MANUAL

OF

OPERATIONAL PROCEDURES

FOR FLOOD MITIGATION

FOR

WIVENHOE DAM

AND SOMERSET DAM

Revision No.	Date of Approval	Amendment Details
0	27 October 1968	Original Issue
1	6 October 1992	Complete revision and re-issue
2	13 November 1997	Complete revision and re-issue
3	24 August 1998	Change to page 23
4	6 September 2002	Complete revision and re-issue
5	May 2004	Revision for PMF Works

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APPENDICES

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1 INTRODUCTION

1.1 Preface

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

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

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

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

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

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

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1.2 Meaning of Terms

In this Manual, save where a contrary definition appears -

"Act"
means the *Water Act 2000*;

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

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

"AHD"
means Australian Height Datum;

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

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

"Chief Executive"
means the Chief Executive or Director General of the Department of Natural Resources, Mines & Energy;

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

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

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

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

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

"FSL"[1] or "FULL SUPPLY LEVEL"
means the level of the water surface when the reservoir is at maximum operating level, excluding periods of flood discharge;

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"Gauge"

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

"Headworks Operator"

for the purposes of this manual the Headworks Operator is the South-East Queensland Water Corporation:

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There is a need to better distinguish between the Headworks Operator and the Corporation.

"Manual" or " Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam"

means the current version of this Manual;

"Power Station"

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

"Senior Flood Operations Engineer"

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

"South East Queensland Water Corporation"

means the body corporate constituted by that name pursuant to Part III of the South East Queensland Water Board Act 1979. The Board became a government owned corporation in 2000;

Deleted: "Technical Advisory Committee"¶
means the South East Queensland Water Corporation Limited (ACN 088 729 765), an unlisted public company which owns and operates Wivenhoe Dam, Somerset Dam and North Pine Dam.¶

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1.3 Purpose of Manual

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

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

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

1.4 Legal Authority

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

1.5 Application and Effect

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

1.6 Date of Effect

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

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

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

1.7 Observance of Manual

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

1.8 Provision for Variations to Manual

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

1.9 Distribution of Manual

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

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

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Where it is reasonable to expect that the safety of either dam will not be reduced, temporary deviations from the procedures detailed in this manual may be made in accordance with Section 2.8

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2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

Pursuant to the provisions of the Act, the Corporation is responsible for and has the duty for operation and maintenance of Wivenhoe Dam and Somerset Dam, and while it may enter into contracts for the purpose of discharging these responsibilities, for the purposes of this manual the Headworks Operator is the Corporation.

2.1.1 Designation of Senior Flood Operations Engineer

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

2.1.2 Designation of Flood Operations Engineer

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

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

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

2.2 Qualifications and Experience of Engineers

2.2.1 Qualifications

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

2.2.2 Experience

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

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

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

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

(b) Operation and maintenance of major dams;

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

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

2.3 Schedule of Authorities

The Corporation must maintain a Schedule of Authorities containing a list of the Senior Flood Operations Engineers and Flood Operations Engineers authorised to direct flood operations at the dams during floods.

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

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

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

2.4 Training

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

2.5 Dam Operation Arrangements

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

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

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

2.6 Responsibilities of the Senior Flood Operations Engineer

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

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

2.7 Responsibilities of the Flood Operations Engineer

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

2.8 Reasonable Discretion

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

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

the Chairperson of the Corporation, and

the Chief Executive or nominated delegate.

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

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2.9 Report

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

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3 FLOOD MITIGATION OBJECTIVES

3.1 General

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

(a) Ensure the structural safety of the dams;

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

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

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

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

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3.2 Structural Safety of Dams

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

3.2.1 Wivenhoe Dam

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

Wivenhoe Dam is predominantly a central core rockfill dam. Such dams are not resistant to overtopping and are susceptible to breaching should such an event occur. Overtopping is considered a major threat to the security of Wivenhoe Dam. Works are being undertaken between May 2004 and December 2005 to build an auxiliary spillway to cope with the 1:100,000 AEP event without overtopping of the dam.

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3.2.2 Somerset Dam

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

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

Somerset Dam is a mass concrete dam. Such dams can withstand limited overtopping without damage. For Somerset Dam the risk of failure increases once a water level of EL 109.7 is exceeded. Failure of such structures is rare but when they do occur, they occur suddenly without warning, creating very severe and destructive flood waves.

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Extreme Floods and Closely Spaced Large Floods

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

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

The discharges should be regulated so as to have little impact on the urban reaches of the Brisbane River taking into account inflows into the river downstream of the dams. However they may result in submergence of some bridges. The level of flooding as a result of emptying stored flood-waters after the peak has passed is to be less than the flood peak unless accelerated release is necessary to reduce the risk of overtopping.

3.3 Inundation of Urban Areas

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

The auxiliary spillway being constructed in 2004 and 2005 incorporates fuse plugs. Triggering of a fuse plug will significantly increase floods levels downstream. Where possible, and taking into account the other objectives, gate operations should be designed to prevent operation of the fuse plug in situations where .

Gates clear of the flow before the fuse plug operates.

3.4 Disruption to Rural Areas

While the dams are being used for flood mitigation purposes, bridges and areas upstream of the dams may be temporarily inundated. Downstream of the dam, bridges and lower river terraces will be submerged. The operation of the dams should not prolong this inundation unnecessarily. The deck levels of bridges potentially inundated during flood events are shown on the Drawings in Appendix D.

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SEQWC has maps on their website suitable, though with recent road and bridge works on D'Aguilar Highway levels there may not be up to date.

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3.5 Provision of Pumping Pool for Power Station

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

3.6 Disruption to Navigation

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

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

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

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4 FLOOD CLASSIFICATION

For the reference purposes of this Manual, five magnitudes of flooding are classified as follows:

Fresh
This causes only very low-level bridges to be submerged.

Minor Flooding
This causes inconvenience such as closing minor roads and the submergence of low-level bridges. Some urban properties are affected.

Moderate Flooding
This causes inundation of low-lying areas and may require the evacuation of some houses and/or business premises. Traffic bridges may be closed.

Major Flooding
This causes flooding of appreciable urban Areas. Properties may become isolated. Major disruption occurs to traffic. Evacuation of many houses and business premises may be required.

Extreme Flooding
This causes flooding well in excess of floods in living memory and general evacuation of whole areas are likely to be required.

Usually a flood does not cause the same category of flooding along its entire length and the relevant agencies shall have regard to this when flooding is predicted.

(The classifications of minor, moderate and major flooding are based on the Bureau of Meteorology Standard Flood Classifications for Australia)

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5 FLOOD MONITORING AND WARNING SYSTEM

5.1 General

A real time flood monitoring and warning system is established in the Brisbane Valley. This system is based upon an event reporting protocol. A radio telemetry system (ALERT) is used to collect, transmit and receive rainfall and streamflow information. The system consists of more than 50 field stations that automatically record rainfall and/or river heights at selected locations in the Stanley and Brisbane River catchments. Some of the field stations are owned by the Corporation with the remainder belonging to other agencies.

The rainfall and river height data is transmitted by radio telemetry, via repeater stations, to base stations at the head office of the Headworks Operator (and the Corporation). There the data is processed in real time by computer programs to assess what is occurring in the catchments in terms of flood flows and what could occur if weather conditions continued, or changed.

Other agencies with their own base stations can, and do, receive data transmissions direct, and so collect and are able to process rainfall and streamflow information appropriate to their needs.

The real time flood model (RTFM) is a suite of hydrologic and hydraulic computer programs that utilise the real time ALERT data to assist in the operation of the dams during flood events.

5.2 Operation

The Headworks Operator is responsible for operating the computer model provided by the Corporation for flood monitoring and forecasting during flood events to optimise flood gate operations and minimise the impacts of flooding.

It is the responsibility of the Corporation to maintain and keep calibrated its own equipment; and to enter into such arrangements with other agencies or to provide such further equipment as the Corporation deems necessary for the Headworks Operator to properly operate the computer model for flood monitoring and forecasting.

A system such as this is expected to improve over time due to:

- improved operation and reliability with experience,
- improved calibration as further data becomes available,
- software upgrades, and
- the number, type and locations of sensors being varied.

A regular process of internal audit and management review must be maintained to achieve this.

A log of the performance of all field equipment necessary to properly operate the computer model must be kept by the Corporation. The log is to also include all revised field

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calibrations and changes to the number, type and locations of gauges. Entries onto the log are to be notified to the Headworks Operator without delay in writing.

A log of the performance of the system (ALERT and RTFM) must be kept by the Senior Flood Operations Engineer. Any faults to the computer hardware or software, and any faults to field equipment which the Corporation has not advised the Headworks Operator of, are to be notified to the Corporation without delay in writing. The Corporation must promptly attend to the matters under its control and refer other matters to the appropriate agencies.

Whenever the Senior Flood Operations Engineer considers that the performance and functionality of the system can be improved, by whatever means, a recommendation must be made to the Headworks Operator accordingly. The Headworks Operator must promptly consider, act on, or refer such recommendations to the Corporation as it considers appropriate.

5.3 Storage of Documentation

The performance of any flood monitoring and warning system is reliant on accurate historical data over a long period of time. The Senior Flood Operations Engineer must ensure that all available data and other documentation is appropriately collected and catalogued as approved by the Corporation, for future use.

