seqwater
WATER FOR LIFE

MANUAL

OF

OPERATIONAL PROCEDURES

FOR FLOOD EVENTS

AT

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	September 2009	Complete Revision

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Preface

Given their potential significant impact on downstream populations, it is imperative that Wivenhoe and Somerset Dams be operated during flood events in accordance with clearly defined procedures to minimise impacts to life and property. 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 1968 covering flood operations at Somerset Dam (Wivenhoe Dam was completed in 1984). Six revisions of the Manual have occurred since 1992 to account for updates to the Flood Alert Network and the Real Time Flood Models, the construction of Fuse Plugs at Wivenhoe Dam in 2005 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 dams;
- Provide optimum protection of urbanised areas from inundation;
- Minimise disruption to rural life in the valleys of the Brisbane and Stanley Rivers;
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.
- Minimise Impacts to riparian flora and fauna during the drain down phase of the Flood Event.
- ~~Minimise disruption and impact upon Wivenhoe Power Station;~~
- ~~Minimise disruption to navigation in the Brisbane River.~~

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

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.

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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;

"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;

"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 dams;

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

"Flood Event"
Situations where the Duty Flood Operations Engineer expects the water level in either of the Dams to exceeds the Full Supply Level.;

"Flood Operations Engineer"

means athe person designated at the time to direct the flood operations at the samsof Wivenhoe Dam and Somerset Dam and in accordance with Section 2.3 of this Manualthe 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 (m^3/sec) means flow rate in cubic metres per second;

"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 athe person designated in accordance with at the time pursuant to Section 2.2 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 Wivenhoe Dam and Somerset Dam to reduce, so far as practicable, the effects of flooding associated with the dams. This is achieved by the proper control and regulation in time of the water release infrastructure at the dams, with due regard to the safety of the dam structures.

The procedures in this Manual have been developed on the basis that the community is to be protected to the maximum extent practical against flood hazards recognising the limitations on being able to:

- Accurately forecast rainfall and associated flood run-off during a flood event;
- Identify all potential flood hazards and their likelihood;
- Remove or reduce community vulnerability to flood hazards;
- Effectively respond to flooding;
- Provide resources in a cost effective manner.

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 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 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, 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 used for the operation of the dams during flood events.

1.8 Provision for Variations to 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 B. 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 dams 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 dams during Flood Events, Seqwater must ensure that:

- Sufficient numbers of suitably qualified personnel are available to operate the dams 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 full supply level of either Wivenhoe or Somerset 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 dams during Flood Events is ~~be~~ carried out under the direction of the Duty Flood Operations Engineer.
- All~~Make 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~~3~~). When rostered on duty during a Flood Event, the responsibilities of the Senior Flood Engineer are as follows:

- Set the overall strategy for management of the Flood Event in accordance with the objectives of this Manual.
- Provide instructions to site staff to make releases of water from the Dams during Flood Events that are in accordance with this Manual.
- Apply reasonable discretion in managing a Flood Event as described in Section 2.6.

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

- Follow any direction from the Senior Flood Operations Engineer in relation to applying reasonable discretion in managing a Flood Event as described in Section 2.6. Unless otherwise directed, a Flood Operations Engineer is to follow this Manual in managing Flood Events and is not to apply reasonable discretion unless directed by the Senior Flood Operations Engineer or the Chief Executive.

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

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

2.5 Qualifications and Experience of Engineers

Qualifications

All engineers referred to in Sections 2.2 and 2.3 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 2.2 and 2.3 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 flood forecastingwarning 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 control 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 not able to contact 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 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 operational procedures in this Manual, the following objectives, listed in descending order of importance, are as follows:

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

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

Additionally, the auxiliary spillway constructed at Wivenhoe Dam in 2005 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 potential scenario is possible only 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.

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.

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. Wivenhoe Dam is overtopped by a 1 in 100000 year event.

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. Although Somerset Dam is overtopped by a 1 in 10000 year event, it is expected that the dam could withstand at least 1.5 metres of overtopping without failure. This equates to a 1 in 100000 year event.

3.3 Extreme Floods and Closely Spaced Large Floods

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

Historical records show that there is a significant probability of two or more flood producing storms occurring in the Brisbane River system within a short time of each other. Therefore, unless determined otherwise by the Senior Flood Operations Engineer in accordance with Section 2.6, the aim during a Flood Event should be 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 from the dams should be regulated so as to have little impact on the urban reaches of the Brisbane River, taking into account inflows into the river downstream of the dams. However the seven day drainage requirementy may result in submergence of some bridges. Regardless, tThe 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.

3.4 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 ofn 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 floodgates to control~~controlling water releases from the dams, while 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, 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.~~

Disruption to navigation in the Brisbane River is also a consideration when considering disruption to rural areas downstream of the dam. This consideration is secondary however to considerations associated with reducing bridge inundation.

~~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 lowest 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 while the Moggill Ferry is 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.~~ .

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:

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.

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.

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 Brisbane area is classified as a major flood.

Extreme Flooding
This causes flooding impacts equal to or in excess of levels previously experienced. ~~in the greater Brisbane area during the 1974 floods and i~~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~~warning~~ system has been established in the dam catchments. This system employs radio telemetry to collect, transmit and receive rainfall and streamflow information. The system consists of more than 100 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 bases 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 Duty and Duty 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 forecastingwarning 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, Brisbane City Council and Ipswich 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 relaventtive 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 Wivenhoe and Somerset Dams.

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 Table 6.1.

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 dams and each agency is to receives 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 and disseminated in accordance with agreed responsibilities. All

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.
Department of Environment and Resource Management	Review of flood operations and discretionary powers.	Actual and predicted lake levels and discharges	
Somerset Regional Council	Flood level information upstream of Somerset Dam and upstream and downstream of Wivenhoe Dam	Actual and predicted lake levels, Somerset Dam and actual and predicted lake levels and discharges, Wivenhoe Dam	Somerset Dam water level predicted to exceed EL 102 and 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)	

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 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 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 Personnel 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 ForecastingWarning 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., and
- The overall state of preparedness of the system.

Seqwater must at all times take any action considered necessary for the proper functioning and improvement of the 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 Control Centre.

7.5 Five Yearly Review

Prior to the expiry of the approval period, the Corporation 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 forecastingwarning 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.~~

8 WIVENHOE DAM FLOOD OPERATIONS

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.

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 for hydro power generation. Splityard Creek Dam impounds a volume of 28 700 ML at FSL (EL 166.5). This volume can be emptied into Lake Wivenhoe within 12 hours and this 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 release of water from Splityard Creek Dam to Lake Wivenhoe is outside the control of Seqwater, but should be considered when assessing the various trigger levels of Wivenhoe Dam.

8.2 Flood Release Infrastructure

The arrangement of the Wivenhoe Dam Radial Gates is shown in the diagram below:

In addition to the five radial gates, an auxiliary spillway was constructed in 2005 as part of an upgrade to improve flood adequacy of this storage. The auxiliary spillway consists of a three bay fuse plug spillway at the right abutment. In association with other works constructed at the dam, this gives the dam crest flood 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.

