	3	3	3	3	337
39.870	inoperable	3	4	3	3	366
39.885	inoperable	3	4	3	4	396
39.900	inoperable	3	4	4	4	425
39.915	inoperable	4	4	4	4	454
39.930	inoperable	4	5	4	4	483
39.945	inoperable	4	5	4	5	512
39.960	inoperable	4	5	5	5	541
39.975	inoperable	5	5	5	5	570
39.990	inoperable	5	6	5	5	599
40.005	inoperable	5	6	5	6	629
40.020	inoperable	5	6	6	6	659
40.035	inoperable	6	6	6	6	689
40.050	inoperable	6	7	6	6	719
40.065	inoperable	6	7	6	7	749
40.080	inoperable	6	7	7	7	779
40.095	inoperable	7	7	7	7	810
40.110	inoperable	7	8	7	7	839
40.125	inoperable	7	8	7	8	868
40.140	inoperable	7	8	8	8	897
40.155	inoperable	8	8	8	8	926
40.170	inoperable	8	9	8	8	956
40.185	inoperable	8	9	8	9	987
40.200	inoperable	8	9	9	9	1017
40.215	inoperable	9	9	9	9	1047
40.230	inoperable	9	10	9	9	1077
40.245	inoperable	9	10	9	10	1108
40.260	inoperable	9	10	10	10	1138
40.275	inoperable	10	10	10	10	1168
40.290	inoperable	10	11	10	10	1199
40.305	inoperable	10	11	10	11	1230
40.320	inoperable	10	11	11	11	1261
40.335	inoperable	11	11	11	11	1292
40.350	inoperable	11	12	11	11	1321
40.365	inoperable	11	12	11	12	1350
40.380	inoperable	11	12	12	12	1379
40.395	inoperable	12	12	12	12	1408
40.410	inoperable	12	13	12	12	1435

Deleted: 17/04/02

Table E.2 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE A STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
40.425	inoperable	12	13	12	13	1462
40.440	inoperable	12	13	13	13	1489
40.455	inoperable	13	13	13	13	1517
40.470	inoperable	13	14	13	13	1543
40.485	inoperable	13	14	13	14	1570
40.500	inoperable	13	14	14	14	1597
40.515	inoperable	14	14	14	14	1623
40.530	inoperable	14	15	14	14	1649
40.545	inoperable	14	15	14	15	1675
40.560	inoperable	14	15	15	15	1702
40.575	inoperable	15	15	15	15	1728
40.590	inoperable	15	16	15	15	1753
40.605	inoperable	15	16	15	16	1779
40.620	inoperable	15	16	16	16	1804
40.635	inoperable	16	16	16	16	1830
40.650	inoperable	16	17	16	16	1855
40.665	inoperable	16	17	16	17	1879
40.680	inoperable	16	17	17	17	1904
40.695	inoperable	17	17	17	17	1929
40.710	inoperable	17	18	17	17	1954
40.725	inoperable	17	18	17	18	1978
40.740	inoperable	17	18	18	18	2002
40.755	inoperable	18	18	18	18	2027
40.770	inoperable	18	19	18	18	2050
40.785	inoperable	18	19	18	19	2074
40.800	inoperable	18	19	19	19	2097
40.815	inoperable	19	19	19	19	2121
40.830	inoperable	19	20	19	19	2290
40.845	inoperable	19	20	19	20	2461
40.860	inoperable	19	20	20	20	2634
40.875	inoperable	20	20	20	20	2810
40.890	inoperable	20	21	20	20	2818
40.905	inoperable	20	21	20	21	2826
40.920	inoperable	20	21	21	21	2835
40.935	inoperable	21	21	21	21	2843
40.950	inoperable	21	22	21	21	2851
40.965	inoperable	21	22	21	22	2859
40.980	inoperable	21	22	22	22	2867
40.995	inoperable	22	22	22	22	2884
41.010	inoperable	22	23	22	22	2893
41.025	inoperable	22	23	22	23	2901
41.040	inoperable	22	23	23	23	2909
41.055	inoperable	23	23	23	23	2917
41.070	inoperable	23	23	23	23	2926
41.085	inoperable	23	23	23	23	2934
41.100	inoperable	23	23	23	23	2942
41.115	inoperable	23	23	23	23	2950
41.130	inoperable	23	23	23	23	2959
41.145	inoperable	23	23	23	23	2967
41.160	inoperable	23	23	23	23	2975
41.175	inoperable	23	23	23	23	2984

