



seqwater
WATER FOR LIFE

MANUAL

OF

OPERATIONAL PROCEDURES

FOR

FLOOD MITIGATION

AT

NORTH PINE DAM

Uncontrolled Copy

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1 INTRODUCTION

1.1 Preface

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

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

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

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

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

1.2 Meaning of Terms

In this manual, save where a contrary definition appears -

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

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

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

“**AHD**” means Australian Height Datum;

“**Chairperson**” means the Chairperson of Seqwater;

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

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

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

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

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

“EL” means elevation in metres Australian Height Datum;

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

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

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

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

“Gauge” when referred to in (m) means river level referenced to AHD, and when referred to in (m³/s) means flow rate in cubic metres per second;

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

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

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

1.3 Purpose of Manual

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

1.4 Legal Authority

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

1.5 Application and Effect

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

1.6 Date of Effect

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

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

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

1.7 Observance of Manual

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

1.8 Provision to Variation of Manual

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

1.9 Distribution of Manual

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

2 DIRECTION OF OPERATIONS

2.1 Statutory Operation

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

2.2 Operational Arrangements

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

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

2.3 Designation and Responsibilities of Senior Flood Operations Engineer

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

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

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

2.4 Designation and Responsibilities of Flood Operations Engineer

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

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

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

2.5 Qualification and Experience of Engineers

Qualifications

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

Experience

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

1. Knowledge of design principles related to the structural, geotechnical and hydraulic design of large dams, and
2. At least a total of five years of suitable experience and demonstrated expertise in at least two of the following areas:
 - Investigation, design or construction of major dams;
 - Operation and maintenance of major dams;
 - Hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;
 - Applied hydrology with particular reference to flood forecasting and/or flood forecasting systems.

2.6 Schedule of Authorities

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

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

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

2.7 Training

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

2.8 Reasonable Discretion

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

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

2.9 Report

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

3 FLOOD MITIGATION OBJECTIVES

3.1 General

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

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

3.2 Structural Safety of Dam

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

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

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

Critical Levels for North Pine Dam

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

3.3 Extreme Floods and Closely Spaced Large Floods

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

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

3.4 Minimise disruption to Downstream Communities

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

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

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

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

3.6 Minimising Impacts to Riparian Flora and Fauna

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

4 FLOOD CLASSIFICATION

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

1. Minor Flooding

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

2. Moderate Flooding

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

3. Major Flooding

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

4. Extreme Flooding

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

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

5 FLOOD MONITORING AND FORECASTING SYSTEM

5.1 General

A real time flood monitoring and forecasting system has been established in the dam catchment. This system employs radio telemetry to collect, transmit and receive rainfall and stream flow information. The system consists of 30 field stations that automatically record rainfall and/or river heights at selected locations in the dam catchments. Some of the field stations are owned by Seqwater with the remainder belonging to other agencies.

The rainfall and river height data is transmitted to Seqwater's Flood Operations Centre in real time. Once received in the Flood Operations Centre, the data is processed using a Real Time Flood Model (RTFM) to estimate likely dam inflows and evaluate a range of possible inflow scenarios based on forecast and potential rainfall in the dam catchments. The RTFM is a suite of hydrologic and hydraulic computer programs that utilise the real time data to assist in the operation of the dams during flood events. Seqwater is responsible for providing and maintaining the RTFM and for ensuring that sufficient data is available to allow proper operation of the RTFM during a Flood Event.

5.2 Operation

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

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

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

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

Seqwater must also maintain a log of the performance of the data collection network. The log must include all revised field calibrations and changes to the number, type and locations of gauges. Senior Flood Operations and Flood Operations Engineers are to be notified of all significant changes to the Log.

Seqwater must also maintain a log of the performance of the RTFM. Any faults to the computer hardware or software are to be noted and promptly and appropriately attend to.

5.3 Storage of Documentation

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

5.4 Key Reference Gauges

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

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

5.5 Reference Gauge Values

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

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

6 COMMUNICATIONS

6.1 Communications between Staff

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

6.2 Dissemination of Information

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

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

Seqwater must liaise and consult with these agencies with a view to ensuring all information relative to the flood event is consistent and used in accordance with agreed responsibilities.