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

[redacted]

The arrangement of the Auxillary Spillway is shown in the diagram below:

[redacted]

8.3 Initial Flood Control Action

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

- A prediction of the maximum storage levels in Wivenhoe and Somerset Dams.
- A prediction of the peak flow rate at the Lowood Gauge excluding Wivenhoe Dam releases.
- A prediction of the peak flow rate at the Moggill Gauge excluding Wivenhoe Dam releases.

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

8.4 Flood Operations Strategies

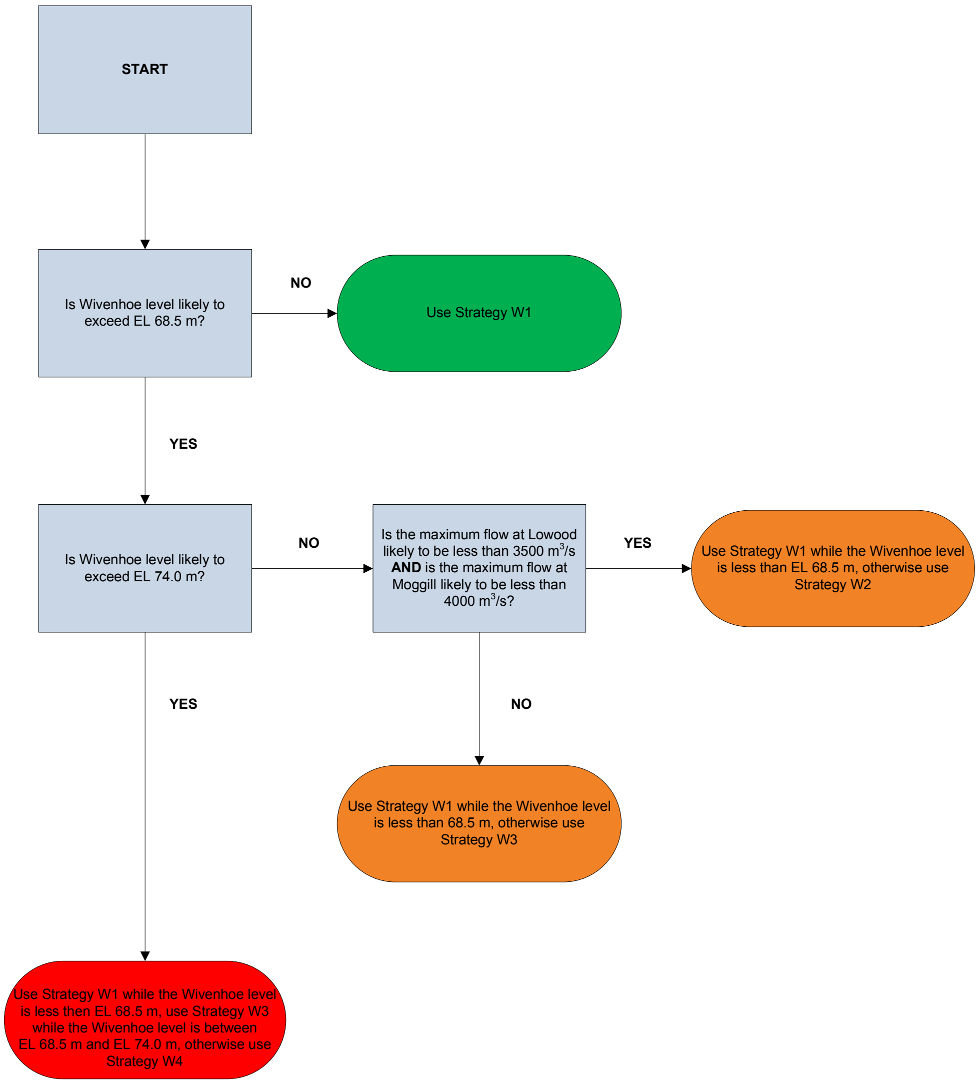
There are four strategies used when operating Wivenhoe Dam during a flood event as outlined below. These strategies are based on the Flood Objectives of this manual. The strategy chosen at any point in time will depend on predictions of the following factors, made with the best rainfall forecast and streamflow information available at that time:

- The maximum storage levels in Wivenhoe and Somerset Dams.
- The peak flow rate at the Lowood Gauge excluding Wivenhoe Dam releases.
- The peak flow rate at the Moggill Gauge excluding Wivenhoe Dam releases.

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

A flowchart showing how best to select the appropriate strategy to use at any point in time is shown below:

WIVENHOE FLOOD STRATEGY FLOW CHART

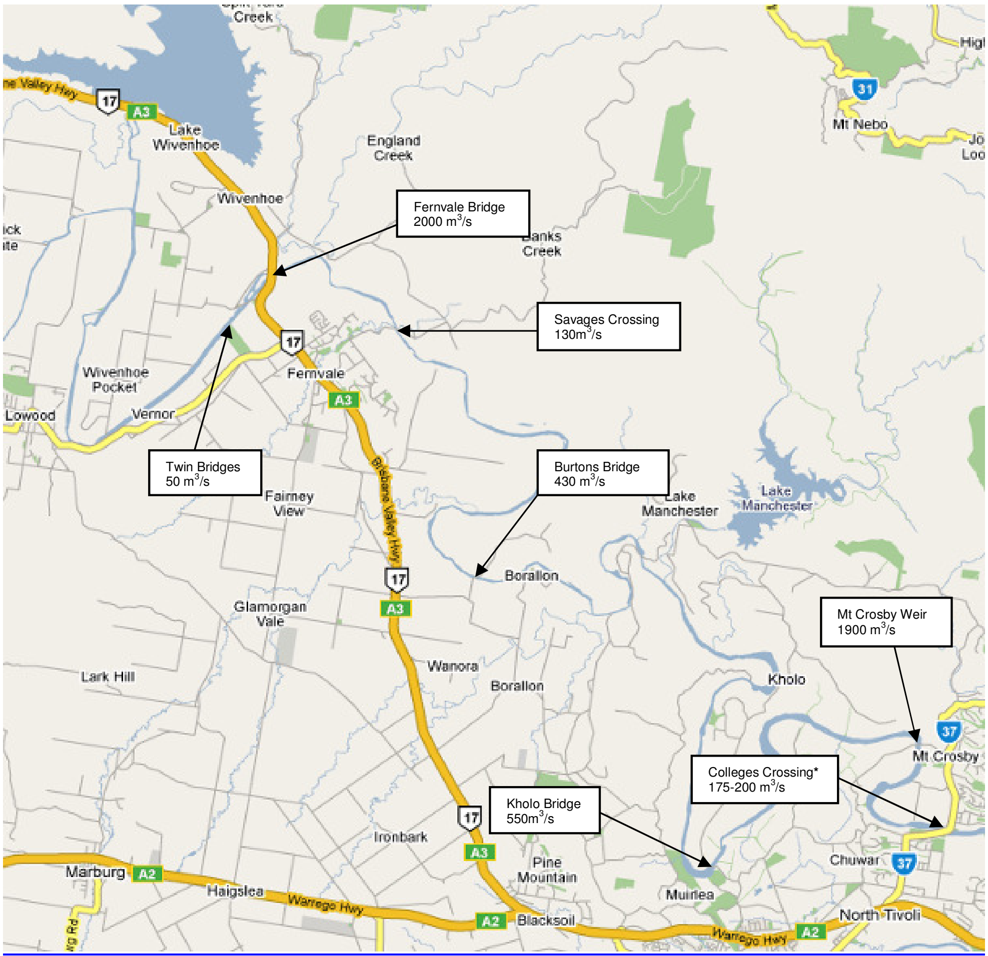


Strategy W1- Minimising Impact On Rural Life Downstream

Conditions	• **Wivenhoe Lake Level predicted to be less than 68.50 m AHD.** • **Maximum Release 1 900 m^3/sec.** • **The primary consideration is minimising disruption to downstream rural life.**

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

Submergence Flows for Bridges



* Affected by tides

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.

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

Strategy W1A Twin Bridges, Savages Crossing and Colleges Crossing

Lake level between 67.25 and 67.5 m AHD
[Maximum Release 110 m^3/sec]

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

Once Twin Bridges is closed to traffic, endeavour to maintain Savages Crossing trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 110 m^3/s.

Once Savages Crossing is closed to traffic, endeavour to maintain College's Crossing trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 110 m^3/s.

When the flood event subsides, all gates are to be closed when the dam achieves FSL in accordance with Section 8.5.

Strategy W1B College's Crossing and Burtons Bridge

Lake level between 67.50 and 67.75 m AHD
[Maximum Release 380 m^3/sec]

No consideration is given to maintaining Twin Bridges or Savages Crossing open.

Endeavour to maintain College's Crossing trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 175 m^3/s.

Once College's Crossing is closed to traffic, endeavour to maintain Burtons Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 380 m^3/s.

<u>Strategy W1C</u> Burtons Bridge and Kholo Bridge

Lake level between 67.75 and 68.00 m AHD
[Maximum Release 500 m^3/sec]

No consideration is given to maintaining College's Crossing open.

Endeavour to maintain Burtons Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 430 m^3/s.

Once Burtons Bridge is closed to traffic, endeavour to maintain Kholo Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 500 m^3/s.

<u>Strategy W1D</u> Kholo Bridge and Mt Crosby Weir Bridge

Lake level between 68.00 and 68.25 m AHD
[Maximum Release 900 m^3/sec]

No consideration is given to maintaining Burtons Bridge open.

Endeavour to maintain KholoBridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 550 m^3/s.

Once Kholo Bridge is closed to traffic, endeavour to maintain Mt Crosby Weir Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 900 m^3/s.

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

Lake level between 68.25 and 68.50 m AHD
[Maximum Release 1,900 m^3/sec]

No consideration is given to maintaining Kholo Bridge open.

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

Once Mt Crosby Weir Bridge is closed to traffic, endeavour to maintain Fernvale Bridge trafficable by limiting the combined flows from Wivenhoe Dam and Lockyer Creek to a maximum of 1900 m^3/s.

If the level reaches EL 68.5 m AHD in Wivenhoe Dam, operations switch to Strategy 2 or 3 as appropriate.

~~Procedure 2 may be bypassed if it is clear from the flood modelling that Procedure 3 will be activated.~~

Strategy W2 - Transition Strategy from W1 to W3

Conditions	• **Wivenhoe Lake Level predicted to be between 68.50 and 74.00 m AHD.** • **Maximum Release 3 500 m^3/s.** • **This is a trasition strategy in which the primary consideration changes from minimising disruption to downstream rural life to protecting urban areas from inundation.**

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The intent of Strategy W2 is limit the flow in the Brisbane Rriver to less than the naturally occurring peaks at Lowood and Moggill, while remaining within the upper limit of non-damaging floods at Lowood (3500 m^3/s). In these instances, the combined peak river flows should not exceed those shown in the following table:

LOCATION	TARGET MAXIMUM FLOW IN THE BRISBANE RIVER
Lowood	The lesser of: • the natural peak flow at Lowood excluding Wivenhoe Dam releases, and; • 3500m^3/s.
Moggill	The lesser of: • the natural peak flow at Moggill excluding Wivenhoe Dam releases, and; • 3500m^3/s.

Strategy W3 – Protect Urban Areas from Innundation

Conditions	• **Wivenhoe Lake Level predicted to be between 68.50 and 74.00 m AHD.** • **Maximum Release 4 000 m^3/s.** • **The primary consideration is protecting urban areas from inundation.**

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

TIMING	**TARGET MAXIMUM FLOW IN THE BRISBANE RIVER**
Prior to the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases).	The flow at Moggill is the be minimised.~~lesser of the peak from the Lockyer or 3500m^3/s~~
After the naturally occurring peak at Moggill (excluding Wivenhoe Dam releases).	The flow at Moggill is to be lowered to 4000m^3/s as soon as possible.~~.~~

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Strategy W4 – Protect the Structural Safety of the Dam.

Conditions	• **Wivenhoe Lake Level predicted to exceed 74.00m AHD.** • **No limit on Maximum Release rate.** • **The primary consideration is protecting the structural safety of the dam.**

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

This strategy~~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 S~~s~~ection 2.8 if earlier commencement is able to prevent triggering of a fuse plug.

Under Strategy~~Procedure~~ W4 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

Strategy 4A – No Fuse Plug Initiation Expected

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

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

Gate openings are to occur at the minimum intervals and sequences as specified in Section 8.4 until the storage level of Wivenhoe Dam begins to fall. Generally, this requires gates to be raised at a rate of one metre per ten minutes in the sequence of Gate 3, Gate 2, Gate 4, Gate 1, Gate 5. In these circumstances, to protect the safety of the dam, minimum opening intervals can be reduced and gate opening sequences can be modified.

~~Procedure~~ Strategy 4B – Fuse Plug Initiation Possible

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

~~Procedure~~ Strategy 4B applies once indications are the peak flood level in Wivenhoe Dam may exceed EL75.5 and trigger the fuse plug under normal operations. Two scenarios are possible under this strategy~~procedure~~. The first scenario is where it may be possible to prevent fuse plug initiation by early opening of the gates. The second scenario is where fuse plug initiation cannot be avoided. The actions associated with these scenarios are contained in the following table:

SCENARIO	ACTION
[redacted]	

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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.

8.48.5 Gate Closing ProceduresStrategies

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

- Unless determined otherwise by the Senior Flood Operations Engineer in accordance with Section 2.6, the aim should be to empty stored floodwaters stored above EL 67.5m within seven days after the flood peak has passed through the lower reaches of the Brisbane River.