Deleted: 17/04/02

Table E.2 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE A STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
41.190	inoperable	23	23	23	23	2992
41.205	inoperable	23	23	23	23	3000
41.220	inoperable	23	23	23	23	3009
41.235	inoperable	23	23	23	23	3017
41.250	inoperable	23	23	23	23	3025
41.265	inoperable	23	23	23	23	3034
41.280	inoperable	23	23	23	23	3042
41.295	inoperable	23	23	23	23	2050
41.310	inoperable	23	23	23	23	3059
41.325	inoperable	23	23	23	23	3067
41.340	inoperable	23	23	23	23	3075
41.355	inoperable	23	23	23	23	3084
41.370	inoperable	23	23	23	23	3092
41.385	inoperable	23	23	23	23	3100
41.400	inoperable	23	23	23	23	

Deleted: 17/04/02

Table E.3 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM
(GATE B STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
39.600	closed	inoperable	closed	closed	closed	0
39.650	closed	inoperable	1	closed	closed	19
39.700	closed	inoperable	1	closed	1	38
39.715	1	inoperable	1	closed	1	57
39.730	1	inoperable	1	1	1	77
39.750	1	inoperable	2	1	1	111
39.765	1	inoperable	2	1	2	145
39.780	2	inoperable	2	1	2	179
39.795	2	inoperable	2	2	2	213
39.810	2	inoperable	3	2	2	244
39.825	2	inoperable	3	2	3	275
39.840	3	inoperable	3	2	3	306
39.855	3	inoperable	3	3	3	337
39.870	3	inoperable	4	3	3	366
39.885	3	inoperable	4	3	4	396
39.900	4	inoperable	4	3	4	425
39.915	4	inoperable	4	4	4	454
39.930	4	inoperable	5	4	4	483
39.945	4	inoperable	5	4	5	512
39.960	5	inoperable	5	4	5	541
39.975	5	inoperable	5	5	5	570
39.990	5	inoperable	6	5	5	599
40.005	5	inoperable	6	5	6	629
40.020	6	inoperable	6	5	6	659
40.035	6	inoperable	6	6	6	689
40.050	6	inoperable	7	6	6	719
40.065	6	inoperable	7	6	7	749
40.080	7	inoperable	7	6	7	779
40.095	7	inoperable	7	7	7	810
40.110	7	inoperable	8	7	7	839
40.125	7	inoperable	8	7	8	868
40.140	8	inoperable	8	7	8	897
40.155	8	inoperable	8	8	8	926
40.170	8	inoperable	9	8	8	956
40.185	8	inoperable	9	8	9	987
40.200	9	inoperable	9	8	9	1017
40.215	9	inoperable	9	9	9	1047
40.230	9	inoperable	10	9	9	1077
40.245	9	inoperable	10	9	10	1108
40.260	10	inoperable	10	9	10	1138
40.275	10	inoperable	10	10	10	1168
40.290	10	inoperable	11	10	10	1199
40.305	10	inoperable	11	10	11	1230
40.320	11	inoperable	11	10	11	1261
40.335	11	inoperable	11	11	11	1292
40.350	11	inoperable	12	11	11	1321
40.365	11	inoperable	12	11	12	1350
40.380	12	inoperable	12	11	12	1379
40.395	12	inoperable	12	12	12	1408
40.410	12	inoperable	13	12	12	1435

