



# North Pine Dam Optimisation Study

## Report



March 2014



1. Aerial view of Lake Samsonvale, 2001 (North Pine Dam on the right, middle). Source: Queensland Government
2. North Pine Dam spilling, May 2009. Source: Seqwater

This publication has been compiled by the Department of Energy and Water Supply

© State of Queensland, 2014.

The Queensland Government supports and encourages the dissemination and exchange of its information. The copyright in this publication is licensed under a Creative Commons Attribution 3.0 Australia (CC BY) licence.



Under this licence you are free, without having to seek our permission, to use this publication in accordance with the licence terms.

You must keep intact the copyright notice and attribute the State of Queensland as the source of the publication.

For more information on this licence, visit  
<http://creativecommons.org/licenses/by/3.0/au/deed.en>

The information contained herein is subject to change without notice. The Queensland Government shall not be liable for technical or other errors or omissions contained herein. The reader/user accepts all risks and responsibility for losses, damages, costs and other consequences resulting directly or indirectly from using this information

# Contents

List of tables	i
List of figures	iii
Preface	vi
Acknowledgments	vii
Glossary	viii
Executive summary	xii
S1 Purpose	xii
S2 Project management	xii
S3 Operational options	xiii
S4 Conclusions	xiv
Summary of studies undertaken	xvii
S5 Key findings	xviii
S6 Integrated assessment of operational options (Chapter 15)	xxiii
S7 Potential to operate as a flood mitigation dam	xxvii
Chapter 1 – Background	1
Chapter 2 – Purpose and scope	6
Chapter 3 – North Pine Dam overview	7
3.1 History	7
3.2 Catchment description	7
3.3 Development	8
3.4 North Pine Dam	8
3.5 Water supply	11
3.6 Historical flood events	12
3.7 Flood Manual	13
3.8 Flood mitigation objectives	13
3.9 Flood event management	15
3.10 Recent revisions of the Flood Manual	18
3.11 Flood warnings	20
Chapter 4 – Understanding the issues and challenges	21
4.1 Scoping the QFCoI Final Report recommendations	21
4.2 Dam operations	24
Chapter 5 – Project management	31

Chapter 6 – Operational strategy options	33
6.1 Options considered	33
6.2 Operational options assessment	35
Chapter 7 – Dam operations assessment	38
7.1 Flood Manual operational strategy	38
7.2 Dam operations simulation model	39
7.3 Dam operations modelling assessments	39
7.4 Flood events modelled	41
7.5 Dam operations modelling results	42
7.6 Conclusions	52
Chapter 8 – Dam safety	53
8.1 Legislation	53
8.2 Dam failure and acceptable flood capacity	54
8.4 2011 Flood	55
8.5 Dam safety assessment	56
8.6 Upgrade options	58
8.7 Conclusions	59
Chapter 9 – Notifications and warning of flood releases	60
9.1 Queensland’s disaster management arrangements	60
9.2 Regulatory standards for notifications and warnings	62
9.3 Roles of responsible organisations in flood warning	63
9.4 Warning time for downstream residents	67
9.5 Conclusions	69
Chapter 10 – Floodplain risk assessment	70
10.1 Scope of the assessment	70
10.2 Hydrology	73
10.3 Hydraulic modelling	74
10.4 Flood impact assessment of options	75
10.5 Conclusions	80
Chapter 11 – Water Supply Security	81
11.1 SEQ water supply system	82
11.2 Modelling	83
11.3 Water quality	88
11.4 Conclusions	88

Chapter 12 – Bridge and Crossing Submergence	90
12.1    January 2011 Flood	90
12.2    Infrastructure	90
12.3    Dam operations	91
12.4    Traffic modelling	93
12.5    Conclusions	96
Chapter 13 – Downstream bank slumping and erosion	97
13.1    Desktop study	97
13.2    Bank erosion	98
13.3    Bank slumping and erosion assessment	101
13.4    Key Findings	101
13.5    Future work	102
Chapter 14 – Downstream flora and fauna	103
14.1    Desktop study	103
14.2    Ecological consequences	104
14.3    Flora and fauna assessment	104
14.4    Key findings	106
14.5    Future work	106
Chapter 15 – Integrated assessment of options	107
15.1    Integrated assessment	107
15.2    Phase 1 - Flood damages	113
15.3    Phase 2 - Flood impacts (bridges and crossings)	118
15.4    Phase 3 - Bulk water supply infrastructure	123
15.5    Phase 4 Operational costs	125
15.6    Phase 5 - Net Present Costs	127
15.7    Integrated Assessment	132
Chapter 16 – Future Flood Risk Management	135
16.1    Potential to Operate as a Flood Mitigation Dam	135
16.2    Future Investigations	137
16.3    Flood information and awareness	140
16.4    Land use planning and development controls	140
16.5    Structural flood mitigation improvements	141
References	142
Legislation	144

## List of tables

Table S1	Options modelled	xiii
Table S2	Implications of the operational options (Wivenhoe Dam at 100% FSV)	xxv
Table S3	Estimated net present costs of operational options – 40 year (medium term) analysis horizon	xxvii
Table 1.1	QFCoI – Interim report recommendations relevant to North Pine Dam Optimisation Study	4
Table 1.2	QFCoI – Final report recommendations relevant to North Pine Dam Optimisation Study	5
Table 3.1	Characteristics of North Pine Dam	9
Table 3.2	SEQ water storages	12
Table 3.3	Historical floods	13
Table 6.1	Operational options	33
Table 6.2	FSVs assessed	34
Table 7.1	Operational options and gate operations sensitivity assessments	40
Table 7.2	Flood events modelled	41
Table 7.3	Peak outflows from North Pine Dam – historical flood events	49
Table 8.1	Schedule for dam safety upgrades based on AFC guidelines	54
Table 8.2	2011 flood event statistics	55
Table 8.3	North Pine Dam – dam crest flood capacity versus FSV	57
Table 10.1	Design flood events utilised in floodplain risk assessment	73
Table 10.2	Properties and buildings impacted and populations at risk	76
Table 10.3	Major and minor crossings flooded and population isolated	79
Table 11.1	Water security assessment modelling cases	84
Table 11.2	Cumulative probability of SEQ water storages reaching trigger levels – various North Pine and Wivenhoe dams FSVs (with manufactured water available)	87
Table 11.3	Cumulative probability of SEQ water storages reaching trigger levels – various North Pine and Wivenhoe dams FSVs and manufactured water availability	87
Table 12.1	Principal transport bridges and crossings downstream of North Pine Dam	91
Table 12.2	Number and duration of flood events at Youngs Crossing from IQQM flow examination of the historical record from January 1889 – June 2011	93

Table 12.3	Traffic modelling scenarios for NPDOS	94
Table 13.1	Observed riverbank erosion – North Pine River 2013	99
Table 15.1	Operational options subject to net present cost assessment	108
Table 15.2	Operational options not subject to net present cost assessment	108
Table 15.3	Average annual flood damage costs for downstream areas	117
Table 15.4	Average annual flood impact costs for downstream areas	122
Table 15.5	Current bulk water supply augmentation timing and costs	123
Table 15.6	Timing of bulk supply augmentation	124
Table 15.7	Likely timing of water supply augmentation with alteration to manufactured water	124
Table 15.8	Water restrictions cost estimates	126
Table 15.9	Manufactured water operating costs	127
Table 15.10	Net present cost conditions	128
Table 15.11	Influence of dam supply volumes on net present costs for the medium term conditions (\$M)	129
Table 15.12	Influence of dam supply volumes on net present costs for the short term conditions (\$M)	131
Table 15.13	Implications of the operational options (Wivenhoe Dam at 100% FSL)	134

## List of figures

Figure S1	Relationship of specialist studies to main report	xvii
Figure S2	Option 3 – Impact of lowered dam levels on outflows for January 2011 Flood Event	xix
Figure S3	North Pine net present costs (Wivenhoe Dam at 100% FSV) – 20 year (short term) analysis horizon	xxvi
Figure S4	North Pine net present costs (Wivenhoe Dam at 100% FSV) – 40 year (medium term) analysis horizon	xxvi
Figure 1.1	North Pine Dam – January 2011 flood event – dam inflow and outflow	2
Figure 1.2	Pine River catchment	3
Figure 3.1	North Pine Dam – general view	8
Figure 3.2	North Pine Dam spillway and outlet works	9
Figure 3.3	North Pine Dam – saddle dam locations	11
Figure 3.4	Developing a flood release plan	16
Figure 3.5	Rainfall and stream height gauges	17
Figure 3.6	North Pine Dam spillway outflow (total discharge from all five radial gates)	19
Figure 4.1	Flood extents under current conditions	27
Figure 4.2	Potential areas of isolation under current conditions (PMF Event)	28
Figure 5.1	Project management arrangements	31
Figure 5.2	Study components	32
Figure 6.1	North Pine Dam Optimisation Study – key reports	36
Figure 7.1	Results of gate operations sensitivity analyses (some events omitted for plotting clarity)	43
Figure 7.2	5% (1 in 20) AEP 12 hour design flood routing – 75% FSV	44
Figure 7.3	Predicted peak outflows (m <sup>3</sup> /s) for lowered FSV options with initial detention (operational alternative 2)	45
Figure 7.4	Predicted peak lake water levels for lowered FSV options with initial detention (operational alternative 2)	46
Figure 7.5	Predicted average peak flows for lowered FSV options with lowered flood release level (operational alternative 3)	47
Figure 7.6	Peak lake water levels for lowered FSV options with lowered flood release level (operational alternative 3)	47

Figure 7.7	Duration of dam releases (operational alternative 3)	48
Figure 7.8	Impact of lower dam levels on 1 in 100 AEP flood event outflows (operational alternative 3)	48
Figure 7.9	Impact of lower dam levels on 2011 flood event outflows (operational alternative 3)	50
Figure 7.10	Impact of lower dam levels on 1974 flood event outflows (operational alternative 3)	50
Figure 7.11	Peak North Pine Dam water levels for dam overtopping assessment	51
Figure 8.1	Maximum recorded flows for Australian and international catchments	56
Figure 8.2	North Pine Dam – dam crest flood capacity versus FSV from Table 8.3	58
Figure 9.1	Queensland disaster management structure	61
Figure 9.2	Flood releases warning time for downstream residents	68
Figure 10.1	Floodplain risk assessment area	71
Figure 10.2	January 2011 flood extent as mapped by local residents	72
Figure 10.3	Properties impacted by external flooding	77
Figure 10.4	Buildings impacted by above habitable floor flooding	77
Figure 10.5	Population at risk from above habitable floor level flooding	78
Figure 11.1	SEQ water supply system	81
Figure 11.2	Current triggers for changes to operations	83
Figure 11.3	Modelled water security scenarios	85
Figure 11.4	Supply demand balance - effect of manufactured water	85
Figure 12.1	Map showing diverted traffic routes considered in assessment of traffic delays	94
Figure 13.1	A framework for investigating the effects of reservoirs on downstream riverbank erosion	98
Figure 13.2	Aerial photograph - Seqwater assessment sections	99
Figure 13.3	Site 01 - planar erosion	100
Figure 13.4	Site 04 - wet flow erosion	100
Figure 13.5	Site 05 - cantilever matt grass caused by fluvial entrainment undercutting the base of the bank	100
Figure 14.1	Flood frequency at North Pine Dam (no dam analysis case)	105

Figure 15.1	Methodology for assessing the net present costs of options	110
Figure 15.2	Flood damage and impact costs	111
Figure 15.3	Residential stage damage curves for structural damage – adopted curve for study (refer Aurecon 2013, Section 5.2)	114
Figure 15.4	Flood damage rating curves for downstream areas (Option 1)	116
Figure 15.5	Flood damage costs for downstream areas (Option 1)	117
Figure 15.6	Average annual flood damage costs for downstream areas	118
Figure 15.7	Flood impact rating curves for downstream areas ( Option 1 - traffic diversion and delay and bridge repair / reconstruction)	119
Figure 15.8	Flood impact probability curve for downstream areas (Option 1 - traffic diversion and delay and bridge repair/reconstruction)	120
Figure 15.9	Youngs Crossing inundation durations	121
Figure 15.10	Durations and frequencies of Youngs Crossing closures	121
Figure 15.11	Average annual flood impact costs for downstream areas	122
Figure 15.12	Projected augmentation costs for current conditions ('average' discount rate = 7%)	125
Figure 15.13	Influence of dam supply volumes on net present costs for medium term conditions	130
Figure 15.14	Influence of dam supply volumes on net present costs for short-term conditions	130

## Preface

The North Pine Dam Optimisation Study (NPDOS) delivers a Queensland Government commitment to implement the recommendations of the Queensland Floods Commission of Inquiry.

The January 2011 inflows into North Pine Dam were the largest on record and necessitated the highest ever outflows since the dam was completed in 1976. The January 2011 flood in the North Pine River was the largest since records commenced in 1916. The big wet of October 2010 to January 2011 was preceded by the Millennium Drought resulting in the water supply compartment of the dam dropping to as low as 13% in 2007. No significant flood releases were made from North Pine Dam in a 20 year period from 1989 to 2009.

NPDOS is the product of two years of cooperation and knowledge sharing between Queensland Government entities and the Moreton Bay Regional Council. The cooperation and knowledge sharing between state and local government has ensured the assessments and findings of NPDOS are evidence based and informed by specialist studies. Much of the work done builds on information that became available during and after the 2010–2011 wet season.

The purpose of NPDOS is to assess and present various operational options to enable the government to make informed decisions on the future operation of North Pine Dam.

The options have been assessed against competing objectives for dam operations, in particular balancing water supply security, dam safety, impacts downstream of the dam and economic benefits. The optimisation of North Pine Dam is particularly challenging in that it is a gated dam located a short distance upstream of urban areas and was designed for water supply purposes not flood mitigation.

In 2014 the Queensland Government will make informed decisions on the future operation of both North Pine Dam and Wivenhoe and Somerset Dams following completion of both Optimisation Studies and consideration of the results of community consultation.

## Acknowledgments

The Department of Energy and Water Supply (DEWS) would like to thank officers from the following organisations who undertook significant assessments as part of the study:

- Moreton Bay Regional Council
- Seqwater
- Department of Science, Information Technology, Innovation and the Arts
- Department of Transport and Main Roads

# Glossary

## Terms

<b>AAD</b>	Average Annual Damage – the total damage caused by all floods over a long period of time divided by the number of years in that period (CSIRO 2000).
<b>AAI</b>	Average Annual Impact – the total impact caused by all floods over a long period of time divided by the number of years in that period.
<b>Act</b>	<i>Water Supply (Safety and Reliability) Act 2008</i> (QLD).
<b>AFC</b>	Acceptable Flood Capacity for a referable dam – varies dependent on the hazard category (DEWS 2013b).
<b>AFC Guidelines</b>	<i>Guidelines on Acceptable Flood Capacity for Water Dams</i> (DEWS 2013b).
<b>AEP</b>	Annual Exceedance Probability – is a measure of the likelihood (expressed as a probability) of a flood event reaching or exceeding a particular magnitude in any one year. A 1% (AEP) flood has a 1% (or 1 in 100) chance of occurring or being exceeded at a location in any year.
<b>AHD</b>	Australian Height Datum.
<b>ANUFLOOD</b>	A software package for estimating flood loss adjustment and abatement.
<b>Cumulative probability</b>	The probability of an event occurring over a period of time, any time in that period. This probability increases over time.
<b>DCF</b>	Dam Crest Flood – the flood which just overtops the crest of the dam wall.
<b>Design flood event</b>	Hypothetical flood events based on a design rainfall event of a given probability of occurrence (i.e. AEP). The probability of occurrence for a design flood event is assumed to be the same as the probability of rainfall event upon which it is based (IEAust 2003).
<b>EAP</b>	Emergency Action Plan that is approved under section 352I(1)(a) or taken to be an approved emergency action plan under section 352Q(2) of the <i>Water Supply (Safety and Reliability) Act 2008</i> (QLD).
<b>EL (mAHD)</b>	Elevation (in metres) above the Australian Height Datum.
<b>EY</b>	Exceedances per year – the likelihood of very frequent (or small) floods expressed as the number of times or exceedances per year that a flood of a given size occurs.
<b>FFS</b>	Flood Forecasting System – suite of computer programs that Seqwater use to forecast flood flows and assist decision making during flood events using real-time data.
<b>Flood mitigation manual ('the Flood Manual')</b>	A flood mitigation manual approved under section 371E(1)(a) or 372(3) of the <i>Water Supply (Safety and Reliability) Act 2008</i> (QLD).

<b>Floodplain</b>	Area of land adjacent to a creek, river, estuary, lake, dam or artificial channel, which is subject to inundation by the PMF (CSIRO 2000).
<b>FRA</b>	Floodplain Risk Assessment – assessment of premises, populations and transport infrastructure affected by flooding, undertaken by MBRC to support NPDOS.
<b>FSL</b>	Full Supply Level - maximum normal water supply storage level of a reservoir behind a dam.
<b>FSV</b>	Full Supply Volume – volume of the reservoir at FSL.
<b>Flood immunity level</b>	The probability when an asset being assessed is initially affected by flooding and is therefore no longer immune to flooding.
<b>Gate operating table</b>	A table provided in the Flood Manual which establishes the target minimum spillway outflow rate during flood operations for a given uniform lake level. The table provides a guide for a given uniform lake level on the number of spillway gates to be opened and the amount of opening for these gates (referred as the number of gate increments) to achieve a given outflow rate.
<b>GIS</b>	Geographic Information System.
<b>GCDP</b>	Gold Coast Desalination Plant. Located at Tugun on the Gold Coast.
<b>GoldSim</b>	A multi-purpose simulation software package that can be used for dynamic modelling of complex systems in business, engineering and science applications.
<b>Hydrologic / Hydrology</b>	Relating to rainfall and runoff.
<b>Hydraulic</b>	Relating to flow characteristics – level, depth, velocity and extent and combinations thereof.
<b>Hydrodynamic</b>	Relating to time-variant hydraulic characteristics.
<b>IAM</b>	Integrated Assessment Methodology used for determining the overall costs and benefits of flood mitigation options.
<b>IQQM</b>	Integrated Quantity and Quality Model for water resources planning.
<b>LiDAR</b>	LiDAR (combination of the words light and radar) is a remote sensing technology that measures distance by illuminating a target with a laser and analysing the reflected light.
<b>LOS</b>	Level of service refers to objectives specifying the level of performance that South East Queensland residents can expect from their bulk water supply system.
<b>LPR</b>	Lower Pine River.
<b>MHWS</b>	Mean High Water Spring.
<b>ML</b>	Megalitres = 1,000,000 litres.

<b>m<sup>3</sup>/s</b>	The units of measurement for flow or discharge expressed in cubic metre per second.
<b>NPC</b>	Net Present Cost.
<b>NPDOS</b>	North Pine Dam Optimisation Study.
<b>PMF</b>	Probable Maximum Flood – the largest flood that could conceivably occur at a particular location, resulting from the PMP (CSIRO 2000) and Australia Rainfall and Runoff, 2003 (IEAust, 2003)
<b>PMP</b>	Probable Maximum Precipitation – the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of year, with no allowance made for long-term climatic trends (CSIRO 2000) and Australian Rainfall and Runoff (IEAust 2003).
<b>PMPDF</b>	Probable Maximum Precipitation Design Flood (refer to Australian Rainfall and Runoff (IEAust 2003)).
<b>Population at risk</b>	Depending on the context, population at risk refers to the population affected by: <ul style="list-style-type: none"> <li>• Dam Safety – the population living within a failure impact zone (DEWS 2013b)</li> <li>• Flooding – the population affected by flooding above habitable floor level flooding</li> <li>• Isolation – the population isolated due to road access being cut off by floodwaters.</li> </ul>
<b>Purified recycled water (PRW)</b>	Purified recycled water is wastewater that has been treated to a very high standard using an advanced water treatment process (including microfiltration, reverse osmosis and ultraviolet light).
<b>QFCoI</b>	Queensland Floods Commission of Inquiry.
<b>RFD</b>	Regional Floodplain Database – Moreton Bay Regional Council’s flood information database prepared to support the delivery of flood information for emergency management, flood awareness and strategic planning.
<b>ROP</b>	Resource Operation Plan under the <i>Water Act 2000</i> (QLD).
<b>TUFLOW</b>	A proprietary two-dimensional flood and coastal hydraulic simulation software package.
<b>SEQ</b>	South east Queensland.
<b>SEQ water storages</b>	Key water supply system storages: <ul style="list-style-type: none"> <li>• Wivenhoe Dam</li> <li>• Somerset Dam</li> <li>• North Pine Dam</li> <li>• Leslie Harrison Dam</li> <li>• Lake Kurwongbah</li> <li>• Baroon Pocket Dam</li> <li>• Ewen Maddock Dam</li> <li>• Cooloolabin Dam</li> <li>• Wappa Dam</li> <li>• Lake Macdonald</li> <li>• Hinze Dam</li> <li>• Little Nerang Dam.</li> </ul>

<b>SEQ water supply system</b>	The system supplying water to water service providers in SEQ. Currently made up of 12 SEQ water storages, raw water treatment plants and associated bulk water distribution mains (including the Northern Pipeline, Southern Regional Pipeline, Eastern Pipeline Inter-connectors), the Western Corridor Recycled Water Scheme, and the Gold Coast Desalination Plant.
<b>WATHNET</b>	A suite of programs capable of simulating the operation of a wide range of water supply headworks and transfer systems serving urban, industrial, irrigation and in-stream demands.
<b>WBNM</b>	Watershed Bounded Network Model – event based catchment hydrologic model
<b>WCRWS</b>	Western Corridor Recycled Water Scheme.
<b>WSDOS</b>	Wivenhoe and Somerset Dams Optimisation Study.
<b>WSS</b>	Water supply security.

## Abbreviations of organisations and agencies

<b>BCC</b>	Brisbane City Council.
<b>BoM</b>	Bureau of Meteorology.
<b>DEWS</b>	Queensland Department of Energy and Water Supply.
<b>DNRM</b>	Queensland Department of Natural Resources and Mines.
<b>DSDIP</b>	Queensland Department of State Development and Infrastructure Planning.
<b>DSITIA</b>	Queensland Department of Science, Information Technology, Innovation and the Arts.
<b>DTMR</b>	Queensland Department of Transport and Main Roads.
<b>IEAust</b>	Engineers Australia (formerly known as the Institution of Engineers Australia).
<b>MBRC</b>	Moreton Bay Regional Council.
<b>Seqwater</b>	South east Queensland bulk water authority trading as Seqwater.

# Executive summary

## S1 Purpose

North Pine Dam, located on the North Pine River, is a water supply dam which was not designed to provide downstream flood mitigation.

The North Pine Dam Optimisation Study (NPDOS) was initiated in response to the recommendations of the Queensland Floods Commission of Inquiry (QFCoI) to investigate potential alternative operations of North Pine Dam during floods.

Consideration was given to relevant sections/recommendations of the QFCoI March 2012 Final Report and the August 2011 Interim Report. The key QFCoI recommendations influencing this study were the Final Report Recommendations 17.3 and 17.9. Other QFCoI recommendations relevant to the operations of North Pine Dam are outlined in Tables 1.1 and 1.2 of Chapter 1.

QFCoI recommendation 17.3 states that the Queensland Government should consider a wide range of options, prioritise differing objectives for the operation of the dam and consider implications over a wide range of flood events for inundation of urban and rural areas; water supply security; dam safety; submergence of bridges; bank slumping and erosion; and riparian fauna and flora.

QFCoI recommendation 17.9 states that the Queensland Government should consider whether North Pine Dam should be operated as a flood mitigation dam when it considers possible operating strategies and full supply levels as part of the longer term review of the Manual of Operational Procedures for Flood Mitigation at North Pine Dam.

NPDOS addresses only operational options with a view to making better use of existing infrastructure. New or augmented infrastructure (such as the raising of Youngs Crossing, provision of an alternative transport route or augmentation of North Pine Dam) and planning and development controls and other local initiatives (such as property buy back, river bank stabilisation and backflow prevention) were not within the scope of this study.

## S2 Project management

The Department of Energy and Water Supply (DEWS) managed the optimisation study with substantial input from Seqwater on water supply security investigations and flood management and dam operations investigations including dam safety and Moreton Bay Regional Council (MBRC) on flood inundation assessments. The Department of Transport and Main Roads (DTMR) provided advice on the transport implications of submerging Youngs Crossing, while the Department of Science, Information Technology, Innovation and the Arts (DSITIA) provided advice on bank slumping and erosion and riparian flora and fauna.

## S3 Operational options

Implementing QFCoI Final Report recommendations 17.3 and 17.9 requires consideration of a range of operational options which include possible alternative operating strategies and full supply volumes (FSVs). Assessment of these options requires consideration of the necessary trade-offs, in particular between flood inundation of urban areas and water supply security, and also having regard for dam safety, submergence of bridges and crossings, bank slumping and erosion, and riparian fauna and flora.

Basically, there are only three factors that can be varied to create operational options for North Pine Dam – the full supply level (FSL), the trigger level for commencement of flood releases and the rate at which the gates are opened. The only other consideration is whether the adjustments are made temporarily, semi-permanently or permanently, but these temporal choices have little impact on the analysis of flood impacts.

Four operational alternatives for operating North Pine Dam were assessed:

- 1 – Existing situation with the dam at FSL
- 2 – Lowered dam levels with flood release trigger at the current FSL
- 3 – Lowered dam levels and flood release trigger levels, and
- 4 – Gates lifted to the fully open position (i.e. no gate control).

The resulting operational options developed to evaluate these alternatives are summarised in Table S1:

**Table S1 Options modelled**

Option	Dam Level		Flood Release Level		Description
	%FSV	mAHD	%FSV	mAHD	
1	100	39.60	100	39.60	Existing situation with the dam at its current full supply volume
2.1	85	38.04	100	39.60	Lower dam level to 85% FSV with the flood release level at 100%FSV
2.2	75	36.88	100	39.60	Lower dam level to 75% FSV with the flood release level at 100%FSV
2.3	42	32.004	100	39.60	Lower dam level to 42% FSV with the flood release level at 100% FSV
3.1	85	38.04	85	38.04	Dam level and flood release level lowered to 85% FSV
3.2	75	36.88	75	36.88	Dam level and flood release level lowered to 75% FSV
3.3	42	32.004	42	32.004	Dam level and flood release level lowered to 42% FSV
4 No Gates	42	32.004	42	32.004	Gates lifted to the fully open position (that is, no gate control)

Option 1 formed the 'base case' against which the outcomes of all other options can be compared over a range of historical and selected design flood events. Operational alternatives 2 and 3 were assessed for dam FSLs at 85%, 75% and 42% of the FSV with the dam gates operational. The 42% level corresponds to the dam spillway fixed crest level. An additional option was assessed for the case where the dam gates are not operational i.e. kept fully open.

Under operational alternatives 2 and 3, the dam can be operated at the lowered dam levels either temporarily, permanently or semi-permanently to effectively create additional operational options.

## **S4 Conclusions**

The QFCol required that the Queensland Government be presented with options, rather than specific policy recommendations governing the operations of North Pine Dam. However, some broad overall findings are becoming increasingly apparent from the body of work completed, which will assist consideration on how to best balance the potentially competing objectives. These are summarised below.