- If the flood storage compartments of Wivenhoe Dam and Somerset Dam can be emptied within seven days, the maximum combined flow in the Brisbane River at Lowood should not exceedbe less than 3500 m^3/sec.

- The maximum discharge from the dam during closure should generally be less than the peak flow into Wivenhoe Dam experienced during the event. The discharge from Wivenhoe Dam includes discharge from triggered fuse plugs, gates, regulator cone dispersion valve and hydro release.

- Where possible, total releases during closure should not produce greater flood levels downstream than occurred during the flood event.

- 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.

- To prevent the stranding of fish downstream of the dam, final closure sequences should consider Seqwater policies relating to fish protection at the dam.s 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.

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

Intervals Between Operations

Rapid opening of dam outlets (spillway gates and regulators) can cause hydraulic surges and other effects in the Brisbane River that could endanger life and property and may have other adverse effects. Additionally, rapid closure of outlets can affect river-bank stability Therefore, under normal operations during Flood Events, the gates and regulators are to be operated one at a time at intervals that will minimise adverse impacts on the river system as outlined in the table below.

MINIMUM INTERVALS FOR NORMAL GATE OPERATIONS	
OPERATION	TIME INTERVAL BETWEEN SUCCESSIVE OPERATIONS (minutes)
[redacted]	

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.

More rapid gate opening intervals are permitted at any time to protect the structural safety of the dam.

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.

Protection of the Spillway Walls

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 spillway structures and 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. As these walls have been excavated into erodible sandstone rock, this impingement may cause non-predictable erosion. Upstream migration of this erosion is to be avoided. This can be achieved by operating Gates 1 and 5 to deflect the discharge away from the walls of the plunge pool.

Therefore in operating the spillway, the principles to be observed in order of priority are:

(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.

Normal Gate Operation Sequences

Under normal operation, only one gate is to be opened at any one time and the sequences shown in the table below are to be adopted. Variations are allowed at any time to protect the structural safety of the dam.

RADIAL GATE OPENING SEQUENCES[1]

[redacted]

Gate Failure or Malfunction Procedures

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 impact of the flow on the sidewalls of the plunge pool should be minimised, and
- The flow in the spillway is as symmetrical as practicable.

Radial Gate Turbulence Considerations

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.

Lowering Radial Gates that have been fifted 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.

~~8.5~~8.7 Modification to Flood Operating Procedures if a Fuse Plug T~~t~~riggers ~~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:

- T~~t~~he discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;
- T~~t~~he 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.

~~8.6~~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:

- T~~t~~he discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;
- T~~t~~he 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.

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 to be operated in conjunction to optimise the flood mitigation benefits downstream of Wivenhoe Dam.

The arrangement of the Somerset Dam Radial Gates, Sluice Gates and Regulator Valves is shown in the diagram below:

[redacted]

~~A general plan and cross-section of Somerset Dam, and relevant dam operating levels are included in Appendix J. Storage anddischarge capacities for various storage levels of Somerset Dam are listed in Appendix F.~~

9.2 Initial Flood Control Action

Once a Flood Event is declared, all radial gates are to be fully opened and all sluice gates and regulator valves are to be fully closed. An assessment is to be made of the magnitude of the Flood Event, including:

- A prediction of the maximum storage levels in Wivenhoe and Somerset Dams.

~~Upon indications being received of a significant inflow, the flood control operation of the dam shall commence with the raising of any closed radial gates and the closure of all low level regulators and sluices, whilst an assessment is made of the magnitude of the flood.~~

9.3 Flood~~Gate~~ Operations Strategies~~Opening and Closing Procedure~~

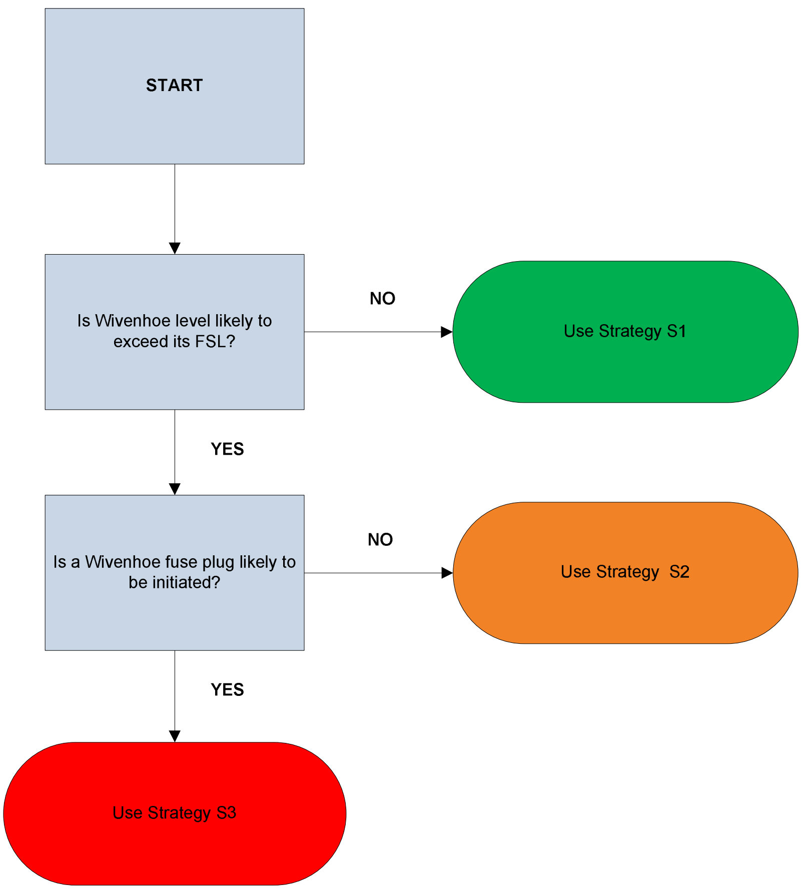
There are three strategies used when operating Somerset Dam during a flood event as outlined below. These strategies are based on the Flood Objectives of this manual. The strategy chosen at any point in time will depend on predictions of the following factors, made with the best rainfall forecast and streamflow information available at that time:

- The maximum storage levels in Wivenhoe and Somerset Dams.

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

A flowchart showing how best to select the appropriate strategy to use at any point in time is shown below:

SOMERSET FLOOD STRATEGY FLOW CHART



Strategy S1 – Minimising Impact on Rural Life Upstream

Conditions	• **Somerest Dam Level expected to exceeds EL 99.0 and Wivenhoe Dam not expected to reach EL 67.0 (FSL) during the course of the Flood Event.**

The intent of this strategy~~procedure~~ is to return the dam to full supply level while minimising the impact on rural life upstream of the dam. Consideration is also given to minimising the downstream environmental impacts from the release.

The crest gates at Somerset Dam are raised to enable uncontrolled discharge. The Regulator Valves and Sluice gates are to be used to maintain the level in Somerset dam below EL 102.0 (deck level of Mary Smokes Bridge). The release rate from Somerset dam is not to exceed the peak inflow into the dam.