AGENCY INFORMATION REQUIREMENTS

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

6.3 Release of Information to the Public

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

The Bureau of Meteorology has responsibility for issuing flood warnings.

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

7 REVIEW

7.1 Introduction

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

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

7.2 Personal Training

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

7.3 Monitoring and Forecasting System and Communication Networks

Seqwater must provide a report to the Chief Executive by 30 September each year on the state of the Flood Monitoring and Forecasting System and Communication Networks. The report must assess the following in terms of hardware, software and personnel:

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

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

7.4 Operational Review

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

7.5 Five Yearly Review

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

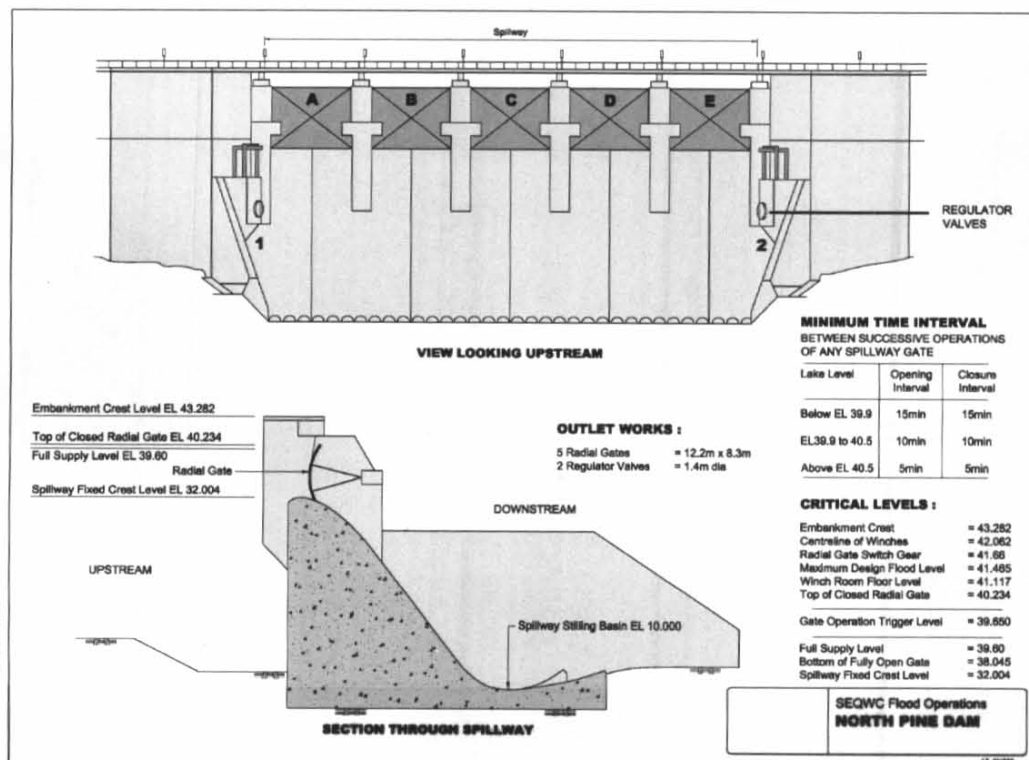
8 FLOOD RELEASE OPERATION

8.1 Introduction

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

8.2 Flood Release Infrastructure

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



8.3 Initial Action

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

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

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

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

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

8.4 Flood Operations Strategies

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

- Ensure the structural safety of the dam;
- Minimise disruption to the community in areas downstream of the dam;
- Retain the storage at Full Supply Level at the conclusion of the Flood Event.
- Minimise impacts to riparian flora and fauna during the drain down phase of the Flood Event.