The integrated assessment of options indicates that on balance only a small lowering of North Pine Dam FSV in the shorter term should be contemplated, if at all. However, lowering the dam below 94% FSV to say 90% FSV would provide an interim response to meet Queensland's tranche 2 dam spillway upgrade requirement and improve the dam's ability to pass extreme floods.

### **S4.1 QFCol Final Report recommendation 17.3 – Operational options assessment**

#### **General**

Operational alternative 3 offers improved flood mitigation benefits above alternatives 1 and 2 over the whole range of flood events for all lowered dam levels likely to be adopted. A range of lower FSVs were modelled for operational alternative 3, specifically 85%, 75% and 42% (as compared to existing 100%). These flood mitigation benefits can be achieved without significant impacts on water supply security if the FSV is not dropped below around 80%. The results for lowering North Pine Dam to other FSVs (e.g. 90%) within the range investigated can be estimated using the results from the modelled FSVs.

The integrated assessment indicates that flood mitigation and dam safety outcomes may be improved by a small lowering of the dam until such time as the dam safety upgrade for North Pine Dam is completed. Additionally, there would be some operational benefits with slightly more time to complete flood operations activities.

Chapter 8 indicates that lowering of the dam below 94% FSV to say 90% FSV would provide an interim response to meet Queensland's tranche 2 dam spillway upgrade requirement which has largely arisen out of the Bureau of Meteorology (BoM) 2003 revisions (Walland et al. 2003) of the probable maximum precipitation estimates. (The probable maximum flood estimates are calculated from these precipitation estimates.) The economic assessment indicates that flood mitigation benefits alone do not justify a lowering of the dam levels due to the cost of future water supply upgrades.

The limits of accuracy and uncertainties associated with the estimates and modelling underpinning the analysis presented in this report mean that the flood mitigation benefits of lowering North Pine Dam from 100%FSV to either 85% or 75% FSV are marginal and accrue mainly due to reductions in transport infrastructure damage (local road damage).

However, a semi-permanent lowering of the dam below 94% FSV to say 90% FSV until the dam spillway upgrade has been completed appears justifiable on the basis of improvements to the dam's ability to pass extreme floods (refer Chapter 8), the additional flood mitigation and operational benefits along with reduced downstream community disruption and environmental benefits resulting from not having to declare and implement temporary full supply levels.

### Dam operations

- The modelling indicates that lowering the FSL and the trigger level for commencement of flood releases and increasing the rate at which the gates are opened all improve flood mitigation outcomes, although the flood mitigation benefits tend to decline as the magnitude of the flood event increases.
- The modelling results for operational alternative 3 (lowering both the FSL of the dam and the trigger level for commencement of flood releases) indicate better flood mitigation outcomes to operational alternatives 1 and 2 over the full range of flood events modelled.
- The most significant short term cost implication identified in the integrated assessment is traffic rerouting associated with submergence of Youngs Crossing. MBRC and the DTMR are assessing transport improvement options in the area which would greatly diminish flood impact costs.
- The modelling indicates that the existing flood risk is small with only 6 residential and non-residential buildings being prone to flood inundation in 1% (1 in 100) annual exceedance probability (AEP)<sup>1</sup> and 20 residential and non-residential buildings being prone to flood inundation in 0.2% (1 in 500) AEP flood events respectively.
- The risk of above habitable floor level flooding halves when the dam level is lowered to 85% of the current FSV.
- The integrated assessment of options indicates that on balance only a small lowering of the dam FSV in the shorter term should be contemplated, if at all.

### Dam safety

- The integrated assessment indicates lowering of the dam to around 90% FSV (refer Chapter 8) would improve its ability to pass extreme floods and reduce flooding risks in the shorter term, but ultimately may increase overall costs due to the large cost of medium to long term water supply augmentations.
- Seqwater recently completed a detailed risk assessment for all dams in its portfolio which identifies options for future upgrade of North Pine Dam. Depending on a more detailed assessment, lowering the FSV to 90% would give the dam owner scope in its portfolio dam improvement upgrade schedule to potentially delay mandated upgrades from 2025 to 2035.
- Until dam safety upgrades are completed, lowering of the FSL of North Pine Dam would reduce the magnitude of adverse impacts from large to rare flood events and improve flood mitigation outcomes.

---

<sup>1</sup> AEP is a measure of the likelihood (expressed as a probability) of a flood event reaching or exceeding a particular magnitude in any one year. A 1% (AEP) flood has a 1% (or 1 in 100) chance of occurring or being exceeded at a location in any year.

## Water supply

- There is little shorter term impacts on the system yield of the south east Queensland (SEQ) water supply system caused by making either temporary or permanent lowering of the level in North Pine Dam down to 90%, 85% or even as low as 75% of the FSV.
- Any water security impacts over the shorter term may be addressed by implementing a semi-permanent lowering of the FSL with this position to be reviewed when the dam safety upgrades have been completed.
- DEWS is currently reviewing the desired level of service objectives for SEQ and subsequently it is proposed that Seqwater establish a new SEQ water security program (currently anticipated in late 2015).

## Flood warning

- Appropriate flood warning arrangements should be negotiated between stakeholders and documented in emergency management plans in conformity with recent amendments to the *Water Supply (Safety and Reliability) Act 2008* (QLD) and national guidelines for emergency planning for floods affected by dams.

## Investigation and research

- Potential future investigation and research includes:
  - review of the Manual of Operational Procedures for Flood Mitigation at North Pine Dam (Flood Manual) objective relating to the level in North Pine Dam targeted at the conclusion of a flood event to provide increased latitude for the management of floods, noting regional water supply security is unaffected by a small lowering of the dam. (Such an outcome may require amendment of the *Water Supply (Safety and Reliability) Act 2008* (QLD) in regard to Flood Manual requirements.)
  - the development of objective criteria to take advantage of this increased latitude and enable application of discretion to make advance or increased releases in response to seasonal forecasts and rainfall forecasts by BoM.
  - a strategic survey and monitoring program to document evidence of any change in bank erosion rates and processes over time. (This could support the future inclusion of an objective relating to bank slumping and erosion in the Flood Manual.)
  - partial or stepped ramp-down of dam releases on the falling stage of a flood and to drain the dam down when declarations of temporary FSLs are made as:
    - constant rates of discharge for long durations are likely to have a greater impact on downstream bank erosion than a slightly varied flow level
    - cues are needed to reduce the potential for fish stranding, especially under arrangements where a sequence of night time releases is made.

### S4.2 QFCoI Final Report recommendation 17.9 – Operating as a flood mitigation dam

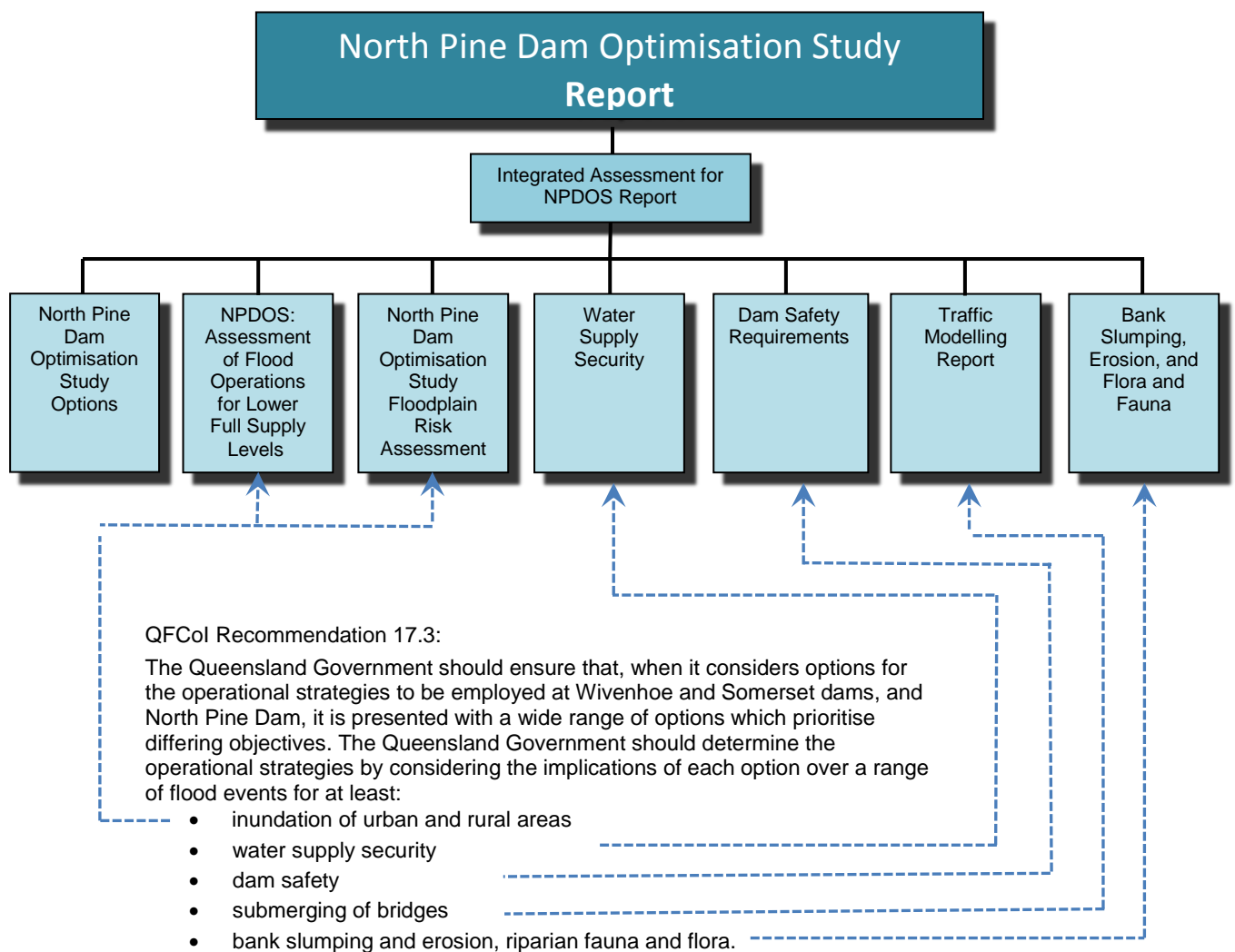
The evidence (considering the dam design characteristics, the rapid flooding experienced in the catchment, the dam operations and floodplain modelling results and the economic assessments) indicates that there is little value in operating North Pine Dam as an actively managed flood mitigation dam. (Note: The dam will still provide flood mitigation benefits by reducing peak outflows relative to inflows through storage routing / attenuating effects.)

## Summary of studies undertaken

Eight main specialist studies (Figure S1) were completed to evaluate the operational options (identified in the North Pine Dam Optimisation Study – Addendum to Options Discussion Paper (DEWS 2013a)) and address the QFCoI Final Report recommendations 17.3 and 17.9 as follows:

1. Dam operations and associated hydrologic assessments by Seqwater
2. Floodplain risk assessments by MBRC
3. Water supply security assessments by DEWS and Seqwater
4. Traffic studies by DTMR
5. Bank slumping, erosion and flora and fauna studies by DSITIA
6. Dam safety requirements by DEWS, and
7. Integrated assessment of the options commissioned by DEWS.

Assessments were undertaken based on Revision 7 of the Manual of Operational Procedures for Flood Mitigation at North Pine Dam (the Flood Manual). The recent Revision 8 of the Flood Manual does not impact the assessments completed.



**Figure S1 Relationship of specialist studies to main report**

A range of design flood events were modelled including:

- 5% (1 in 20) AEP
- 1% (1 in 100) AEP
- 0.2% (1 in 500) AEP
- 0.1% (1 in 1,000) AEP
- 0.05% (1 in 2,000) AEP, and
- Probable Maximum Flood (PMF).

In addition, the five largest historical floods (January 2011, January 2013, January 1974, March 1989 and February 1999) for which suitable data are available were modelled.

## **S5 Key findings**

When determining how best to operate North Pine Dam, it is necessary to consider the trade-offs between each of the key areas of consideration recognising that it is not possible to optimise outcomes in all areas for every flood. A balanced solution is required as there will be different perspectives held by individuals, stakeholders and the community as a whole.

Hence, the investigative approach under NPDOS has been to determine how well each of the operational options (involving consideration of reduced dam levels) satisfies specific objectives relating to:

- minimising urban flood inundation
- minimising impacts on water supply security
- improving dam safety and flood warning
- reducing the impacts of submergence of bridges and crossings, and
- reducing bank slumping and erosion, and riparian fauna and flora impacts.

Overall, options that reduce flooding tend to improve dam safety but reduce water supply security and increase community disruption due to bridge and crossing submergence.

Outcomes can vary from event to event because every flood is different.

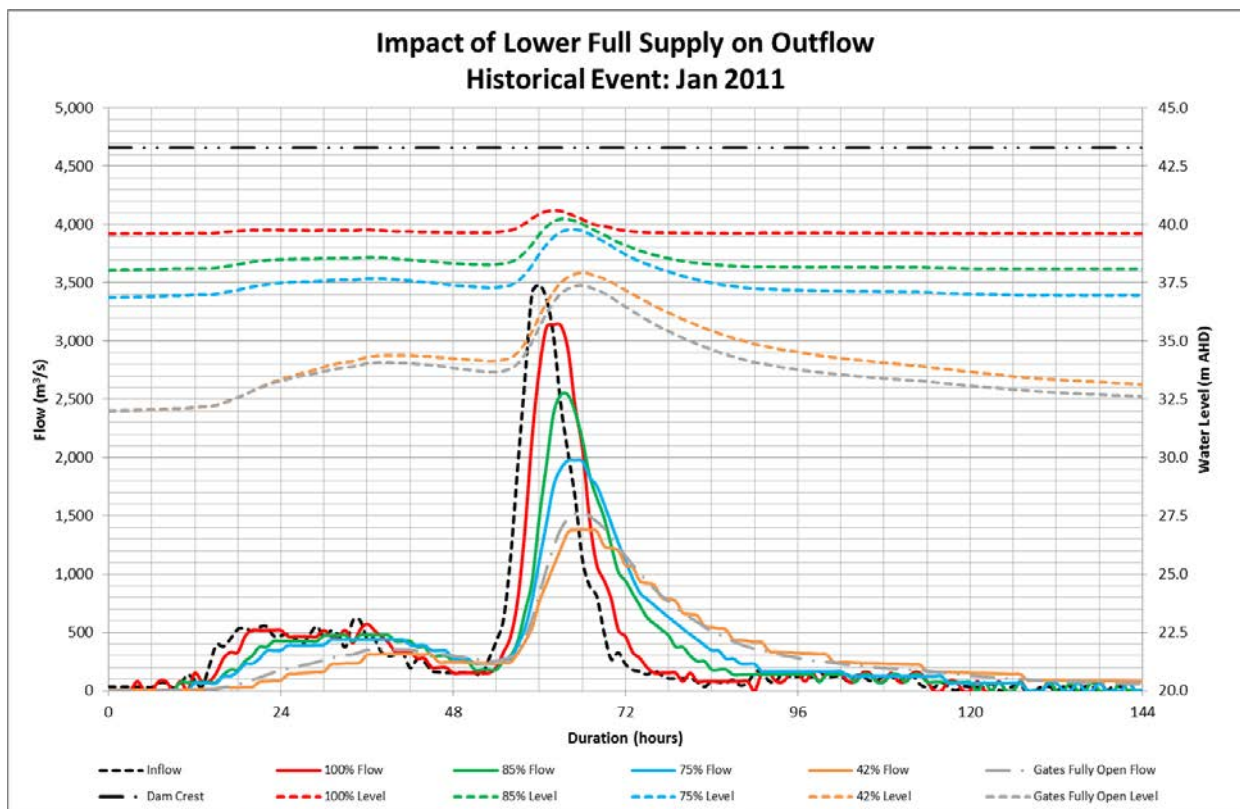
Optimising the outcomes requires balancing the findings (described below under each of the specific objective areas investigated) along with the findings of the integrated assessment of the net present costs of the direct and indirect tangible impacts presented below.

### **S5.1 Dam flood operations (Chapter 7)**

- The Flood Manual has been reviewed several times since the January 2011 Flood Event to improve dam safety and operations.
- Peak outflows for any given flood event reduce as the dam FSV is reduced (as occurs under operational alternative 3). (This benefit occurs due to the increased flood storage available to manage floods.)
- Peak outflows for any given flood event reduce as the threshold for triggering flow releases is also lowered. (This is the result of the earlier commencement of releases and the greater volume released early in the event.)

- A lower dam FSV decreases the probability of overtopping of the dam crest during a flood event. (This benefit occurs due to the increased flood storage available to manage floods.)
- A lower dam FSV tends to reduce the frequency of short duration (less than 6 hours) and increase the frequency of longer duration (greater than 6 hours) closures of Youngs Crossing. (The longer duration closures occur as the reduction in peak outflow from the dam results in longer duration of outflow from the dam.)

Figure S2 illustrates the effects of reducing dam levels on dam outflows for the January 2011 Flood, the largest flood on record in the Pine Rivers catchment. As dam levels are lowered, peak outflows are reduced. However the duration of outflows is increased resulting in a longer submergence of Youngs Crossing downstream.



Note:

1. Revision 7 Manual operating rules with appropriate adjustments
2. The peak discharge is different to that actually achieved in 2011 (Figure 1.1) and is due to more aggressive releases under revised Manual operating rules.

Source: Seqwater 2013a, Figure 11.4

**Figure S2 Option 3 – Impact of lowered dam levels on outflows for January 2011 Flood Event**

## S5.2 Floodplain risk assessment (Chapter 10)

- The relatively low numbers of buildings affected by floods up to and including the 0.05% (1 in 2,000) AEP design flood event demonstrates that the management of the lower Pine Rivers floodplain to date has been effective in minimising the impacts of flooding in the affected area.
- Both Brisbane City Council (BCC) and MBRC have planning schemes and apply planning and development controls. Hence, the amount of flood risk in the North Pine Dam floodplain is unlikely to grow significantly.

- Under current operations, an estimated 36 buildings are at risk of inundation above habitable floor level for floods up to a 0.05% (1 in 2,000) AEP design flood.
- Under current operations, an estimated 6 buildings are at risk of inundation above habitable floor level for floods up to a 1.0% (1 in 100) AEP design flood.
- In absolute terms, reductions in dam FSLs achieve minor reductions in the numbers of properties and buildings inundated and populations at risk for floods up to a 0.05% (1 in 2,000) AEP design flood.
- Small reductions in dam FSVs achieve minimal improvements in road access, reductions in property isolation and bridge submergence (except for Youngs Crossing).
- Reductions in dam levels achieve only marginal improvements to the flood immunity of most of the major and minor road and railway crossings, which already have significant flood immunity (except for Youngs Crossing).

### **S5.3 Water supply security (Chapter 11)**

- Modelling to simulate the operation of the SEQ water supply system indicates there is little impact on the system yield caused by making either temporary or permanent lowering of the level in North Pine Dam down to 85% or even 75% of the FSV.
- The average supply contribution to the SEQ water supply system from North Pine Dam is around 6% of the system yield or around 25,000 megalitres per annum (ML/a) (This is expected as North Pine Dam provides only about 10% of the total surface water supply storage in the SEQ water supply system and is in a small catchment).
- The estimated system yield for SEQ is 430,000 ML/a (based on achieving level of service objectives outlined in the SEQ System Operating Plan (SOP) and assuming a most likely demand scenario (residential use - 185 litres/person/day)). Under the most likely projected demands, augmentation of the supply yield of the SEQ water supply system would need to commence around 2031.
- Without the Western Corridor Recycled Water Scheme (WCRWS), the system yield reduces to 415,000 ML/a and without both the WCRWS and desalinated water from the Gold Coast Desalination Plant (GCDP) the system yield drops to about 355,000 ML/a. The corresponding timelines for the commencement of augmentation of supply would be brought forward from 2031 to approximately 2028 and 2019 respectively, allowing for construction and commissioning.
- Nevertheless, North Pine Dam plays an important role in minimising the costs of supply distribution to the northern Brisbane metropolitan areas and the Sunshine Coast.
- North Pine Dam is prone to algal blooms which affects raw water quality when the dam is at low levels, hence from a water supply perspective it may not be prudent to consider lowering the dam significantly.
- The probabilities of triggering manufactured water production in the next 10 to 20 years increases substantially if, along with a lowering of the levels in North Pine Dam, the levels in Wivenhoe Dam are also lowered below 85% FSV.
- The desired level of service objectives for SEQ are currently being reviewed and subsequently it is currently anticipated that Seqwater would establish a new SEQ water security program in late 2015. The findings of this study may be reviewed at that time if necessary.

#### **S5.4 Dam safety (Chapter 8)**

- North Pine Dam is an extreme hazard dam which will ultimately need to be augmented to allow it to safely pass the probable maximum flood. It has been estimated that North Pine Dam can pass a flood with an AEP of between 1 in 200,000 and 1 in 300,000 (with one gate not operating).
- Lowering of the FSL of North Pine Dam for flood mitigation purposes would reduce the likelihood of dam crest overtopping occurs and consequential adverse flood impacts from large and rare flood events.
- Seqwater recently completed a risk assessment for all dams in its portfolio to provide an understanding of the major dam safety risks and enable prioritisation of future risk reduction activities.
- There may be some potential to delay upgrade work for North Pine Dam from 2025 to 2035 if the FSV of the dam is lowered below 94% FSV to say 90% FSV.
- Further investigation of options to meet dam safety requirements is needed, as significant works to upgrade spillway capacity will ultimately be required.
- Preliminary estimates indicate that a full dam spillway upgrade will be in the hundreds of millions of dollars.

#### **S5.5 Flood warning (Chapter 9)**

- Generally, Seqwater, MBRC and the BoM have robust warning and notification systems in place to warn community and stakeholder agencies of the potential negative impacts of flooding in all its forms. These are aligned within the Queensland Disaster Management Arrangements (QDMA) structure.
- The Queensland Government has recently introduced new legislation which sets statutory criteria for the requirements for Dam Safety Emergency Action Plans in Queensland. The legislative standards and regulator's guidelines aim to ensure that dam owners place a premium on notification processes that are negotiated with stakeholders, the community and Local and District Disaster Management Groups.
- Queensland's legislation builds upon and is consistent with the Australian Emergency Management Guidelines and Manuals for providing warning and notification for floods affected by dams.
- North Pine Dam is relatively uncommon in being a large water supply dam that is located immediately upstream of residential dwellings. During extreme events, residents in close proximity to the dam require more urgent warnings than those who are further downstream and are not at immediate risk. For North Pine Dam it is estimated that up to approximately 30 residential dwellings may require these urgent warnings.
- Accordingly, responsible government agencies and entities aim to provide timely and appropriately detailed warning messages and notifications to those potentially impacted.

#### **S5.6 Bridge and crossing submergence (Chapter 12)**

- Bridge and crossing submergence does not significantly impact the flood operations of North Pine Dam as Youngs Crossing is submerged at very low flows and the other bridges have high flood immunity.
- The A.J. Wyllie Bridge is now only submerged during large flood events. Any lowering of the dam will further reduce its frequency of submergence.

- On the other hand, Youngs Crossing is submerged during very small flows and may be submerged several times in any year. The modelling indicates that as the level of North Pine Dam is lowered, there are increases in the duration of submergence of Youngs Crossing. Youngs Crossing may also be submerged by uncontrolled releases from the ungated Sideling Creek Dam even without releases from North Pine Dam.
- MBRC seeks a dam operation solution that will minimise periods of closure of Youngs Crossing to no greater than 48 hours where practicable. Hence night time releases occur when appropriate during drawdown of the dam to minimise closure of the crossing during peak traffic periods.
- DTMR is currently undertaking planning studies of the West Moreton corridor and to compare options for an east or west bypass of Petrie. Both studies are due for completion in 2014. The studies will investigate alternative alignments to the West Petrie Bypass project proposed by MBRC.
- Any raising of Youngs Crossing would need to be justified on the basis of the costs and benefits of improving traffic flows with the impacts of crossing submergence being just one consideration.
- Ultimately, any transport improvements would need to be negotiated between MBRC and DTMR.

### **S5.7 Downstream bank slumping and erosion (Chapter 13)**

- Between 1990 and 2009 only minor flooding was experienced in the North Pine River downstream of the dam.
- No flood releases occurred between February 1999 and April 2009 due to the Millennium Drought and the consequential low lake level in North Pine Dam. Only two minor flood releases of 360 m<sup>3</sup>/s or less occurred in May 2009 and February 2010.
- In October 2010 and January 2011 substantial flooding occurred, with peak dam outflows estimated to be 910 m<sup>3</sup>/s and 2850 m<sup>3</sup>/s respectively. These floods were followed by moderate floods in January 2012 and February to March 2013. The January 2011 flood was the largest on record in the Pine River catchment.
- These sequences of events may explain why the community had not observed major erosion over the previous 20 years.
- There is a tendency for the public to assume the 'no erosion' case as a reference point when making judgements about river erosion. This is misguided, as riverbanks are dynamic zones that are continually changing in response to complex interactions between flow regimes, sediment transport, riverbank material and form, riparian vegetation and land-use.
- The investigation concluded that based on the review of available data, the North Pine River system appears relatively insensitive to changes to these complex interactions (DSITIA 2014).
- The investigation indicated that the effects of the dam and adopted release strategies relative to other anthropogenic (man-made) disturbances in the systems (e.g. riparian vegetation clearing, sand and gravel extraction, etc.) appear to be minor.

- Release strategies which maintain a constant level for long durations are likely to have a greater impact on downstream bank erosion than a slightly varied flow level. A fixed release discharge is simple to set but may cause notching or undercutting at low levels, or completely saturate the bank at higher levels.

## **S5.8 Flora and fauna (Chapter 14)**

- Some potential aquatic ecosystem impacts associated with dam operations, especially ‘hydro-peaking’ (pulsed (sequences of night time) releases) include:
  - stranding of fish and other aquatic fauna
  - washing away of instream macro-invertebrate populations when flow rises
  - rapid and frequent change in habitat condition and availability.
- In small and potentially isolated systems with limited opportunities for recruitment due to altered patterns of connectivity, such as North Pine River downstream of the dam, long term impacts on the aquatic flora and fauna community composition may occur over time.
- Stepped ramp-down of dam releases could be implemented to provide cues to fish and other fauna of dropping flows before full dewatering of habitat occurs. This will reduce the potential for fish stranding.

## **S6 Integrated assessment of operational options (Chapter 15)**

Based on all the key findings above, operational alternative 2 (lowered dam levels with flood release triggered at the current FSL) offers few advantages over operational alternative 3 (lowered dam and lowered flood release trigger levels). The main advantage of operational alternative 2 is the slightly shorter duration closures of Youngs Crossing.

Operational alternative 3 offers improved flood mitigation benefits over the whole range of flood events for all the lowered dam level cases analysed. Operational alternative 2 only provides flood mitigation improvements over a range of smaller flood events similar to those experienced historically.