Deleted: 17/04/02

Table E.3 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE B STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
40.425	12	inoperable	13	12	13	1462
40.440	13	inoperable	13	12	13	1489
40.455	13	inoperable	13	13	13	1517
40.470	13	inoperable	14	13	13	1543
40.485	13	inoperable	14	13	14	1570
40.500	14	inoperable	14	13	14	1597
40.515	14	inoperable	14	14	14	1623
40.530	14	inoperable	15	14	14	1649
40.545	14	inoperable	15	14	15	1675
40.560	15	inoperable	15	14	15	1702
40.575	15	inoperable	15	15	15	1728
40.590	15	inoperable	16	15	15	1753
40.605	15	inoperable	16	15	16	1779
40.620	16	inoperable	16	15	16	1804
40.635	16	inoperable	16	16	16	1830
40.650	16	inoperable	17	16	16	1855
40.665	16	inoperable	17	16	17	1879
40.680	17	inoperable	17	16	17	1904
40.695	17	inoperable	17	17	17	1929
40.710	17	inoperable	18	17	17	1954
40.725	17	inoperable	18	17	18	1978
40.740	18	inoperable	18	17	18	2002
40.755	18	inoperable	18	18	18	2027
40.770	18	inoperable	19	18	18	2050
40.785	18	inoperable	19	18	19	2074
40.800	19	inoperable	19	18	19	2097
40.815	19	inoperable	19	19	19	2121
40.830	19	inoperable	20	19	19	2290
40.845	19	inoperable	20	19	20	2461
40.860	20	inoperable	20	19	20	2634
40.875	20	inoperable	20	20	20	2810
40.890	20	inoperable	21	20	20	2818
40.905	20	inoperable	21	20	21	2826
40.920	21	inoperable	21	20	21	2835
40.935	21	inoperable	21	21	21	2843
40.950	21	inoperable	22	21	21	2851
40.965	21	inoperable	22	21	22	2859
40.980	22	inoperable	22	21	22	2867
40.995	22	inoperable	22	22	22	2884
41.010	22	inoperable	23	22	22	2893
41.025	22	inoperable	23	22	23	2901
41.040	23	inoperable	23	22	23	2909
41.055	23	inoperable	23	23	23	2917
41.070	23	inoperable	23	23	23	2926
41.085	23	inoperable	23	23	23	2934
41.100	23	inoperable	23	23	23	2942
41.115	23	inoperable	23	23	23	2950
41.130	23	inoperable	23	23	23	2959
41.145	23	inoperable	23	23	23	2967
41.160	23	inoperable	23	23	23	2975
41.175	23	inoperable	23	23	23	2984

Deleted: 17/04/02

Table E.3 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE B STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
41.190	23	inoperable	23	23	23	2992
41.205	23	inoperable	23	23	23	3000
41.220	23	inoperable	23	23	23	3009
41.235	23	inoperable	23	23	23	3017
41.250	23	inoperable	23	23	23	3025
41.265	23	inoperable	23	23	23	3034
41.280	23	inoperable	23	23	23	3042
41.295	23	inoperable	23	23	23	2050
41.310	23	inoperable	23	23	23	3059
41.325	23	inoperable	23	23	23	3067
41.340	23	inoperable	23	23	23	3075
41.355	23	inoperable	23	23	23	3084
41.370	23	inoperable	23	23	23	3092
41.385	23	inoperable	23	23	23	3100
41.400	23	inoperable	23	23	23	3109

Deleted: 17/04/02

Table E.4 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM
(GATE C STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
39.600	closed	closed	inoperable	closed	closed	0
39.650	closed	closed	inoperable	closed	1	19
39.700	1	closed	inoperable	closed	1	38
39.715	1	closed	inoperable	1	1	57
39.730	1	1	inoperable	1	1	77
39.750	1	1	inoperable	1	2	111
39.765	2	1	inoperable	1	2	145
39.780	2	1	inoperable	2	2	179
39.795	2	2	inoperable	2	2	213
39.810	2	2	inoperable	2	3	244
39.825	3	2	inoperable	2	3	275
39.840	3	2	inoperable	3	3	306
39.855	3	3	inoperable	3	3	337
39.870	3	3	inoperable	3	4	366
39.885	4	3	inoperable	3	4	396
39.900	4	3	inoperable	4	4	425
39.915	4	4	inoperable	4	4	454
39.930	4	4	inoperable	4	5	483
39.945	5	4	inoperable	4	5	512
39.960	5	4	inoperable	5	5	541
39.975	5	5	inoperable	5	5	570
39.990	5	5	inoperable	5	6	599
40.005	6	5	inoperable	5	6	629
40.020	6	5	inoperable	6	6	659
40.035	6	6	inoperable	6	6	689
40.050	6	6	inoperable	6	7	719
40.065	7	6	inoperable	6	7	749
40.080	7	6	inoperable	7	7	779
40.095	7	7	inoperable	7	7	810
40.110	7	7	inoperable	7	8	839
40.125	8	7	inoperable	7	8	868
40.140	8	7	inoperable	8	8	897
40.155	8	8	inoperable	8	8	926
40.170	8	8	inoperable	8	9	956
40.185	9	8	inoperable	8	9	987
40.200	9	8	inoperable	9	9	1017
40.215	9	9	inoperable	9	9	1047
40.230	9	9	inoperable	9	10	1077
40.245	10	9	inoperable	9	10	1108
40.260	10	9	inoperable	10	10	1138
40.275	10	10	inoperable	10	10	1168
40.290	10	10	inoperable	10	11	1199
40.305	11	10	inoperable	10	11	1230
40.320	11	10	inoperable	11	11	1261
40.335	11	11	inoperable	11	11	1292
40.350	11	11	inoperable	11	12	1321
40.365	12	11	inoperable	11	12	1350
40.380	12	11	inoperable	12	12	1379
40.395	12	12	inoperable	12	12	1408
40.410	12	12	inoperable	12	13	1435