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

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

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

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

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

8.5 Gate Closing Strategies

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

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

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

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

8.6 Gate Operation Sequences

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

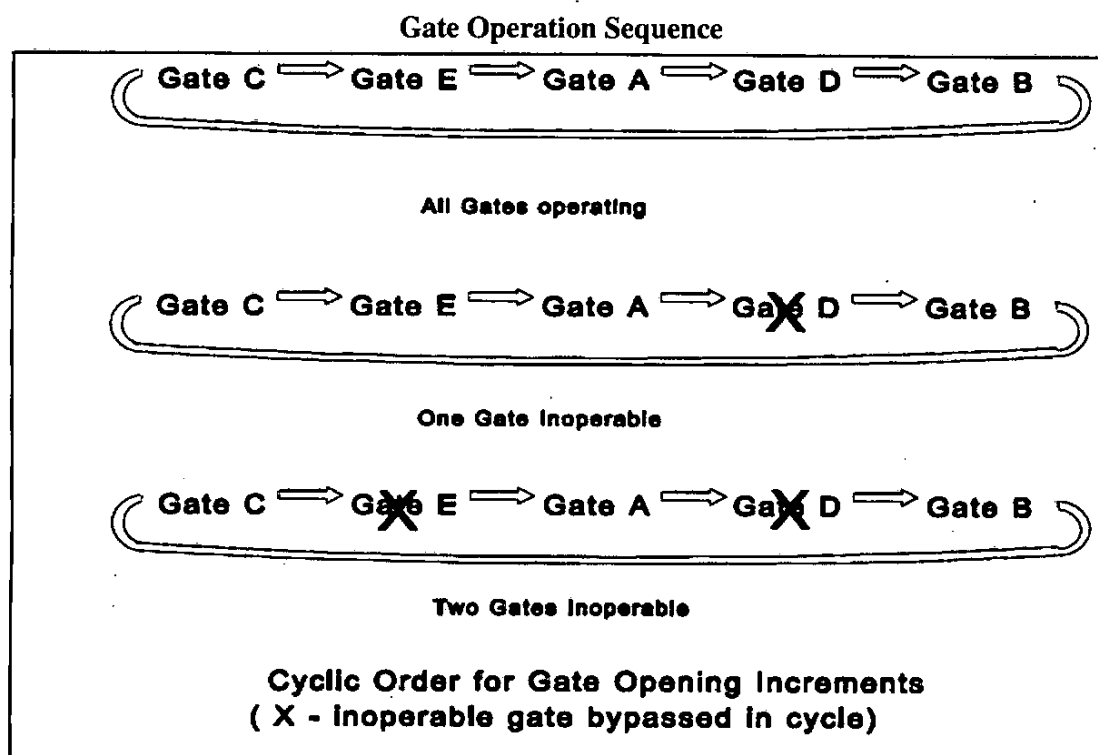
TARGET MINIMUM INTERVALS FOR RADIAL GATE OPENING

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

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

8.7 Protection of the Spillway

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



8.8 Gate Failure or Malfunction Procedures

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

8.9 Radial Gate Turbulence Considerations

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

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

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

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

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

9 EMERGENCY

9.1 Introduction

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

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

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

9.2 Overtopping of Dam

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

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

9.3 Communications Failure

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

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

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

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

TARGET MINIMUM INTERVALS FOR RADIAL GATE OPENING UNDER LOSS OF COMMUNICATIONS

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

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

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

APPENDIX A
AGENCIES HOLDING CONTROLLED COPIES OF THIS MANUAL

Copy No	Agency	Responsible Person	Location
1	Seqwater	Dam Safety and Source Operations Manager	Brisbane
2	Seqwater	Principal Engineer Dam Safety	Ipswich
3	Seqwater	Storage Supervisor	North Pine Dam
4	Seqwater	Operations Coordinator	North Coast
5	Seqwater	Senior Flood Operations Engineer	Flood Operations Centre, Brisbane
6	Department of Environment and Resource Management	Director Dam Safety	Brisbane
7	Moreton Bay Regional Council	Local Disaster Response Coordinator	Strathpine
8-11	Brisbane City Council	Local Disaster Response Coordinator	Brisbane