Strategy S2 – Minimise Impacts Below Wivenhoe Dam

Conditions	• **Somerest Dam Level expected to exceed EL 99.0 and Wivenhoe Dam level expected to exceed EL 67.0 (FSL) but not exceed EL 75.5 (fuse plug initiation) during the course of the Flood Event.**

The intent of this strategy~~procedure~~ is maximise the benifits of the flood storage capabilities of the dam while protection the structural safety of both dams. The table below contains the operating conditions and actions for ~~Procedure~~ Strategy S2.

[redacted]

[redacted]

~~TABLE 9.2 – Water Level Correlation Targets~~

[redacted]

[redacted]

Strategy S3 - Protect the Structural Safety of the Dam.

Conditions	• **Somerest Dam Level expected to exceed EL 99.0 and Wivenhoe Dam level expected to exceed EL 75.5 (fuse plug initiation) during the course of the Flood Event.**

The intent of this strategy is maximise the benifits of the flood storage capabilities of the dam while protection the structural safety of both dams. ~~**The intent of this procedure is**~~

In addition to the operating protocols used in Strategy S2~~Procedure 2~~, to prevent fuse plug initiation, consideration can be given to temporary departure from the operating protocols contained in Table 9.2 under the following conditions:

- The safety of Somerset Dam is the primary consideration and cannot be compromised.
- The peak level in Somerset dam cannot exceed EL 107~~6~~.5.

9.4 Gate Closing Strategies~~Procedures~~

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

- Unless determined otherwise by the Senior Flood Operations Engineer in accordance with Section 2.6, the aim should be to empty stored floodwaters within seven days after the flood peak has passed through the lower reaches of the Brisbane River.

- To prevent the stranding of fish downstream of the dam, final closure sequences should consider Seqwater policies relating to fish protection at the dam.~~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.~~

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.

9.5 Gate Operation Sequences

Intervals Between Operations

The following minimum intervals must generally be observed whilst opening and closing regulators, sluices and crest gates at Somerset Dam for flood mitigation purposes. :

MINIMUM INTERVALS FOR NORMAL GATE OPERATIONS		
DAM COMPONENT	OPENING	CLOSING
Regulator Valves	30 minutes	60 minutes
Sluice Gates	120 minutes	180 minutes
Crest Gates	Gates are normally open	-

Regulator Valve Considerations

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.

It must also be noted that the Regulator Valves are not to be operated when the tailwater level below Somerset Dam is above the invert of the valves. Operating the valves under these circumstances can damage the valves. This requirement can be ignored if the structural safety of the dam is at risk.

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. 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;

Responses to these conditions are included in Emergency Action Plans for the dams.

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 Auxilliary Spillway constructed at the dam in 2005 gives the dam crest flood 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, thereby increasing this immunity.

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

10.3 Communications Failure

If communications are lost between the Flood Operations Centre and either 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 communication failure with the Flood Operations Centre, radial gate operations are to be undertaken in accordance with Table 10.1.

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.			

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 high inflow rates into the dam, the minimum gate openings shown in Table 10.1 cannot be maintained, the time intervals between successive openings shown in the table below are to be halved.

500 mm Incremental gate openings	10 minutes
500 mm Incremental gate closures	20 minutes
Full regulator opening or closures	30 minutes

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.

If communications with Wivenhoe Dam are lost, the level in Wivenhoe Dam is to be assumed as the level shown on 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. Additionally, the following table showing minimum regulator, sluice and gate operation intervals is to be observed.

GATE	OPENING	CLOSING
Regulator	30 minutes	60 minutes
Sluice Gate	120 minutes	180 minutes
Crest Gate	Gates to remain open	Gates to remain open

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). Table 10.2 gives the water level correlations. The regulators and sluices are to be closed if the water level in Wivenhoe Dam exceeds the level set out below for corresponding water levels in Somerset Dam.

TABLE 10.2 – Water Level Correlation Targets

[redacted]

The minimum gate opening interval 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.

APPENDIX A AGENCIES HOLDING DOCUMENTS

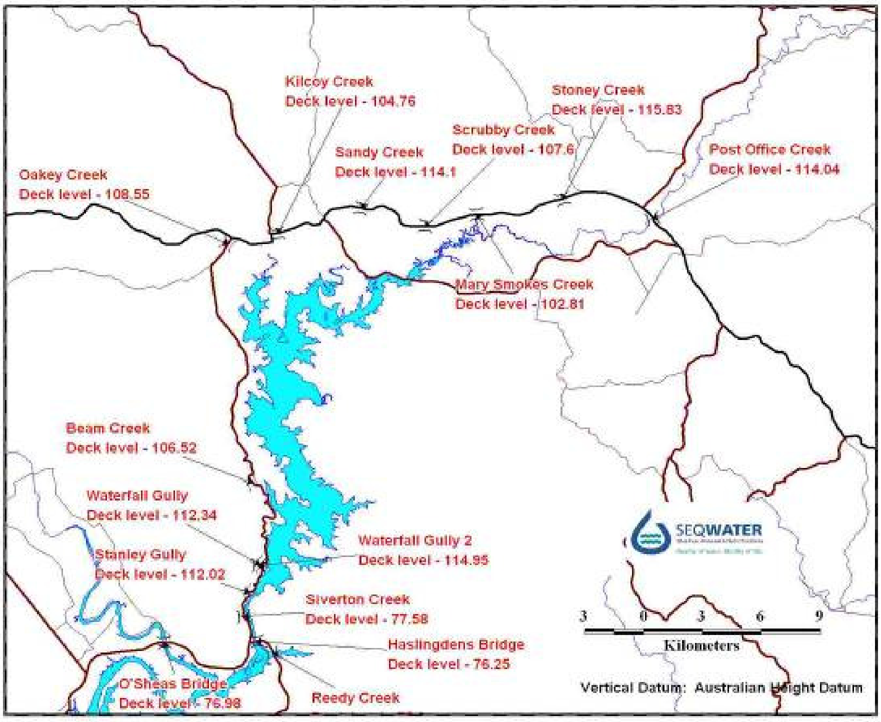
AGENCIES HOLDING CONTROLLED DOCUMENTS OF MANUAL OF OPERATIONAL PROCEDURES FOR FLOOD MITIGATION FOR WIVENHOE DAM AND SOMERSET DAM

Dam Owner	Seqwater
Emergency Services	Emergency Management Queensland
Severe Weather Warning Authority	Bureau of Meteorology
Primary Response Authorities	Brisbane City Council Ipswich City Council Somerset Regional Council
Regulator of Dam Safety	Department of Environment and Resource Management
Other Agencies	SunWater