5.4 Key Reference Gauges

Key field station locations have been identified for reference purposes when flood information is exchanged between authorities or given to the public. Should it be deemed desirable to relocate field stations from these locations, or vary flood classification levels, agreement must first be obtained between the Corporation, Headworks Operator, Bureau of Meteorology and the Local Governments within whose boundaries the locations are situated. The locations and gauge readings at which the various classifications of flooding occur are contained in Appendix D.

Gauge boards that can be read manually must be maintained as part of the equipment of each key field station. The Corporation must have procedures to ensure such gauge boards are read in the event of failure of field stations to operate.

5.5 Reference Gauge Values

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

The Corporation must ensure that information relative to the calibration of the Corporation's field stations is shared with such agencies.

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6 COMMUNICATIONS

6.1 Communications between Staff

The Corporation is responsible for providing and maintaining equipment to allow adequate channels of communication to exist at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams.

The Headworks Operator is responsible for ensuring that adequate communication exists at all times between the Flood Operations Engineer and site staff at Wivenhoe and Somerset Dams. Where equipment deficiencies are detected during normal operations, such deficiencies are to be reported within one week to the Corporation for timely corrective action.

6.2 Dissemination of Information

Some agencies have responsibilities for formal flood predictions, the interpretation of flood information and advice to the public. The Corporation, Headworks Operator, Senior Flood Operations Engineer and Flood Operations Engineer must liaise and consult with those agencies with a view to ensuring all information relative to the flood event is consistent, and used and disseminated in accordance with agreed responsibilities.

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 ???.

The Flood Operations Engineer must supply information to each of these agencies during dam releases. For this purpose, the Corporation must maintain a Register of Contact Persons for Information, their means of contact including back up systems, and the specific information to be supplied to each. The Corporation must ensure that each agency receives a copy of the updated Register of Contact Persons for Information whenever amendments are made, but at least every 6 months.

All enquiries other than provided for in the Register of Contact Persons for Information, either to the Headworks Operator, the Senior Flood Operations Engineer, the Flood Operations Engineer or dam site staff must be referred to the Corporation. The Corporation must provide a mechanism to receive these enquiries from the time it is advised that releases from the dams are likely until flood release operations are completed.

Agency	Interest / Activity	Information Requirement	Trigger level and frequency of reporting
Kilcoy Shire Council	Flood levels upstream of Somerset Dam	Current and predicted flood levels, Somerset Dam	Somerset Dam water level exceeds EL????
Esk Shire Council	Flood Levels upstream and downstream of Wivenhoe Dam Evacuations?	Current and predicted flood levels and discharges, Wivenhoe Dam	Initial gate operation.
Ipswich City Council			
Brisbane City Council			
NRM&E			
Bureau of Meteorology		Actual and projected discharges from Somerset Dam and Wivenhoe Dam	Initial gate operation and thereafter at 3 hourly intervals. annually

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6.3 Release of Information to the Public

The Corporation is responsible for the issue of information regarding storage conditions and current and proposed releases from the dams to the public and the media.

The Bureau of Meteorology has responsibility for issuing flood warnings.

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

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¶
<#>Nature of Information¶
¶
When, in the opinion of the Flood Operations Engineer, a flood situation is imminent and gate operations are likely, and is of a magnitude that it is likely to cause flows to exceed 2,000 m^3/sec at Lowood, the Flood Operations Engineer must advise those listed in the Register of Contact Persons for Information of : [Is the 2000 m3/sec limit reasonable?]¶
¶
(a) the current and proposed releases from the dams, and¶
¶
(b) the estimated flow rates and water heights at the key reference gauges listed in Appendix D.¶
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This information is to be updated at intervals as better and more accurate information becomes available.¶
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7 REVIEW

7.1 Introduction

This review of the Manual has addressed the mechanisms of delegation and control of the dams in periods of operation of the dams for flood mitigation. It is known overtopping of the dams can result should floods occur which are derived from lesser rainfall than the probable maximum precipitation storm or from the combination of two lesser storms in close proximity. The dams may also overtop in the eventuality that the flood-gate control systems fail to operate or partially malfunction during the passage of a major flood or combination of floods.

Procedures and systems have been developed that should enable lower risk operation of the dams for flood mitigation purposes. This technology is intended to provide longer warning times and the capability of examining options to optimise the safety of the dams and minimise the hazard potential and risk to the community.

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With the passage of time neither the technical assumptions nor the physical conditions on which this Manual is based may remain unchanged. It is also recognised that the relevance of the Manual may change with changing circumstances.

It is important, therefore, that the Manual contain operational procedures which in themselves cause the Manual's procedures, and the assumptions and conditions upon which they are based, to be checked and reviewed regularly.

The checking and reviewing process must involve the Headworks Operator and all associated operations personnel in order that changes of personnel do not result in a diminished understanding of the basic principles upon which the operational procedures are based.

Variations to the Manual may be made in accordance with provisions in Section 1.8.

7.2 Personnel Training

The Headworks Operator must report to the Corporation by 30th September each year on the training and state of preparedness of operations personnel. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources, Mines & Energy within 14 days of it being received by the Corporation.

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7.3 Monitoring and Warning System and Communication Networks

The Headworks Operator must provide a report to the Corporation by the 1st May and 1st November of each year; and after each flood event. The report must assess in terms of hardware, software and personnel, the :

- adequacy of the communication and data gathering facilities,

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- reliability of the system over the previous period,
- reliability of the system under prolonged flood conditions,
- accuracy of forecasting flood flows and heights, and
- the overall state of preparedness of the system.

The Corporation must review the report, and taking into account its own log of the performance of the field equipment, take any action considered necessary for the proper functioning and improvement of the system. . A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources, Mines & Energy within 14 days of it being received by the Corporation.

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7.4 Operational Review

After each significant flood event, the Corporation must review the effectiveness of the operational procedures contained in this manual. The Headworks Operator is required to prepare a report for submission to the Corporation within six weeks of any flood event that requires mobilisation of the Flood Control Centre. A copy of this report must be forwarded to the Chief Executive of the Department of Natural Resources, Mines & Energy within 14 days of it being received by the Corporation.

7.5 Five Yearly Review

Prior to the expiry of the approval period, the Corporation must review the Manual pursuant to Section 6 Division 2 of the Act. The review is to take into account the continued suitability of the communication network, and the flood monitoring and warning system as well as hydrological and hydraulic engineering assessments of the operational procedures. The hydrologic investigations performed for the purpose of this manual are discussed in Appendix I.

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8 WIVENHOE DAM

8.1 Introduction

Wivenhoe Dam is capable of being operated in a number of ways to reduce flooding in the Brisbane River downstream of the dam, depending on the part of the catchment in which the flood originates and depending also on the magnitude of the flood.

A general plan and cross-section of Wivenhoe Dam, and relevant elevations are included in Appendix J.*[The suite of drawings need to be modified to reflect the new arrangement]*

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Storage and discharge data are included in Appendix E. *[The headwater discharge relationships for the fuse plug bays need to be included in Appendix E]*

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

Spiltyard Creek Dam is part of the overall Wivenhoe Area Project and it forms the upper pumped storage of the peak power generation scheme. Splityard Creek Dam impounds a volume of 28 700 ML at its normal full supply level (El 166.5). The contents of Splityard Creek Dam can be emptied into Lake Wivenhoe within 12 hours by releasing water through the power station conduits. This volume of water can affect the level in Wivenhoe Dam by up to 300mm when Wivenhoe Dam is close to FSL. The operational level of Splityard Creek Dam should be considered when assessing the various trigger levels of Wivenhoe Dam.

The Corporation has acquired land above FSL to a level of EL 75.0 to provide temporary flood storage. Reasonable care must be exercised to confine the flood rises to below this level. This requirement should be ignored in the case of extreme floods that threaten the safety of the dams.

8.2 Initial Action

When indications are received of an imminent flood, the flood control operation of the dam must commence with the storing of all inflow of the Brisbane River in Wivenhoe Dam, whilst an assessment is made of the origin and magnitude of the flood. The spillway gates are not to be opened for flood control purposes prior to the reservoir level exceeding EL 67.25.

8.3 Regulator and Gate Operation Sequences

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Rapid opening of outlets (spillway gates and regulators) can cause hydraulic surges and other effects in the Brisbane River that can endanger life and property and may sometimes have other adverse effects. Under normal gate operations, the gates and regulators are therefore to be operated one at a time at rates that will minimise adverse impacts on the river system.

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Rapid closure of the gates can affect river-bank stability. Rapid closure of more than one gate at a time should only be used when time is critical and there is a requirement to correct a malfunction to preserve storage or to reduce downstream flooding rapidly. For flood operations where time is not critical, longer closure intervals should be used. The minimum closure intervals specified below are based on experience from the 1974 flood.

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a gate by the immediate opening of a regulator valve (or the reverse operation). This allows for greater control of low flows and enables a smooth transition and closure as slow as possible to prevent the stranding of fish downstream of Wivenhoe Dam.

Except as provided for in procedure 4 of Section 8.4 where it is necessary to have the gate clear of the flow prior to the fuse plug operating and as indicated above, the gate opening and closing intervals as tabled below are the most rapid permitted for flood mitigation purposes.

Table 8.1

8.3.1 WIVENHOE DAM

MINIMUM INTERVALS for Normal Operation

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

The flip bucket spillway is designed to control the discharge from the reservoir and to dissipate the energy of the discharge. The flip throws the discharge clear of the concrete structures into a plunge pool where the energy is dissipated by turbulence. Under non-symmetric flow conditions, or when gates 1 and 5 are not operating, the discharge jet may impinge on the walls of the plunge pool, which has been excavated into erodible sandstone rock, and cause non-predictable erosion. Upstream migration of this erosion is to be avoided. The wing walls adjacent to the flip bucket deflect the discharge away from the walls of the plunge pool when gates 1 and 5 are operated.