APPENDIX B KEY REFERENCE GAUGES

Moreton Bay Regional Council

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

Note: Heights are in metres AHD

APPENDIX C

GATE & VALVE SETTINGS

Discharge from North Pine Dam may be controlled by:

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

RADIAL GATE SETTINGS

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

* Gate should be fully open

RADIAL GATE SETTINGS**All Gates Operational**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

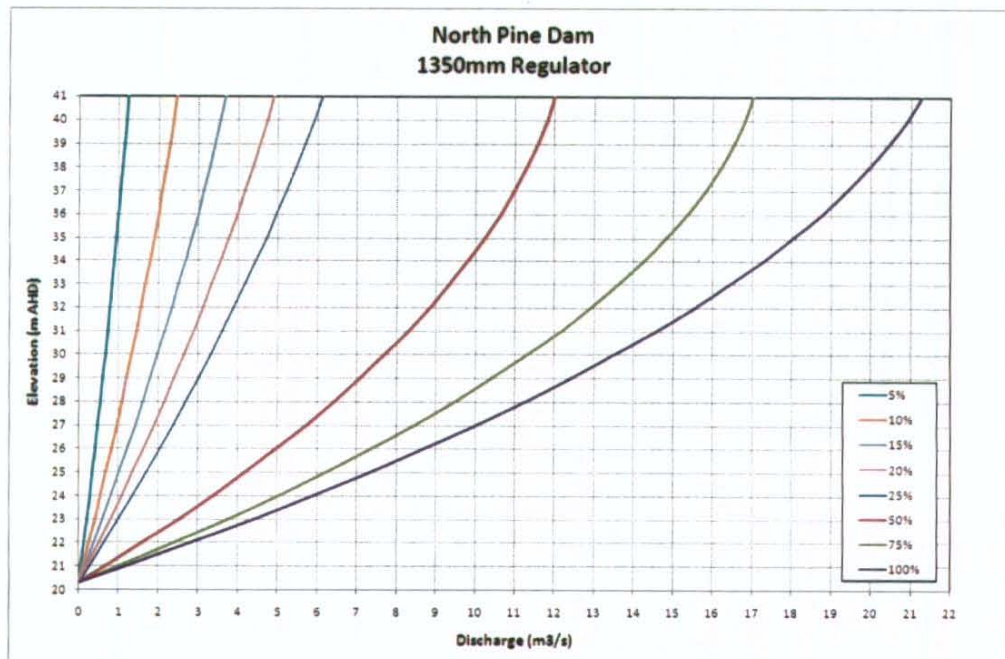
Gate E Stuck or Inoperable								
Level (m AHD)	Gate A	Gate B	Gate C	Gate D	Gate E	Total Opening	Discharge (m ³ /sec)	Gate Operated
40.360	12	11	12	11	closed	46	1183	A
40.375	12	11	12	12	closed	47	1210	D
40.390	12	12	12	12	closed	48	1237	B
40.405	12	12	13	12	closed	49	1264	C
40.420	13	12	13	12	closed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