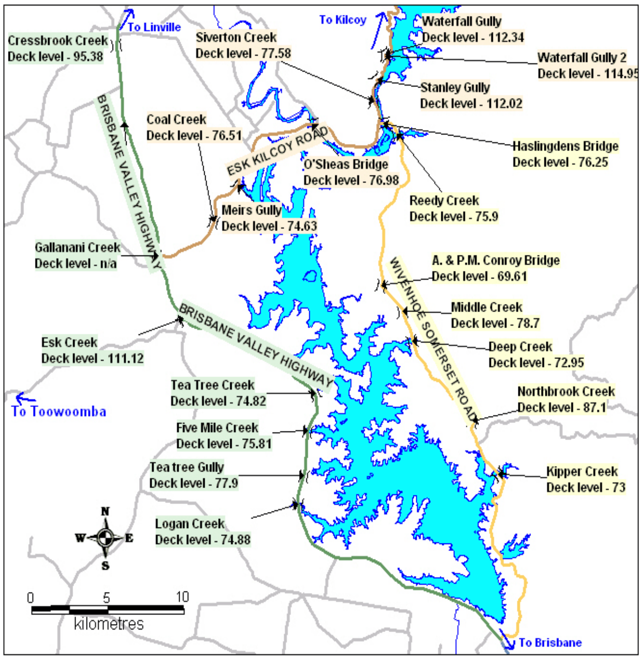
The Corporation must keep a register of contact persons of holders of controlled documents (Section 1.9 refers).

APPENDIX C BRIDGE DECK LEVELS

Roads Upstream of Somerset Dam



Roads Surrounding Wivenhoe Dam



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	m^3/s	m	m^3/s	m	m^3/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

APPENDIX E WIVENHOE DAM TECHNICAL DATA

TABLE E1 STORAGE AND UNCONTROLLED GATE DISCHARGES

[redacted]

* 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)

[redacted]

TABLE E2 CONTROLLED GATE DISCHARGES (continued)

Wivenhoe Dam Gate Opening (m of Tangential Travel)

[redacted]

TABLE E.3 – WIVENHOE DAM AUXILIARY SPILLWAY RATING TABLE

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[redacted]

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APPENDIX F SOMERSET DAM TECHNICAL DATA

[redacted]

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 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:

[redacted]

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:

[redacted]

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

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.

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 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".

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 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
PMP	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.

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 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

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]

[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;

(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.

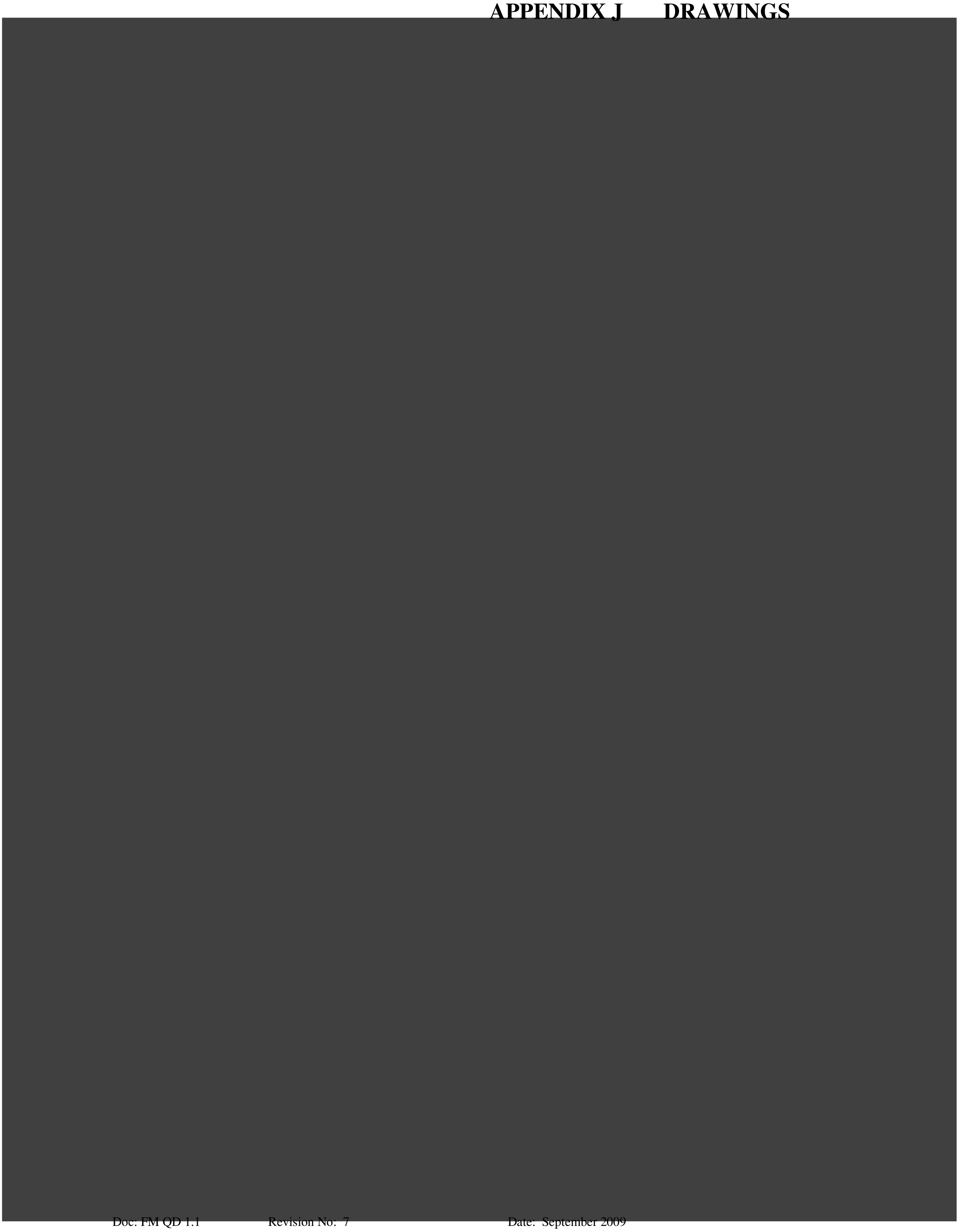
The previous flood studies recommended that one procedure be selected for the operation at Somerset Dam. This procedure had two advantages over the other procedures tested. Firstly, it was feasible for all magnitudes of Stanley River floods tested and, secondly, it was the simplest procedure to carry 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.