Hence, operational alternative 2 is not considered further in the integrated assessment of the operational options below. In essence, the small flood outcomes for operational alternative 2 are similar to operational alternative 3, while the large flood outcomes are similar to operational alternative 1 (existing situation).

Integrated assessment of the options to satisfy the requirements of QFCoI Final Report recommendation 17.3 requires trade-off considerations between:

- the damage and impacts associated with flooding
- the water supply security costs associated with increased production of manufactured water and the need to bring forward infrastructure upgrades
- the ability to reduce dam safety risks and improve flood mitigation while any necessary upgrades of the dam are planned and executed
- the ability to minimise disruption to the community by reducing the cost of traffic rerouting resulting from the submergence of bridges, crossings and roads.

Strategies for minimising bank slumping and erosion and flora and fauna impacts identified in the key findings above are confined to small floods less than 500 m<sup>3</sup>/s on the rising and falling stages of a flood.

Net present costs have been estimated for tangible flood inundation damages and impacts and brought forward costs of water infrastructure and manufactured water production. Where it has not been possible to quantify the costs, evidence has been presented to support qualitative judgement based on the key considerations discussed above.

Indicative comparisons of the operational alternative 1 existing operations with the lowered dam levels under operational alternative 3 are summarised in Tables S1 and S2 and Figures S3 and S4. Numerous assumptions were made to develop these tables. These are outlined in the specialist reports underpinning the North Pine Dam Optimisation Study.

Table S2 summarises the implications of operational alternatives 1 and 3, and highlights that lowering the dam:

- improves dam safety outcomes
- reduces peak dam outflow rates for flood events
- reduces the inundation of residential and non-residential buildings and critical infrastructure such as bridges and roads, however the numbers of affected buildings is low and benefits are mostly gained only in very large events
- results in only small reductions in the number of buildings where inundation of the habitable floor levels occurs as there is already a high level of flood immunity for the downstream areas
- does not impact the system yield of the SEQ water supply system but increases the likelihood of requiring desalinated water production and resultant increased operating costs
- increases the likelihood of triggering restrictions
- would not change the timing for the next augmentation of the SEQ water supply system (although longer term augmentation timings are affected)
- increases the likelihood that algal blooms will be triggered as occurred during the Millennium Drought of 2001 to 2007.

Table S3 also shows:

- estimated average annual damages for residents is low
- estimated average annual damages for transport infrastructure is more significant
- estimated average annual impacts, mainly due to road closures and traffic rerouting, would be greatest at a dam volume of 42% due to the increasing impact of submergence of Youngs Crossing – despite the declining impact on Gympie Road and Bruce Highway
- making either or both desalinated water and purified recycled water unavailable brings forward timelines for augmentation of bulk water supplies.

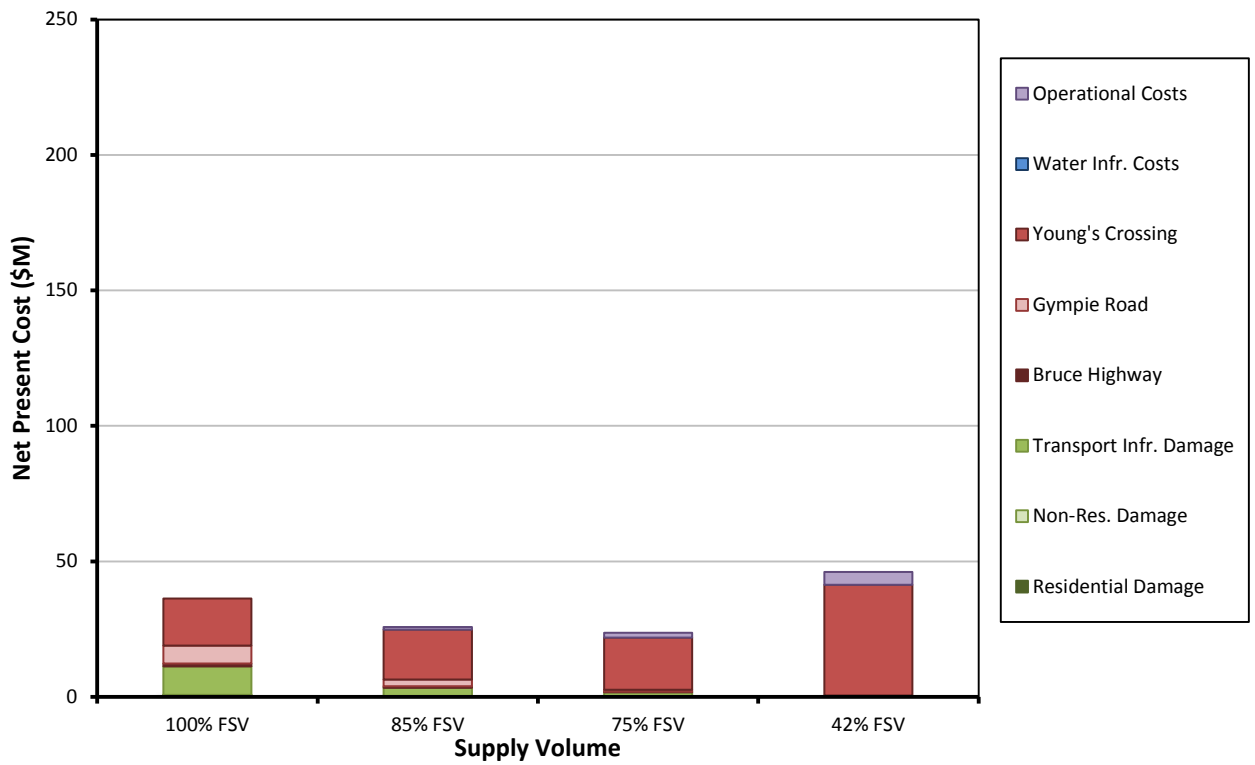
Figures S3 and S4 (refer also Table S3) illustrate the significant costs associated with traffic rerouting due to bridge and crossing submergence, in particular of Youngs Crossing, and the sensitivity of the analysis to assumptions about water infrastructure costs. The figures also demonstrate that most of the water supply costs arise from the need to implement supply augmentations sooner than currently anticipated beyond 2031.

**Table S2 Implications of the operational options (Wivenhoe Dam at 100% FSV)**

Issue	Measure	Option 1	Option 3.1	Option 3.2	Option 3.3
		Existing	85% FSV	75% FSV	42% FSV <sup>1</sup>
Dam design	Supply Level (mAHD)	39.6	38.04	36.88	32.00
	Volume (ML)	214,300	182,200	160,700	90,000
Dam safety	Flood capacity of the dam	Increasing dam safety →			
	Approximate flood capacity (% PMF) <sup>2</sup>	63%	68% (interpolated)	71%	85%
	Dam crest flood probability (AEP) (assumes 5 gates operating)	1 in 570,000	1 in 840,000	1 in 940,000	1 in 1,340,000
Flood mitigation	Dam outflows relative to inflows	Increasing reduction in dam outflows →			
	Reduction of PMF inflow (5 gates)	15%	20%	25%	43%
	Buildings flooded above habitable floor	Reducing flood inundation →			
	• 1.0% (1 in 100) AEP	6	1	1	1
	• 0.2% (1 in 500) AEP	20	11	5	1
	• 0.05% (1 in 2,000) AEP	36	24	15	3
	• PMF <sup>3</sup>	1524	1200	915	241
	Flooding of major / minor roads	Reducing submergence →			
	• 5.0% (1 in 20) AEP	7	7	7	7
	• 1.0% (1 in 100) AEP	8	7	7	7
	• 0.2% (1 in 500) AEP	13	8	7	7
	Damage and impact costs	Damage costs reduce, variable impact costs →			
	Residential average annual damage (AAD)	\$0.07M	\$0.02M	\$0.01M	\$0.0M
	Non-residential AAD	~\$0.0M	~\$0.0M	~\$0.0M	~\$0.0M
	Transport infrastructure AAD	\$1.15M	\$0.34M	\$0.17M	\$0.03M
Transport average annual impact (AAI)	\$2.75M	\$2.36M	\$2.21M	\$4.50M	
Total AAD and AAI	\$3.98M	\$2.72M	\$2.39M	\$4.53M	
Water supply security	System (level of service) yield (ML/a) <sup>4</sup>	430,000	430,000	430,000	430,000
	Timing of future supply augmentations	Without WCRWS / GCDP supply upgrades are brought forward			
	• Existing SEQ water supply system	2031	2031	2031	2031
	• WCRWS <sup>5</sup> unavailable	2028	2028	2028	2028
	• WCRWS and GCDP <sup>6</sup> unavailable	2019	2019	2019	2019
	Drinking water quality concerns <sup>7</sup>	Increasing risk of algal blooms in North Pine Dam →			
	Cumulative probability of desalination water production being required	Increasing likelihood desalination will be required → ↓			
	• Probability by 2018	2.6%	3.0%	3.5%	6.0%
	• Probability by 2023	13.0%	14.7%	16.3%	23.3%
	• Probability by 2033	43.5%	46.7%	49%	60.1%
Cumulative probability of restrictions <sup>8</sup>	Increasing likelihood restrictions will be required				
• Probability by 2033	7.7%	7.8%	8%	8.5%	

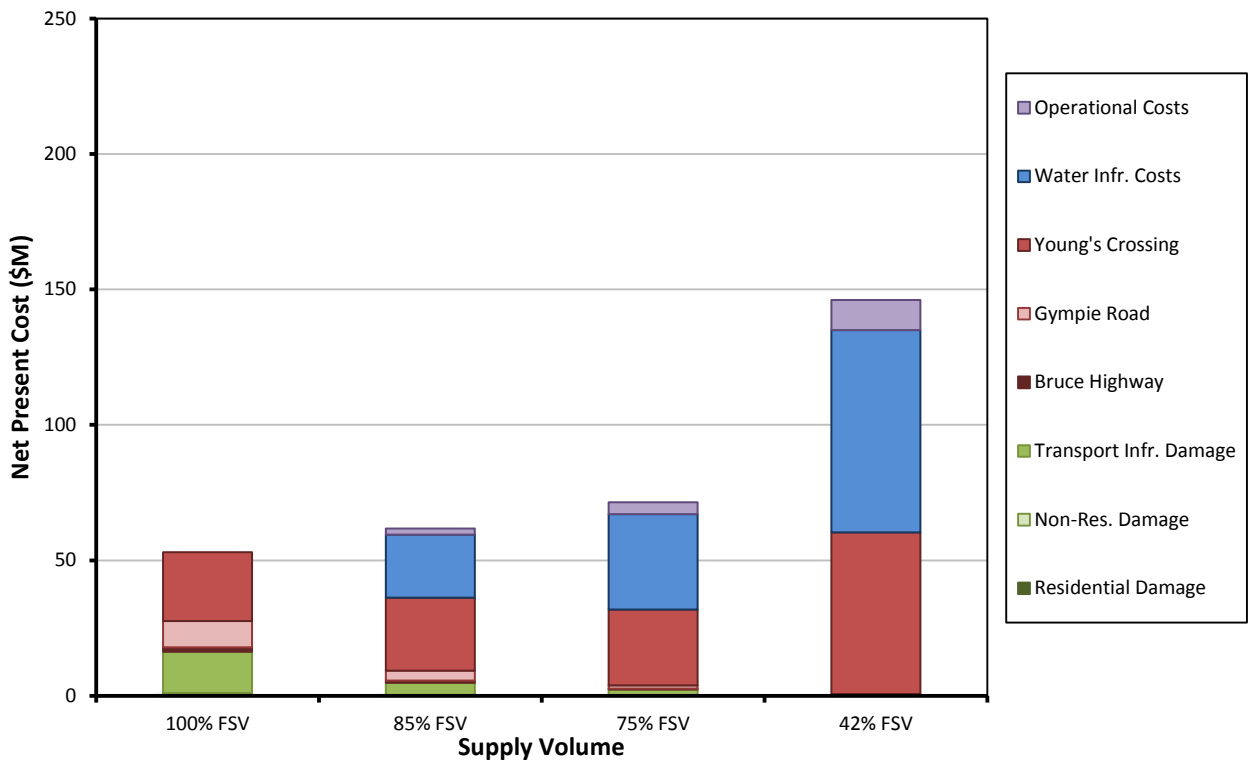
**Notes:**

1. The statistics for the no gates case generally provide slightly higher flood immunity and dam safety.
2. From *North Pine Dam Acceptable Flood Capacity Report* (URS 2012) prepared for Seqwater.
3. While there is considerable exposure to flooding in a PMF (probable maximum flood), this is the case throughout Queensland and the world.
4. Assumes that Wivenhoe Dam is not lowered.
5. Purified recycled water via the Western Corridor Recycled Water Scheme.
6. Gold Coast Desalination Plant
7. Potentially, the augmentation schedule could be impacted due to drinking water quality issues and associated increased transport costs.
8. Probability of restrictions being triggered in the first 10 years is very low with or without manufactured water.



Source: Aurecon 2014, Figure 36

**Figure S3** North Pine net present costs (Wivenhoe Dam at 100% FSV) – 20 year (short term) analysis horizon



Source: Aurecon 2014, Figure 35

**Figure S4** North Pine net present costs (Wivenhoe Dam at 100% FSV) – 40 year (medium term) analysis horizon

**Table S3 Estimated net present costs of operational options – 40 year (medium term) analysis horizon**

Damage/Impact Type	North Pine Dam Supply Volume (%FSV) / \$M			
	100%	85%	75%	42%
Residential damage	\$0.99	\$0.30	\$0.13	\$0.04
Non-residential damage	\$0.05	\$0.01	\$0.01	\$0.00
Transport infrastructure damage	<u>\$15.27</u>	<u>\$4.49</u>	<u>\$2.22</u>	<u>\$0.32</u>
<b>Total flood damage</b>	<b>\$16.30</b>	<b>\$4.81</b>	<b>\$2.35</b>	<b>\$0.36</b>
Bruce Highway	\$1.60	\$0.87	\$0.39	\$0.01
Gympie Road	\$9.73	\$3.68	\$1.12	\$0.38
Youngs Crossing	<u>\$25.39</u>	<u>\$26.92</u>	<u>\$28.00</u>	<u>\$59.65</u>
<b>Total flood impact</b>	<b>\$36.71</b>	<b>\$31.47</b>	<b>\$29.51</b>	<b>\$60.03</b>
<b>Total flood damage and impact</b>	<b>\$53.01</b>	<b>\$36.28</b>	<b>\$31.86</b>	<b>\$60.39</b>

Wivenhoe Dam at 100% FSV				
Water infrastructure costs	\$-	\$23.21	\$35.17	\$74.65
Operational costs (Manufactured water -mostly desalination)	\$-	\$2.32	\$4.37	\$11.11
<b>Total water costs</b>	<b>\$-</b>	<b>\$25.53</b>	<b>\$39.54</b>	<b>\$85.76</b>
<b>NET PRESENT COST</b>	<b>\$53.01</b>	<b>\$61.82</b>	<b>\$71.41</b>	<b>\$146.15</b>
<b>Total benefit of scenario</b>	<b>\$-</b>	<b>(\$8.80)</b>	<b>(\$18.39)</b>	<b>(\$93.13)</b>

Note:

1. Numerous assumptions were made in producing the Net Present Costs
2. The Table includes only the Net Present Costs of direct tangible damages and impacts and brought forward costs of water infrastructure.
3. The Net Present Costs have been estimated using a 7% discount rate over 40 years.
4. Sensitivity testing results are available in the report on the Integrated Assessment for the North Pine Dam Optimisation Study.
5. A difficult complex issue was the apportionment of future water supply infrastructure costs due to the potential lowering of both Wivenhoe Dam and North Pine Dam. It requires an understanding of how the SEQ water supply system functions and how the dams are used to maximise yields and reduce system risks.

Source: Aurecon 2014, Table 33

## S7 Potential to operate as a flood mitigation dam

QFCoI Final Report recommendation 17.9 requires that consideration of whether North Pine Dam should be operated as a flood mitigation dam when the Queensland Government considers possible operating strategies and FSLs as part of the longer term review of the Flood Manual.

Most dams, including ungated dams, provide some passive flood mitigation by attenuation of the peak dam outflow relative to peak dam inflows. This occurs as flood water is temporarily stored in space above the water supply FSL which delays and reduces the peak outflow relative to peak inflow. For gated dams it may be possible to increase the flood mitigation by actively regulating the flood outflow and increasing the temporary storage of floodwater.

In order for a gated dam to be operated *actively* as a flood mitigation dam, two essential criteria need to be satisfied. There must be:

1. adequate flood storage capacity above FSL
2. sufficient time available to actively assess the flood conditions and regulate the flood outflow through the temporary storage of the floodwater.

In regard to the matter of 'sufficient time', it is noted that significant flooding in the North Pine River catchment can occur within six hours (sometimes shorter) to 12 hours of the commencement of heavy rainfall. This is a short timeframe to allow for assessment of flood conditions including the collection of rainfall and streamflow records, analysis of weather forecasts, undertaking of predictive modelling and management of the dam gates.

The following discussion describes the potential under each operational option for North Pine Dam to be actively operated as a flood mitigation dam.

### **S7.1 Operational alternative 1 – existing situation with the dam at its current FSL**

North Pine Dam under existing operations was not designed or intended to operate as a flood mitigation dam. The existence of the Flood Manual does not mean that North Pine Dam is a flood mitigation dam. The Flood Manual exists because there is a public interest to ensure that the radial gates are operated safely during flood events and to ensure the safety of the dam. The need for a flood mitigation manual is prescribed by legislation.

Under existing operations, there is limited opportunity to provide active flood mitigation by using the spillway gates to regulate outflows and increase the temporary storage of floodwater in the dam. This is due to:

- the limited available storage capacity between the FSL and the dam crest level (90,000 ML). (Note: Historical floods have had flood inflows in excess of 400,000 ML.)
- the need to have sufficient storage reserved for dam safety so that the probability of overtopping the dam crest is acceptably low. (Dam safety objectives require the spillway gates to be fully open when the reservoir level reaches EL 40.7 mAHD. Thus, the flood storage above the current FSL and EL 40.7 mAHD is approximately 25,000 ML.)

Hence, a range of possible lowered dam levels has been investigated to potentially increase flood storage to enable the dam to be operated as a flood mitigation dam. The additional flood storage available by lowering the FSL to 85%, 75% and 42% of FSV is 32,000 ML, 54,000 ML and 125,000 ML respectively.

### **S7.2 Operational alternative 2 – lowered dam levels, flood release at the current FSL**

The modelling results indicate significant flood mitigation potential by lowering the dam to 42% FSV. Lowering the dam down to 75% FSV only provides flood mitigation benefit for smaller floods with the benefits for extreme events above that achieved under operational alternative 1 almost non-existent. The assessment of the net present costs indicates that lowering the dam to 42% FSV results in the worst economic outcomes of all the potential options for lowering the FSV of the dam.

### **S7.3 Operational alternative 3 – Lowered dam levels and flood release trigger levels**

Operational alternative 3 is an operational option in which the flood release level is set at the adopted lowered dam FSL. It is therefore an option where the dam is not actively operated during a flood event to mitigate downstream flooding. The modelling results for Operational alternative 3 indicate better flood mitigation outcomes to operational alternative 2 over the full range of flood events modelled.

On the basis of the above discussion, there is little advantage in considering operational alternative 2 and actively operating North Pine Dam during a flood event to mitigate flooding.

## Chapter 1 – Background

SEQ experienced persistent, above average, rainfall over the 2010–11 spring and summer seasons. Rainfall in September 2010 was typically 55 mm above average and in October, was 250 to 400 mm above average, resulting in most catchments being at or near saturation by the end of October 2010. The catchments dried out slightly during November in response to slightly below average rainfall. However, this was followed by a prolonged period of heavy rainfall during December 2010 and January 2011 that yielded total rainfalls for the period up to 1,000 mm above average and resulted in widespread flooding between late December 2010 and mid-January 2011.

The heavy rainfall produced the largest flood recorded in the North Pine River (flow records for the North Pine River commenced in 1916) and also produced major floods in the Brisbane River basin and other river systems across Queensland.

The Bureau of Meteorology's Queensland Flood Summary for January 2011 describes the period as follows:

*'Southeast Queensland had experienced very much above average to highest on record rainfall for the month of December. Further rainfall then followed in the first week of January, saturating the catchment area.'*

*'By the 7th of January a combination of weather systems centred themselves over land over the Burnett River catchment area. These systems combined to produce heavy rainfall and major flooding in the Mary River catchment and about the Sunshine Coast before moving southward into the Pine and Brisbane River catchments. Heavy to very intense rainfall from the 9th to the 12th of January resulted, causing rapid creek rises and extreme flash flooding in the Lockyer Valley and major river flooding in the Brisbane and Bremer Rivers.'*

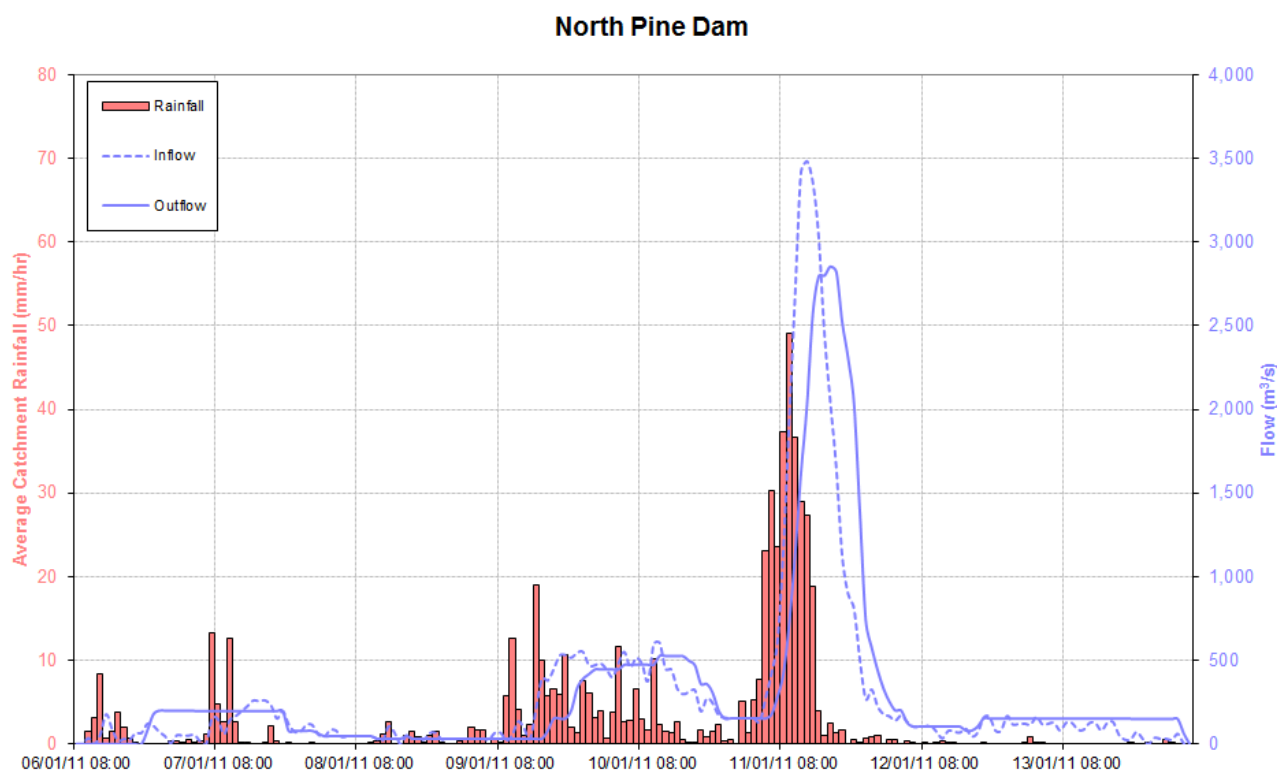
*'Record flood heights were recorded at various locations along Lockyer and Warrill Creeks and the Bremer and the upper Brisbane River. Peak river levels on the Bremer River at Ipswich and along the Brisbane River between Mt Crosby and Brisbane city remained below the 1974 flood level.'*

*'Heavy rainfall causing river level rises was also recorded in other areas of the state including the Mary, Burnett, Dawson, Condamine, Macintyre, Moonie, Logan/Albert Rivers and in Charley's and Myall Creek.'*

*'Renewed rises were recorded in many areas of the state which had already been affected including Warwick, Dalby, Chinchilla, Condamine, Bundaberg and the Dawson River towns of Taroom, Theodore, Moura and Baralaba.'*

BoM further highlighted that, with respect to the seasonal conditions from which the January events arose:

*'The 2010–11 La Niña event was one of the strongest on record, comparable in strength with the La Niña events of 1917–18, 1955–56 and 1975–76. In October and December 2010, and February and March 2011, the Southern Oscillation Index values (a measure of a La Niña's strength) were the highest recorded for each month since records commenced in 1876.'*



Source: Seqwater 2011a, Figure 2.1.1

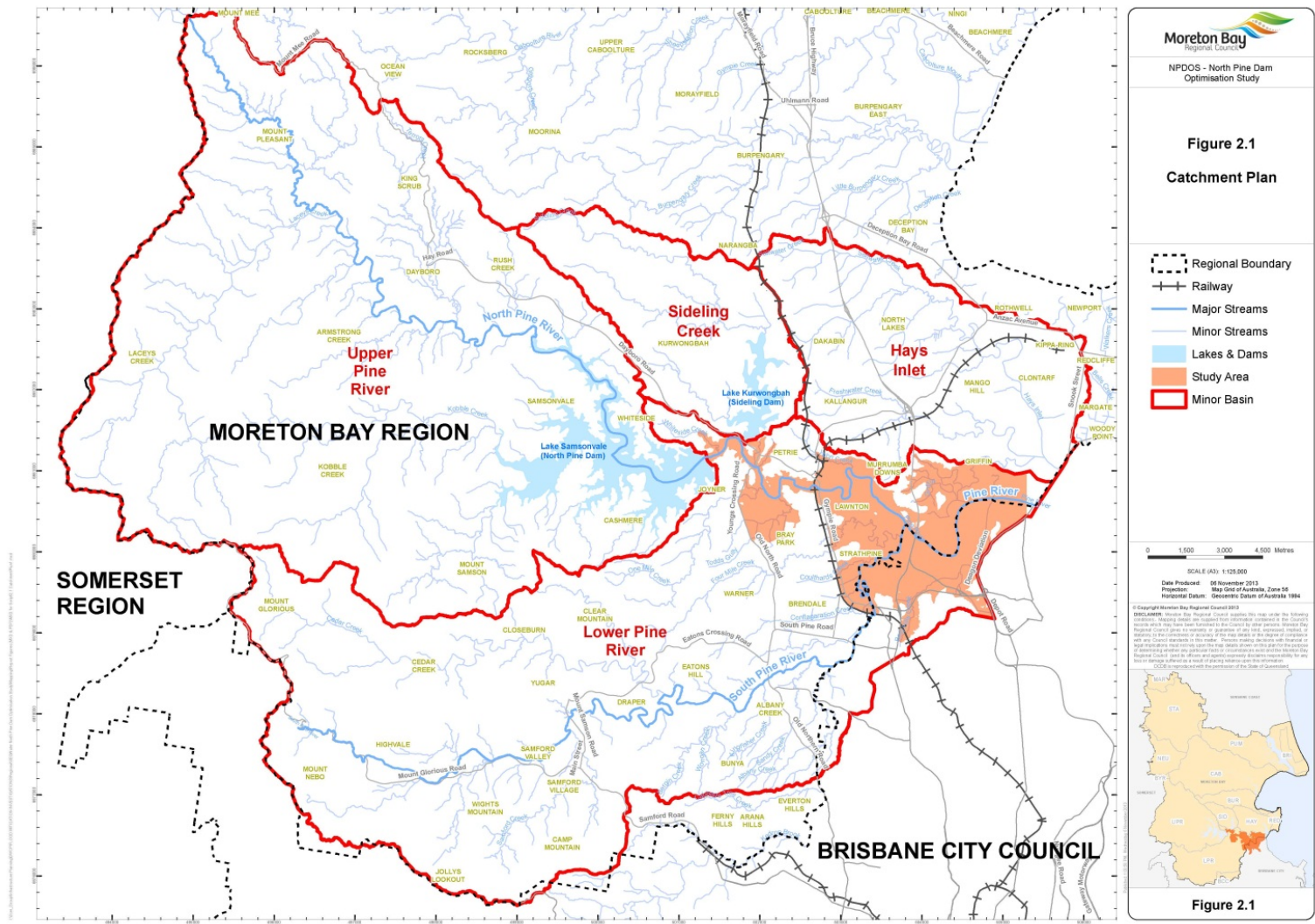
**Figure 1.1 North Pine Dam – January 2011 flood event – dam inflow and outflow**

Water was released from North Pine Dam on 16 occasions between 11 October 2010 and 20 January 2011 in response to inflows resulting from the persistent rainfall (refer Figure 1.1). The largest proportion of the flow into the dam (approximately 50% of the whole event) occurred over 14 hours from around 8.00 am on Tuesday 11 January 2011 (refer Seqwater 2011a, page ii).