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

(i) The discharge jet into the plunge pool is not to impinge on the right or left walls of the plunge pool.

(ii) The flow in the spillway is to be symmetrical.

Under normal operation, only one gate is to be opened at any one time and the following sequences are to be adopted:

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Approximate Discharge Range	Gate opening sequence	Comments
(a) Up to 330 m^3/sec	1. Open Gate 3 up to 3.5 metres	• Gates 1, 2, 4 & 5 remain closed
(b) 330 m^3/sec to 575 m^3/sec	2. Gate 3 at 3.5 metres 3. Open Gates 2 & 4 alternately to 0.5 metre 4. Open Gate 3 to 4.0 metre 5. Open Gates 2 & 4 alternately to 1.0 metre	• Gates 1 & 5 remain closed unless discharge from Gates 2 & 4 impinges on side wall of plunge pool proceed to (c)
(c) 575 m^3/sec to 1160 m^3/sec	6. Gate 3 kept at 4.0 metres 7. Open Gates 1 & 5 alternately one increment followed by Gates 2 & 4 alternately one increment 8. Repeat Step 7 until at the end of the sequence Gates 1 & 5 are open 1.5 metres and Gates 2 & 4 are open 2.5 metres	• Flow in spillway to be as symmetrical as possible • Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5
(d) 1 160 m^3/sec to 1385 m^3/sec	9. Open Gate 3 to 4.0 metres 10. Open Gates 1 & 5 alternately to 2.0 metres followed by opening Gates 2 & 4 alternately to 3.0 metres	• Flow in spillway to be as symmetrical as possible • Gates 2 & 4 are to have openings not more than 1.0 metre more than Gates 1 & 5
(e) 1 385 m^3/sec to 2290 m^3/sec	11. Open ALL gates to 5.0 metre openings	• Flow in spillway to be as symmetrical as possible • Gates 2 & 4 are to have openings not less than Gates 1 & 5 or not more than 1.0 metre more than Gates 1 & 5 • Gate 3 is to have an opening not less than Gates 2 & 4 or not more than 1.0 metre more than Gates 2 & 4.
(f) Greater than 2290 m^3/sec	12. Open ALL gates to incrementally in the sequence 3, 2, 4, 1, 5	• Flow in spillway to be as symmetrical as possible • Gate 3 to have the largest opening • Gates 2 & 4 are to have openings greater than Gates 1 & 5

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This doesn't seem consistent with the other discharge ranges.

Gates are numbered 1 to 5 from the left bank looking downstream.

Gate openings are occur in 500mm increments unless

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I am not sure what more needs to be done here.

Gate operating procedures in the event of equipment failure are contained in Appendix G. If one or more gates are inoperable during the course of the flood event, the gate openings of the remaining gates are to be adjusted to compensate. These adjustments should ensure that:

- The flow in the spillway is as symmetrical as practicable.

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- The impact of the flow on the sidewalls of the plunge pool should be minimised.

In general, gate closing is to occur in the reverse order. The final gate closure should occur when the lake level has returned to Full Supply Level.

8.4 Auxiliary Spillways [I think the bulk of this should be moved to Appendix G]

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The auxiliary spillway works for Wivenhoe Dam will consist of a three bay fuse plug spillway on the right abutment and a one bay fuse plug spillway at Saddle Dam two. Works will also be undertaken on the main embankment to raise the maximum lake level to 80 m AHD. In setting the maximum lake level, zero freeboard is proposed. Details of the two auxiliary spillways are provided in **Error! Reference source not found.**.
It is proposed to undertake the works in two stages. The works proposed for the first stage consist of:

- The three right bank fuse plug spillways separated by concrete divider walls;
- The construction of a new highway bridge;
- A concrete cut off trench along the main dam wall to intersect with the existing clay core and strengthening of the existing crash barrier to raise the maximum lake level to 80 m AHD; and
- Post tensioning the main spillway monolith to resist overturning at the new maximum lake level.

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Stage 1 works increase the dam crest flood to an annual exceedance probability (AEP) of approximately 1 in 100,000. The current dam crest flood is 1 in 22,000 AEP. Pending approvals, Stage 1 works are proposed to commence early 2004 and are to be completed by the end of 2005.
Stage 2 works consist of the construction of a si ngle bay fuse plu g at saddle dam 2. It is proposed to review the Stage 2 at the next comprehensive dam safety review due in 2017

Table 8.2 Dam Water Levels at Fuse Plug Initiation Levels, Wivenhoe Dam

Auxiliary Spillway Location	Spillway Crest Control Type	Spillway Crest Width (m)	Spillway Crest Level (m AHD)	Peak Lake Level at Fuse Plug Initiation (m AHD)
Right Bank				
Fuse plug 1	Ogee	34	67	75.7
Fuse plug 2	Ogee	64.5	67	76.25
Fuse plug 3	Ogee	65.5	67	77.2
Saddle Dam 2				
Fuse plug 4	Ogee	100	67	78.3

Error! Reference source not found. shows a cross section of a typical fuse plug embankment. It is effectively a zoned earth and rock fill embankment that is constructed on a non erosive sill or weir. The embankment is designed to erode in a controlled manner when the lake water level reaches a pre-determined level. Below this level, the embankment impounds water in the same manner as a typical zoned earth and rock fill embankment. The upstream face of the embankment consists of a riprap layer to protect against wave action. Consecutive layers consist of coarse rock followed by a coarse filter and then the impermeable clay core that are laid on a similar slope to the riprap. Downstream of the

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sloping clay core are more layers of filters that lie on compacted rock fill, which extends to the downstream slope of the embankment.

The controlled erosion is initiated at a low point, or pilot channel located in the embankment crest. A narrow vertical slot of coarse filter is located immediately downstream of the pilot channel that extends to the downstream slope of the dam and replaces the compacted rock fill. As the lake water level rises above the pilot channel crest to a depth of about 0.15 m, fast flowing water starts to erode the coarse filter in the vertical slot, which removes the material supporting the sloping clay core eventually causing it to collapse. The material adjacent to the slot is then exposed to the fast flowing water initiating lateral erosion.

Fuse plug performance is largely based on two research projects undertaken by Tinney & Hsu (1961) and Pugh (1985).

The Tinney & Hsu study was conducted as part of the design of the Oxbow Fuse plug at Snake River in the United States. In the study, scale model tests were conducted in both the laboratory and the field to investigate the behaviour and performance of fuse plug spillways. Pugh's study used laboratory models to simulate full sized fuse plugs from 3 m to 9 m high. Both studies found that the fuse plugs washed out in an orderly and predictable manner. They found that the rate of erosion is proportional to the type of material used and height of the embankment.

The NSW Public Works and Services, now the NSW Department of Commerce, extrapolated the results of these studies to design the 15 m high fuse plug embankments at Warragamba Dam in Sydney (DPWS, 1998). The analysis undertaken for Warragamba Dam has been used to select the material and estimate the lateral erosion rates for the proposed fuse plugs at Wivenhoe Dam. Based on the fuse plug material selected for Wivenhoe, lateral erosion rates of 100 m per hour are expected.

Error! Reference source not found. cross section of a typical fuse plug embankment.

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8.5 Flood Control Procedures

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When the preliminary estimation of the degree of expected flooding has been made, the operating procedures set out hereunder shall be used at Wivenhoe Dam in line with the Flood Mitigation Objectives.

When considering the discharge to be made from both Wivenhoe Dam and Somerset Dam under particular procedures, the total discharge for each dam from all sources is to be considered when determining the appropriate openings for gates, valves and sluices.

The procedures to be adopted commence with Procedure 1 and extend through to Procedure 4 as the magnitude of the flood as predicted by the RTFM increases. Table ?? provides **indicative** limits of application for each procedure for the initial filling of Wivenhoe Dam. Once Wivenhoe Dam has peaked and the drainage phase has commenced the indicative limits will not apply.

Provision is made for the releases to be regulated so as to lessen the impact when peak flows from Lockyer Creek, Bremer River and other tributaries enter the Brisbane River. This may result in the releases being decreased for a time even though lake levels are rising.

Provision is also made for the releases from Wivenhoe Dam to be regulated in the early procedures so as not to unduly submerge bridges. The relevant bridges and their estimated submergence flows are included in Appendix D.

Comment [r10]: Page: 13 This shouldn't refer to Somerset Dam.