Deleted: 17/04/02

Table E.4 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE C STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
40.425	13	12	inoperable	12	13	1462
40.440	13	12	inoperable	13	13	1489
40.455	13	13	inoperable	13	13	1517
40.470	13	13	inoperable	13	14	1543
40.485	14	13	inoperable	13	14	1570
40.500	14	13	inoperable	14	14	1597
40.515	14	14	inoperable	14	14	1623
40.530	14	14	inoperable	14	15	1649
40.545	15	14	inoperable	14	15	1675
40.560	15	14	inoperable	15	15	1702
40.575	15	15	inoperable	15	15	1728
40.590	15	15	inoperable	15	16	1753
40.605	16	15	inoperable	15	16	1779
40.620	16	15	inoperable	16	16	1804
40.635	16	16	inoperable	16	16	1830
40.650	16	16	inoperable	16	17	1855
40.665	17	16	inoperable	16	17	1879
40.680	17	16	inoperable	17	17	1904
40.695	17	17	inoperable	17	17	1929
40.710	17	17	inoperable	17	18	1954
40.725	18	17	inoperable	17	18	1978
40.740	18	17	inoperable	18	18	2002
40.755	18	18	inoperable	18	18	2027
40.770	18	18	inoperable	18	19	2050
40.785	19	18	inoperable	18	19	2074
40.800	19	18	inoperable	19	19	2097
40.815	19	19	inoperable	19	19	2121
40.830	19	19	inoperable	19	20	2290
40.845	20	19	inoperable	19	20	2461
40.860	20	19	inoperable	20	20	2634
40.875	20	20	inoperable	20	20	2810
40.890	20	20	inoperable	20	21	2818
40.905	21	20	inoperable	20	21	2826
40.920	21	20	inoperable	21	21	2835
40.935	21	21	inoperable	21	21	2843
40.950	21	21	inoperable	21	22	2851
40.965	22	21	inoperable	21	22	2859
40.980	22	21	inoperable	22	22	2867
40.995	22	22	inoperable	22	22	2884
41.010	22	22	inoperable	22	23	2893
41.025	23	22	inoperable	22	23	2901
41.040	23	22	inoperable	23	23	2909
41.055	23	23	inoperable	23	23	2917
41.070	23	23	inoperable	23	23	2926
41.085	23	23	inoperable	23	23	2934
41.100	23	23	inoperable	23	23	2942
41.115	23	23	inoperable	23	23	2950
41.130	23	23	inoperable	23	23	2959
41.145	23	23	inoperable	23	23	2967
41.160	23	23	inoperable	23	23	2975
41.175	23	23	inoperable	23	23	2984

Deleted: 17/04/02

Table E.4 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE C STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
41.190	23	23	inoperable	23	23	2992
41.205	23	23	inoperable	23	23	3000
41.220	23	23	inoperable	23	23	3009
41.235	23	23	inoperable	23	23	3017
41.250	23	23	inoperable	23	23	3025
41.265	23	23	inoperable	23	23	3034
41.280	23	23	inoperable	23	23	3042
41.295	23	23	inoperable	23	23	2050
41.310	23	23	inoperable	23	23	3059
41.325	23	23	inoperable	23	23	3067
41.340	23	23	inoperable	23	23	3075
41.355	23	23	inoperable	23	23	3084
41.370	23	23	inoperable	23	23	3092
41.385	23	23	inoperable	23	23	3100
41.400	23	23	inoperable	23	23	3109