In response to the widespread flooding that occurred in 2010–11, the QFCoI was established to review all aspects of flood events. The QFCoI reviewed all relevant data, examined the flood operations at Wivenhoe, Somerset and North Pine dams, commissioned experts to analyse the event and offer opinion on the actions taken and received public submissions between February 2011 and March 2012. The QFCoI issued an Interim Report in August 2011 (QFCoI 2011) and handed down its Final Report in March 2012 (QFCoI 2012).

The main QFCoI Interim and Final Report recommendations relating to the North Pine Dam Optimisation Study (NPDOS) and flooding in the Pine Rivers system are summarised in Tables 1.1 and 1.2.

The location of North Pine Dam and downstream floodplain are illustrated in Figure 1.2.



Source: MBRC 2013a, Figure 2.1

Figure 1.2 Pine River catchment

**Table 1.1 QFCoI – Interim report recommendations relevant to North Pine Dam Optimisation Study**

<b>QUEENSLAND FLOODS COMMISSION OF INQUIRY INTERIM REPORT</b>	
<b>No</b>	<b>Recommendation</b>
2.29	The Moreton Bay Regional Council should investigate the options for the upgrade of Youngs Crossing and undertake a cost benefit analysis of these to determine an outcome which best serves the public interest
4.16	Dam operators should plan to contact people identified by their emergency action plans about dam outflow in sufficient time for them to be able to respond to the information
4.17	Dam operators should ensure each emergency action plan includes a clear statement as to the frequency of, and circumstances in which, warnings will be issued to people listed in the emergency action plan
4.18	Dam operators should assess the effectiveness of using SMS and/or email as a bulk instantaneous communication to all people on the notification list while individually contacting those whom it is essential to inform immediately

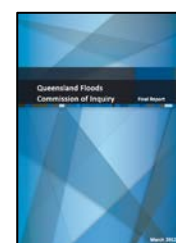
Source: QFCoI 2011



Table 1.2 QFCoI – Final report recommendations relevant to North Pine Dam Optimisation Study

QUEENSLAND FLOODS COMMISSION OF INQUIRY FINAL REPORT	
No	Recommendation
7.17	If the Queensland Government does not include such assessment criteria in the model flood planning controls, councils should consider including assessment criteria in their planning schemes ...”.
10.14	All councils should periodically conduct risk assessments to identify areas at risk of backflow flooding. In respect of such areas, councils should consider how such risks can be lessened, including in that process consideration of the installation of backflow prevention devices. Backflow devices should not, however, be installed unless and until a full risk based assessment has been undertaken
11.1	Councils should consider implementing a property buy-back program in areas that are particularly vulnerable to regular flooding, as part of a broader floodplain management strategy, where possible obtaining funding from the Natural Disaster Resilience Program for this purpose.”
17.3	The Queensland Government should ensure that, when it considers options for the operational strategies to be employed at Wivenhoe and Somerset dams, and North Pine Dam, it is presented with a wide range of options which prioritise differing objectives. The Queensland Government should determine the operational strategies by considering the implications of each option over a range of flood events for at least: <ul style="list-style-type: none"> <li>• inundation of urban and rural areas</li> <li>• water supply security</li> <li>• dam safety</li> <li>• submerging of bridges</li> <li>• bank slumping and erosion</li> <li>• riparian fauna and flora.</li> </ul>
17.4	Seqwater should, in creating the new Wivenhoe and North Pine flood mitigation manuals, comprehensively consider: <ul style="list-style-type: none"> <li>• The amount of discretion that is able to be exercised by the flood engineers and the senior flood engineers, and the description of the circumstances in which such discretion may be exercised</li> <li>• The circumstances in which it might be appropriate to release water in advance of an impending flood on the basis of forecasts from the Bureau of Meteorology</li> <li>• If strategies of the form of strategy W2 and W3 in Revision 7 are included in the revised manual, or any strategy defined as a ‘transition strategy’, when and how those strategies should be implemented</li> <li>• If the concept of ‘urban inundation’ is relevant to the operation of the dam, how it should be defined, and if the definition involves diverse concepts, how those concepts can be related back to the strategies, so that flood engineers can reach a clear understanding of their objectives and primary considerations</li> </ul> <p>If the concept of ‘natural peak flow’ is relevant, how it should be defined.</p>
17.5	The conditions for the use of a particular strategy in all flood mitigation manuals should reflect objective standards
17.9	The Queensland Government should consider whether North Pine Dam should be operated as a flood mitigation dam when it considers possible operating strategies and full supply levels as part of the longer term review of the Manual of Operational Procedures for Flood Mitigation at North Pine Dam.
17.13	Prior to approving a flood mitigation manual, the Queensland Government should be satisfied that its terms are expressed in a manner that allows a determination of compliance with it to be made by reference to objective standards

Source: QFCoI 2012



## Chapter 2 – Purpose and scope

This NPDOS report presents the findings of investigations initiated to address the key QFCoI Final Report recommendations 17.3 and 17.9. In addressing these recommendations, relevant matters in other recommendations listed in Tables 1.1 and 1.2 were also considered.

The purpose of NPDOS is to present the Queensland Government with:

1. a wide range of operational strategy options for North Pine Dam
2. advice to consider whether North Pine Dam should be operated as a flood mitigation dam (when it considers possible operating strategies and FSLs as part of the longer term review of the *Manual of Operational Procedures for Flood Mitigation at North Pine Dam* (Flood Manual)).

In fulfilling the purpose of NPDOS, investigations have been undertaken to enable consideration and presentation of the implications of each operational strategy option over a range of flood events for:

- inundation of urban and rural areas
- water supply security
- dam safety
- submerging of bridges
- bank slumping and erosion
- riparian fauna and flora.

The operational options (refer Chapter 6 for details of operational options considered) available at North Pine Dam are few. They incorporate:

- introduction of a flood mitigation component to the dam by sacrificing part of the current water supply storage volume, and/or
- changes to the triggering of releases and rate of releases made through the flood operations of the spillway gates.

This report describes the operational strategies and options selected for analysis. It also outlines the outcomes of investigations undertaken to determine the advantages and disadvantages of each option with respect to the above considerations highlighted in QFCoI Final Report recommendation 17.3. Relevant matters relating to a future revision of the Flood Manual are also discussed.

NPDOS does not address QFCoI recommendations that do not relate to operational options at North Pine Dam. These include floodplain planning and local infrastructure solutions for mitigating flood impacts. These are generally the responsibility of the relevant local authorities (MBRC and BCC) (refer Chapter 16).

## Chapter 3 – North Pine Dam overview

### 3.1 History

North Pine Dam was designed by the former Department of Local Government and constructed under the supervision of the then Co-ordinator General's Department on behalf of BCC in the early 1970s. It was officially opened on 12 August 1976. The dam is now owned and operated by Seqwater.

The dam was designed solely for urban water supply and has no active flood mitigation capability. The dam does provide passive flood mitigation benefit due to the routing through 2200 ha Lake Samsonvale that results in the peak flow released from the dam being less than the peak inflow into the dam in major flood events.

### 3.2 Catchment description

The Pine River catchment drains from the relatively steep D'Aguilar Ranges in an easterly direction towards the flat coastal plains of Bramble Bay, in Moreton Bay between Sandgate and Redcliffe. The confluence of the North and South Pine rivers is some 7 km upstream of the mouth, between which lies the extensive Pine River coastal estuary. The tidal influence extends to Youngs Crossing and the Bald Hills Railway Bridge on the North and South Pine rivers respectively.

The North Pine River rises in the north-west of the catchment, joining a major tributary Laceys Creek that flows from the south-west, approximately 3 km west of the township of Dayboro. Kobble Creek, the other major tributary, drains the southern portion of the upper North Pine River catchment into Lake Samsonvale.

The dam and adjacent water treatment plant provide water supply to the Brisbane and Moreton Bay regions. Sideling Creek, which joins the North Pine River 3 km downstream of the dam, was also dammed in 1959 for water supply purposes to form the smaller Lake Kurwongbah. The main urban areas of the North Pine catchment are located downstream of the dam and include Petrie, Lawnton and Strathpine.

The upper floodplain of the North Pine River west of Gympie Road is characterised by a relatively incised valley and well-defined flow paths. The typical width of the upper floodplain (excluding the Bray Park breakout) is 250 m, with localised widening up to 800 m for a short segment opposite Todds Road before narrowing back to 175 m wide just upstream of Petrie town centre.

Downstream of the railway line, the lower floodplain reach is much wider, typically ranging from 1.5 km to almost 3 km width, with some additional widening occurring to the north of the main channel into the low-lying areas around Griffin and wetlands immediately north of the Gateway Motorway.

The South Pine River rises in the D'Aguilar Ranges to the south of the catchment and flows easterly and north-easterly towards the Pine River. Cedar Creek is the major tributary of the South Pine River and joins the river 4 km upstream of Cash's Crossing. At this point the river forms an extensive floodplain area which extends through the urban areas of Albany Creek, Strathpine and Bald Hills.

### 3.3 Development

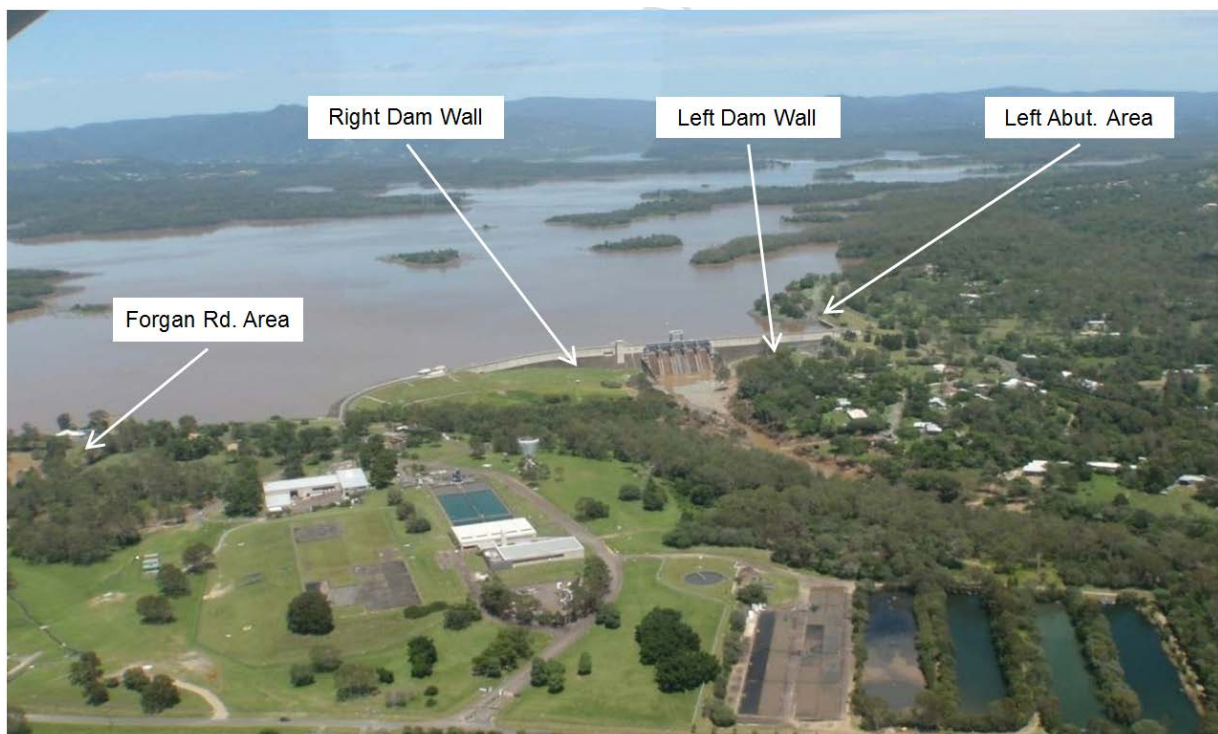
The Pine Rivers district has undergone extensive development and urbanisation beginning in the 1960s. The population of the district in 1976, the year North Pine Dam was built, was approximately 45,000. The population increased to 63,000 in 1981 and had expanded to around 140,000 by late 2004. The population of the Pine Rivers district is expected to approach 200,000 by 2021.

Much of the urbanisation in the district has occurred in the lower catchment. At present there are an estimated 2363 properties located on the floodplain downstream of North Pine Dam. The majority of these properties are situated within the Moreton Bay region with a small number within the bounds of BCC. The majority of these properties are residential (around 2,300), with a smaller number of commercial and industrial properties (around 54).

The upper catchment areas are dominated by rural land uses, predominantly grazing. Approximately 18% of the catchment is State Forest and around 1% is designated national park.

Within the North Pine floodplain there are extensive state and local road networks, including the major thoroughfares of Gympie Road and the Bruce Highway. The catchment is also bisected by the Brisbane-Caboolture railway line. There exist number of road crossings within the floodplain which, if inundated, have the potential to cause disruption and possible isolation of some residents.

### 3.4 North Pine Dam



Source: URS 2012, Figure 8-2

**Figure 3.1** North Pine Dam – general view

North Pine Dam (refer Figure 3.1) is located on the North Pine River approximately 5 km upstream of Petrie and 21.4 km from the mouth of the Pine River at Bramble Bay. The dam is located immediately upstream of an urban area.

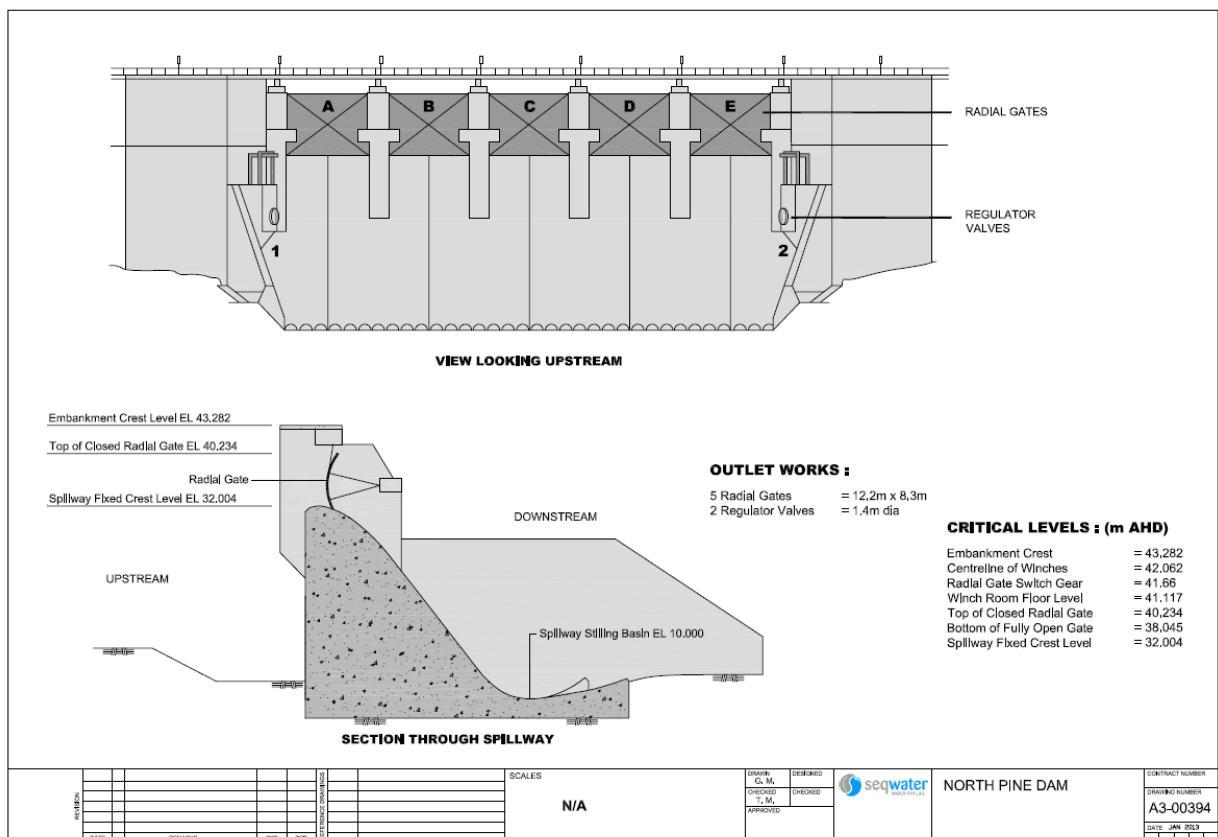
The main wall of the dam is a mass concrete gravity structure having a crest length of 580 m and maximum height of approximately 40 m above the riverbed. The dam has a central spillway fitted with five (5) steel radial gates. The dam wall is flanked by an earth embankment approximately 240 m long at the southern end. In addition to the main dam structure there are three (3) earth embankment saddle dams located approximately 0.5 km, 1.6 km and 2.5 km from the southern end of the main dam wall.

The principal characteristics of the North Pine Dam and Lake Samsonvale storage are summarised in Table 3.1 below.

**Table 3.1: Characteristics of North Pine Dam**

Catchment area	345 km <sup>2</sup>
FSL	39.6 mAHD
Storage at FSL	214,302 ML
Lake Surface area at FSL	2,200 ha
Spillway Gates	5 @ 12.2 m (wide) x 8.3 m (high)
Spillway Crest Level	32.004 mAHD
Top of closed Spillway Gates	40.234 mAHD
Embankment Crest Level	43.282 mAHD

Sources: Seqwater 2011a; Seqwater 2012a



Source: Seqwater 2013b, Figure 4.2.1

**Figure 3.2 North Pine Dam spillway and outlet works**

### 3.4.1 Spillway

The spillway (refer Figure 3.1) is located in the central section of the wall and comprises five (5) radial gates, two (2) 1350 mm diameter regulators and a 300 mm diameter low flow regulator.

The spillway gates are raised and lowered using electric motor driven winches. The five motors, (one for each gate) are normally powered from the mains electric supply. In the event of a failure of the mains supply, a standby diesel generator automatically cuts in to maintain electric supply. An additional diesel powered generator is leased on standby for the wet season each year and can supply the electrical needs for the dam.

There is also a hydraulic gate opening system, comprising a trailer mounted power-pack, permanently fixed hydraulic pipe-work and hydraulic motors mounted at the winch controls under the service deck. In the event of total failure of the electrical system this hydraulic system would be the preferred option for gate operations.

A review of the dam hydrology indicates that extreme events can result in submergence of the radial gate electric winch motors that are located on platforms beneath the bridge deck. During such an event, the electric winch motors would not operate and the winches would not be accessible. The above hydraulic system is designed to operate under water.

An auxiliary gate operating system was installed in 1997-98 comprising a trailer-mounted motor with petrol driven generator, which can be used to operate the winches from the deck of the dam. The shafts of the existing electric winch motors have been extended to the deck level of the dam through right angle gear boxes. In the event of failure of the electrical and hydraulic systems, the trailer mounted motor and petrol driven generator has to be used to operate the radial gates.

The opportunity to provide active flood mitigation by using the spillway gates to regulate outflows and increase the temporary storage of floodwater in the dam is constrained by the limited storage capacity (13,100 ML) available between the FSL at EL 39.6 mAHD and the top of the closed gates at EL 40.234 mAHD.

The absolute maximum flood storage capacity above FSL to dam crest level at EL 43.28 mAHD is approximately 90,000 ML, equivalent to 260 mm depth of runoff from the dam catchment. Not all of the flood storage to the dam crest level can be used for active flood mitigation because sufficient storage must be reserved for dam safety to ensure the probability of overtopping the dam crest is acceptably low.

### 3.4.2 Saddle dams

The three saddle dams (two shown in Figure 3.3) are all earth embankment structures with rock protection on the upstream face and grassed downstream batters. The saddle dams and right embankment were upgraded in the 1990s when the downstream batters were flattened slightly and sub-surface drainage was installed.

### 3.4.3 Right embankment

The right embankment is an earth embankment with rock protection on the upstream face and grassed downstream batter, similar to the saddle dams and links the right end of the main wall to the right abutment. The right embankment has a maximum height of 5.5 m, approximately 4 m less than the height of the vertical, upper section of the concrete wall.



Source: URS 2012, Figure 8-1

**Figure 3.3** North Pine Dam – saddle dam locations

### 3.5 Water supply

North Pine Dam was constructed for the purpose of supplying water to Brisbane's northern suburbs and parts of the Moreton Bay region. As a consequence of its location in the SEQ water supply system, North Pine Dam is of strategic importance to the supply of water to the northern Brisbane metropolitan areas and the Sunshine Coast via the Northern Pipeline Interconnector.

At full supply, North Pine Dam has a capacity of approximately 214,300 ML. This is equivalent to around 10% of the total volume of SEQ water storages (Table 3.2). Due to North Pine Dam's relatively small contribution to total storage volume, a reduction in the FSV of the dam is unlikely to have a significant impact on the overall system storage capacity or supply yield. The average volume contribution from North Pine Dam towards the total system yield of the SEQ water supply system of 430,000 ML/a is estimated to be approximately 25,000 ML/a based on current operations, i.e. around 6%. This volume is significantly lower than the allocation of 59,000 ML/a under the Moreton Resource Operations Plan (ROP) and estimated historical no failure yield of 39,000 ML/a.

Any reduction in the supply of water to the system resulting from a reduction to the FSV of North Pine Dam would ultimately need to be met from other sources of supply. The historical no failure yield at 42% FSV of the dam has been estimated to be approximately 25,500 ML/a.

In recent years, shortfalls in supply from the SEQ water storages have been supplemented by water from the GCDP with the potential to add purified recycled water to the system via the WCRWS to Wivenhoe Dam. The manufactured water assets are a key component of the SEQ water supply system, enhancing water security and able to address regional water supply shortages. Changes to the operation of the manufactured water assets are likely to affect water security in SEQ and may impact the ability to reduce the FSVs of the dams for flood mitigation purposes.

**Table 3.2 SEQ water storages**

Sub-Region	Storages
Central	Wivenhoe Dam Somerset Dam North Pine Dam Leslie Harrison Dam Lake Kurwongbah
Northern	Baroon Pocket Dam Ewen Maddock Dam Cooloolabin Dam Wappa Dam Lake Macdonald
Southern	Hinze Dam Little Nerang Dam

Source: Seqwater 2014a

North Pine Dam is prone to algal blooms when the dam is at low levels, hence from a water supply perspective it may not be prudent to consider lowering the dam significantly. Lowering the dam FSL could increase vulnerability of the dam to algal blooms due to:

- increased concentration of nutrients
- reduced buffering capacity of the reservoir
- increased interaction of the sediments with the surface of the lake.

### 3.6 Historical flood events

The January 1974 flood event occurred during the construction of the dam at a time when the spillway monoliths had not been completed and the dam was filled for the first time in the January 1976 event.

There have been 12 significant flood events, listed in Table 3.3, since the dam was completed in 1976 in addition to numerous minor events that yielded minor releases to maintain the FSL.

Many historical flood events have produced flood inflow volumes that are significantly larger than the flood storage capacity of North Pine Dam (90,000 ML). The flood inflow for the January 2011 flood was approximately 206,000 ML (URS, 2012). The flood inflow for the January 1974 flood has also been estimated to be in excess of 200,000 ML and the flood inflows for events in February 1893 have been estimated to be well in excess of 400,000 ML (DNR 1991). There have been seven flood events with inflow volume exceeding 90,000 ML since 1988 (URS 2012 and Seqwater 2013c).

**Table 3.3 Historical floods**

Event	Peak Inflow (m <sup>3</sup> /s)	Estimated Flood Volume (ML)	Peak Outflow (m <sup>3</sup> /s)
Apr-1988	790	178,000	630
Mar-1989	1,430	124,000	1,440
Apr-1989	1,150	94,700	980
Feb-1999	1,180	117,000	0
Apr-2009	790	45,600	0
May-2009	910	79,400	330
Feb-2010	380	57,700	360
Oct-2010	1,000	69,400	910
Jan-2011	3,480	202,000	2,850
Jan-2012	850	71,300	630
Jan-2013	1,650	101,000	840
Feb–Mar-2013	630	108,000	490

Note: Estimated flood volumes are approximate. Flood volumes may be from multiple flood events which occurred within the month.

Source: Seqwater 2013c, Table 8.2

### 3.7 Flood Manual

The operation of North Pine Dam during flood periods is specified in the Flood Manual – Revision 8 (Seqwater 2013b). The Flood Manual was prepared and approved in accordance with Chapter 4 Part 2 of the *Water Supply (Safety and Reliability) Act 2008* (QLD) (the Act).

A flood mitigation manual is an approved document that sets out clearly the defined procedures for operating a dam during flood events in order to minimise hazard to life and property. Flood mitigation manuals are approved by the Minister for Energy and Water Supply and are reviewed at intervals not greater than five years.

### 3.8 Flood mitigation objectives

Prescribed flood mitigation dams, including North Pine Dam, are to be operated in accordance with an approved flood mitigation manual during flood events. The Act requires the flood mitigation manual to state, in addition to other matters, the objectives for flood mitigation for the dam in the order of importance.