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Deleted: set out in the following table in response to current and predicted inflows both into the dams, and into the Brisbane River from tributaries downstream of the dams. This t

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Wivenhoe Dam - Normal Gate Operating Procedures: Initial Filling Phase

Procedure	Current Reservoir Level	Applicable Limits		
0	EL ≤ 67.25	$Q_{Wivenhoe}$ = 0 m^3/sec ... i.e No Releases		$Q_{Moggill}$ < 4000 m^3/sec
1A	67.25 < EL ≤ 67.50	$Q_{Wivenhoe}$ < 110 m^3/sec	$Q_{Colleges\ Crossing}$ < 175 m^3/sec with care taken not to submerge Twin Bridges prematurely	
1B	67.50 < EL ≤ 67.75	$Q_{Wivenhoe}$ < 380 m^3/sec	$Q_{Burtons/Noogoorah}$ < 430 m^3/sec with care taken not to submerge Colleges Crossing prematurely	
1C	67.75 < EL ≤ 68.00	$Q_{Wivenhoe}$ < 500 m^3/sec	Q_{Kholo} < 550 m^3/sec with care taken not to submerge Burtons/Noogoorah prematurely	
1D	68.00 < EL ≤ 68.25	$Q_{Wivenhoe}$ < 900 m^3/sec	$Q_{MtCrosby}$ < 1900m^3/sec with care taken not to submerge Kholo prematurely	
1E	68.25 < EL ≤ 68.50	$Q_{Wivenhoe}$ < 1500 m^3/sec	$Q_{MtCrosby}$ < 1900m^3/sec with care taken not to submerge Kholo prematurely	
2	68.50 < EL < 74.00	Q_{Lowood} < 3500 m^3/sec	Q_{Lowood} < peak of Lockyer and Q_{Lowood} < peak of Bremer	Gates are NOT to be overtopped
3	68.50 < EL < 74.00[1]	Q_{Lowood} < 3500 m^3/sec	$Q_{Moggill}$ < 4000 m^3/sec	
4	EL ≥ 74.00 or dam safety may be compromised	Gates are to be opened until reservoir level begins to fall	Gate opening interval restrictions NO LONGER apply	

1 The EL 74.00 trigger level for the initiation of Procedure 4 may be varied in accordance with the provisions of Section ?.?.

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

In procedure 2, if there is little or no flow in Lockyer Creek, the release from Wivenhoe Dam should be limited to between 1900 m^3/sec and 2000 m^3/sec with care taken not to submerge Mt Crosby Weir Bridge or Fernvale Bridge prematurely. If the flood storage compartments of Wivenhoe Dam and Somerset Dam cannot be emptied within the prescribed time of seven days, the release from Wivenhoe Dam should be limited to between 1900 m^3/sec and 3500 m^3/sec. In such circumstances, the release from the dam should be less than the peak inflow into the lake.

8.6 Closing Procedures

If at the time the lake level in Wivenhoe Dam begins to fall, the combined flow at Lowood is in excess of 3500 m^3/sec, then the combined flow at Lowood is to be reduced to 3500 m^3/sec as quickly as practicable having regard to Section 3.3, and is to remain at this rate until final gate closure procedures can commence.

Gate closing procedures should be initiated having regard to the following requirements:

(a) Early release of stored water to regain flood-mitigating ability for any subsequent flood inflows as described in Section 3.3.

(b) Gate operation procedures as described in Section 8.3.

(c) Downstream impact of the discharges. To prevent the stranding of fish downstream of the dam, closures below flows of 275 m^3/sec should be undertaken as slow as practicable and if possible such closures should occur during daylight hours on a weekday so that personnel are available for fish rescue.

(d) Establishment of storage at FSL at completion of flood events.

(e) The total discharge from Wivenhoe Dam from all sourc es is to be considered when considering appropriate closing procedures. This includes any discharge from triggered fuse plugs.

8.7 Modification to Flood Operating Procedures to Prevent Fuse Plug Operation

Where flood modelling indicates that it is possible to modify gate openings to 'just prevent a fuse plug from operating', the Senior Flood Operations Engineer is given the discretion to do so. This may be done by:

- Reducing the headwater level at which Procedure 4 initiates;

  The minimum level at which Procedure 4 is to be triggered under these circumstances is EL 73.0 m AHD. *[What studies can be done to validate this level??]*

- Varying the interval between gate operations;

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Deleted: <#>8.6 Coping with Extreme Floods¶
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The current procedures apply for floods with predicted levels up to EL 74 and greater but where the flood discharge is through the existing gated spillway. In order to cope with large volume floods auxillary spillways will be built where flood levels are predicted to exceed EL 75 and outflows greater than the gated spillway capacity. This will be a second spillway will be a fuse plug spillway in the right embankment, and a future third spillway in saddle dam 2¶
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If the flood level in Wivenhoe using the minimum gate opening intervals for normal operation specified in Section 8.3 is predicted to peak below a level of 75.5 m AHD no changes are to be made to the specified flood operating procedures.

If the flood level in Wivenhoe using the minimum gate opening intervals for normal operation is predicted to be above 75.5 m AHD, but is predicted to be below 75.5 m AHD using a 1 m in 10 minute gate opening procedure, the gates may be raised at a rate to maximise flood storage capacity but to prevent the first fuse plug from initiating. (An allowance of 0.2 m below the initiation level of the first fuse plug has been given to account for errors in predicting flood levels and possible wave run up, which may cause premature initiation of the fuse plug).

- Storing additional water in Somerset Dam;

  Somerset gates and valves can be temporarily closed to prevent a fuse plug from initiating. With respect to the safety of Somerset, SMEC (2004) estimated that the dam has an increased risk of cracking at a headwater level of 109.7 m AHD. Altering the Somerset gate operating procedures is considered safe below this level

- A combination of the above.

This discretion is given subject to:

- the safety of either Wivenhoe Dam or Somerset Dam not being compromised;
- The increase in the resultant discharges is not to be more than 50% (??) of the incremental discharge produced by the operation of the fuse plug;
- the decision to modify the flood operation procedures is only to be taken after careful consideration of the impact of forecast rainfall and inflows on headwater levels and the consultation procedure specified in Section 2.8 is to be followed;

8.8 Modification to Flood Operating Procedures with Fuse Plug Operation

The general philosophy is to maintain the existing flood storage to mitigate downstream flooding but to maximise the capacity of the existing spillway to reduce the chance of the fuse plugs initiating. A release from a fuse plug will cause significant erosion immediately downstream of the dam and will also increase downstream flood flows and flood levels within a short period. Initiation of a fuse also limits the opportunity to mitigate consecutive floods until the fuse plugs are re-constructed. A summary of the proposed changes to the gate opening procedures following the completion of the proposed upgrade works is outlined below:

- Wivenhoe gate opening procedures 1, 2 and 3 will remain unchanged. ;
- If the flood level in Wivenhoe using a 1 m in 10-minute gate opening procedure is predicted to be above 75.5 m AHD, the gates are to be raised at a rate to ensure they are out of the water before the initiation of the first fuse plug. Where practicable, the gates are to be secured in a locked position before the dam water level reaches 75.7 m AHD.

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Deleted: This means that the proposed works will not affect outflows until the dam reaches a water level of 74 m AHD. It is noted that the 1999 flood, which had an AEP of about 1 in 100 at the dam reached a peak water level of 70.41 m AHD

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- The concepts of the Wivenhoe gate closure rules will remain unchanged. However, releases from the main spillway may be reduced to recompense the releases from the auxiliary spillways to reduce the downstream flows below the non-damaging flows as quickly as possible, whilst still ensuring flood storage is available for consecutive floods within 7 days.

8.9 Modification to Flood Operating Procedures if a subsequent flood event occurs prior to the reconstruction of Triggered Fuse Plugs

Where the operation of any or all of the fuse plug spillway bays has been triggered and a flood event occurs before the fuse plug can be reinstated, the flood operation procedures are to be modified such that:

- The discharge from the triggered fuse plug is to be taken into account when determining total flood releases from the dam;
- the gates are to be operated, to the extent possible, so that the same discharge restrictions apply as would have if the fuse plug embankment was intact.

8.10 Modification to Flood Operating Procedures during Construction of Right Abutment Auxiliary Spillway

8.10.1 Works in the Auxiliary Spillway

For the Stage 1 auxiliary spillway, it is proposed to construct a temporary road diversion on the upstream side of the works that will act as a temporary coffer dam for the first half of the project. The lowest point of the diversion road/coffer dam is 77 m AHD, which is at the height of the clay core of the existing dam. That is, there will be no loss of flood storage during the first half of the construction program. When the fuse plug has been constructed to a level of 74 m AHD and the new road bridge is built, the temporary coffer dam will be removed and the upstream spillway chute will be excavated, thereby lowering the available flood storage before a fuse plug initiates. Current assessments indicate the annual exceedance probability of the flood that reaches a lake level of 74 m AHD is about 1 in 500 at the dam. Floods exceeding this level will flow through the construction works. The fuse plug construction program for this period will be of a number of months duration programmed for winter 2005. During this period flow through the existing gated spillway should be maximised.

8.10.2 Construction Works within the Gated Spillway

The following provisions will apply for works undertaken within the gated spillway:

- The opening of spillway gates to discharge floodwaters is at the sole discretion of the Senior Flood Operations Engineer;
- There is to be no obstruction of any spillway bay without the approval of the Senior Flood Operations Engineer;
- No more than one gated spillway bay is to be obstructed at any one time;
- All construction material will be removed from the main spillway within 12 hours of being notified by the Senior Flood Operations Engineer. The bulkhead will also be

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raised once the construction material has been removed. That is, all gates are to be capable of being operated at short notice during a flood if required;

- A gate can remain closed if a flood will severely damage works if it is opened, and the expected flood magnitude can be catered for with 4 gates. The other gates are to be operated in accordance with the existing flood operational procedures but to compensate for the loss of flow in the closed gate;

- As the flood rises to the top of the closed gate, at an elevation of 73 m AHD, the gate is incrementally raised to prevent it from being overtopped. It is noted that a large flood is required for the lake level to reach 73 m AHD.