Table E.5 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM
(GATE D STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
39.600	closed	closed	closed	inoperable	closed	0
39.650	closed	closed	1	inoperable	closed	19
39.700	closed	closed	1	inoperable	1	38
39.715	1	closed	1	inoperable	1	57
39.730	1	1	1	inoperable	1	77
39.750	1	1	2	inoperable	1	111
39.765	1	1	2	inoperable	2	145
39.780	2	1	2	inoperable	2	179
39.795	2	2	2	inoperable	2	213
39.810	2	2	3	inoperable	2	244
39.825	2	2	3	inoperable	3	275
39.840	3	2	3	inoperable	3	306
39.855	3	3	3	inoperable	3	337
39.870	3	3	4	inoperable	3	366
39.885	3	3	4	inoperable	4	396
39.900	4	3	4	inoperable	4	425
39.915	4	4	4	inoperable	4	454
39.930	4	4	5	inoperable	4	483
39.945	4	4	5	inoperable	5	512
39.960	5	4	5	inoperable	5	541
39.975	5	5	5	inoperable	5	570
39.990	5	5	6	inoperable	5	599
40.005	5	5	6	inoperable	6	629
40.020	6	5	6	inoperable	6	659
40.035	6	6	6	inoperable	6	689
40.050	6	6	7	inoperable	6	719
40.065	6	6	7	inoperable	7	749
40.080	7	6	7	inoperable	7	779
40.095	7	7	7	inoperable	7	810
40.110	7	7	8	inoperable	7	839
40.125	7	7	8	inoperable	8	868
40.140	8	7	8	inoperable	8	897
40.155	8	8	8	inoperable	8	926
40.170	8	8	9	inoperable	8	956
40.185	8	8	9	inoperable	9	987
40.200	9	8	9	inoperable	9	1017
40.215	9	9	9	inoperable	9	1047
40.230	9	9	10	inoperable	9	1077
40.245	9	9	10	inoperable	10	1108
40.260	10	9	10	inoperable	10	1138
40.275	10	10	10	inoperable	10	1168
40.290	10	10	11	inoperable	10	1199
40.305	10	10	11	inoperable	11	1230
40.320	11	10	11	inoperable	11	1261
40.335	11	11	11	inoperable	11	1292
40.350	11	11	12	inoperable	11	1321
40.365	11	11	12	inoperable	12	1350
40.380	12	11	12	inoperable	12	1379
40.395	12	12	12	inoperable	12	1408
40.410	12	12	13	inoperable	12	1435

Deleted: 17/04/02

Table E.5 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE D STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
40.425	12	12	13	inoperable	13	1462
40.440	13	12	13	inoperable	13	1489
40.455	13	13	13	inoperable	13	1517
40.470	13	13	14	inoperable	13	1543
40.485	13	13	14	inoperable	14	1570
40.500	14	13	14	inoperable	14	1597
40.515	14	14	14	inoperable	14	1623
40.530	14	14	15	inoperable	14	1649
40.545	14	14	15	inoperable	15	1675
40.560	15	14	15	inoperable	15	1702
40.575	15	15	15	inoperable	15	1728
40.590	15	15	16	inoperable	15	1753
40.605	15	15	16	inoperable	16	1779
40.620	16	15	16	inoperable	16	1804
40.635	16	16	16	inoperable	16	1830
40.650	16	16	17	inoperable	16	1855
40.665	16	16	17	inoperable	17	1879
40.680	17	16	17	inoperable	17	1904
40.695	17	17	17	inoperable	17	1929
40.710	17	17	18	inoperable	17	1954
40.725	17	17	18	inoperable	18	1978
40.740	18	17	18	inoperable	18	2002
40.755	18	18	18	inoperable	18	2027
40.770	18	18	19	inoperable	18	2050
40.785	18	18	19	inoperable	19	2074
40.800	19	18	19	inoperable	19	2097
40.815	19	19	19	inoperable	19	2121
40.830	19	19	20	inoperable	19	2290
40.845	19	19	20	inoperable	20	2461
40.860	20	19	20	inoperable	20	2634
40.875	20	20	20	inoperable	20	2810
40.890	20	20	21	inoperable	20	2818
40.905	20	20	21	inoperable	21	2826
40.920	21	20	21	inoperable	21	2835
40.935	21	21	21	inoperable	21	2843
40.950	21	21	22	inoperable	21	2851
40.965	21	21	22	inoperable	22	2859
40.980	22	21	22	inoperable	22	2867
40.995	22	22	22	inoperable	22	2884
41.010	22	22	23	inoperable	22	2893
41.025	22	22	23	inoperable	23	2901
41.040	23	22	23	inoperable	23	2909
41.055	23	23	23	inoperable	23	2917
41.070	23	23	23	inoperable	23	2926
41.085	23	23	23	inoperable	23	2934
41.100	23	23	23	inoperable	23	2942
41.115	23	23	23	inoperable	23	2950
41.130	23	23	23	inoperable	23	2959
41.145	23	23	23	inoperable	23	2967
41.160	23	23	23	inoperable	23	2975
41.175	23	23	23	inoperable	23	2984