The Act also requires the flood mitigation manual to state the operational strategies required to achieve those objectives for flood mitigation and to achieve the appropriate balance of the following:

1. preventing failure of the dam, including, for example by protecting the structural integrity of the dam (dam safety)
2. minimising risk to property
3. minimising disruption to transport
4. maintaining the FSL for the dam after a flood event
5. minimising environmental impacts on the stability of banks of watercourses and on riparian flora and fauna.

The carrying out of the operational strategies and procedures for the dam must also minimise risk to human life and safety.

The above requirements for flood mitigation manual were introduced in November 2012 by the Water Legislation (Dam Safety and Water Supply Enhancement) and Other Legislation Amendment Act 2012. The amendments addressed findings and recommendations in the Final Report of the QFCoI. Prior to the amending legislation, there were no clear criteria for the government to assess the adequacy of a flood mitigation manual submitted for approval.

The importance of the objectives is supported by the amending legislation which introduced a prescribed process for the dam owner to seek the regulator's approval for an alternative procedure during flood events. An alternative procedure may be developed and approved to respond effectively to the particular circumstances of a flood event if an operational strategy and procedure in the flood mitigation manual is inadequate to meet all or one of the stated objectives for flood mitigation.

The Flood Manual for North Pine Dam states the objectives for flood mitigation as follows and in order of importance:

1. ensure the structural safety of North Pine Dam
2. minimise disruption to the community in areas downstream of North Pine Dam
3. retain North Pine Dam near FSL at the conclusion of a flood event
4. minimise impacts to riparian flora and fauna during the drain down phase of a flood event.

The strategies in the Flood Manual place paramount importance on the structural safety of the dam aiming to protect the population at risk to the maximum extent practicable against flood hazards, recognising that flood forecasting involves estimation and judgment as there are limitations on the:

- accuracy of forecasts of rainfall during flood events
- accuracy of estimated flood run-off within the Pine River catchment
- capability to identify all potential flood hazards and their likelihood
- capability to remove or reduce community vulnerability to flood hazards.

### **3.8.1 Ensure the structural safety of North Pine Dam**

This objective relates to dam safety obligations. The structural safety of the dam is paramount as the failure of the dam would have catastrophic consequences with an extreme risk to human life and safety. Further, the failure of a dam will adversely and directly impact on all of the lower objectives and statutory criteria for the Flood Manual. A failure of the dam will also cause major property damage and disruption to the downstream community, disrupt transport, prevent the dam from returning to its FSV for water security and cause adverse environmental impacts (river banks and riparian vegetation and fauna).

### **3.8.2 Minimise disruption to the community in areas downstream of North Pine Dam**

Minimising downstream disruption is primarily directed towards downstream transport and inundation of community infrastructure (e.g. parks). Given North Pine Dam was not designed as a flood mitigation dam; there is only limited opportunity to retain flood water above FSL to mitigate a flood event for the purposes of minimising risk to property. Whether or not North Pine Dam may be operated as a flood mitigation dam is discussed elsewhere in this report.

### **3.8.3 Retain North Pine Dam near full supply level at the conclusion of a flood event**

This objective recognises the water supply role of North Pine Dam and implements a relevant statutory criterion. This objective directly impacts on the ability of the dam owner to undertake advance releases in response to forecasts for imminent and substantial rainfall. If advance releases are undertaken and forecasts rainfall does not eventuate, there is a real risk the dam may not return to its FSL at the conclusion of a flood event. The issue of advance releases in response to short term forecasts is separate to the issue of declarations of temporary FSLs based on seasonal forecasts.

### **3.8.4 Minimise impacts to riparian flora and fauna during the drain down phase of a flood event**

Near the conclusion of a flood event, consideration is given to minimising the impacts on riparian flora and fauna. Bank slumping is relevant to this objective but not expressly stated. The issue of bank slumping is discussed Chapter 13.

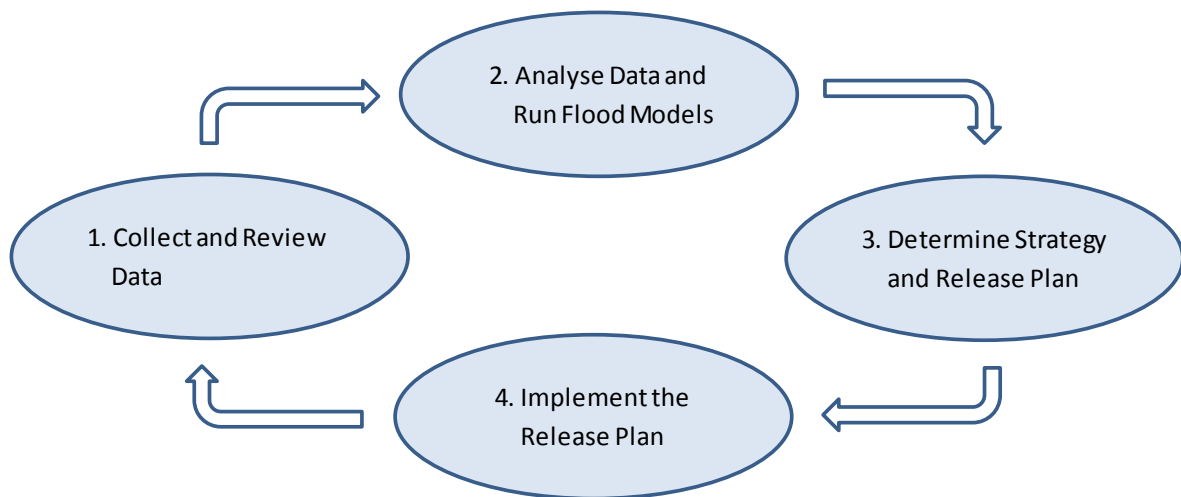
## **3.9 Flood event management**

Flood events that impact North Pine Dam are caused by rainfall events that vary in intensity, duration and distribution over a catchment area of 345 km<sup>2</sup> above the dam. During flood events, decisions regarding dam releases are based on the rainfall occurring in the dam's catchment area and the resulting inflow into the dam.

BoM rainfall forecasts for the dam's catchment area assist Seqwater in making operational decisions during flood events. These forecasts are derived using the best available meteorological practice; however, they are not sufficiently accurate to be used as the basis for making flood water releases from the dam. Currently, a degree of uncertainty exists in all weather forecasts (particularly quantitative rainfall forecasts), and the longer the forecast lead times, the higher the degree of uncertainty in the forecast.

Significant inflows into the dam can occur within two hours after heavy rainfall begins in the catchment area. Thus, the time available to prepare for large outflows can be limited. Because the Pine Rivers Basin responds to rainfall within six hours, BoM classifies flooding in the Pine River as 'flash flooding'. BoM does not issue specific flood warnings for the Pine Rivers; however, the region is covered by generalised regional flood warnings and severe weather warnings.

Flood operations for North Pine Dam are conducted in an iterative manner. Development of a Release Plan is undertaken at regular intervals. To develop a Release Plan, a number of steps are taken, as illustrated in Figure 3.4.



**Figure 3.4** Developing a flood release plan

Steps 1 and 2 are performed using the Flood Forecasting System (FFS). Steps 3 and 4 are performed using the procedures described in the Flood Manual and professional engineering judgment.

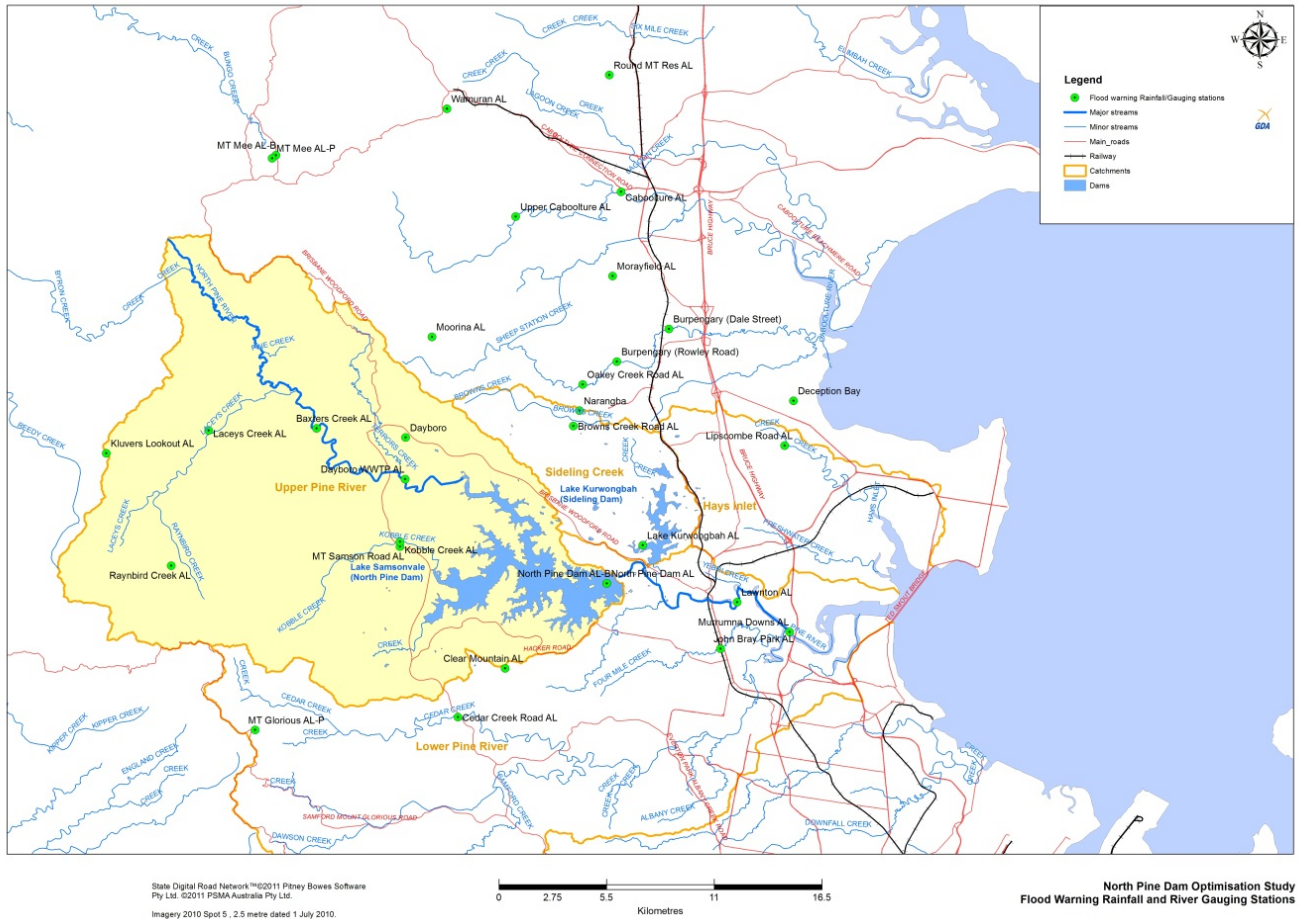
The Flood Forecasting System (FFS) is a suite of tools comprising the following:

- Data collection – real-time rainfall and stream height (including lake level) data from stations located throughout the North Pine Dam catchment and areas downstream transmitted to the Flood Operations Centre via the Event Reporting Radio Telemetry System for input into the stream flow prediction component. The data collection runs continuously and can output data to the stream flow prediction component at any selected point in time.
- Stream flow prediction – stream flow hydrographs generated from the rainfall data using validated catchment models covering the dam catchment and areas downstream. The models are run at discrete times selected by the duty flood operations engineer(s), based on how rainfall is occurring in the Pine River basin and may include rainfall predictions within the modelling. The output from the stream flow prediction component is used in the dam outflow modelling component.

- Dam outflow modelling – predicted lake levels, based on inflows determined from the stream flow prediction component, enable the duty flood operations engineer(s) to calibrate the flow hydrographs from the stream flow prediction component and to investigate a range of gate operating strategies to determine the most appropriate strategy to use at any point in time. The graphical outputs that are used to evaluate potential gate operations strategies include:
  - inflows and outflows to and from the dam
  - actual and modelled lake levels in the dam
  - actual and modelled Pine River flows.

To protect the structural safety of the dam, the Flood Manual dictates the strategy to be used to operate the dam during flood events is to pass any flood water through the reservoir ensuring peak outflow does not generally exceed peak inflow.

The rainfall and stream height gauges within the North Pine Dam catchment area and downstream areas that provide real-time data to the Flood Operations Centre are shown on Figure 3.5.



**Figure 3.5** Rainfall and stream height gauges

### 3.10 Recent revisions of the Flood Manual

The Flood Manual for North Pine Dam that was in force at the time of the January 2011 flood event was Revision 5 approved by gazette notice dated 17 December 2010.

Revision 5 provided the following guidance on managing floods:

- Flood releases should not commence until the lake level has exceeded EL 39.65 mAHD (i.e. 50 mm above FSL).
- Outflows from the dam should not generally exceed inflows.

The Flood Manual included a schedule of gate openings based on lake level to achieve the objectives of reducing the peak flow and emptying the stored floodwaters as quickly as possible. In order to minimise the adverse impacts on the river system, radial gate operations were carried out at the minimum time intervals based on lake level, as follows:

- 15 minutes when lake level is below EL 39.9 mAHD
- 10 minutes when lake level is between EL 39.9 mAHD and EL 40.5 mAHD
- 5 minutes when the lake level exceeds EL 40.5 mAHD.

The time intervals could be reduced if the gates were at risk of overtopping or the safety of the dam was at risk. Gate operations were generally not to fall more than 3 openings behind the schedule listed in the Flood Manual. The schedule required that all gates be fully open when the lake level rises to EL 41.395 mAHD.

The January 2011 flood event greatly exceeded the previous floods in North Pine Dam and presented some challenges in the implementation of the gate operation schedule. Between 8.00 am and 1.00 pm on the 11 January a total of 72 gate operations were made as the lake level rapidly rose 1.07 metres from EL 39.96 mAHD to EL 41.03 mAHD, before eventually peaking at EL 41.11 mAHD at 2:00pm. The minimum interval between gate operations during that period was 3.5 minutes, significantly less than the 5 minutes target interval given in the Flood Manual. The inflow and flood release data presented in the flood event report (Seqwater 2011a) shows that the gate openings were five increments behind the schedule at 12:00pm, triggering 15 operations within the following hour.

Following the January 2011 event, gate controls have been provided at the bridge deck level to provide safer working conditions during flood operations.

In order to reduce the probability of overtopping of the dam and to prevent water spilling around the sides of the gates onto the support piers and access walkways, the operations were changed in Revision 6 to ensure that the gates are fully open when the lake level rises to EL 40.7 mAHD, approximately 0.6 m below the level in the Revision 5 Flood Manual. The changes in the Flood Manual since the January 2011 event are discussed below.

The Flood Manual has been revised three times since the January 2011 flood event. Revision 6 was approved by gazette notice dated 11 October 2011 with the Revision 7 Flood Manual approved by gazette notice dated 31 October 2012. The differences between Revisions 6 and 7 are mainly changes in administrative detail and do not affect actual flood operations.

The changes introduced in Revision 6 have addressed dam safety issues identified following the January 2011 flood, administrative changes and address QFCol Interim Report Recommendation 2.25 requiring a review of the Flood Manual prior to the commencement of the 2011–12 wet season.

The principal changes to the Flood Manual from Revision 5 were:

- larger openings per gate operation (a single gate operation is now allowed to cover multiple gate increments – up to 3 increments per operation).
- faster gate operations (for a given lake level, the number of openings per gate is larger).
- flood releases commence once the FSL of EL39.6 mAHD is exceeded.
- establishment of 'small' and 'large' flood strategies.

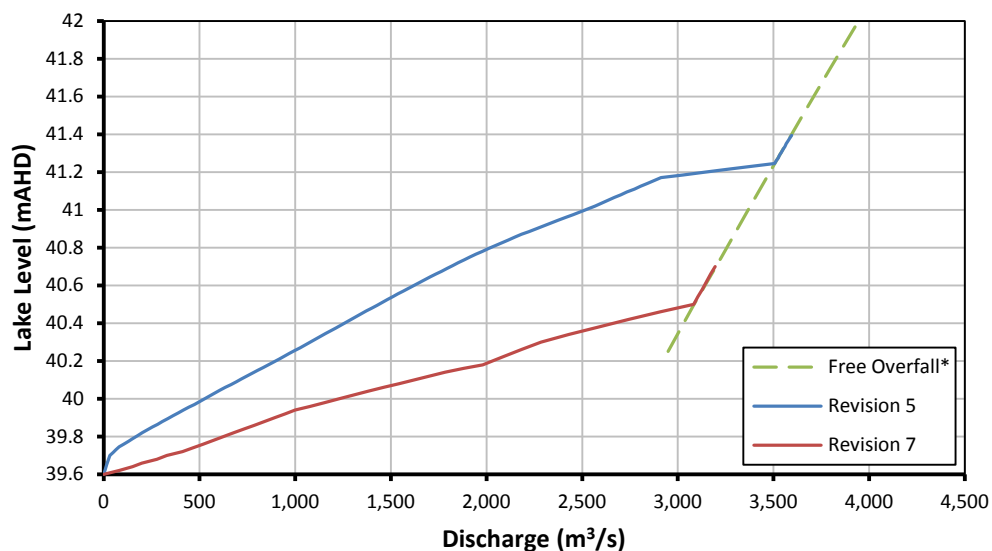
A 'small' flood will not threaten the safety of the dam and is defined as one for which the predicted peak inflow is less than 500 m<sup>3</sup>/s and the predicted lake level is less than EL 39.8 mAHD. 'Large' floods have predicted peak inflows equal to or greater than 500 m<sup>3</sup>/s or the predicted lake levels equal to or above EL 39.8 mAHD and have the potential to pose a risk to the safety of the dam.

The management of a 'small' flood is focused on minimising the adverse impacts on downstream areas whilst still protecting the safety of the dam should the flood transition from a 'small' flood to a 'large' flood. The management of a 'large' flood is focused on passing the flood through the dam as quickly as possible while ensuring that the peak outflow does not exceed the peak inflow.

The changes to faster openings at lower lake levels and the adoption of EL 39.8 mAHD as a critical lake level for dam safety considerations have been reflected in the target minimum opening and closing intervals as summarised below:

- 15 minutes when lake level is below EL 39.8 mAHD
- 10 minutes when lake level is between EL 39.8 mAHD and EL 40.1 mAHD
- No minimum when the lake level exceeds EL 40.1 mAHD.

A radial gate operation is defined as an individual movement of a single radial gate and may exceed one increment. The inclusion of multiple gate increments for a single gate into a single gate operation has reduced the number of gate operations required from the fully closed to all five gates being fully open from 115 to 42. The stage-discharge rating curves under Revision 5 and Revision 7 of the Flood Manuals are compared on Figure 3.6.



Note: \* Free overfall refers to the spillway discharge with all five radial gates in the fully open position

**Figure 3.6 North Pine Dam spillway outflow (total discharge from all five radial gates)**

A further revision, Revision 8, of the Flood Manual for North Pine Dam was gazetted on 19 December 2013. This revision has been necessitated by changes to the Act and reflects changes in the format and content of the Flood Manual as required by the Act as well as designating the Minister for Energy and Water Supply as the person to approve the Flood Manual. This latter change was in direct response to QFCoI Final Report recommendation 17.10.

The gate operating table remains unchanged from Revisions 6 and 7. The principal changes to the Flood Manual as a result of the recent Revision 8 are:

- simplification and clearer guidance on the adoption of flood management strategies
- clear and specific guidance on the flood management strategies to be adopted at the tail end of a flood event (i.e. the drain down phase of discharging the stored floodwaters above FSL)
- inclusion of the AJ Wyllie bridges at Gympie Road as a specific consideration of the flood management strategies
- the inclusion of a section dealing specifically with procedures relating to the declaration of temporary FSLs under the Act.

This latter point is important because it formalised in the Flood Manual the ability to operate the dam at lower lake levels other than the FSL (EL 39.6 mAHD). Revision 7 of the Flood Manual did not refer to operations in relation to temporary FSLs although temporary FSLs legislation has been in force since late 2011. Under the Moreton ROP, it had previously been necessary to make separate additional administrative arrangements, including the approval by the Department of Natural Resources and Mines (DNRM) of an interim program, to facilitate the declaration of a temporary FSL.

The Revision 8 Flood Manual limits the opening across all radial gates to no more than 1500 mm within 30 minutes if the safety of the dam is not threatened in place of the target minimum time intervals listed previously. An opening of 1500 mm is equivalent to 5 normal gate opening increments after initial gate opening, yielding a nominal time interval of 6 minutes between gate increments. The opening may be increased if necessary to protect the safety of the dam or to reduce downstream flood impacts.

### **3.11 Flood warnings**

BoM operates a flood warning system for the Pine Rivers, in conjunction with Seqwater and MBRC. The flood warning system collects real-time rainfall and river height information via telemetry from a network of gauges distributed throughout the Pine Rivers basin and shown on Figure 3.5. The rainfall and river height data is transmitted to a base station computer located in the MBRC office at Strathpine and is forwarded to BoM and Seqwater.

The MBRC base station computer collects and processes the data for display in graphical and tabular formats.

The flood warning process is discussed in more detail in Chapter 9.

Where possible, prior to releases from the radial gates commencing, the Duty Flood Operations Engineer must ensure that MBRC has been advised of the commencement of the flood releases.

## Chapter 4 – Understanding the issues and challenges

North Pine Dam was designed and constructed as a water supply storage for the northern suburbs of Brisbane and Moreton Bay Region. The dam was not intended to provide flood mitigation benefits for occupants downstream of the dam on the lower Pine Rivers floodplains.

This chapter identifies the key issues and challenges in addressing the QFCoI Final Report recommendations, namely:

- developing and implementing a range of operational strategy options and prioritising the differing objectives for the operation of the dam; and
- determining whether or not North Pine Dam should be operated as a flood mitigation dam.

The key issues and challenges discussed below provide the basis for preparing this report and demonstrating that the QFCoI recommendations have been addressed. They relate to:

- the scope of the main recommendations and related recommendations (refer Tables 1.1 and 1.2 in Chapter 1); and
- flood operations of the dam.

### 4.1 Scoping the QFCoI Final Report recommendations

The following sections scope the QFCoI Final Report recommendations.

#### 4.1.1 Wide range of operational strategy options

Implementing recommendation 17.3 requires consideration of a wide range of operational strategy options which prioritise differing objectives. Chapter 6 titled 'Operational Strategy Options' outlines a range of operational alternatives and options for mitigating flooding downstream of the dam. These are operational options that require no new infrastructure to be constructed (i.e. seeking to make better use of existing infrastructure).

Strategies that are not covered in this study include:

- infrastructure related options to enable flood storage to be increased (e.g. raising of North Pine Dam or increasing the capacity of the SEQ water supply system so that the water levels in the dam may be lowered without compromising water supply security)
- local planning and development and other initiatives to mitigate flood impacts.

The idea of assessing the operational options is to determine whether the existing infrastructure can be operated better without causing unnecessary expense to the community. Investigation of infrastructure options could occur if a business case exists.

MBRC and BCC currently implement local planning and development initiatives aimed at limiting community exposure to flood impacts (refer Chapter 16).

### 4.1.2 Prioritising differing objectives

The dam was not designed to provide flood mitigation for the urbanised areas downstream. Consequently, operation of the dam during flood events is focused primarily on safety of the dam and water supply security. Current operations also seek to:

- minimise disruption to the community in areas downstream of the dam
- minimise impacts to riparian flora and fauna during the shutdown phase of flood releases.

The QFCoI identified that the operational strategy options should be determined by considering the implications over a range of flood events for at least:

- inundation of urban and rural areas
- water supply security
- dam safety
- submerging of bridges
- bank slumping and erosion
- riparian fauna and flora.

Given the population at risk in a dam failure event is estimated to be in the order of 15,600 people, it is appropriate to retain the structural safety of the dam as the paramount objective (refer Chapter 8). Disruption to the community in areas downstream of the dam during floods encompasses flood inundation impacts and inconvenience caused by the closure of bridges and crossings.

This study includes discussion on providing more flexibility in regard to the level that must be retained at the conclusion of a flood event (refer Chapter 16) with a view to improving flood mitigation outcomes. This flexibility would enable advance releases to be made in circumstances where the flood producing potential of an imminent flood event is in the rare or extreme category. As is discussed in Chapter 11, the water supply implications of not returning to the FSL of the dam are small providing the reduction in the FSL is small.

Implementation of any options in this report that require new or amended objectives that are not directly consistent with the statutory criteria will require legislative amendment.

The minimisation of bank slumping and erosion impacts is omitted from the existing primary objectives, although these could be considered under the objective to minimise impacts to riparian flora and fauna.

Local residents raised concerns about the effectiveness of flood warning systems (refer 4.2.2 below). Given the proximity of the dam to downstream houses and residents and the fact that flash flooding can occur in the North Pine Dam catchment area, this study includes consideration of the flood warning issue (refer Chapter 9).

### 4.1.3 Operating as a flood mitigation dam

Recommendation 17.9 requires that consideration of whether North Pine Dam should be operated as a flood mitigation dam as part of the longer term review of the Flood Manual (refer Chapter 16).

A range of possible lowered FSLs has been investigated to provide flood storage to enable the dam to be operated as a flood mitigation dam.

The temporary FSL that was declared in 2013 provided increased storage for flood operations during the January, February and March 2013 floods. This increased storage provided the flood engineers with increased flexibility to manage releases to meet the objectives of the Flood Manual in those events. It permitted releases to maintain the level of the dam near the temporary FSL to be made overnight thus limiting traffic impacts on the downstream community.

#### **4.1.4 Exercising discretion**

Recommendation 17.4 states Seqwater should, in creating new North Pine flood mitigation manuals, comprehensively consider ‘the amount of discretion that is able to be exercised by the flood engineers and the senior flood engineers, and the description of the circumstances in which such discretion may be exercised’.

This aspect of recommendation 17.4 related to the use of professional judgement in making Flood Manual operational decisions. Such decisions include, among other matters:

- the use of rainfall and stream flow data
- forecasts or predictions about likely rainfall, dam levels and potential flooding
- responding to incidents or events such as unexpected inflows, dam safety risks, issues with the operation of the gates, and
- engagement with appropriate authorities on matters such as bridge submergence and other impacts.

Such judgements and associated requirements are outlined in the Revision 8 Flood Manual. The main issue is that professional judgement should be based on some reference to objective criteria or evidence leading to a conclusion.

The Flood Manual now includes a section outlining the process that must be adopted and authorisations required on the rare occasions when it may be necessary to implement alternative procedures to achieve flood mitigation objectives.

#### **4.1.5 Releases in advance of an imminent flood and during a flood**

Recommendation 17.4 states Seqwater should, in creating new North Pine flood mitigation manuals, comprehensively consider ‘the circumstances in which it might be appropriate to release water in advance of an impending flood on the basis of forecasts from BoM.

Under Part 3 of the Act, the Minister for Energy and Water Supply may declare temporary FSLs to mitigate flood or drought. Such decisions are made in the public interest having regard to meteorological forecasts and advice obtained on the extent to which the proposed temporary FSL is likely to mitigate the impacts of a potential flood or drought, the impact on water supply security of the dam and dam safety, and possible other public safety, environmental, social and economic impacts.