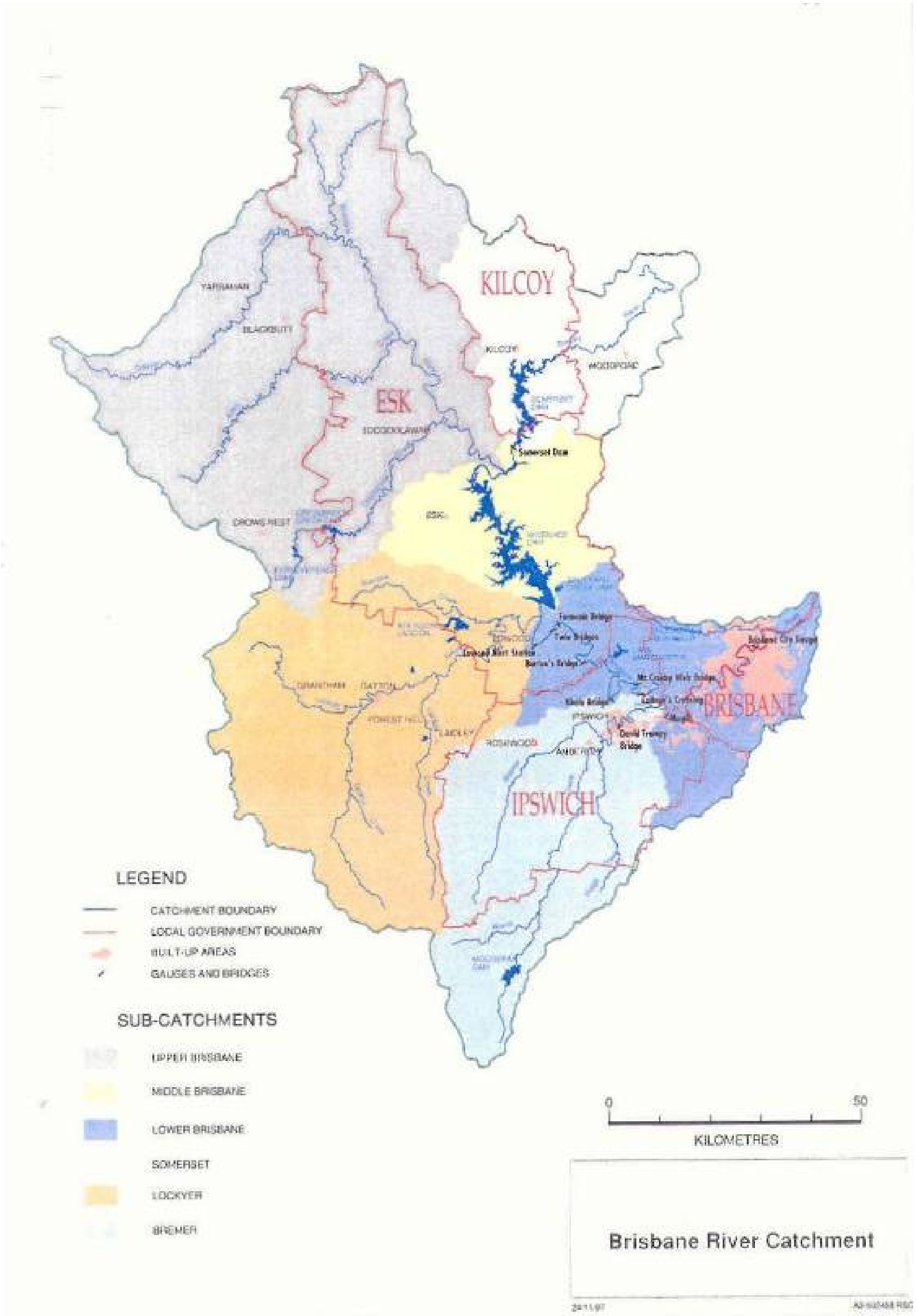
* Assume no failure of Wivenhoe Dam or Somerset Dam

APPENDIX J DRAWINGS



[redacted]

APPENDIX K BRISBANE RIVER CATCHMENT



Comments on Flood Ops Manual Draft 24 August

Rob Ayre SDFOE

Section 1.2 Meaning of Terms Page 6

Suggest that the Flood Operations Engineer and Senior Flood Operations Engineer are referred to as *Duty* (DFOE or SDFOE) to maintain consistency with previous documentation.

Section 3.4 Inundation of Urban Areas Page 15

…controlling *flood* releases not *water* releases….

This is done by optimising *gate operations* to minimise the impacts of flooding….

Wivenhoe Dam Strategy Flow Chart Page 28

Do not need options for W2, W3 and W4. Strategy W2 could be annotated to ensure that bridges are not inundated prematurely.

COMMENT INSERTED IN SECTION 8.6

Strategy W4A – No Fuse Plug Initiation Expected Page 34

Deleted: Section 1.1 Preface Page 5¶
¶
Suggest the fuse plugs are referred to as the *Auxiliary Spillway*.¶

Deleted: Typo Page 7 flood operations at the *dams*.…¶

Deleted: Section 1.3 Purpose of Manual Page 8¶
¶
Accurately forecast rainfall and associated flood run-off…. This implies we forecast rainfall, I suggest this should be reworded to be simply - *Accurately estimate flood run-off within the catchment.*¶

Deleted: Section 2.2 Operational Arrangements Page 10¶ ... [1]

Deleted: Section 2.3 Designation and Responsibilities of SDF ... [2]

Deleted: Section 2.4 Designation and Responsibilities of DFO ... [3]

Deleted: Section 3.2 Structural Security of Dams Page 14¶ ... [4]

Deleted: Section 3.6 Minimising Impacts to Riparian Flora and Faun ... [5]

Deleted: Section 4 Major Flooding Page 17¶
¶ ... [6]

Deleted: Section 5.2 Operation Page 18¶
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Deleted: ¶
First dot point – typo should be *based*¶ ... [7]

Deleted: Section 7.4 Operational Review Page 23¶
¶ ... [8]

Deleted: Section 8 Wivenhoe Dam Flood Operations Page 25¶

Deleted: Section 8.1 Introduction¶
¶ ... [9]

Deleted: Section 8.2 Flood Release Infrastructure Page 25¶ ... [10]

Deleted: Section 8.4 Flood Operation Strategies Page 27¶
¶ ... [11]

Deleted: Strategy W1A Twin Bridges, Savages Crossing and Colleges Crossing ... [12]

Deleted: Strategy W2 – Transition Strategy W1 to W3 Page 32¶ ... [13]

Deleted: Strategy W3 – Protect Urban Areas from Inundation Page 33¶ ... [14]

No maximum release should be 10,400 m^3/sec. Main spillway capacity with all gates open at first Fuse Plug Initiation level.

Strategy W4B – Fuse Plug Initiation Expected Page 35

No maximum release should be 28,100 m^3/sec. Main spillway plus auxiliary spillway capacity.

Require note:

Care should be exercised to ensure gate release does not exceed the peak of the inflow into the dam.

Section 8.5 Gate Closing Strategies Page 36

First dot point:

…floodwaters stored above *FSL (EL 67.0 m AHD) within seven days, after the flood peak has been reached within the dams.*

Section 8.6 Gate Operation Sequences Page 37

More rapid gate opening intervals are permitted when *the water level in Wivenhoe dam is greater than EL 74.0 m AHD* to protect the structural safety of the dam. *This may be allowed at the discretion of the SDFOE for other water levels during dam safety incidents.*

Normal Gate Operation Sequences Page 38

Variations are allowed at *the discretion of the SDFOE* to protect the structural safety of the dam. *Monitoring of the flow patterns in the spillway are to be conducted to ensure erosion is minimised.*

- *Peak storage levels in Somerset dam*

Comments

The Figure shows the Fallback Position. The zones need to be shown to make it clear what actions are to be taken during loss of communications.