Deleted: 17/04/02

Table E.5 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE D STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
41.190	23	23	23	inoperable	23	2992
41.205	23	23	23	inoperable	23	3000
41.220	23	23	23	inoperable	23	3009
41.235	23	23	23	inoperable	23	3017
41.250	23	23	23	inoperable	23	3025
41.265	23	23	23	inoperable	23	3034
41.280	23	23	23	inoperable	23	3042
41.295	23	23	23	inoperable	23	2050
41.310	23	23	23	inoperable	23	3059
41.325	23	23	23	inoperable	23	3067
41.340	23	23	23	inoperable	23	3075
41.355	23	23	23	inoperable	23	3084
41.370	23	23	23	inoperable	23	3092
41.385	23	23	23	inoperable	23	3100
41.400	23	23	23	inoperable	23	3109

Deleted: 17/04/02

Table E.6 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM
(GATE E STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
39.600	closed	closed	closed	closed	inoperable	0
39.650	closed	closed	1	closed	inoperable	19
39.700	1	closed	1	closed	inoperable	38
39.715	1	closed	1	1	inoperable	57
39.730	1	1	1	1	inoperable	77
39.750	1	1	2	1	inoperable	111
39.765	2	1	2	1	inoperable	145
39.780	2	1	2	2	inoperable	179
39.795	2	2	2	2	inoperable	213
39.810	2	2	3	2	inoperable	244
39.825	3	2	3	2	inoperable	275
39.840	3	2	3	3	inoperable	306
39.855	3	3	3	3	inoperable	337
39.870	3	3	4	3	inoperable	366
39.885	4	3	4	3	inoperable	396
39.900	4	3	4	4	inoperable	425
39.915	4	4	4	4	inoperable	454
39.930	4	4	5	4	inoperable	483
39.945	5	4	5	4	inoperable	512
39.960	5	4	5	5	inoperable	541
39.975	5	5	5	5	inoperable	570
39.990	5	5	6	5	inoperable	599
40.005	6	5	6	5	inoperable	629
40.020	6	5	6	6	inoperable	659
40.035	6	6	6	6	inoperable	689
40.050	6	6	7	6	inoperable	719
40.065	7	6	7	6	inoperable	749
40.080	7	6	7	7	inoperable	779
40.095	7	7	7	7	inoperable	810
40.110	7	7	8	7	inoperable	839
40.125	8	7	8	7	inoperable	868
40.140	8	7	8	8	inoperable	897
40.155	8	8	8	8	inoperable	926
40.170	8	8	9	8	inoperable	956
40.185	9	8	9	8	inoperable	987
40.200	9	8	9	9	inoperable	1017
40.215	9	9	9	9	inoperable	1047
40.230	9	9	10	9	inoperable	1077
40.245	10	9	10	9	inoperable	1108
40.260	10	9	10	10	inoperable	1138
40.275	10	10	10	10	inoperable	1168
40.290	10	10	11	10	inoperable	1199
40.305	11	10	11	10	inoperable	1230
40.320	11	10	11	11	inoperable	1261
40.335	11	11	11	11	inoperable	1292
40.350	11	11	12	11	inoperable	1321
40.365	12	11	12	11	inoperable	1350
40.380	12	11	12	12	inoperable	1379
40.395	12	12	12	12	inoperable	1408
40.410	12	12	13	12	inoperable	1435