Declaring a temporary FSL for a dam is a pre-season (or early in the season) decision to mitigate the impacts of a potential flood or drought rather than a response to a potential imminent flood event which is managed by the dam operator under an approved flood mitigation manual. The process for seasonal declarations of a temporary FSL is now well established and it is not proposed to review it.

Seqwater receives forecast rainfall from BoM for consideration in estimating the potential timing and magnitude of flood flows in various catchments. These forecasts can be used in model runs to assist in managing flood events and providing extended projections. The uncertainty of forecast rainfall in terms of spatial and temporal distributions is recognised. The predictability of forecast rainfall will vary from event to event and may depend upon the nature of the underlying synoptic conditions causing or likely to cause the rainfall. Generally, the longer the forecast lead times, the higher the degree of uncertainty in the forecast.

Advice received from BoM (BoM 2013 pers. comm., 30 August), stated that *'it's clear that further work is required to fully explore the use of rainfall information for dam management'* and stated that *'on some occasions, the 7 day rainfall forecast may provide some indication of the flood-producing potential of systems but models cannot be relied upon to capture the development of every rainfall event at that timescale.'*

In such circumstances, it is proposed that the issue of releases in advance of an imminent flood or during a flood and the development of objective standards be progressed subsequent to NPDOS because of the complexity and timelines required to develop processes that would be accepted and receive industry support.

A key issue for the dam owner is the consequences of flood release decisions relying on forecast rainfall that does not eventuate. The future work identified in this study will need to consider when a dam owner should or may be permitted to rely on uncertain rainfall forecasts and the protection from liability, especially for the flood operations engineers when using such information.

#### **4.1.6 Setting objective standards**

Recommendation 17.5 states 'the conditions for the use of a particular strategy in all flood mitigation manuals should reflect objective standards.' Appropriate objective standards exist in the Flood Manual for most dam operations. Sections 4.1.4 and 4.1.5 indicate that the setting of objective standards relating to advance releases prior to an imminent flood or during a flood event requires considerable research and development.

## **4.2 Dam operations**

The Pine Rivers catchment (refer Chapter 2, Figure 2.1) is susceptible to episodes of rapid flooding which can cause significant damage to public and private property throughout the catchment.

### **4.2.1 Dam safety**

Failure of North Pine Dam could potentially have catastrophic consequences due to the magnitude of flood damage that could be caused downstream, and also due to the loss of a regional water supply source.

The most likely cause of dam failure is overtopping. The dam consists of a mass concrete section, and earthen embankment sections. The concrete section can withstand limited overtopping without damage. The embankment sections on the other hand are likely to 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 depends primarily on the proper operation of the spillway gates, which are used to control flood release and minimise lake level rises. Gate operation relies on the proper functioning of the mechanical hoist mechanisms and their electric power supply and controls.

Under the Flood Manual's current operating rules, North Pine Dam is expected to be overtopped and possibly fail during floods having probabilities less than approximately 1 in 200,000 to 600,000 depending of the nature of the event and dam operations at the time. The electric motors for the gate machinery are potentially submerged in events having probabilities less than approximately 1 in 50,000. This highlights the importance of maintaining the dam's safety by ensuring that floods are passed without the lake rising to unacceptable levels.

DEWS (2013b) *Guidelines on Acceptable Flood Capacity for Water Dams* (AFC Guidelines) specifies the flood capacity that all proposed and existing referable dams in Queensland<sup>2</sup> must be able to safely pass. In 2012 a report, *North Pine Dam Acceptable Flood Capacity Report* (URS 2012) was prepared for Seqwater. It was assessed that approximately 63% of the PMF can be passed by the dam spillway before overtopping of the dam crest occurs. This places North Pine Dam in Tranche 2 (refer Chapter 8, Table 8.1) under which it is proposed that a flood capacity upgrade would be required by 2025.

North Pine Dam with a population at risk estimated to be in the order of 15,600 people is classified as an 'Extreme' Hazard Category dam due to the population at risk being greater than 1,000 persons. The AFC for an Extreme Hazard Category dam is the PMF.

This study includes consideration of the reduced probability of overtopping associated with each of the operational strategy options analysed (refer Chapters 7 and 8).

#### 4.2.2 Flood warning

Seqwater ensures public safety remains a primary consideration when making flood water releases during flood events. Prior to releases being made, every attempt is made to ensure the appropriate authorities are provided with sufficient notice to allow communities to prepare for any dam outflows and to allow public roads to be closed prior to their inundation.

Depending on the nature of the rainfall event, catchment antecedent conditions and water levels in North Pine Dam, significant downstream flooding can occur within 6 to 12 hours of the commencement of rainfall. By the time that there is a realisation that the flood event is going to be large, several hours may have passed. This means that the people most likely to be affected by flooding will only have a short time to take action to ensure safety and mitigate potential personal flood impacts. The residents of Vores Road, Whiteside in Moreton Bay Regional Council and Wyampa Road, Bald Hills in Brisbane City are most likely to benefit from improved flood warning.

Given the shortness of times available to manage the flood risk for the residents immediately downstream of the dam, an effective flood warning system is desirable and appropriate measures need to be developed and implemented, where practicable.

Chapter 4 of the QFCol Interim Report includes a range of recommendations relevant to flood warning and Revision 8 of the Flood Manual recognises the role of Seqwater as the dam operator in establishing flood warning systems.

---

<sup>2</sup> Under the *Water Supply (Safety and Reliability) Act 2008* (QLD), referable dams are those assessed, using the DEWS Guidelines for Failure Impact Assessment of Water Dams (DERM 2010), as having a population at risk of two or more in the event of any potential failure of the dam.

QFCoI Interim Report recommendation 4.16 states that ‘dam operators should plan to contact people identified by their emergency action plans about dam outflow in sufficient time for them to be able to respond to the information’. Interim Report recommendation 4.18 suggests that dam operators should individually contact those whom it is essential to inform immediately.

The Flood Manual (Section 1.3 Role of Seqwater) states that Seqwater does not have responsibility for:

- forecasting flood levels along the Pine River during Flood Events
- interpreting forecast flood levels to provide local information on areas likely to be inundated or providing local flood warnings to residents (this being the responsibility of Local Government and the Local Disaster Management Group (LDMG)).

It is imperative that robust flood warning and communications be established via an emergency action plan required under the Act for the dam and the local disaster management plan required under the *Disaster Management Act 2003* (QLD). The implementation of these plans will need to be well integrated recognising the shortness of the available warning times and the population at risk (refer Chapter 9).

#### **4.2.3 Water supply security**

Under current operations, North Pine Dam contributes about 6% of the system yield and 10% of the total water supply storage available from the SEQ water supply system comprising some 12 dams and other storages.

Any change to the FSV of the dam will impact on the supply available from the dam. Such impacts may become more critical if the FSV of Wivenhoe Dam is also lowered for flood mitigation purposes.

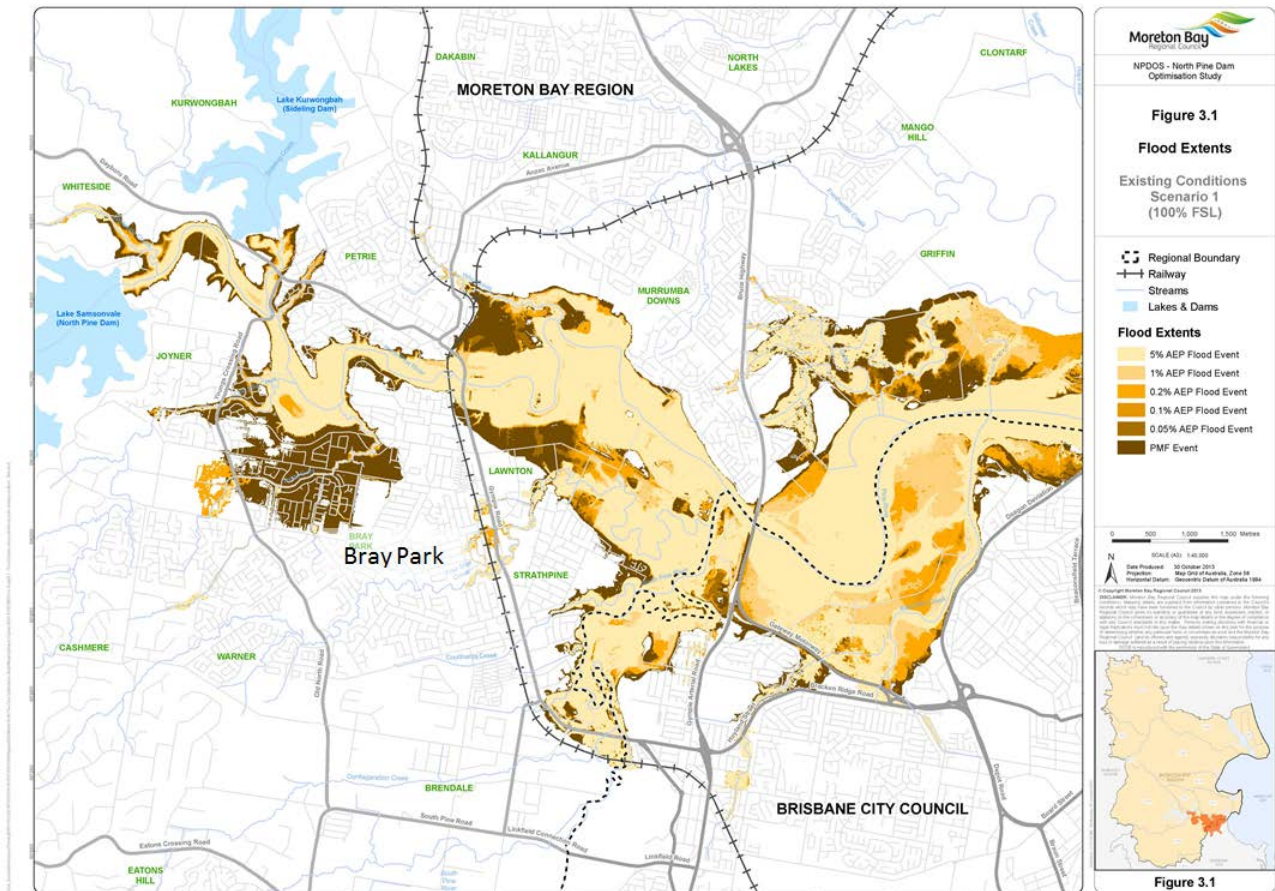
North Pine Dam, while not large, is strategically located to service the northern areas of the Brisbane City and Moreton Bay Regional Council areas and provide backup supplies to the Sunshine Coast.

By lowering the dam levels, there will be consequential (however small) impacts that increase the need to supply desalinated water from the GCDP when the total storage capacity in the SEQ water storages reduces to 60%, impose restrictions when the 40% threshold is reached, and potentially introduce other supplementary supplies (refer Chapter 11) at lower levels.

This study includes an assessment of costs associated with the lowering the FSL of the dam as part of an integrated assessment of all operational strategy options. Given the small contribution of the dam to the overall system yield, consideration has been given to providing more flexibility in application of the primary objective of retaining the dam near the FSL at the conclusion of the flood event. As described in Chapter 16, the aim of this is to provide more flexibility in the use of advance releases thus providing increased flood mitigation potential.

## 4.2.4 Urban inundation

The flood extents for design flood events, ranging from 5% (1 in 20) AEP to PMF under existing North Pine Dam operating conditions are shown in Figure 4.1.



Source: MBRC 2013a, Figure 3.1

**Figure 4.1** Flood extents under current conditions

The overall floodplain can be split into an upper and lower floodplain reach with the dividing line being located at the Petrie railway line just west of Gympie Road.

The upper floodplain reach is characterised by a relatively incised valley and well-defined flow paths with limited change in flood extent across a wide range of flood magnitudes. Significant change in flood extent only occurs under PMF conditions in the Bray Park area.

The lower floodplain reach (downstream of the railway) is much wider, typically ranging from 1500 m to almost 3000 m, with some further widening occurring to the north of the main channel into the low-lying areas around Griffin and wetlands immediately north of the Gateway Motorway.

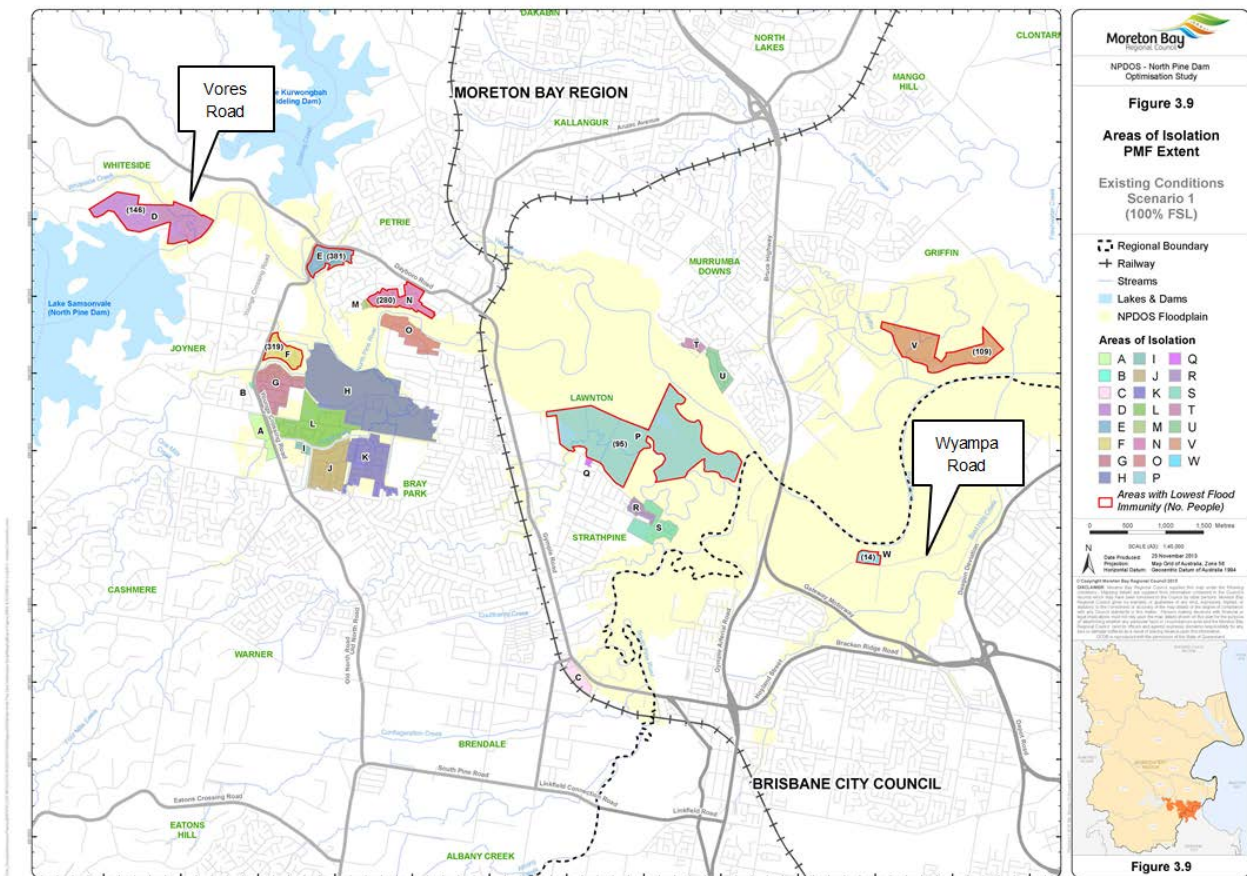
Aside from the main channel, flooding in the lower reach is relatively shallow and slow flowing, when compared to the upper floodplain reach. Due to the overall width of this part of the floodplain, small changes in flow rate do not significantly change the flood surface elevation. However because of the flat topography in the overbank area, some localised but substantial widening in flood extents can occur with increasing flood size.

MBRC has undertaken flood mitigation assessments as part of this study to quantify the benefits of lowering FSLs. This is outlined in Chapter 10. 2,336 residential buildings (dwellings) and 164 non-residential buildings and facility infrastructure located on properties within the floodplain have been assessed for above habitable floor flooding impacts.

#### 4.2.5 Road access and potential isolation

Figure 4.2 highlights potential areas of isolation under current conditions (PMF Event).

Chapter 10 discusses road access and potential isolation. The main areas of concern are Vores Road and Wyampa Road which experience regular flooding. All other areas have reliable road access that experiences infrequent flooding. While other roads may be inundated, the community generally has available alternative access routes for the short periods of inconvenience that may be experienced.



Source: MBRC 2013a, Figure 3.9

Figure 4.2 Potential areas of isolation under current conditions (PMF Event)

#### 4.2.6 Bridge and crossing submergence

The majority of the major road/railway crossings within the floodplain have very low likelihoods of flooding (i.e. the probability of these crossings being impacted by flooding is lower than 0.05% (1 in 2,000) AEP). Three major road crossings including Dayboro Road have a chance in the order of 1 in 500 of being flooded in any one year (0.2% AEP).

Gympie Road at the A.J. Wyllie Bridge is inundated when the flow in the North Pine River reaches approximately 1500m<sup>3</sup>/s.

Youngs Crossing has a very low flow capacity (approximately 10 m<sup>3</sup>/s) and a release from North Pine Dam using radial gates will inundate the crossing. Outflows from the spillway of Sideling Creek Dam (a separate catchment to North Pine Dam) can also impact Youngs Crossing. The Flood Manual allows releases from North Pine Dam to be timed to minimise disruptions to the local community caused by the inundation of Youngs Crossing on Youngs Crossing Road by outflows.

One aim of dam operations is to strike an appropriate balance between competing objectives and not prolong unnecessarily the submergence of bridges and public areas during floods and normal operations.

This study includes assessments of changes to flooding and road closure times associated with each of the operational strategy options investigated for the A.J. Wyllie bridges and Youngs Crossing (refer Chapters 7, 10 and 12).

#### **4.2.7 Bank slumping and erosion**

The minimisation of the impacts of bank slumping and erosion currently is not a priority objective under the Flood Manual.

Local residents have reported increased banks slumping and erosion since the January 2011 flood and claim that such impacts became more evident during the February March 2013 flood and as a result of night time releases from the dam, some of which were related to the lowering of dam levels to meet the requirements of temporary FSL declarations.

In recent times, releases have been made to initially reduce the lake level to a declared temporary FSL and then maintain storage levels after a flood event, at or close to the temporary FSL during the period of declaration. From the end of February 2013, the peak rate of release permitted for such operations was increased from 300 m<sup>3</sup>/s to 500 m<sup>3</sup>/s.

MBRC and local residents have sought a review of this release rate and the implementation of night time releases intended to minimise traffic disruption as part of this study. It is claimed that the higher release rates combined with night time releases (effectively pulse discharges) have exacerbated bank slumping and erosion. Bank slumping and erosion has been addressed in Chapter 13.

#### **4.2.8 Riparian flora and fauna**

Under current flood operations near the conclusion of a flood event, consideration is given to minimising the impacts on riparian flora and fauna. Strategies are implemented by Seqwater to minimise impacts, particularly to fish populations in the vicinity of the dam structures, provided such procedures do not adversely impact on other flood mitigation objectives. These strategies generally involve maintaining low flow releases during the final stage of shutdown for sufficient time to enable fish to return to the river from low-lying overbank areas as the water level drops.

There have been significant impacts on the flow regime in the Pine River with the construction of the dam and other water extractions reducing the mean annual flow at the river mouth to about 68% of total catchment inflows. The greatest impacts have been on the capturing of the smaller stream flows with larger floods being impacted to a lesser degree. The impacts on the flow regime in the river diminish the further downstream of North Pine Dam a location is and the closer it is to the river mouth. Whereas the North Pine River at Youngs Crossing was once a near perennial stream, it now has approximately 17% of the time when there is no flow.

Such impacts have been necessary to support development in SEQ and cannot be changed significantly through dam operational changes.

Releases of up to 500m<sup>3</sup>/s have been identified as potentially:

- causing scouring of the main river channel and anabranch inhibiting regrowth of seedlings in the low flow channel
- causing scouring of and cleansing of riffles and movement of sediment in pools
- providing flows which allow connectivity between the freshwater and estuarine habitat.

The impacts of releases on riparian vegetation, aquatic habitat and fish have been considered in Chapter 14 as part of this study to determine if better flow release strategies can be implemented.

#### **4.2.9 Drawdown**

Operations at North Pine Dam significantly reduced the impact on the downstream community in the February March 2013 event. The main benefit was the reduction in time that Youngs Crossing was inundated estimated to be almost a 40% reduction compared to the likely time of closure for the no dam case. In addition to this reduction in closure time, the targeting of releases in overnight periods further reduced the impact on the downstream community.

This reduction in impact was a product of the characteristics of the event and the method by which the dam was operated. The good predictions of heavy rainfall, the temporary FSL, the modest peak intensity, and the way the gates were operated all contributed to the good outcome achieved in this event.

These operational choices were possible due to the temporary flood storage associated with the declared temporary FSL. The benefits (i.e. reduced traffic disruption) of overnight releases have been compared to their impacts on downstream bank slumping and erosion as part of the integrated assessment in Chapter 15.

#### **4.2.10 Links to other planning**

As indicated in Section 4.2.3, the assessment of water supply impacts has close linkage to decisions about future full supply volumes in Wivenhoe Dam. Therefore it will be necessary to consider the outcomes of both the North Pine Dam Optimisation Study and the Wivenhoe and Somerset Dams Optimisation Study when ultimately making decisions about optimal operational strategies for dam operations and bulk water supply services.

Seqwater recently prepared a dam safety risk assessment for all dams in its portfolio.

This portfolio risk assessment, the SEQ level of service review by DEWS due in the latter half of 2014 and the subsequent water security program for SEQ to be prepared by Seqwater (anticipated in 2015) may all impact on the future operation of North Pine Dam.

## Chapter 5 – Project management

The overall responsibilities for NPDOS were assigned in the June 2012 Queensland Government's response (DPC 2012) to the QFCoI Final Report. Following this, significant restructuring was completed in SEQ resulting in the project management arrangement summarised in Figure 5.1.

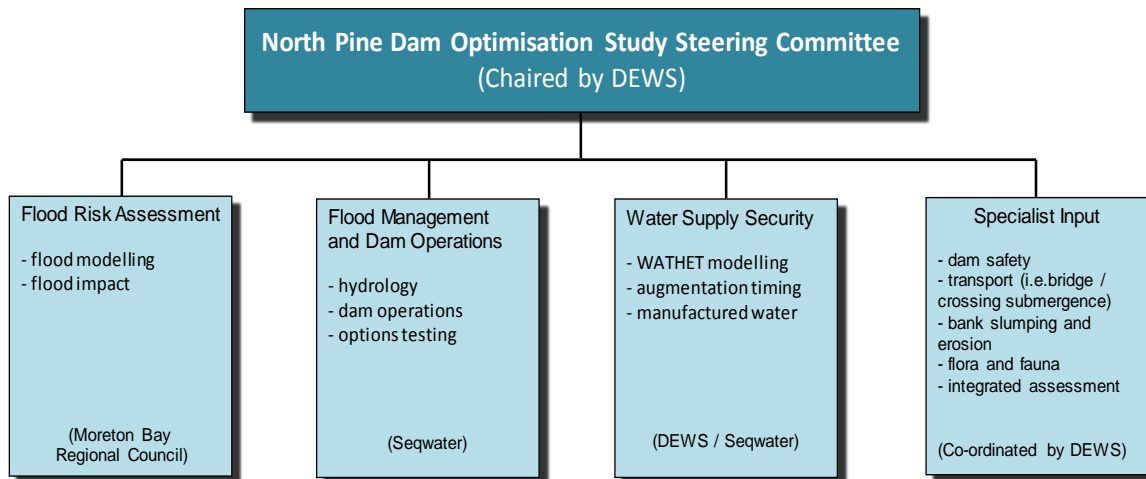


Figure 5.1 Project management arrangements

A project steering committee was established comprising representatives from Seqwater (the owner and operator of North Pine Dam), MBRC (the local government whose area is most affected), BCC (which also has affected areas), DEWS (as the project co-ordinator and agency responsible for the final NPDOS report to the Government) and other stakeholder agencies including DNRM, Department of State Development, Infrastructure and Planning and Queensland Treasury and Trade.

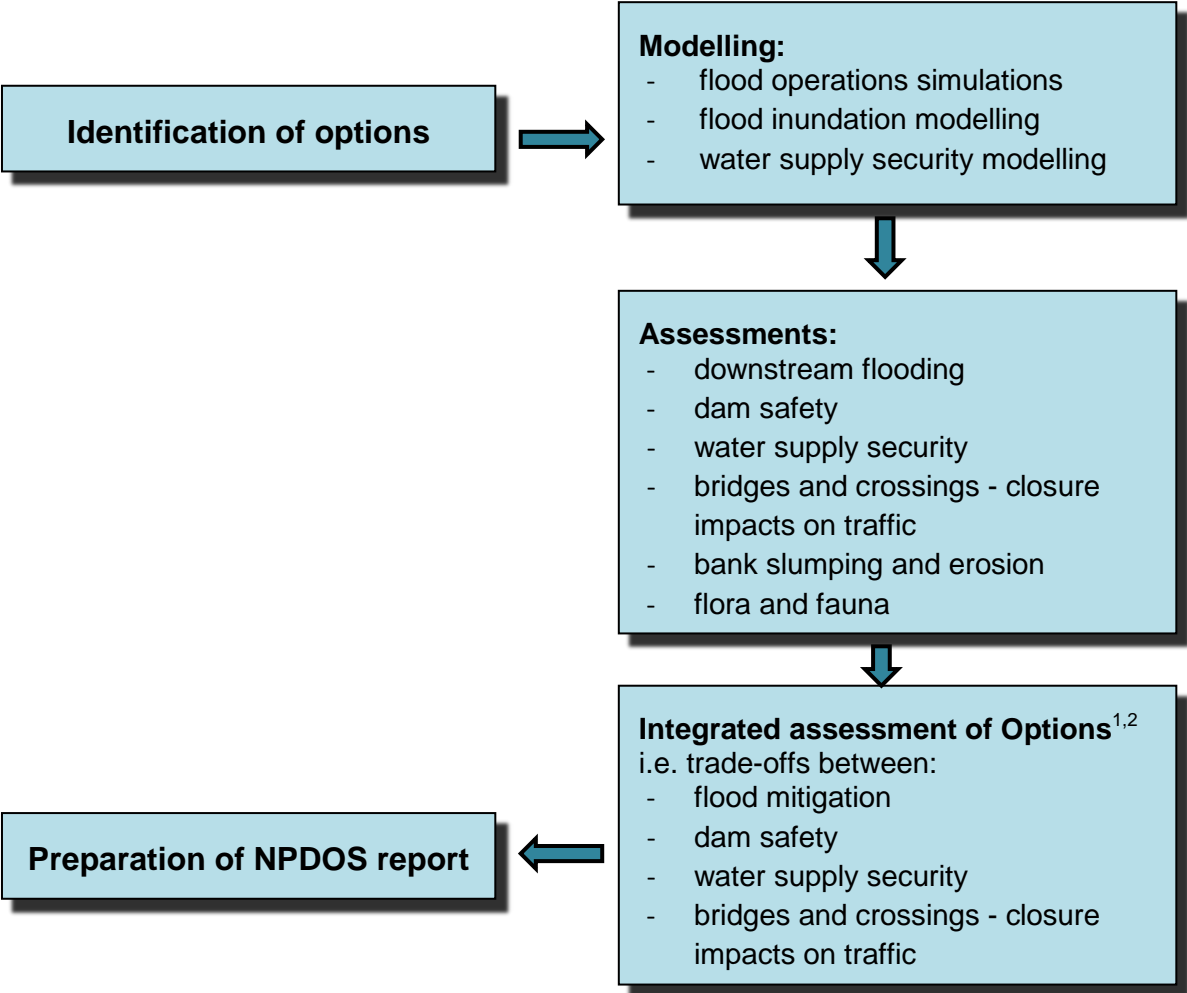
DEWS provided overall project coordination with major input from Seqwater and MBRC. DEWS also commissioned a number of specialist reports to fully address the terms of the QFCoI recommendations as follows:

- dam safety regulatory considerations were reported by DEWS
- bridge and crossing submergence impacts were addressed by MBRC and the DTMR
- bank slumping and erosion and flora and fauna was investigated by DSITIA
- integrated assessment of the operational strategy options was undertaken by consultants.