Table 8.1 Peak Outflows and Maximum Lake Levels at Fuse Plug Initiation, Wivenhoe Dam

Fuse Plug No. Initiated	Approx. AEP (1 in X Years)	Peak Outflow (m^3/s)			Maximum Lake Water Level (m AHD)
		Gated Spillway	Right Abutment Spillway	Saddle Dam 2 Spillway	
1	5,000	10,500	1,600	0	75.7
2	11,500	11,000	5,300	0	76.25
3	30,000	12,200	10,200	0	77.2
4	53,000	13,000	11,850	7,450	78.3

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9 SOMERSET DAM

9.1 Introduction

Somerset Dam is capable of being operated in a number of ways to regulate Stanley River floods and optimise the flood mitigation capacity of Wivenhoe Dam.

A general plan and cross-section of Somerset Dam, and relevant dam operating levels are included in Appendix J.

The discharge capacities for various storage levels of Somerset Dam are listed in Appendix F.

9.2 Initial Action

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

9.3 Regulator and Gate Operation Procedures

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

Table 9.1
SOMERSET DAM
MINIMUM INTEVNALS FOR NORMAL OPERATIONS

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	OPENING	CLOSING
Regulators	30 minutes	60 minutes
Sluice Gates	120 minutes	180 minutes
Crest Gates	Gates are normally open	

During the initial opening or final closure sequences of gate operations it is permissible to replace the discharge through a sluice gate by the immediate opening of one or more regulator valves (or the reverse operation). This allows for greater control of low flows and enables a smooth transition on opening and closing sequences.

9.4 Flood Control Procedure

It is essential that the operating procedures adopted should not endanger the safety of Wivenhoe Dam. Within this constraint, the Senior Flood Operations Engineer must adopt a procedure for the operation of Somerset Dam such that:

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(a) the structural safety of Somerset Dam is not endangered;

As indicated in Section 8.7, Somerset gates and valves can be temporarily closed to prevent a fuse plug from initiating. With respect to the safety of Somerset, SMEC (2004) estimated that the dam has an increased risk of cracking at a headwater level of 109.7 m AHD. Altering the standard Somerset gate operating procedures is considered safe below this level

(b) the Upper Brisbane River flood flow plus Somerset Dam releases does not cause Wivenhoe Dam to be overtopped.

The normal operating procedure to be used for Somerset Dam is as follows.

The crest gates are raised to enable uncontrolled discharge. The low level regulators and sluices are to be kept closed until either:

(i) the lake level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

In the case of (i) above the opening of the regulators and sluices is not to increase the inflow to Wivenhoe Dam above the peak inflow from the Brisbane River just passed or, if possible, not to cause the Wivenhoe Dam lake level to exceed EL 74.

In the case of (ii) above, the Senior Flood Operations Engineer must direct the operation of the low-level regulators and sluices to ensure the safety of Somerset Dam. It should also be recognised that the D'Aguilar Highway at Mary Smokes Creek becomes inundated when Lake Somerset exceeds EL 102.2.

If the flood event emanates from the Stanley River catchment only, without significant runoff in the Upper Brisbane River catchment, the operation of Somerset Dam will proceed on the basis that Wivenhoe Dam has peaked as per (i) above.

Comment [r13]: Page: 20 There must be more to the procedures than this.

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10 EMERGENCY

10.1 Introduction

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

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

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- Other uncommon mechanisms.

Responses to these and other conditions are included in separate Emergency Action Plans.

10.2 Overtopping of Dams

Whatever the circumstances, every endeavour must be made to prevent overtopping of Wivenhoe Dam by the progressive opening of operative spillway gates.

The probability of overtopping of Wivenhoe Dam will be significantly reduced following the completion of the auxiliary spillway.

Somerset Dam should, if possible, not be overtopped by flood water but, if Wivenhoe Dam is threatened by overtopping, the release of water from Somerset Dam is to be reduced, for example by the use of its spillway gates, even at the risk of overtopping Somerset Dam in order to prevent, if possible, the overtopping of Wivenhoe Dam.

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10.3 Communications Failure

In the event of normal communications being lost between the Flood Operations Engineer and either Wivenhoe Dam or Somerset Dam, the dam supervisor at that dam is to maintain contact with the dam supervisor at the other dam, to receive instructions through the remaining communications link.

In the event of normal communications being lost between the Flood Operations Engineer and both Wivenhoe Dam and Somerset Dam, the dam supervisors at each dam are to adopt the procedures set out below during flood events, and are to maintain contact with each other, where possible.

If all communications are lost between the Engineer, Wivenhoe Dam and Somerset Dam, the officers in charge at each dam are to adopt the procedures set out below.

10.4 Wivenhoe Dam Emergency Procedure

In the event of total communication failure, the minimum gate openings related to lake level set out in the table below are to be maintained for both opening and closing operations.

Table 10.4 Minimum Gate Openings Wivenhoe Dam

Lake Level m AHD	Gate 3 Opening (m)	Gates 2 & 4 Opening (m)	Gates 1 & 5 Opening (m)	Total Discharge m^3/sec

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67.0		-	-	0
67.5	0.5	-	-	50
68.0	1.5	-	-	155
68.5	2.5	-	-	260
69.0	3.5	0.5	-	470
69.5	4.0	1.0	-	640
70.0	4.0	1.5	0.5	875
70.5	4.0	2.0	1.0	1115
71.0	4.0	2.5	1.5	1365
71.5	4.5	2.5	2.0	1560
72.0	4.5	3.0	2.5	1820
72.5	5.0	4.0	3.0	2250
73.0	5.0	5.0	5.0	2960
73.5	6.5	6.5	6.5	3850
74	Raise gates at rate of 1 metre per 10 minutes			
74.5				
75				
75.5	FULLY OPEN	FULLY OPEN	FULLY OPEN	5500
76				7112
76.5				8723
77				10335
77.5				10790
78				11250
78.5				11720
79				13600
79.5				13500
80				13440

If one or more gates become inoperable, then by reference to Table E-2 the gate openings of operable gates are to be increased in order that the discharges for the lake levels shown in Table 10.4 are achieved.

If, because of compliance with the provisions of Section 8.3 and the high inflow rate, the minimum gate openings cannot be maintained, the time intervals between successive openings shown in Table 8.1 are to be halved.

If the actual gate openings fall more than three settings below the cumulative number of minimum settings of Table 10.4, then successive gate operations are to be carried out as rapidly as possible until the minimum settings are achieved. Under these circumstances, it may be necessary to operate more than one gate at any one time.

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10.5 Somerset Dam Emergency Procedure

In the event of total communication failure, the spillway gates are to be kept raised to allow uncontrolled discharge. The regulators and sluices are to be kept closed until either:

(i) the level in Wivenhoe Dam begins to drop or

(ii) the level in Somerset Dam exceeds EL 102.25.

The level in Wivenhoe Dam can be determined locally by the Dam Supervisor at Somerset Dam from the tailwater gauge located just downstream of Somerset Dam.

In the case of (i) above, the opening of the regulators and sluices is not to increase the level in Wivenhoe Dam above the peak level already attained. Section 9.3 on regulator and gate operation interval is to be observed.

In the case of (ii) above, the regulators and sluices are to be operated such that the free-board between the flood level in Wivenhoe Dam and EL 77 is the same as the free-board between the flood level in Somerset Dam and the non- spillway crest level in Somerset Dam (EL 107.46). The low level outlets in Somerset Dam are not to be opened if the water level in Wivenhoe Dam exceeds the level set out below for given water levels in Somerset Dam.

Somerset Lake Level m AHD	**Wivenhoe Lake Level m AHD**
102.5	72
103.5	73
104.5	74
105.5	75
106.5	76
107.46	77

The constraints applicable to case (i) operation above do not apply to case (ii) operation.

10.6 Equipment Failure

In the event of equipment failure the action to be taken is indicated in Appendix G for Wivenhoe Dam and Appendix H for Somerset Dam.

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APPENDIX A EXTRACT FROM ACT

EXTRACT FROM WATER ACT 2000

Division 2 – Flood Mitigation

Owners of certain dams must prepare flood mitigation manual

496.(1) A regulation may nominate an owner of a dam as an owner who must prepare a manual (a “flood mitigation manual”) of operational procedures for flood mitigation for the dam.

(2) The regulation must nominate the time by which the owner must comply with section 497(1).

Approving flood mitigation manual

497.(1) The owner must give the chief executive a copy of the flood mitigation manual for the chief executive’s approval.

(2) The chief executive may, by gazette notice, approve the manual.

(3) The approval may be for a period of not more than 5 years.

(4) The chief executive may get advice from an advisory council before approving the manual.

Amending flood mitigation manual

498.(1) The chief executive may require the owner, by notice, to amend the flood mitigation manual.

(2) The owner must comply with the chief executive’s request under subsection (1).

(3) The chief executive must, by gazette notice, approve the manual as amended.

(4) The approval of the manual as amended must be for-

(a) the balance of the period of the approval for the manual before amendment; or

(b) a period of not more than 5 years from the day the manual as amended was approved.

(5) The chief executive may get advice from an advisory council before approving the manual as amended.

Regular reviews of flood mitigation manual

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499. Before the approval for the flood mitigation manual expires, the owner must-

(a) review, and if necessary, update the manual; and

(b) give a copy of it to the chief executive under section 497.

Protection from liability for complying with flood mitigation manual

500.(1) The chief executive or a member of the council does not incur civil liability for an act done, or omission made, honestly and without negligence under this division.