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

1350mm Regulator

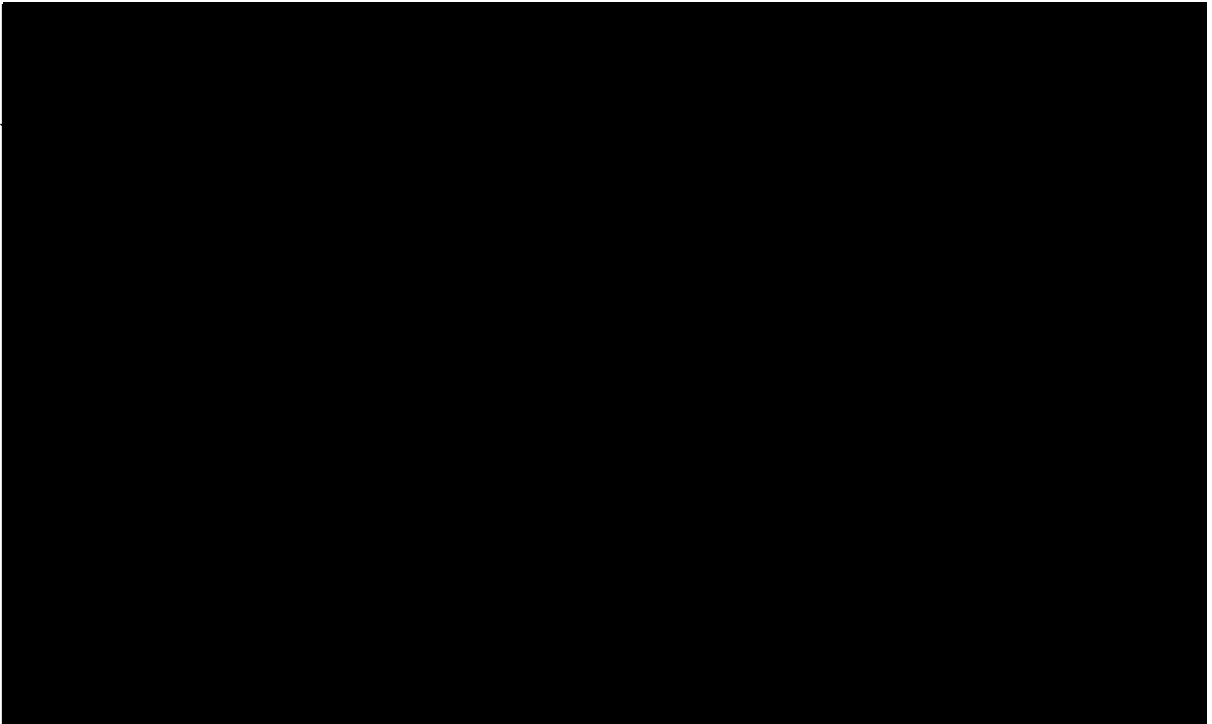
EL	Opening (%)							
	5	10	15	20	25	50	75	100
m AHD	m3/s							
20.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.0	0.1	0.1	0.2	0.2	0.3	0.7	1.0	1.2
22.0	0.1	0.3	0.4	0.5	0.6	1.6	2.4	2.8
23.0	0.2	0.4	0.6	0.8	1.0	2.5	3.7	4.4
24.0	0.3	0.5	0.8	1.1	1.3	3.4	5.0	5.9
25.0	0.3	0.7	1.0	1.4	1.7	4.2	6.2	7.3
26.0	0.4	0.8	1.2	1.6	2.0	5.0	7.4	8.7
27.0	0.5	0.9	1.4	1.9	2.4	5.7	8.4	10.0
28.0	0.5	1.1	1.6	2.1	2.7	6.4	9.5	11.2
29.0	0.6	1.2	1.8	2.4	3.0	7.1	10.4	12.4
30.0	0.7	1.3	2.0	2.6	3.3	7.7	11.3	13.5
31.0	0.7	1.4	2.2	2.9	3.6	8.3	12.1	14.5
32.0	0.8	1.6	2.3	3.1	3.9	8.8	12.9	15.5
33.0	0.8	1.7	2.5	3.3	4.2	9.3	13.6	16.4
34.0	0.9	1.8	2.7	3.6	4.4	9.8	14.2	17.3
35.0	0.9	1.9	2.8	3.8	4.7	10.2	14.8	18.0
36.0	1.0	2.0	3.0	4.0	5.0	10.6	15.3	18.7
37.0	1.0	2.1	3.1	4.2	5.2	11.0	15.8	19.4
38.0	1.1	2.2	3.3	4.4	5.4	11.3	16.2	19.9
39.0	1.1	2.3	3.4	4.5	5.7	11.6	16.5	20.5
40.0	1.2	2.4	3.5	4.7	5.9	11.8	16.8	20.9
41.0	1.2	2.4	3.7	4.9	6.1	12.0	17.0	21.3