MBRC has undertaken the floodplain management investigation as part of its existing Regional Flood Database project and subsequently provided the necessary flood risk assessments for NPDOS.

Seqwater undertook the dam flood hydrology and operational strategy option assessments and also provided the water supply modelling capability to determine impacts on water supply security for the region.

NPDOS has been a multi-disciplinary exercise requiring the integration of a range of considerations that are affected by how the dam is operated. Figure 5.2 shows the general relationship between study components. The study has focused on optimising dam operations to provide flood mitigation benefits while balancing water supply security, social and environmental impacts.



Note:

1. The integrated assessment of operational options comprised a comparison of:
  - a. net present costs of tangible estimated flood damages and impacts along with brought forward water supply capital expenditure and operational costs
  - b. flood mitigation benefits, dam safety impacts, water supply security impacts and disruption to the community due to bridge and crossing submergence.
2. The integrated assessment of operational options did not include a comparison of bank slumping and erosion and flora and fauna impacts as the assessments undertaken did not identify any strategies for improved operations that could be used to distinguish between the operational options being investigated.

Figure 5.2 Study components

## Chapter 6 – Operational strategy options

Implementing QFCoI Final Report recommendation 17.3 requires consideration of a wide range of operational strategy options which prioritise differing objectives. Chapter 4, Section 4.1.1, explained that it is desirable to investigate whether or not the operation of the existing North Pine Dam can be improved before investing in infrastructure solutions to improve flood mitigation and dam safety.

This chapter outlines the operational alternatives and options investigated and the investigations undertaken to consider the implications of each option over a range of flood events. The implications considered include inundation of urban and rural areas, water supply security, dam safety, submerging of bridges, bank slumping and erosion and riparian fauna and flora.

### 6.1 Options considered

The options considered for assessment under NPDOS and the process for their selection are presented in the report North Pine Dam Optimisation Study – Addendum to the Options Discussion Paper (DEWS 2013a).

Four operational alternatives for operating North Pine Dam were assessed:

- Alternative 1 – Existing situation with the dam at FSL
- Alternative 2 – Lowered dam levels with flood release trigger at the current FSL
- Alternative 3 – Lowered dam levels and flood release trigger levels, and
- Alternative 4 – Gates lifted to the fully open position (i.e. no gate control).

The resulting operational options developed to evaluate these alternatives are summarised in Table 6.1.

**Table 6.1 Operational options**

Option	Dam Level		Flood Release Level		Description
	%FSV	mAHD	%FSV	mAHD	
1	100	39.60	100	39.60	Existing situation with the dam at its current full supply volume
2.1	85	38.04	100	39.60	Lower dam level to 85%FSV with the flood release level at 100% FSV
2.2	75	36.88	100	39.60	Lower dam level to 75%FSV with the flood release level at 100% FSV
2.3	42	32.004	100	39.60	Lower dam level to 42%FSV with the flood release level at 100%FSV
3.1	85	38.04	85	38.04	Dam level and flood release level lowered to 85% FSV
3.2	75	36.88	75	36.88	Dam level and flood release level lowered to 75% FSV
3.3	42	32.004	42	32.004	Dam level and flood release level lowered to 42% FSV
4 No Gates	42	32.004	42	32.004	Gates lifted to the fully open position (that is, no gate control)

The operational alternatives selected specifically address the principal QFCoI Final Report recommendations 17.3 and 17.9 and require no new infrastructure. Other flood mitigation and management strategies, including new infrastructure, planning controls and local solutions to mitigate the impacts of flooding have not been assessed under NPDS.

Operational alternatives 2 and 3 can be operated at the lowered dam levels either temporarily, permanently or semi-permanently to effectively create additional operational options. The hydrologic analysis for the temporary, permanent or semi-permanent does not change.

The upper bound for considerations is the existing FSL of EL 39.6 mAHD whilst the lower bound of EL 32.00 mAHD corresponds to the level of the fixed concrete crest of the dam. Facts about North Pine Dam at the different supply volumes are summarised in Table 6.2.

**Table 6.2 FSVs assessed**

Full Supply Volume (FSV) (%) <sup>1</sup>	Corresponding FSL (mAHD)	Level below FSL (m)	Level above fixed crest spillway level (m)	Additional flood storage volume <sup>2</sup> (ML)	Comments
100	39.60	n/a	7.60	0	Current situation
85	38.04	1.56	6.04	32,000	
75	36.88	2.72	4.88	54,000	
42	32.004	7.60	0.00	125,000	Fixed spillway crest level

Notes:

1. Percentage compared to the existing FSV.
2. Additional flood storage volume is the storage volume difference between the lowered FSL and the existing FSL of EL 39.6 mAHD

Options to raise the FSL were not considered because the reduction of the available flood storage would reduce the dam safety capability of North Pine Dam without a corresponding raising of the crest level of the dam wall and saddle dams.

### 6.1.1 Operating alternative 1 – existing situation

The existing situation is the base case adopted for the comparison of options. Flood operations have been assessed under the Revision 7 Flood Manual with the existing FSL of EL 39.6 mAHD. The opening and closing of the radial gates is based on the lake level with target minimum time intervals between individual radial gate operations that are based on lake level only. All gates are fully open when the lake level rises to EL 40.7 mAHD.

### 6.1.2 Operating alternative 2 – lowered dam level with flood release at FSL

Operational alternative 2 incorporates lowered dam levels but with retention of the existing flood release level of EL 39.6 mAHD for flood operations.

Under Option 2 the lake level would be drained down to the lowered FSL. With inflows to the dam, the lake level would be allowed to rise above the lowered FSL until such time as the existing flood release level of EL 39.6 mAHD was exceeded. At this point flood releases would commence. Releases would continue until the lake level is returned to the lowered FSL.

### **6.1.3 Operating alternative 3 – lowered dam and flood release levels**

Operational alternative 3 comprises a lowering of both the dam and flood release levels with the idea being to commence releases earlier with the intention being to lower the flood peak.

### **6.1.4 Operating alternative 4 – gates lifted to the fully open position**

In this alternative, the dam level would be lowered to the level of the existing fixed crest (EL 32.00 mAHD) with the gates locked in a fully open position to allow free flow over the spillway.

### **6.1.5 Modified gate operations**

Apart from the lowering of the lake level in the dam, the only other operational strategy to improve flood mitigation is to modify gate operations. Revisions 6 and 7 of the Flood Manual following the January 2011 flood increased the gate openings and the rate of gate opening to improve dam safety.

The limits to further changes in gate operations are the physical constraints of the gate machinery and not creating an unacceptable hazard to people downstream of the dam due to large sudden increases in flow rate.

There are multitudes of possible dam gate operating strategies associated with each of the operational options analysed. Sensitivity analyses were conducted for each operational option to illustrate the potential upper and lower bounds of mitigation benefits of alternative practical gate operating strategies.

These are discussed in Chapter 7, Section 7.3 'Dam operations modelling assessments' and Section 7.5 'Dam operations modelling results'.

## **6.2 Operational options assessment**

### **6.2.1 Reports prepared**

Figure 6.1 below shows the key investigations undertaken to consider the implications of each option over a range of flood events. These include:

- hydrologic studies to enable selection of a range of flood events for the assessment of the operational strategy options
- development of a gate operations model and assessment of the dam outflows and dam safety based on the selected flood events under the various operational strategy options
- flood studies to assess the extent of inundation downstream of the dam and associated flood risk assessment
- dam safety regulatory requirements
- water supply security assessments so that trade-off considerations between loss of water supply security and improvements in flood mitigation can be made
- assessment of the impacts of downstream bridge and crossing closures considering in particular the frequency and duration of the closures and the implications of traffic re-routing
- assessment of the bank slumping and erosion and riparian fauna and flora impacts
- flood warning needs
- integrated assessment.

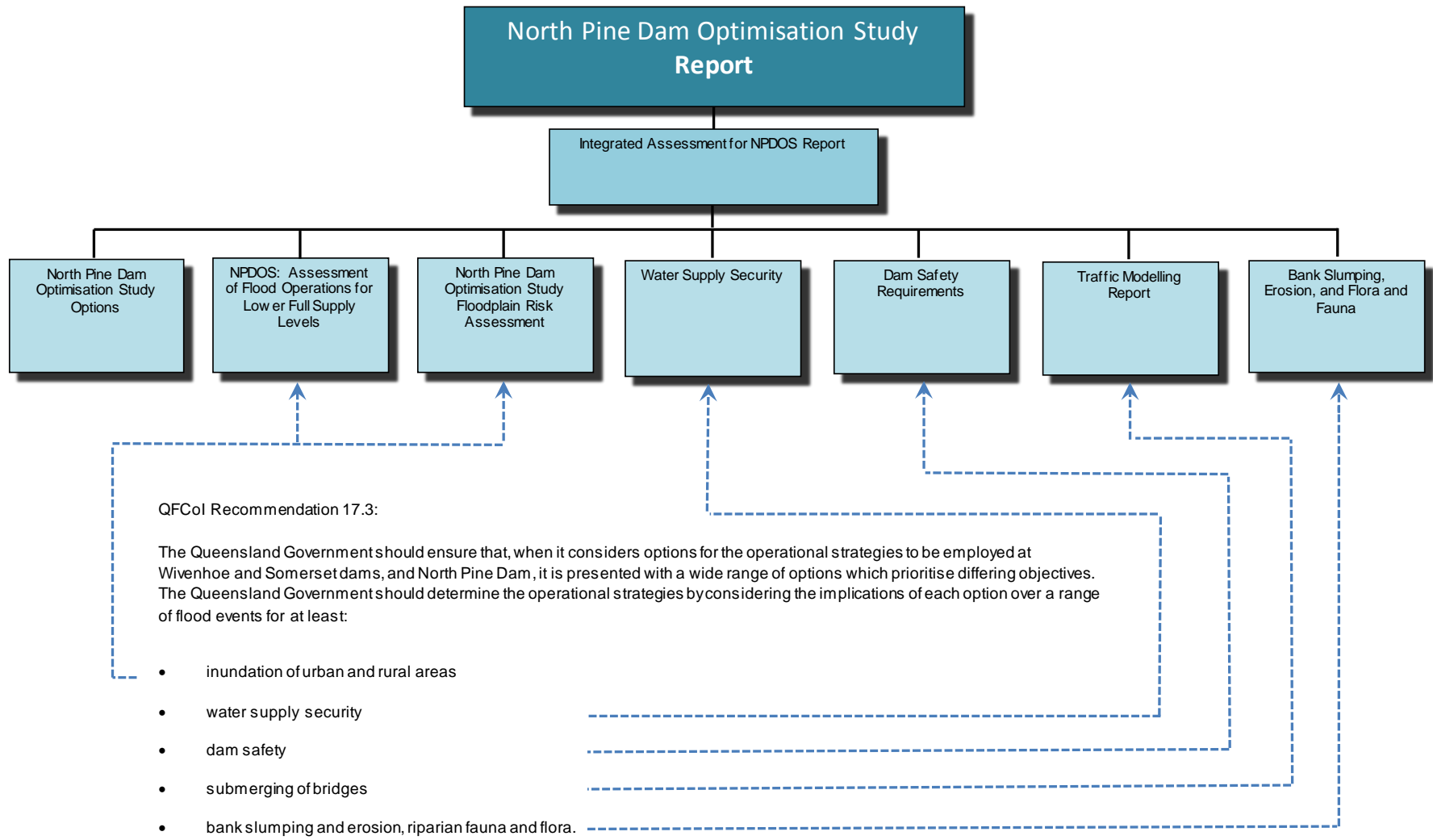


Figure 6.1 North Pine Dam Optimisation Study – key reports

## 6.2.2 Planning for the optimisation study

Planning for the optimisation study has recognised that every flood is different and progressed on the basis that:

- dam safety would not be reduced below current levels and would be increased if possible
- water supply security would not be adversely affected
- major flood impacts would be minimised to:
  - reduce flooding, isolation and damage of property and infrastructure, and
  - if practicable, to enhance timeframes for residents to respond to imminent flooding
- dam operations during minor and moderate inflows will minimise disruption to the community in downstream areas by managing releases in a way that:
  - seeks to reduce bank slumping and erosion and flora and fauna impacts, and
  - responsibly minimises traffic impacts associated with the closure of Youngs Crossing
- objective standards should provide the basis for the operation of the dam to achieve relatively predictable flood mitigation outcomes but that the dam operator should have sufficient discretion to optimise flood mitigation outcomes.

## Chapter 7 – Dam operations assessment

This chapter outlines the assessments undertaken of the operational options summarised in Table 6.1. Seqwater undertook the dam operations assessments and prepared a report titled *North Pine Dam Optimisation Study: Assessment of Flood Operations for Lower Full Supply Levels* (Seqwater 2013a).

Outputs of the dam operations modelling over a range of design and historical flood events include:

1. the dam outflows for incorporation into the flood modelling undertaken by MBRC
2. estimates of the AEP of the dam crest flood to enable consideration of the dam safety impacts
3. estimates of the flows causing disruption to the downstream community, and
4. estimates of the duration of road closures due to bridge and crossing submergence causing disruption to the downstream community.

The hydrology developed by MBRC specifically for the purposes of flood modelling has been adopted for assessment of dam outflows for flood modelling and the duration of road closures.

The hydrology developed by Seqwater for dam safety assessments has been adopted for the purposes of undertaking dam crest flood assessments.

The hydrologic assessments undertaken by MBRC and Seqwater have been shown to be similar apart from the adoption of different temporal rainfall patterns resulting in different shaped hydrographs but generally similar peaks.

### 7.1 Flood Manual operational strategy

At North Pine Dam, there is only one flood operations strategy. The operational procedures are broadly summarised below:

- When the predicted peak lake level is judged likely to be less than EL 39.75 mAHD, the aim is to keep the lake level as close as possible to the FSL while keeping releases below 500 m<sup>3</sup>/s. The radial gates may be opened for flood management purposes prior to the Lake Level exceeding FSL.
- When the predicted peak Lake Level is judged likely to be greater than EL 39.75 mAHD, the aim is to minimise the peak outflow from the dam.

In addition, operations aim to ensure that the safety of the dam is protected and also to minimise the adverse impacts of a flood event on downstream areas. Operational releases from North Pine Dam need to account for outflows from Lake Kurwongbah and other downstream tributary inflows if downstream flows are to be contained within a 'non-damaging' (limited impact) discharge currently assumed to be 500 m<sup>3</sup>/s.

All large floods begin as small floods and it is often not possible to predict the size of a flood accurately at the commencement of a flood event.

Operations during floods are highly dynamic and are dependent on a range of factors that may require professional judgement to be exercised by the flood operations engineers.

The modelling of operations is such that:

- all gates must be opened fully when the reservoir reaches EL 40.7 mAHD to meet dam safety objectives, and
- all gates are to be operated outside the transition zone between controlled orifice flow under the gate and free overfall flow over the spillway to avoid unstable flow through the gates that could damage the gates or supports.

## 7.2 Dam operations simulation model

A dynamic simulation hydrologic model was developed using GoldSim software to simulate flood routing through North Pine Dam for a range of historical and design flood inflow hydrographs. GoldSim is a multi-purpose simulation software package that can be used for dynamic modelling of complex systems in business, engineering and science applications.

The inputs to the GoldSim model comprised:

- inflow hydrographs
- starting dam water levels, and
- gate operating tables.

The outputs from the GoldSim model are time series hydrographs for:

- modelled water levels, and
- modelled outflows (gate outflows and crest overflows).

The modelling was undertaken using a 'level pool' water balance routing of inflows through the dam to determine lake water levels and outflows. The model incorporated 'lookup' tables of reservoir level, storage relationships, gate settings and gate outflow relationships from the Flood Manual with appropriate adjustments for lowered dam level scenarios to provide the necessary information to carry out the flood routing simulations.

To ensure robustness of the GoldSim model, outputs were verified against results obtained from the 'Gate Operations Spreadsheet' that is used in the Seqwater Flood Operations Centre during events in real-time to route modelled inflows through North Pine Dam.

The flood modelling was undertaken for comparative purposes only and do not include the benefits of discretionary decisions that can be made in actual flood events by the duty flood operations engineers during actual flood events. The standardised gate operating strategies used for this assessment may be varied during operations in a flood event to reflect actual and predicted inflows to the dam.

## 7.3 Dam operations modelling assessments

### 7.3.1 Options

Dam operations assessments were completed for the operational options outlined in Table 6.1 and included some gate operations sensitivity assessments to settle on operating procedures to be adopted for the comparison of the operational options. These are summarised in Table 7.1.

The flood modelling was undertaken by Seqwater for seven options that combined various combinations of dam levels and flood release levels. Additionally, the 'No gates' option was run to simulate free overfall flood discharge for the dam lowered to 42% of the FSV.

Operating the dam lowered to 42% of the FSV with the gates fully open provides the greatest increase in dam safety as both the flood storage and total dam outflows are maximised due to free overfall over the spillway.

Assessments have been based on gate operations in accordance with the Flood Manual with appropriate adjustments where necessary.

There are multitudes of possible dam gate operating strategies associated with each of the operational options analysed. Hence sensitivity analyses of the gate operating options (refer options prefixed with 'SA' in Table 7.1) were undertaken to model an upper and lower bounds of the mitigation benefit that was considered practicable.

**Table 7.1: Operational options and gate operations sensitivity assessments**

Option	Supply Volume		Flood Release Level		Operation
	% FSV	mAHD	% FSV	mAHD	
Option 1	100	39.60	100	39.60	Revision 7 Manual
SA100.2	100	39.60	100	39.60	Rapid initial gate opening
Option 2.1	85	38.04	100	39.60	Revision 7 Manual
Option 3.1	85	38.04	85	38.04	Gradual gate operation
SA85.2	85	38.04	85	38.04	Rapid initial gate opening
Option 2.2	75	36.88	100	39.60	Revision 7 Manual
Option 3.2	75	36.88	75	36.88	Gradual gate operation
SA75.2	75	36.88	75	36.88	Rapid initial gate opening
Option 2.3	42	32.004	100	39.6	Revision 7 Manual
Option 3.3	42	32.004	42	32.004	Gradual gate operation
SA42.2	42	32.004	42	32.004	Rapid initial gate opening
Option 4 No Gates	42	32.004	42	32.004	No gate control (i.e. gates fully open)

Option 1 represents existing operations for design FSV conditions and is the base case for comparison of options.

### 7.3.2 Sensitivity analyses of dam gate operating strategies

The sensitivity analyses (refer Section 7.5.1) of dam gate operating strategies comprised:

- uniform lake level rise based gradual rate of gate openings, and
- rapid initial openings of gates up to 500 m<sup>3</sup>/s outflow then similar to gradual gate operation.

The gradual and rapid initial gate opening strategies are considered to represent the upper and lower bound of practical gate operations.

The gradual rate of gate opening strategy uses a uniform lake level change gate operating table, adjusted for the corresponding lowered dam level of the option being investigated. This gate operating strategy aims to release water at a steadily increasing rate relative to rising dam water level. The gradual rate of gate opening strategy is slightly slower than the lake level based rates set out in the Revision 7 Flood Manual and results in some slight differences in peak discharge rates.

Above 500 m<sup>3</sup>/s outflow, the gate opening strategies for both the gradual and rapid opening of the gates are similar.

A flow of approximately 500 m<sup>3</sup>/s was assumed to be the threshold of limited impact flows downstream of the dam.

## 7.4 Flood events modelled

The flood events modelled are listed in Table 7.2. They were divided into three sub-sets:

- design flood events that were to be used in the risk assessment of flooding impacts downstream of North Pine Dam
- very large design flood events, including Probable Maximum Precipitation Design Flood (PMPDF) events for dam crest flood overtopping assessments, and
- significant historical flood events.

**Table 7.2: Flood events modelled**

Floodplain Risk Assessment Events		Dam Overtopping Assessment Events		Historical Events (in rank order of peak outflow)
MBRC Hydrology		Seqwater Hydrology		Seqwater Hydrology
AEP	Storm Duration (hr)	AEP	Storm Duration (hr)	
1 in 20	12	1 in 500,000	12, 18, 24, 36, 48, 72	January 2011
1 in 100	12	1 in 600,000	12, 18, 24, 36, 48, 72	January 2013
1 in 100	24	1 in 700,000	12, 18, 24, 36, 48, 72	January 1974
1 in 500	24	1 in 800,000	12, 18, 24, 36, 48, 72	March 1989
1 in 1,000	24	1 in 900,000	12, 18, 24, 36, 48, 72	February 1999
1 in 2,000	24	1 in 1,000,000	12, 18, 24, 36, 48, 72	
PMF	24	1 in 2,900,000	12, 18, 24, 36, 48, 72	

MBRC had previously developed design flood hydrology and a hydraulic model of the lower Pine Rivers floodplain as part of council's Regional Floodplain Database (RFD) project, discussed in Chapter 10 'Floodplain Risk Assessment'. The MBRC design flood hydrology was adopted to enable comparison of the lowered FSV options with this existing regional floodplain database results.

MBRC supplied the dam inflow hydrographs for the flood events that were to be used for the assessment of downstream effects for input into the dam operations assessment. The critical storm durations were selected based on the maximum flood levels determined by the previous hydrodynamic modelling undertaken by MBRC rather than peak flows obtained from hydrologic modelling. The critical storm durations were 12 hours for the 5% (1 in 20) AEP and 1% (1 in 100) AEP design flood events and 24 hours for the 0.2% (1 in 500) AEP and larger design flood events. The 1% (1 in 100) AEP design flood event with a 24 hours storm duration was selected to analyse a storm duration longer than the critical storm durations.

Seqwater reviewed the MBRC inflow hydrographs to determine if the hydrology undertaken by MBRC for floodplain planning assessments was comparable to the hydrology undertaken by Seqwater previously for dam safety assessment. The comparison of the inflow peaks and the volumes indicated that the hydrology undertaken independently by Seqwater and MBRC generally provided similar results. Differences in the shape of the hydrographs were evident for the 0.2% (1 in 500), 0.1% (1 in 1,000) and 0.05% (1 in 2,000) AEP events. The peak inflows were generally similar, though the MBRC peaks were approximately 6 to 9 hours later. The differences in timing of inflow peaks appear to be due to different temporal rainfall patterns adopted for the events.

The comparisons indicated that the MBRC hydrology and Seqwater hydrology are derived from comparable methods. However, to facilitate integration into the MBRC hydraulic model and to remain consistent with planning decisions by MBRC, the MBRC design event inflow hydrographs for 5% (1 in 20) to 0.05% (1 in 2,000) AEP and PMF events were used for assessing downstream impacts.

The design flood events modelled cover the range of flood events identified by MBRC in its 'Flood Check – Flood Explorer' website mapping database as having a 'high likelihood' of occurrence up to the estimated probable maximum flood limit (MBRC 2013b, 2013c).

The very large design flood events developed by Seqwater are very rare events that were modelled to assess the probability of overtopping of North Pine Dam and saddle dams and to assess changes in the risk to structural safety of the dam for operational alternatives 2 and 3. The five largest historical flood events recorded in North Pine River catchment were also modelled, including the January 1974 flood that occurred during construction of the dam. The largest recorded flood prior to construction of the dam occurred in February 1931, when the North Pine River reached a peak flood level of 9.75 m at Youngs Crossing. The 1931 flood resulted from up to 480 mm of rain in 24 hours and was 1.2 m higher than the 1893 flood at Petrie (Middelmann et al. 2001). The 1931 peak flood level at Youngs Crossing was approximately 3.7 m below the January 2011 peak level. There is insufficient temporal rainfall data available to model the 1893 and 1931 flood events. Therefore only historical events for which dam inflow hydrographs are available were modelled.

## **7.5 Dam operations modelling results**

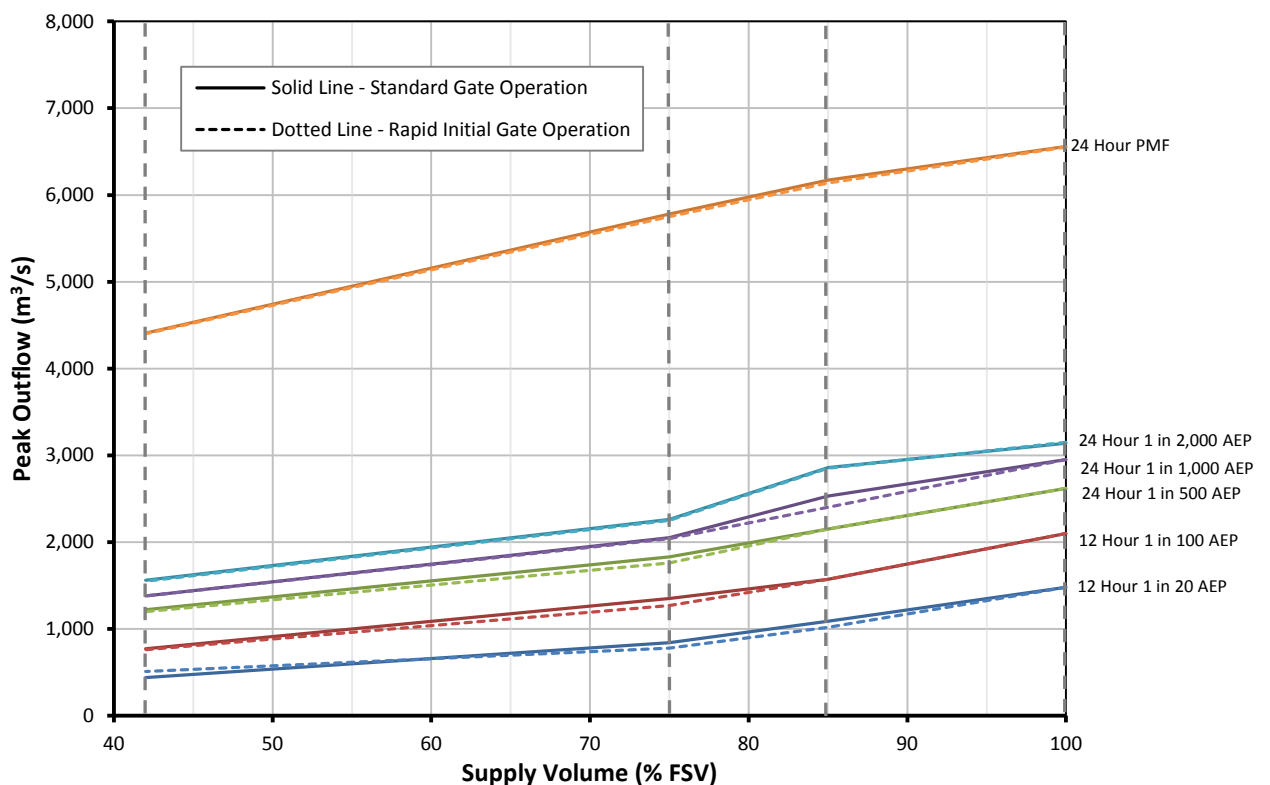
### **7.5.1 Gate opening strategy sensitivity analyses**

As described in Section 7.3.2, a sensitivity analysis of the gate operating options was undertaken to model the upper and lower bounds of the mitigation benefit that was considered practicable.