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

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

(4) In this section-

"**owner**" includes-

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

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

(c) an agent of the owner or operator of the dam

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APPENDIX B AGENCIES HOLDING DOCUMENTS

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

Dam Owner	South East Queensland Water Corporation
Emergency Services	Department of Emergency Services, Disaster Management Service Brisbane City Counter Disaster Committee Esk Shire Counter Disaster Committee Ipswich City Counter Disaster Committee Kilcoy Shire Counter Disaster Committee
Severe Weather Warning Authority	Bureau of Meteorology
Primary Response Authorities	Brisbane City Council Esk Shire Council Ipswich City Council Kilcoy Shire Council
Regulator of Dam Safety	Department of Natural Resources and Mines
Schedule of Authorities, Appendix C	Agencies and persons listed in Appendix C

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

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APPENDIX C SCHEDULE OF AUTHORITIES

AUTHORITY	AGENCY /PERSON	APPROVED BY	APPROVAL DATE	REFERENCE
Senior Flood Operations Engineer	Robert Arnold Ayre SunWater	Chief Executive	Date of approval of this manual	
	John Lawrence Ruffini Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	
Flood Operations Engineer	Peter Hugh Allen Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	
	Robert Arnold Ayre SunWater	Chief Executive	Date of approval of this manual	
	John Lawrence Ruffini Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	
	Toby Leonard McGrath SunWater	Chief Executive	Date of approval of this manual	
	Donald James Cock Department of Natural Resources and Mines	Chief Executive	Date of approval of this manual	

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APPENDIX D GAUGES AND BRIDGES

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D.1. KEY REFERENCE GAUGES

BRISBANE CITY

	FLOOD CLASSIFICATION			
Gauge	Minor	Moderate	Major	1974 Flood
Moggill	10.0	13 .0	15.5	19 .9
Jindalee	6.0	8. 0	10.0	14 .1
Brisbane City Gauge (B.C.G)	1.7	2. 6	3.5	5. 5

(Reference: Brisbane City Disaster Management Plan, Flood Management Special Plan 30 July, 1996)

IPSWICH CITY

	FLO OD CLASSIFICATION			
Gauge	Minor	Moderate	Major	1974 Flood
David Trumpy Bridge	7.0	9.0	11.7	20.7
Mt Crosby Weir	11.0	13.0	21.0	26.7
Moggill	10.0	13.0	15.5	19.9

ESK SHIRE

	FLOOD CLASSIFICATION		
Gauge	Minor	Moderate	Major
Lowood Alert Station	8.6	15.9	21.2

KILCOY SHIRE

	FLOOD CLASSIFICATION		
Gauge	Minor	Moderate	Major
Somerset Dam Reservoir Level	103.0	105.0	106.0

Values are in metres AHD

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APPENDIX D GAUGES AND BRIDGES

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D.2. SUBMERGENCE FLOWS FOR BRIDGES

AMTD	Bridge Name	Estimated Submergence Flow m^3/sec
140	Twin Bridges	50
132	Savage's Crossing	130
87	College's Crossing	175-200*
120	Burton's Bridge	430
100	Kholo Bridge	550
91	Mt.Crosby Weir Bridge	1900
136	Fernvale Bridge	2000

* Affected by tides.

Twin Bridges, Wivenhoe Pocket Road, Fernvale
Savage's Crossing, Banks Creek Road, Fernvale
College's Crossing, Mt Crosby Rd, Karana Downs
Burton's Bridge, E Summerville Rd, Borallon
Kholo Bridge, Kholo Rd, Ipswich
Mt Crosby Weir Bridge, Allawah Rd, Mt Crosby
Fernvale Bridge, Brisbane Valley Highway, north of Fernvale

Flood Level Increases in metres in Brisbane River due to Fuse Plug Operation

Location	Fuse Plug 1	Fuse Plug 2	Fuse Plug 3	Fuse Plug 4 (Saddle Dam 2)
Savages Crossing (Fernvale)	0.7	1.1	0.9	1.5
Moggill Gauge	0.3	0.5	0.4	0.6

APPENDIX D 3

Flood Peak Travel Time Following Fuse Plug Initiation, Brisbane River

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Location	Flood Peak Travel Time Following Fuse Plug Initiation (hours)							
	Fuse Plug 1		Fuse Plug 2		Fuse Plug 3		Fuse Plug 4 (Saddle Dam 2)	
	Before	After	Before	After	Before	After	Before	After
Wivenhoe Dam	53.0	53.0	54.0	51.5	53.5	52.5	53.5	53.5
Savages Crossing (Fernvale)	60.0	60.5	58.0	57.5	56.5	55.5	55.5	55.0
Mt Crosby Weir	70.5	69.5	68.5	67.0	65.5	64.0	61.5	61.0
Moggill Gauge	76.5	76.0	75.5	75.0	73.0	72.5	70.0	69.0
Port Office Gauge	88.0	88.0	88.0	87.5	86.5	87.0	84.0	82.5

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APPENDIX E WIVENHOE DAM TECHNICAL DATA
TABLE E1 STORAGE AND UNCONTROLLED DISCHARGES
[MODIFY TO INCLUDE FUSE PLUG DISCHARGES OR PUT IN TABLE E2]

Lake level m AHD	Storage Capacity 10^6 m^3	*** Flood Capacity 10^6 m^3	** Net Inflow per 1mm rise per hour m^3/sec	* Discharge per Regulator m^3/sec	* Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
57.0	414	-	11.10	24.9	0	50
57.5	453	-	12.04	25.2	4	69
58.0	466	-	12.97	25.4	15	128
58.5	494	-	13.90	25.7	32	211
59.0	523	-	14.84	25.9	53	316
59.5	553	-	15.77	26.2	77	439
60.0	584	-	16.71	26.4	105	579
60.5	616	-	17.64	26.6	136	735
61.0	649	-	18.58	26.9	170	905
61.5	683	-	19.51	27.1	207	1 090
62.0	719	-	20.45	27.3	246	1 290
62.5	756	-	21.38	27.5	288	1 495
63.0	795	-	22.32	27.8	333	1 720
63.5	835	-	23.25	28.0	379	1 950
64.0	877	-	24.19	28.2	428	2 195
64.5	920	-	25.12	28.4	479	2 450
65.0	965	-	26.06	28.7	532	2 720
65.5	1 012	-	26.99	28.9	587	2 995
66.0	1 061	-	27.92	29.1	645	3 280
66.5	1 112	-	28.86	29.3	704	3 580
67.0	1 165	0	29.79	29.5	765	3 885
67.5	1 220	56	30.73	29.7	828	4 200
68.0	1 276	112	31.66	29.9	893	4 525
68.5	1 334	171	32.60	30.1	959	4 860
69.0	1 393	230	33.53	30.3	1 028	5 200
69.5	1 454	290	34.47	30.5	1 098	5 550
70.0	1 517	350	35.40	30.7	1 170	5 910
70.5	1 581	418	36.33	30.9	1 244	6 280
71.0	1 647	485	37.27	31.1	1 319	6 660
71.5	1 714	550	38.20	31.3	1 396	7 040
72.0	1 783	615	39.14	31.5	1 474	7 430
72.5	1 854	683	40.07	31.7	1 554	7 840
73.0	1 926	750	41.01	31.9	1 636	8 240
73.5	2 000	830	41.94	32.1	1 719	8 660
74.0	2 076	910	42.87	32.3	1 804	9 080
74.5	2 153	995	43.81	32.5	1 890	9 520
75.0	2 232	1 080	44.74	32.7	1 978	9 960
75.5	2 313	1 160	45.68	32.9	2 067	10 400
76.0	2 395	1 240	46.61	33.1	2 158	10 860
76.5	2 480	1 258	47.55	33.3	2 250	11 320
77.0	2 566	1 420	48.48	33.4	2 343	11 780
77.5	2 655	1 500	49.41	36.6	2 438	12 260
78.0	2 746	1 580	50.35	33.8	2 535	12 740
78.5	2 839	1 680	51.28	34.0	2 632	13 230
79.0	2 934	1 780	52.22	34.2	2 731	13 730

* This is the maximum discharge of an individual spillway bay or regulator. Total discharge is calculated by adding the contributions of each gate or regulator. There are two (2) regulators to five (5) spillway bays.

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** 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.

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TABLE E2 CONTROLLED GATE DISCHARGES