Deleted: 17/04/02

Table E.6 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE E STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE CUMECS)
40.425	13	12	13	12	inoperable	1462
40.440	13	12	13	13	inoperable	1489
40.455	13	13	13	13	inoperable	1517
40.470	13	13	14	13	inoperable	1543
40.485	14	13	14	13	inoperable	1570
40.500	14	13	14	14	inoperable	1597
40.515	14	14	14	14	inoperable	1623
40.530	14	14	15	14	inoperable	1649
40.545	15	14	15	14	inoperable	1675
40.560	15	14	15	15	inoperable	1702
40.575	15	15	15	15	inoperable	1728
40.590	15	15	16	15	inoperable	1753
40.605	16	15	16	15	inoperable	1779
40.620	16	15	16	16	inoperable	1804
40.635	16	16	16	16	inoperable	1830
40.650	16	16	17	16	inoperable	1855
40.665	17	16	17	16	inoperable	1879
40.680	17	16	17	17	inoperable	1904
40.695	17	17	17	17	inoperable	1929
40.710	17	17	18	17	inoperable	1954
40.725	18	17	18	17	inoperable	1978
40.740	18	17	18	18	inoperable	2002
40.755	18	18	18	18	inoperable	2027
40.770	18	18	19	18	inoperable	2050
40.785	19	18	19	18	inoperable	2074
40.800	19	18	19	19	inoperable	2097
40.815	19	19	19	19	inoperable	2121
40.830	19	19	20	19	inoperable	2290
40.845	20	19	20	19	inoperable	2461
40.860	20	19	20	20	inoperable	2634
40.875	20	20	20	20	inoperable	2810
40.890	20	20	21	20	inoperable	2818
40.905	21	20	21	20	inoperable	2826
40.920	21	20	21	21	inoperable	2835
40.935	21	21	21	21	inoperable	2843
40.950	21	21	22	21	inoperable	2851
40.965	22	21	22	21	inoperable	2859
40.980	22	21	22	22	inoperable	2867
40.995	22	22	22	22	inoperable	2884
41.010	22	22	23	22	inoperable	2893
41.025	23	22	23	22	inoperable	2901
41.040	23	22	23	23	inoperable	2909
41.055	23	23	23	23	inoperable	2917
41.070	23	23	23	23	inoperable	2926
41.085	23	23	23	23	inoperable	2934
41.100	23	23	23	23	inoperable	2942
41.115	23	23	23	23	inoperable	2950
41.130	23	23	23	23	inoperable	2959
41.145	23	23	23	23	inoperable	2967
41.160	23	23	23	23	inoperable	2975
41.175	23	23	23	23	inoperable	2984

Deleted: 17/04/02

Table E.6 - MINIMUM GATE SETTINGS FOR NORTH PINE DAM (Continued)
(GATE E STUCK OR INOPERABLE)

LEVEL (m AHD)	GATE A	GATE B	GATE C	GATE D	GATE E	DISCHARGE (CUMECS)
41.190	23	23	23	23	inoperable	2992
41.205	23	23	23	23	inoperable	3000
41.220	23	23	23	23	inoperable	3009
41.235	23	23	23	23	inoperable	3017
41.250	23	23	23	23	inoperable	3025
41.265	23	23	23	23	inoperable	3034
41.280	23	23	23	23	inoperable	3042
41.295	23	23	23	23	inoperable	2050
41.310	23	23	23	23	inoperable	3059
41.325	23	23	23	23	inoperable	3067
41.340	23	23	23	23	inoperable	3075
41.355	23	23	23	23	inoperable	3084
41.370	23	23	23	23	inoperable	3092
41.385	23	23	23	23	inoperable	3100
41.400	23	23	23	23	inoperable	3109

Deleted: 17/04/02

APPENDIX F AUXILIARY EQUIPMENT

The spillway gates at North Pine Dam are raised and lowered using electric motor driven winches. These motors are normally powered from the mains electric supply. In the event of a failure of the mains supply, a standby diesel generator (located on level 2 of the dam) automatically cuts in to maintain electric supply.

The original design of North Pine Dam also provided an electrically powered air compressor (located on level 2 of the dam). In the event of failure of a radial gate electric winch motor, a compressed air tool could be attached to the motor shaft and a radial gate operated from the compressed air supply. In the event of a power failure coupled with an electric winch motor failure, a portable compressor could be brought in to drive the compressed air tool and hence operate the gates.