5	10	15	20	25	50	75	100
ML/d							
0	0	0	0	0	0	0	0
5	9	14	18	23	59	87	102
11	22	33	44	55	139	208	243
17	34	52	69	86	217	323	379
23	47	70	93	117	291	432	508
29	59	88	117	146	362	536	632
35	70	105	140	176	429	635	751
41	82	122	163	204	493	729	863
46	93	139	185	232	554	817	970
52	104	155	207	259	611	899	1071
57	114	171	228	285	665	976	1166
62	124	186	249	311	716	1048	1256
67	134	201	269	336	763	1115	1340
72	144	216	288	360	807	1176	1418
77	153	230	307	383	847	1231	1491
81	162	244	325	406	884	1281	1558
86	171	257	343	428	918	1326	1619
90	180	270	360	450	949	1366	1674
94	188	282	376	470	976	1400	1724
98	196	294	392	490	999	1428	1768
102	204	306	408	510	1020	1452	1806
106	211	317	423	528	1036	1469	1838



APPENDIX D

NORTH PINE DAM AUXILIARY EQUIPMENT



APPENDIX E

HYDROLOGIC INVESTIGATIONS

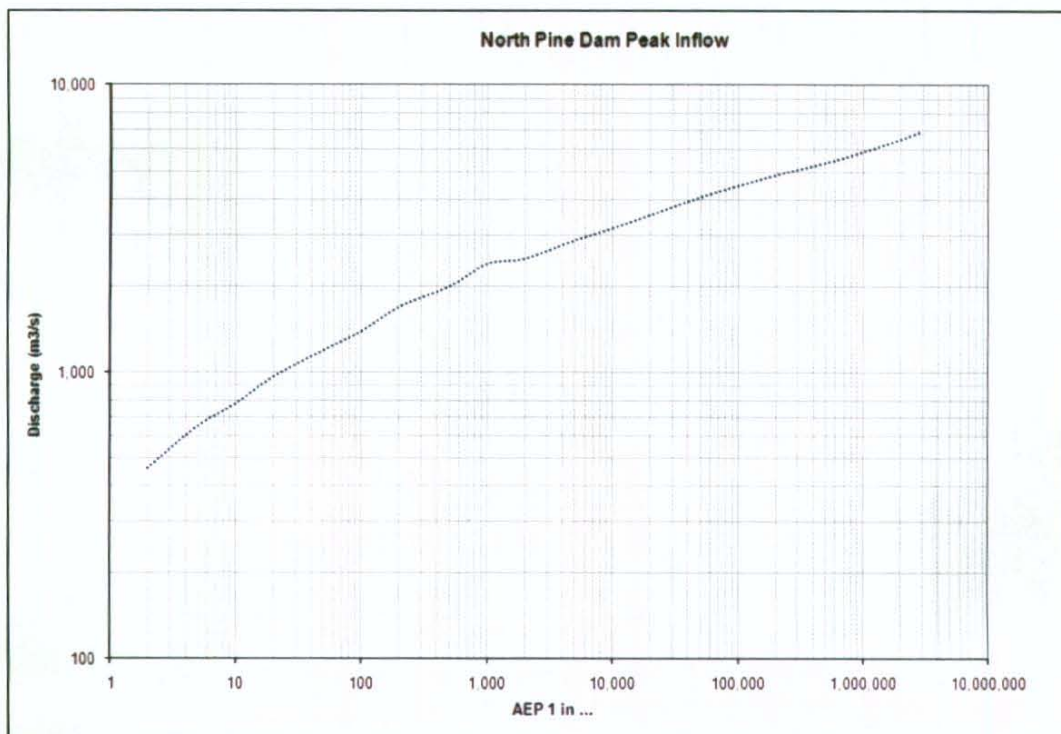
The design flood hydrology for North Pine Dam was updated by SunWater in October 2007 (North Pine Dam Design Flood Hydrology, Oct 2007).