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
67.0	0	49	98	146	194	240	285	329	372	413	453	492	530	567	603	639	675	709	744	765															
67.2	0	49	99	148	196	243	288	333	376	418	458	498	537	574	611	648	684	720	755	790															
67.4	0	50	100	149	198	245	291	336	380	422	464	504	543	582	619	657	693	730	766	802	815														
67.6	0	50	101	151	200	248	294	340	384	427	469	510	550	589	627	665	702	740	777	814	841														
67.8	0	51	102	152	202	250	297	343	388	432	474	515	556	596	635	673	712	750	787	825	863	867													
68.0	0	51	103	154	204	253	300	347	392	436	479	521	562	603	642	682	721	759	798	837	876	893													
68.2	0	52	104	155	206	255	303	350	396	441	484	527	569	610	650	690	729	769	808	848	888	919													
68.4	0	52	105	156	207	257	306	354	400	445	489	532	575	616	657	698	738	778	818	859	899	940	946												
68.6	0	53	105	158	209	260	309	357	404	450	494	538	581	623	665	706	747	788	829	870	911	953	973												
68.8	0	53	106	159	211	262	312	360	408	454	499	543	587	630	672	714	755	797	838	880	923	965	1000												
69.0	0	54	107	160	213	264	315	364	412	458	504	549	593	636	679	722	764	806	848	891	934	977	1022	1028											
69.2	0	54	108	162	215	267	317	367	415	463	509	554	599	643	686	729	772	815	858	901	945	989	1035	1056											
69.4	0	54	109	163	217	269	320	370	419	467	514	560	605	649	693	737	780	824	868	912	956	1001	1047	1084											
69.6	0	55	110	164	218	271	323	373	423	471	518	565	611	656	700	744	789	833	877	922	967	1013	1060	1107	1112										
69.8	0	55	111	166	220	273	326	377	427	475	523	570	616	662	707	752	797	842	887	932	978	1025	1072	1121	1141										
70.0	0	56	112	167	222	276	328	380	430	479	528	575	622	668	714	759	805	850	896	942	989	1036	1085	1134	1170										
70.2	0	56	112	168	224	278	331	383	434	484	532	580	628	674	721	767	813	859	905	952	1000	1048	1097	1147	1198	1199									
70.4	0	56	113	170	225	280	334	386	437	488	537	586	633	680	727	774	821	867	914	962	1010	1059	1109	1160	1212	1229									
70.6	0	57	114	171	227	282	336	389	441	492	542	591	639	687	734	781	828	876	923	972	1020	1070	1121	1173	1226	1258									
70.8	0	57	115	172	229	284	339	392	445	496	546	596	644	693	741	788	836	884	932	981	1031	1081	1133	1185	1239	1289									
71.0	0	58	116	173	230	286	341	395	448	500	551	601	650	699	747	795	844	892	941	991	1041	1092	1144	1198	1252	1309	1319								
71.2	0	58	117	175	232	289	344	398	452	504	555	605	655	705	754	802	851	900	950	1000	1051	1103	1156	1210	1266	1323	1349								
71.4	0	58	117	176	234	291	347	401	455	508	559	610	661	710	760	809	859	908	959	1009	1061	1114	1167	1222	1279	1337	1380								
71.6	0	59	118	177	235	293	349	404	458	512	564	615	666	716	766	816	866	916	967	1019	1071	1124	1179	1234	1292	1350	1410	1411							
71.8	0	59	119	178	237	295	352	407	462	515	568	620	671	722	773	823	874	924	976	1028	1081	1135	1190	1246	1304	1364	1425	1443							
72.0	0	60	120	180	239	297	354	410	465	519	572	625	676	728	779	830	881	932	984	1037	1091	1145	1201	1258	1317	1377	1439	1474							
72.2	0	60	121	181	240	299	357	413	469	523	577	629	682	733	785	837	888	940	993	1046	1100	1156	1212	1270	1330	1391	1454	1506							
72.4	0	60	121	182	242	301	359	416	472	527	581	634	687	739	791	843	895	948	1001	1055	1110	1166	1223	1282	1342	1404	1468	1533	1538						
72.6	0	61	122	183	243	303	361	419	475	531	585	639	692	745	797	850	903	956	1009	1064	1119	1176	1234	1293	1354	1417	1482	1548	1570						
72.8	0	61	123	184	245	305	364	422	478	534	589	643	697	750	803	856	910	963	1018	1073	1129	1186	1245	1305	1367	1430	1496	1563	1603						

UNCONTROLLED DISCHARGE

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TABLE E2 CONTROLLED GATE DISCHARGES

Wivenhoe Dam Gate Opening (m of Tangential Travel)

Water EL (m AHD)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
73.0	0	62	124	185	247	307	366	425 4	82 5	38	593 648		702	756	809	863	917	971	1026	1081	1138	1196	1255	1316	1379 144	3	1509	1577	1636						
73.2	2	62 1	24	187	248	309	369	427 4	85 5	42	597 653		707	761	815	869	924	978	1034	1090	1147	1206	1266	1327	1391 145	6	1523	1592	1663	1669			UNCONTROLLED		
73.4	6	62 1	25	188	250	311	371	430 4	88 5	45	602 657		712	767	821	876	931	986	1042	1099	1156	1216	1276	1339	1403 146	9	1536	1606	1678	1702			DISCHARGE		
73.6	11	64	126 18	9	251	313	373	433 4	91 5	49	606 662		717	772	827	882	937	993	1050	1107	1166	1225	1287	1350	1414 148	1	1550	1620	1693	1736					
73.8	17	69	127 19	0	253	315	376	436 4	95 5	53	610 666		722	778	833	888	944	1001	1058	1116	1175	1235	1297	1361	1426 149	4	1563	1635	1708	1770					
74.0	23	74	129	191	254	317	378	438 4	98 5	56	614 671		727	783	839	895	951	1008	1065	1124	1184	1245	1307	1372	1438 150	6	1576	1648	1723	1800	1804				
74.2	31	80	133	192	256	319	380	441 5	01 5	60	618 675		732	788	845	901	958	1015	1073	1132	1192	1254	1317	1382	1449 151	8	1589	1662	1738	1815	1838				
74.4	39	87	139	195	257	321	383	444 5	04 5	63	622 679		737	793	850	907	964	1022	1081	1140	1201	1264	1327	1393	1461 153	0	1602	1676	1752	1831	1873				
74.6	47	94	145	200	259	322	385	447 5	07 5	67	626 684		741	799	856	913	971	1029	1089	1149	1210	1273	1337	1404	1472 154	2	1615	1690	1767	1846	1908				
74.8	56	103	153	206	262	324	387	449 5	10 5	70	629 688		746	804	862	919	978	1036	1096	1157	1219	1282	1347	1414	1483 155	4	1628	1703	1781	1861	1943				
7 5.0	6 6	112	161	213	267	326	390	452 5	13 5	74	633 692		751	809	867	926	984	1044	1104	1165	1227	1291	1357	1425	1494 156	6	1640	1717	1795	1876	1960	1978			
75.2	76	121	169	220	274	330	392	455 5	16 5	77	637 697		756	814	873	932	991	1051	1111	1173	1236	1301	1367	1435	1506 157	8	1653	1730	1809	1891	1976	2013			
75.4	87	131	178	229	281	336	394	457 5	19 5	81	641 701		760	819	878	938	997	1057	1119	1181	1245	1310	1377	1446	1517 159	0	1665	1743	1823	1906	1992	2049			
75.6	98	141	188	237	289	343	399	460 5	22 5	84	645 705		765	824	884	944	1004	1064	1126	1189	1253	1319	1386	1456	1527 160	1	1678	1756	1837	1921	2007	2085			
75.8	109	152 1	98	247	298	350	405	463	525 5	87	649 709		769	829	889	949	1010	1071	1133	1197	1261	1328	1396	1466	1538 161	3	1690	1769	1851	1936	2023	2112	2121		
				OVERTOPPING of GATE																															
76.0	121	164 2	09	257	307	359	412	468	528 5	91	652 713		774	834	895	955	1016	1078	1141	1205	1270	1337	1405	1476	1549 162	4	1702	1782	1865	1950	2038	2129	2158		
76.2	133	175 2	20	268	317	368	421	475 53	2	594	656 718		779	839	900	961	1023	1085	1148	1212	1278	1346	1415	1486	1560 163	6	1714	1795	1878	1965	2053	2145	2194		
76.4	146	187 2	32	279	327	378	429	483 53	9	597	660 722		783	844	906	967	1029	1092	1155	1220	1286	1354	1424	1496	1570 164	7	1726	1808	1892	1979	2069	2161	2231		
76.6	159	200 2	44	290	338	388	439	492 54	6 60	3	664 726		788	849	911	973	1035	1098	1162	1228	1295	1363	1434	1506	1581 165	8	1738	1820	1905	1993	2084	2177	2268		
76.8	173	213	257	302	350	399	449	501	554	610	668	730	792	854	916	978	1041	1105	1170	1235	1303	1372	1443	1516	1591	1669	1750	1833	1919	2007	2099	2193	2289	2306	
				OVERTOPPING of GATE																															
77.0	186	226 2	70	315	362	410	460	511 5	64 6	18	674	734	797	859	921	984	1047	1112	1177	1243	1311	1380	1452	1526	1602 168	0	1762	1845	1932	2021	2113	2208	2306	2343	
77.2	200	240 2	83	328	374	422	471	522 5	74 6	27	682 739		801	864	927	990	1054	1118	1184	1250	1319	1389	1461	1536	1612 169	1	1773	1858	1945	2035	2128	2224	2322	2381	
77.4	215	254 2	97	341	387	435	483	533 5	84 6	37	691 747		806	869	932	996	1060	1125	1191	1258	1327	1398	1470	1545	1622 170	2	1785	1870	1958	2049	2143	2239	2339	2419	
77.6	230	269 3	11	355	400	447	496	545 5	95 6	47	700 756		813	873	937	1001	1066	1131	1198	1265	1335	1406	1479	1555	1633 171	3	1796	1882	1971	2063	2157	2255	2355	2457	
77.8	245	283 3	25	369	414	461	508	557 6	07 6	58	711 765		821	880	942	1007	1072	1138	1205	1273	1343	1414	1488	1564	1643 172	4	1808	1894	1984	2076	2172	2270	2371	2475	2496
78.0	260	299 3	40	383	428	474	522	570 6	19 6	70	722 775		831	888	948	1012	1078	1144	1211	1280	1351	1423	1497	1574	1653 173	5	1819	1907	1997	2090	2186	2285	2387	2492	2535

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APPENDIX F SOMERSET DAM TECHNICAL DATA