The adoption of 71.75 on the interaction diagram was based on ensuring equal freeboard in both Somerset dam and Wivenhoe dam (derived from the previous target duty point of 107.5, 77). The Wivenhoe target duty line could effectively be modified back to 70.5 if this same philosophy is to be adopted.

Mary Smokes Creek deck shown as 102.81 m AHD in Appendix C. Allowance for backwater ?

Deleted: ¶
Third dot point:¶
¶
…generally be less than the peak *inflow* into Wivenhoe dam…¶
¶
Consider re-ordering dot points:¶
¶
<#>1,3,4,5,2 and 6.¶

Deleted: Lowering Radial Gates that have been lifte*d* clear of release flow Page 39. (typo)¶

Deleted: Section 8.6 Modification of Operating Procedures if subsequent flood event occurs prior to the reconstruction of triggered fuse plugs Page 38¶
¶
Note:¶
¶
Discharge from the Auxili ... [15]

Deleted: Strategies are likely to change during a flood event *as rainfall occurs and forecasts are revised.* It is not possible to predict the range of strategies that will be used during the co ... [16]

Deleted: Strategy S1 – Minimising Impact on Rural Life Upstream Page 42¶
¶
Typo - exceeds¶

Deleted: Strategy S2 – Minimise Impacts Below Wivenhoe Dam page 42¶
¶
The intent of this strategy is to maximise the benefits of th ... [17]

Deleted: *Note: Gate operations will enable the movement of the duty point towards the target line in a progressive manner. It will not necessarily be possible to adjust the duty point direc* ... [18]

Deleted: The target duty point (107.5, 75.5) is the point whereby gate control is fully utilised under normal gate operations. It may not be possible to influence the duty point beyond the target du ... [19]

Deleted: Strategy S3 – Protect the Structural Safety of the dam Page 44¶
¶
Refers to previous table – should now reference Figure.¶

Deleted: Section 9.5 Gate Operations Sequence Page 45¶
¶
What is the EL of the invert of the sluices? Should include o ... [20]

Deleted: Table 10.1 Page 47¶
¶
Include Total discharge values for fuse plug trigger level. – 10,400 m3/sec.¶
¶ ... [21]

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Section 2.2 Operational Arrangements Page 10

Third dot point:

…declare a Flood Event if the *water level* of either Wivenhoe dam or Somerset dam….

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Section 2.3 Designation and Responsibilities of SDFOE Page 10

Reference to use of discretion should be Section 2.8 not 2.6.

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Section 2.4 Designation and Responsibilities of DFOE Page 11

Suggest first dot point should be:

> *Direct the operation of the dams during a flood event in accordance with the general strategy determined by the SDFOE.*

Section 2.5 Qualifications and Experience of *DFOE* Page 12

Last dot point in (2):

> *Applied hydrology with particular reference to flood forecasting systems.*

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Section 3.2 Structural Security of Dams Page 14

This applies to all sections that refer to flood exceedence probabilities.

ARR (1987) recommends that probability terminology when applied to floods should adopt the following format:

Annual Exceedence Probability (AEP) is generally expressed as '1 in Y AEP'.

Therefore, the sentence should read – *Wivenhoe Dam is overtopped by a 1 in 100,000 AEP event.*

Ditto for reference of Somerset dam on page 15.

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Section 3.6 Minimising Impacts to Riparian Flora and Fauna Page 16

Include sentences such as:

Consideration of the time interval between successive gate closures should also be based upon effects such as bank slumping. Therefore, wherever possible the closure sequence should follow naturally occurring flood hydrograph recessions.

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Section 4 Major Flooding Page 17

Include reference to Ipswich area as well as Brisbane.

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First dot point – typo should be *based*

Ensure consistent reference to DFOE and SDFOE.

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Section 7.4 Operational Review Page 23

Replace Flood Control Centre with *Flood Operations Centre*.

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Section 8.1 Introduction

….depending upon the *origin, magnitude and spatial extent* of the flood.

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Section 8.2 Flood Release Infrastructure Page 25

Suggest separate into Main Spillway and Auxiliary Spillway.

Perhaps should include General Arrangement showing location of main, auxiliary and Saddle dam Two.

Can remove figures from Appendix J.

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Section 8.4 Flood Operation Strategies Page 27

The strategy chosen at any point in time will depend upon predictions at the following *locations which were made with the best actual and forecast rainfall and streamflow* information available at that time.

> *Peak storage levels in Wivenhoe and Somerset dams*
> *Peak flow rate at Lowood gauge (excluding Wivenhoe dam releases)*
> *Peak flow rate at Moggill gauge (excluding Wivenhoe dam releases)*

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

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Strategy W1A Twin Bridges, Savages Crossing and Colleges Crossing Page 30

Note: Colleges crossing is subject to tidal influences.

Strategy W1D Kholo Bridge and Mt Crosby Weir Bridge Page 31

Maximum release 900 m^3/sec should read 1,900 m^3/sec.

I think this was a typo in the previous version.

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Strategy W2 – Transition Strategy W1 to W3 Page 32

As WD EL is in the range EL68.5 to EL74.0 m AHD, it may be possible for the top of a closed gate to be overtopped, if the gate is not already open.

Require note:

The gate opening constraints are to be overridden when the gates will be overtopped during normal operation.

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Strategy W3 – Protect Urban Areas from Inundation Page 33

As above.

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Section 8.6 Modification of Operating Procedures if subsequent flood event occurs prior to the reconstruction of triggered fuse plugs Page 38

Note:

Discharge from the Auxiliary Spillway will occur before the Gate Trigger Level of EL 67.25 m AHD. This flow should be taken into account when applying the flood operation strategies relevant to the low level bridge crossings.

Section 9.3 Flood Operation Strategies page 41

The strategy chosen at any point in time will depend upon predictions at the following *locations which were made with the best actual and forecast rainfall and streamflow* information available at that time.

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

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Strategy S2 – Minimise Impacts Below Wivenhoe Dam page 42

The intent of this strategy is to maximise the benefits of the flood storage capabilities of the dam while protecting the structural safety of both dams.

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Note: Gate operations will enable the movement of the duty point towards the target line in a progressive manner. It will not necessarily be possible to adjust the duty point directly towards the target line in a single gate operation.

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The target duty point (107.5, 75.5) is the point whereby gate control is fully utilised under normal gate operations. It may not be possible to influence the duty point beyond the target duty point, other than by closing sluices, gates and regulator valves.

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Section 9.5 Gate Operations Sequence Page 45

What is the EL of the invert of the sluices? Should include on schematic of dam.

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Table 10.1 Page 47

Include Total discharge values for fuse plug trigger level. – 10,400 m3/sec.

Section 10.3.2 Somerset dam Emergency Procedure Page 48

Refer to figure and remove table 10.2

Appendix E1 & E2 Page 54-56

Extend table to EL80 m AHD.

Appendix F Page 58

Extend table to EL109.5 m AHD.