Review of the North Pine Dam hydrology has shown that extreme events can submerge the five radial gate electric winch motors that are located on platforms beneath the bridge deck forming the dam crest. During such an event the electric winch motors would not operate and the winches would not be accessible to enable operation using the compressed air system.

An auxiliary gate operating system installed in 1997/98 comprises a trailer-mounted motor with petrol driven generator, which can be used to operate the winches from the crest of the dam. The shafts of the existing electric winch motors have been extended to the level of the dam crest through right angle gear boxes. In the event of failure of both of the mains electric supply and the standby diesel generator, failure or submergence of the electric winch motor, the trailer mounted motor and petrol driven generator must be used to operate the radial gates.

Deleted: F

Deleted: 17/04/02

APPENDIX G STORAGE AND INFLOW DETERMINATION

Deleted: G

Lake Level EL (m)	Storage 10^6 m^3	Inflow Rate* m^3/s
39.0	187	5.8
39.2	191	5.9
39.4	196	6.0
39.6	200	6.1
39.8	205	6.2
40.0	209	6.3
40.2	214	6.4
40.4	218	6.5
40.6	223	6.6
40.8	228	6.8
41.0	233	6.9
41.2	238	7.0
41.4	243	7.1
41.6	248	7.2
41.8	253	7.3
42.0	258	7.4
42.2	264	7.5
42.4	270	7.7
42.6	275	7.8
42.8	281	7.9
43.0	287	8.1
43.2	292	8.2
43.3	295	8.3

* This is the net inflow that causes the reservoir to rise 1 mm in one hour with the spillway gates functioning normally.

Deleted: 17/04/02

Page 3: [1] Deleted	guppy	17/05/2002 1:45:00 PM

DEPARTMENT OF NATURAL RESOURCES & WATER
OFFICE MEMO

Your Ref.: **Our Ref.:** RRD/130/000(334)
Author: Ron Guppy **Telephone:** [redacted] **Facsimile:** [redacted]

DATE: 11 September 2007

FROM: Principal Engineer, Dam Safety

TO: Director, Dam Safety (Water Supply)

SUBJECT: FLOOD MITIGATION MANUAL, NORTH PINE DAM

Recommendation

The South East Queensland Water Corporation (SEQ Water) has submitted for approval as a Flood Mitigation Manual *Manual of Operational Procedures for Flood Releases from North Pine Dam (Revision 4).*

I recommend that this document (copy attached) be approved as a Flood Mitigation Manual for a period of five years. A gazette notice is required to formalise the approval.

Background

The current Flood Mitigation Manual for North Pine Dam (Revision 3) was approved by gazette notice on 25th October 2002 for a period of five years i.e. up to 25th October 2007. SEQ Water as owner of North Pine Dam was required by s499 of the *Water Act* to review and if necessary update that Manual and submit it for approval prior to its expiry. An updated Manual (Revision 4) was received from SEQ Water with their letter of 5th September 2007 requesting that it be approved as a Flood Mitigation Manual.

The manual submitted contains a number of updates from the previous version. These updates mainly relate to such things as the introductory comments, the timing of reporting, and communication with other agencies. The actual operation of the gates at the dam remains as per the current opening procedures.

The estimated peak lake levels for the various Average Recurrence Interval events in section 3.3 have been updated based on the recently revised flood hydrology for the dam. It should be noted the critical duration PMPDF is now expected to overtop the dam by 0.19 metres even with all gates operating properly. The AEP of the dam crest flood is estimated to be approximately 1 in 2,000,000.

By adjusting the gate opening procedures it should be possible to keep the PMPDF from overtopping the dam but how significant the changes would need to be is an unknown. It might be worthwhile asking SEQ Water to investigate what gate opening procedure changes are needed to prevent overtopping of the dam in the PMPDF event. However this would not be possible before expiry of the current manual.

[redacted]

Summary

The manual submitted by SEQ Water for approval maintains gate operations as per the current procedures that have been in places for a number of years. These provide a good level of security from damages resulting mal-operations of the gates so that I consider the same procedures should remain in place.

Flood mitigation manuals can be approved for periods not exceeding five years. It would seem reasonable to approve this manual for a five year period.

Ron Guppy
PRINCIPAL ENGINEER, DAM SAFETY

[redacted]