Table F-l
STORAGE AND DISCHARGE FOR SOMERSET DAM

Lake level M AHD	Reservoir Capacity 10^6 m^3	Temporary Flood Storage 10^6 m^3	Net Inflow per 1mm rise per hour m^3/sec	* Discharge per Regulator m^3/sec	* Discharge per Sluice m^3/sec	* Discharge per Spillway Bay m^3/sec	Maximum Available Discharge m^3/sec
90.0	120.3	-	5.29	57	163	-	1 529
90.5	129.5	-	5.50	58	165	-	1 550
91.0	139.3	-	4.88	58	167	-	1 572
91.5	149.6	-	5.28	59	170	-	1 593
92.0	160.5	-	5.68	60	172	-	1 614
92.5	172.0	-	6.09	60	174	-	1 635
93.0	184.1	-	6.79	61	176	-	1 655
93.5	196.7	-	7.10	62	179	-	1 676
94.0	210.0	-	7.43	62	181	-	1 695
94.5	224.0	-	7.78	63	183	-	1 715
95.0	238.5	-	8.15	64	185	-	1 735
95.5	253.6	-	8.54	64	187	-	1 754
96.0	269.3	-	8.95	65	189	-	1 773
96.5	285.6	-	9.37	66	191	-	1 792
97.0	302.7	-	9.81	66	193	-	1 810
97.5	320.7	-	10.28	67	195	-	1 829
98.0	339.5	-	10.76	67	197	-	1 847
98.5	359.2	-	11.25	68	199	-	1 865
99.0	379.8	0.0	11.77	69	201	-	1 883
99.5	401.4	21.5	12.31	69	203	-	1 901
100.0	428.9	49.0	13.28	70	205	-	1 918
100.5	447.5	67.6	13.83	70	207	0	1 937
101.0	472.2	92.3	14.39	71	209	4	1 989
101.5	498.0	118.1	14.95	72	211	13	2 076
102.0	524.9	145.1	15.53	72	212	25	2 189
102.5	553.1	173.3	16.11	73	214	40	2 325
103.0	582.6	202.7	16.70	73	216	58	2 482
103.5	613.2	233.4	17.30	74	218	78	2 659
104.0	645.1	265.3	17.90	74	220	100	2 854
104.5	678.3	298.4	18.52	75	221	125	3 067
105.0	712.7	332.8	19.14	75	223	151	3 296
105.5	748.3	368.4	19.78	76	225	180	3 542
106.0	785.2	405.4	20.42	76	226	211	3 803
106.5	823.4	443.6	21.07	77	228	243	4 079
107.0	863.1	483.2	21.73	78	230	278	4 370
107.5	904.0	524.2	22.39	78	232	314	4 675

* This is the maximum discharge of an individual gate or regulator. Total discharge is calculated by adding the contributions of each gate or regulator.

Regulator - Discharge regulator valve of which there are four (4).
Sluice - Sluice gate of which there are eight (8).
Spillway - Overflow section of dam controlled by eight (8) radial gates.
Temporary Flood Storage - The temporary storage above the normal full supply level of El 99 m (AHD)

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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.

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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

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The rainfall runoff models based on a non-linear runoff routing method were used to estimate the floods. The models were calibrated on recorded storm and flood data. The model calibrations were completed in 1993 and were not modified for the latest re-assessment.

Models to simulate the flood operation of Somerset and Wivenhoe Dams developed during the mid-eighties were modified to incorporate the new structure of the hydrologic models and to more accurately reflect the operational procedures of the dams. These models were then used to calculate dam discharges for a range of design floods generated using the rainfall estimates and the runoff routing models.

I.3. RAINFALL ANALYSIS RESULTS

The rainfall analysis was performed in two parts, the Probable Maximum Precipitation estimate by the Bureau of Meteorology and the estimation of large to rare events using the CRC-FORGE method. These were used both for design studies for the dam and to test the effects of flood operation procedures.

The estimates of Probable Maximum Precipitation are listed in Table I-1.

Table I-1
Probable Maximum Precipitation (mm)

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Duration¶
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(new table to come)

The estimates of rainfall frequency are listed in tables I-2. These estimates are based upon the CRC-FORGE methodology as recommended in Book VI of Australian Rainfall and Runoff, (1998).

Table I-2

Catchment Rainfall (mm) on Wivenhoe Dam Catchment

Annual Exceedence Probability %	24 Hours	48 Hours	72 Hours
1	199 274	319	
0.1	276 393	464	
0.01	379 550	659	

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Catchment Rainfall (mm) on Somerset Dam Catchment

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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

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Table I-4

10.6.1 Estimated Model Parameters

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10.6.2 Sub-Catchment Name	Model Parmeters			
	(k)		(	m)
(1) Cooyar Creek	4	3.6	0.	8
(2) Brisbane River at Linville	2	0.6	0.	8
(3) Emu Creek at Boat Mountain	3	7.2	0.	8
(4) Brisbane River at Gregors Creek	2	0.1	0.	8
(5) Cressbrook Creek at Cressbrook Dam	3	4.3	0.	8
(6) Stanley River at Somerset Dam	8	0.7	0.	8
(7) Brisbane River at Wivenhoe Dam	1	08.5	0.	8
(8) Lockyer Creek at Helidon	1	5.0	0.	8
(9) Tenthill Creek at Tenthill	1	9.0	0.	8
(10) Lockyer Creek at Lyons Bridge	7	5.0	0.	8
(11) Brisbane River at Savages Crossing	4	0.0	0.	8
(12) Brisbane River at Mount Crosby	4	7.0	0.	8
(13) Bremer River at Walloon	4	4.0	0.	8
(14) Warrill Creek at Kalbar	3	4.0	0.	8
(15) Warrill Creek at Amberley	3	5.0	0.	8
(16) Purga Creek at Loamside	4	9.0	0.	8
(17) Bremer River at Ipswich		15.7		0.8
(18) Brisbane River at Jindalee	2	0.8	0.	8
(19) Brisbane River at Port Office		19.3		0.8

I.5. WIVENHOE DAM FLOODS

Wivenhoe Dam floods w ere est imated u sing t he rai nfalls and runoff routing model already discussed. Inflows t o Wivenhoe Dam, ass uming t he dam to be i n e xistence and fu ll, w ere cal culated, as well as fl ow at the dam -site wi thout the da m in the catchment. Two-d ay storms w ere found to have th e cri tical st orm d uration for most cases, though the long du ration Probable Maxi mum Precipitations produced very large flood volumes. Table I-6 lists results for the two-day duration storms.

Table I-5
Wivenhoe Dam Floods

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AEP % ... [2]

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Design Inflows and Outflows for Existing, Stage 1 and Stage 2 Upgrades, Wivenhoe Dam.

Event (1in X)	Peak Infl ow (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

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2,000	14,000	6,600	6,600	6,600
5,000	17,200	8,900	10,500 [c]	10,500 [c]
10,000	20,800	11,700	12,500	12,500
22,000 [a]	25,700	12,400 [a]	17,600	17,600
50,000	34,900	- [b]	24,600	24,600
100,000	43,300	- [b]	28,100 [a]	34,900
PMF	49,000	- [b]	- [b]	37,400 [a]

[a] Dam Crest Flood [b] Overtops dam wall [c] Increases due to changes to Procedure 4.

I.6. SOMERSET DAM FLOODS

Somerset Dam floods were estimated using the rainfalls and runoff routing model already discussed. Inflows to Somerset Dam, assuming the dam to be in existence and full, were calculated, as well as flow at the site without the dam in the catchment. The forty-eight hour PMP storm event was found to be critical, though the long duration PMP's produced very large flood volumes. Table I-6 lists results for the forty-eight hour duration storms.

Table I-6
Somerset Dam Floods
(for two-day storm duration)

AEP %	Peak Inflow (m^3/sec)	Peak Outflow (m^3/sec)	Flood Volume (ML)	Peak Lake Level (m AHD)
1 3	,500	1,700	421,000	103.5
0.1 4	,500	2,600	690,000	104.5
0.01 6	,800	4,700	1,042,000	107.5
0.001 9	,200	6,300	1,412,000	109.3
PMF				

+ - NB. This duration does NOT give the maximum Peak Inflow for a given AEP
*** - Overtopped, estimated flow based on no dam failure**

Studies conducted by structural engineers indicate that Somerset could withstand overtopping to EL 111.7 mAHD. *[Is tis still the case with the recent SMEC studies??]*

I.7 FLOOD CONTROL OPERATION MODEL

Floods in the Brisbane River catchment above Wivenhoe Dam can originate in either the Stanley River or upper Brisbane River catchment or both. Both of the dams are capable of being operated in a number of ways, each of which will reduce the flow downstream. However, in order to achieve maximum reduction of flooding downstream of Wivenhoe Dam, it was necessary to review the operations at Somerset and Wivenhoe Dams using a flood operations simulation model.

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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

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APPENDIX J DRAWINGS

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APPENDIX K BRISBANE RIVER CATCHMENT

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Duration (days)	Somerset Dam	Wivenhoe Dam	Brisbane Catchment
1	900 670 530		
2	1420 870		680
3	1770 1080		830
4	2090 1250 1010		
5	2170 1300 1050		
6	2220 1330 1070		
7	2410 1480 1160		

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(for two-day storm duration)

AEP %	Peak Inflow (m^3/sec)	Peak Outflow (m^3/sec)	Flood Volume (ML)	Peak Lake Level (m AHD)
1 5,	400	1,890	1,170,000 73.4	
0.1 9,	380	6,760	1,710,000 74.9	
0.01 15,000		11,300 2,980,000		76.8
PMF	28,600 *	25,800 *	5,270,000 *	81.7 *

+ - NB. This duration does NOT give the maximum Peak Inflow for a given AEP

*** - Overtopped, estimated flow based on no dam failure**