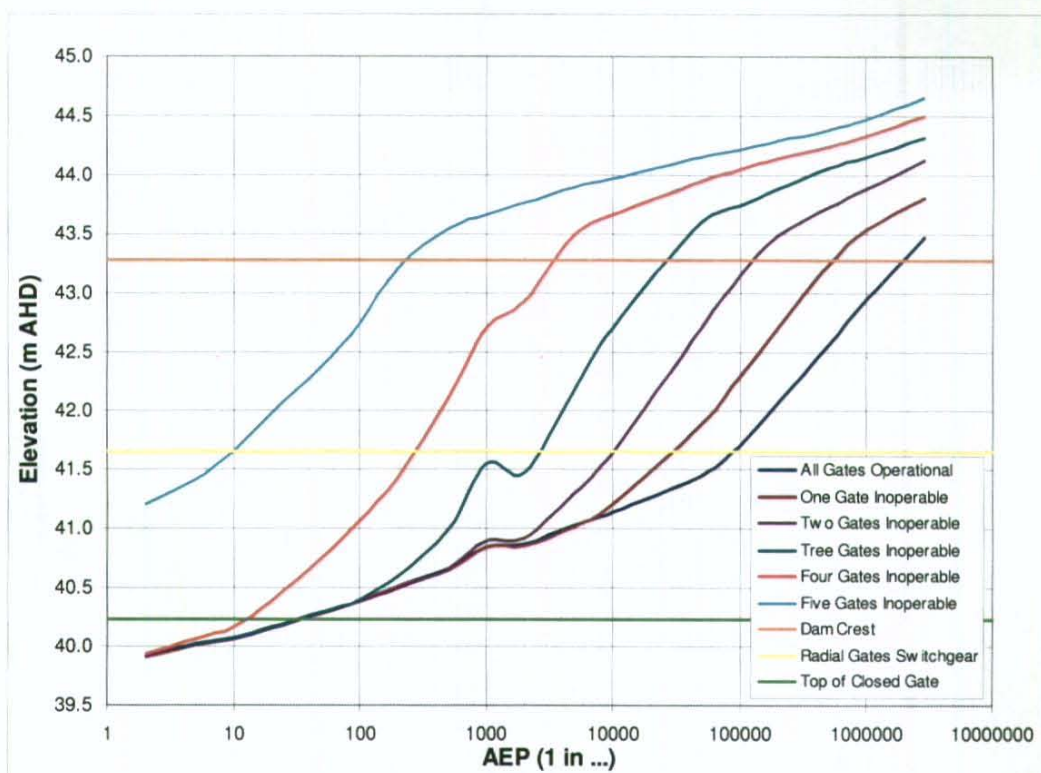
Flood frequency analysis of the flood records at GS120101a Youngs Crossing (pre dam) suggested that the 1974 flood was about a 1 in 100 AEP event.

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

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

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





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

- The notional AEP of the PMP for North Pine Dam is 1 in 2,900,000.
- The critical storm duration for the inflow is generally the 12 hour storm except for the very frequent and very rare events which tend to be longer.
- The 24 hour PMPDF produces the highest peak inflow of 6,900 m³/s.
- Under normal conditions with all gates operating, the critical duration of the outflow remains generally as 12 hours for events between 1 in 20 and 1 in 200 AEP and for the 1 in 2000 AEP event. For other AEPs, the critical duration increases up to 36 hours.
- The Acceptable Flood Capacity with one gate inoperable is approximately 3,960 m³/s or 61% of the PMPDF for the 24 hour critical duration storm.
- With all gates operating normally,
 - The 36 hour PMPDF produces the highest peak outflow of 5,400 m³/s.
 - The AEP of the DCF is about 1 in 2,000,000.
 - In the PMPDF, the dam crest is overtopped for a period of about 12 hours, reached a maximum height of 0.19 metres above the crest.
 - The PMF outflow may be as high as 6,500 m³/s for a critical duration storm of 36 hours.
- With one gate inoperable,
 - The 36 hour PMPDF produces the highest peak outflow of 5,800 m³/s.
 - The AEP of the DCF is about 1 in 550,000.

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

▪ **APPENDIX F**

**NORTH PINE DAM
PLANS, MAPS AND PHOTOGRAPHS**