Sensitivity assessments SA100.2, SA85.2, SA75.2 and SA42.2 provide an indication of the upper limit benefits of what is achievable by both rapidly increasing releases up to the limited impact flow threshold and draining the dam down to the relevant FSV as quickly as possible.

The sensitivity modelling of the gate opening strategies (refer Figure 7.1) indicated:

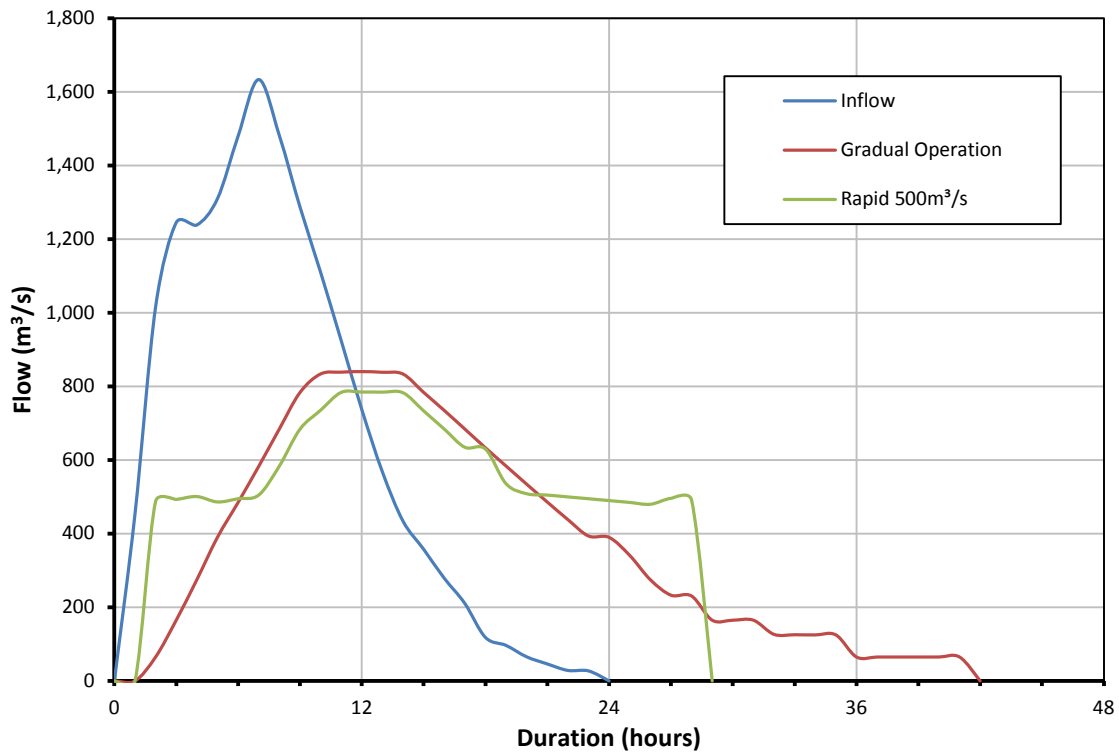
- the gradual rate of gate opening strategy and the rapid initial gate operations provide similar attenuation (dam outflows relative to dam inflows) for the range of events investigated
- the rapid initial gate operations generated a small benefit for small floods and negligible benefit for larger floods
- the benefit provided by the rapid initial gate operations increases slightly as the FSV is lowered, and
- the gradual rate of gate opening strategy was considered the simplest and most practical to implement and provided sufficiently accurate results for the purposes of estimating the mitigation potential for lower FSVs.



Source: Seqwater 2013a, Figure 10.2

Figure 7.1 Results of gate operations sensitivity analyses (some events omitted for plotting clarity)

Figure 7.2 illustrates the differences in the hydrologic behaviour of the gradual rate of gate opening strategy and the rapid initial gate operations.



Source: Seqwater 2013a, Figure 10.4

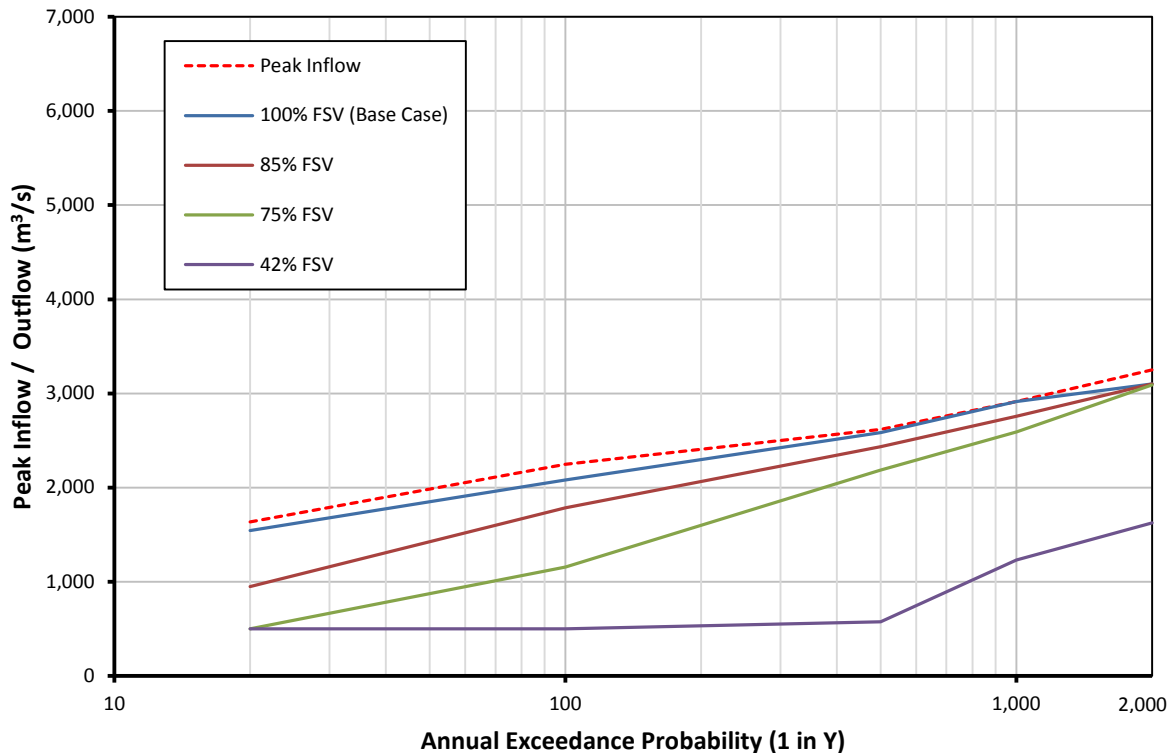
**Figure 7.2** 5% (1 in 20) AEP 12 hour design flood routing – 75% FSV

Based on the sensitivity analysis, the rapid initial gate operations provided small to negligible benefits in terms of flood outflow attenuation. The rapid initial gate operations was not used for further analysis as it provided minimal benefit and would be difficult to effectively implement for historical floods.

The gradual rate of gate opening strategy was adopted for further consideration to assess the effects of lower FSVs and varying the flood release thresholds. A gradual rate of gate opening is more representative of current operations.

## 7.5.2 Operational alternative 2 – dam lowered with FSL release level

Figure 7.3 summarises the predicted peak outflows (m<sup>3</sup>/s) versus the AEP of flood events for lowered dam levels providing initial detention due to releases commencing at FSL (EL 39.6 mAHD). This operational alternative reduces peak outflows during a flood event below that achieved through current operations (operational alternative) due to the initial storage of inflow.



Source: Seqwater 2013a, Table 10.4

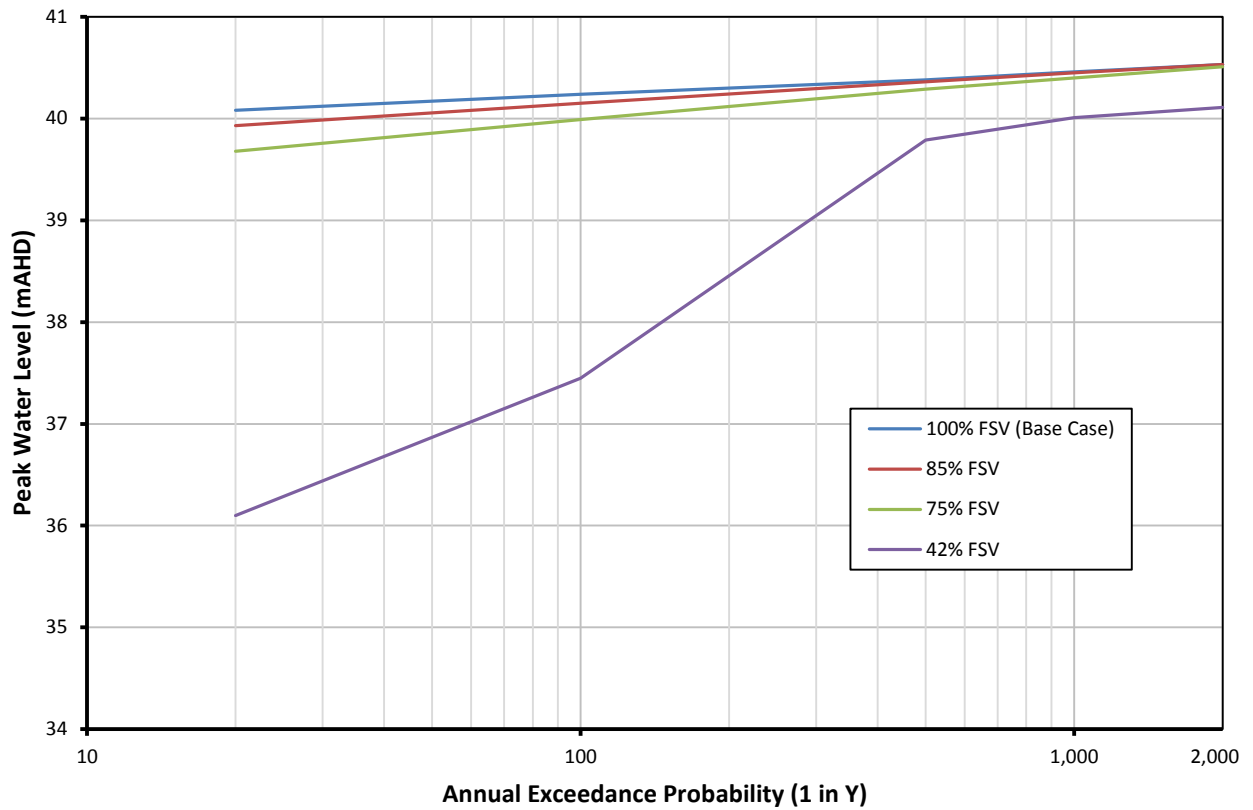
**Figure 7.3** Predicted peak outflows (m<sup>3</sup>/s) for lowered FSV options with initial detention (operational alternative 2)

The extent of the reduction in peak outflows is greatest at higher AEPs (expressed as a %) and diminishes considerably when the AEP of the flood event is less than 0.1% (1 in 1,000) AEP for dam level lowerings down to 75% of the FSV. A major lowering of the dam level to 42% of the FSV provides substantial reductions in peak outflows for all floods.

For lower dam levels down to 75% FSV, the reduction in peak flows for the smaller flood events results from the initial attenuation of floods on the rising stage of a flood hydrograph and corresponding reduced outflow from the dam. However if the flood is large and of sufficient duration, outflows will increase and there is little additional attenuation of the flood peak going from 100% FSV to 75% FSV.

Figure 7.4 summarises the predicted peak lake levels versus the AEP of flood events for lowered dam levels providing initial detention due to releases commencing at FSL (EL 39.6 mAHD).

Further detailed analyses of operational alternative 2, beyond the historical flood events discussed in Section 7.5.4, was not undertaken as, for reductions in dam levels down to 75% FSV, this mode of operation was found to reduce dam outflows in minor and moderate flood events only without significant benefit to downstream residents.

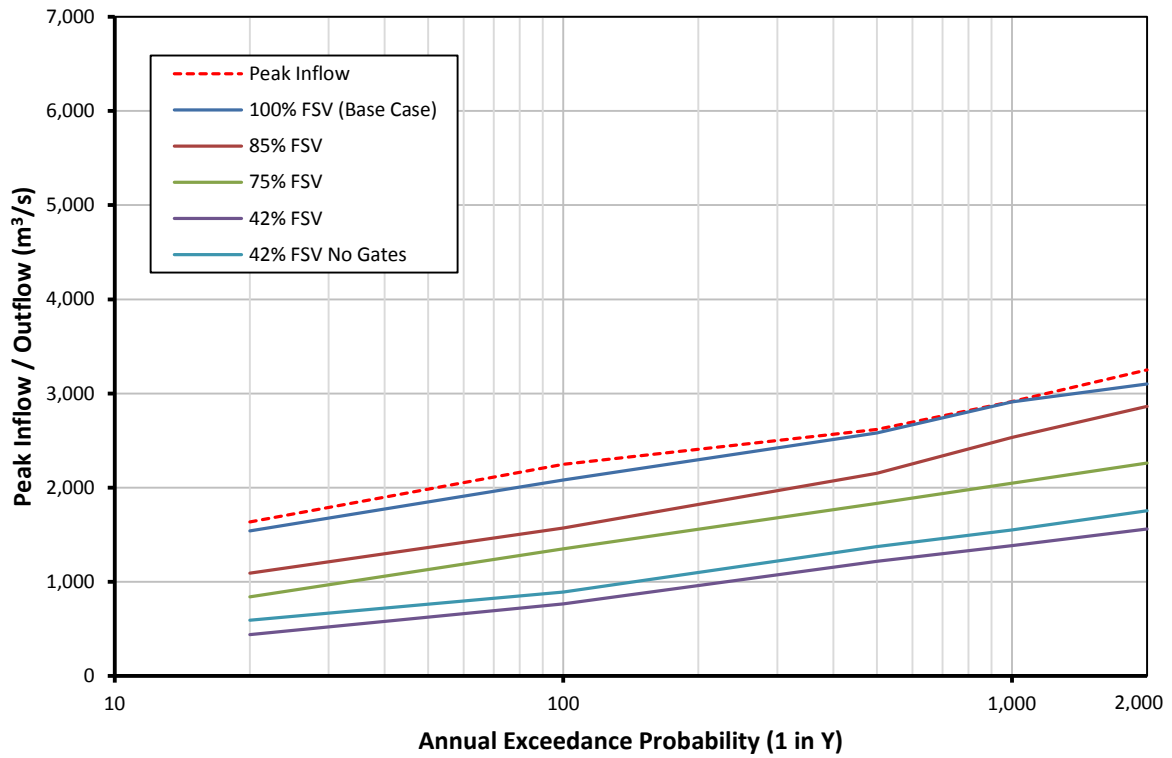


Source: Seqwater 2013a, Table 11.3

**Figure 7.4** Predicted peak lake water levels for lowered FSV options with initial detention (operational alternative 2)

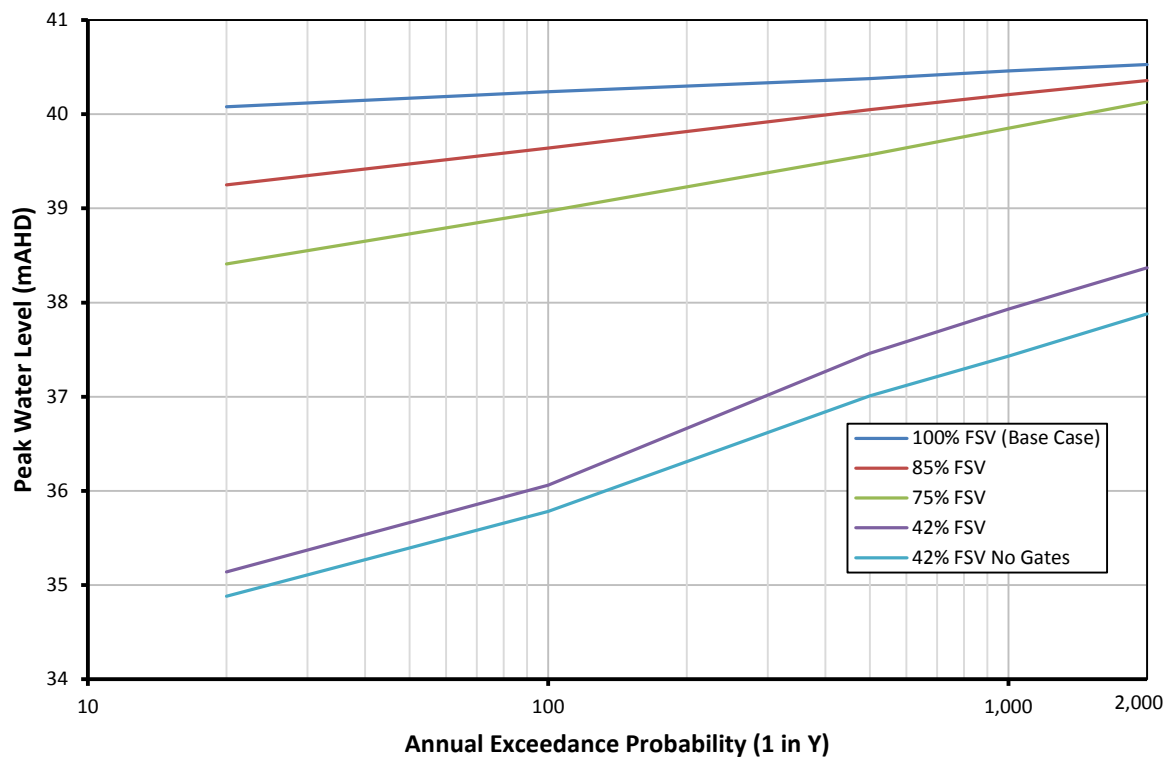
### 7.5.3 Operational alternative 3 – lowered dam and flood release levels

The additional flood storage provided by the lowered dam level options combined with reduced flood release levels enables the peak outflows to be reduced for all events as shown in Figure 7.5. This is a much better outcome than was achieved under operational alternative 2 and resulted in lower peak lake water levels for all flood events, as shown in Figure 7.6.



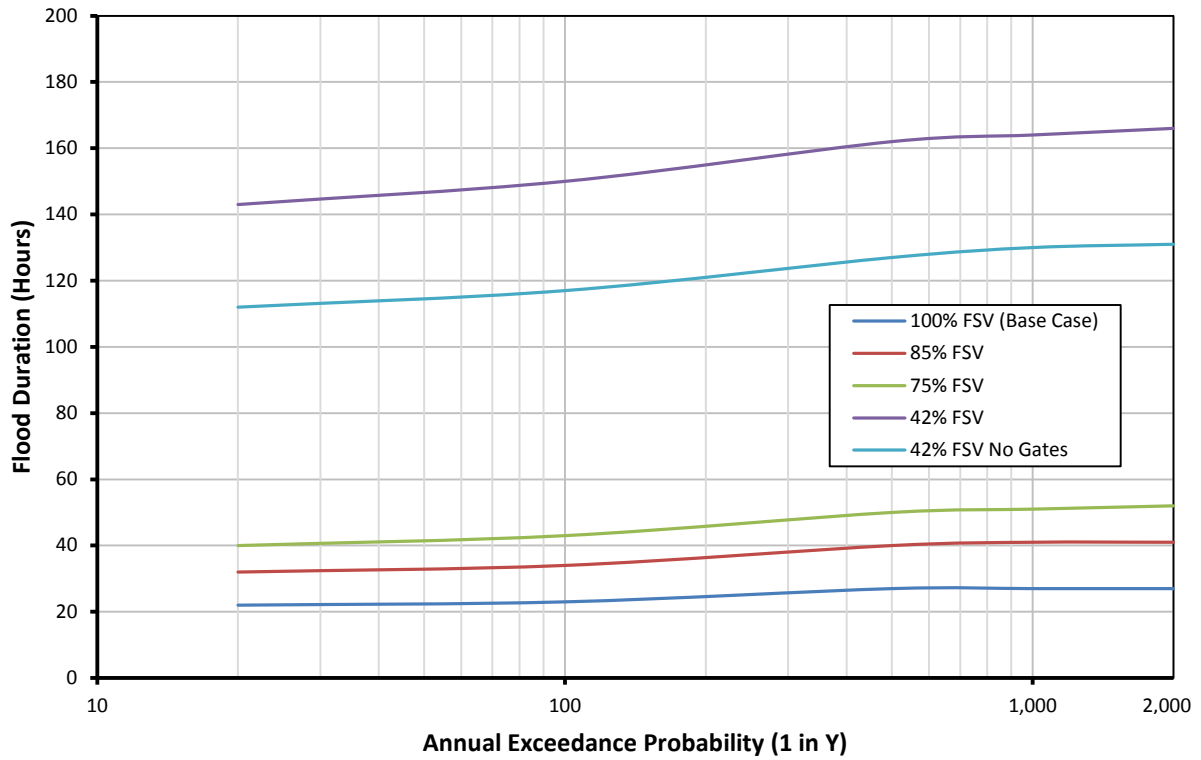
Source: Seqwater 2013a, Tables 11.6 and 11.7

**Figure 7.5** Predicted average peak flows for lowered FSV options with lowered flood release level (operational alternative 3)



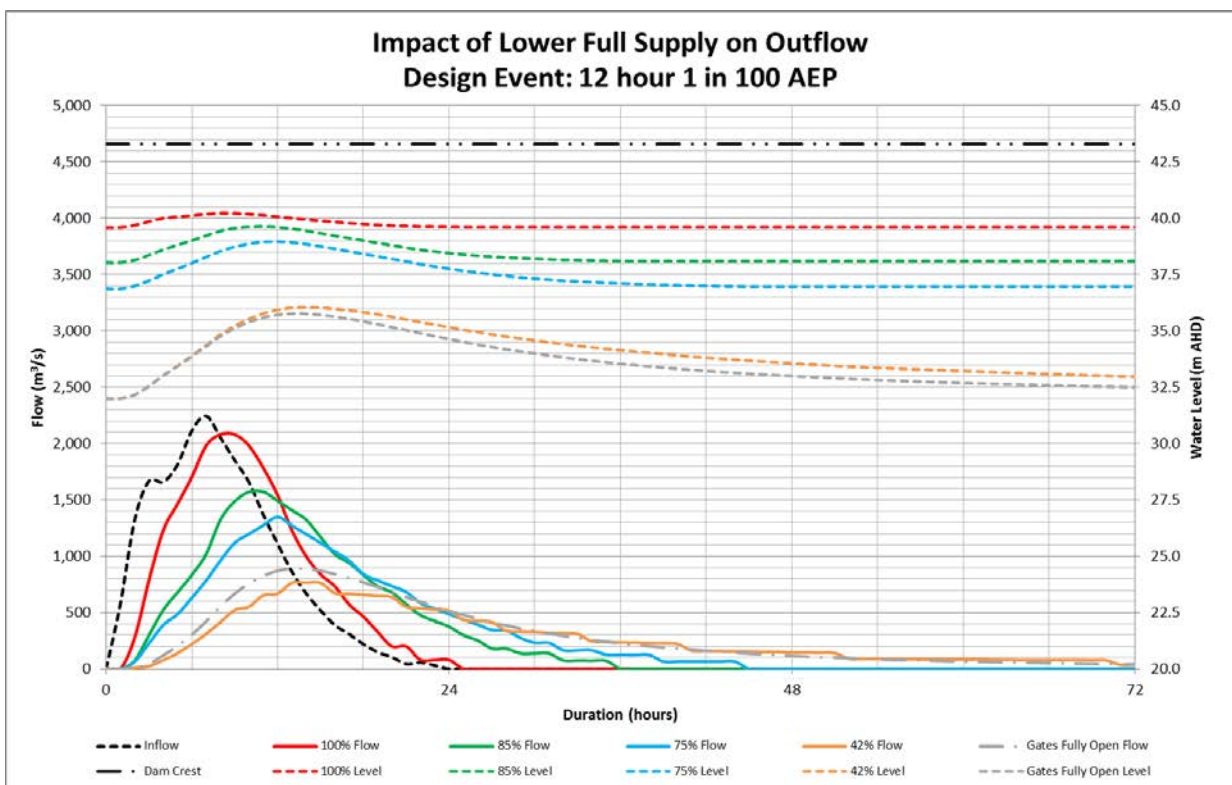
Source: Seqwater 2013a, Table 11.9

**Figure 7.6** Peak lake water levels for lowered FSV options with lowered flood release level (operational alternative 3)



Source: Seqwater 2013a, Table 11.14

Figure 7.7 Duration of dam releases (operational alternative 3)



Source: Seqwater 2013a, Appendix D

Figure 7.8 Impact of lower dam levels on 1 in 100 AEP flood event outflows (operational alternative 3)

Lowering of the dam level results in increases in the duration of releases and inundation of Youngs Crossing due to flood attenuation effects i.e. water tends to be stored in the dam and is released more slowly than the inflows (refer Figure 7.7). This effect is particularly noticeable for the 42% FSV scenarios where the outflows from the dam during the final stages of flood events are dependent on the free overfall spillway discharge yielding significantly prolonged durations for final drain down.

Figure 7.8 illustrates that for a 12 hour 1% (1 in 100) AEP flood event, lowering the dam level also lowers peak flood outflows and increases the duration of outflows relative to the base case (operational option 1 plotted in red). Lowering the dam also delays the peak outflows providing additional time to respond to floods.

#### 7.5.4 Historical flood events

The modelling results for significant historical flood events are presented in Table 7.3.

The base case results are different from the actual historical peak outflows due to:

- changes in gate operations from earlier revisions to the current Flood Manual, and
- modelling on the basis of dam being at the lowered dam FSLs at the commencement of the event rather than actual lake levels at the commencement of historical flood events.

The modelling results for the historical events indicate:

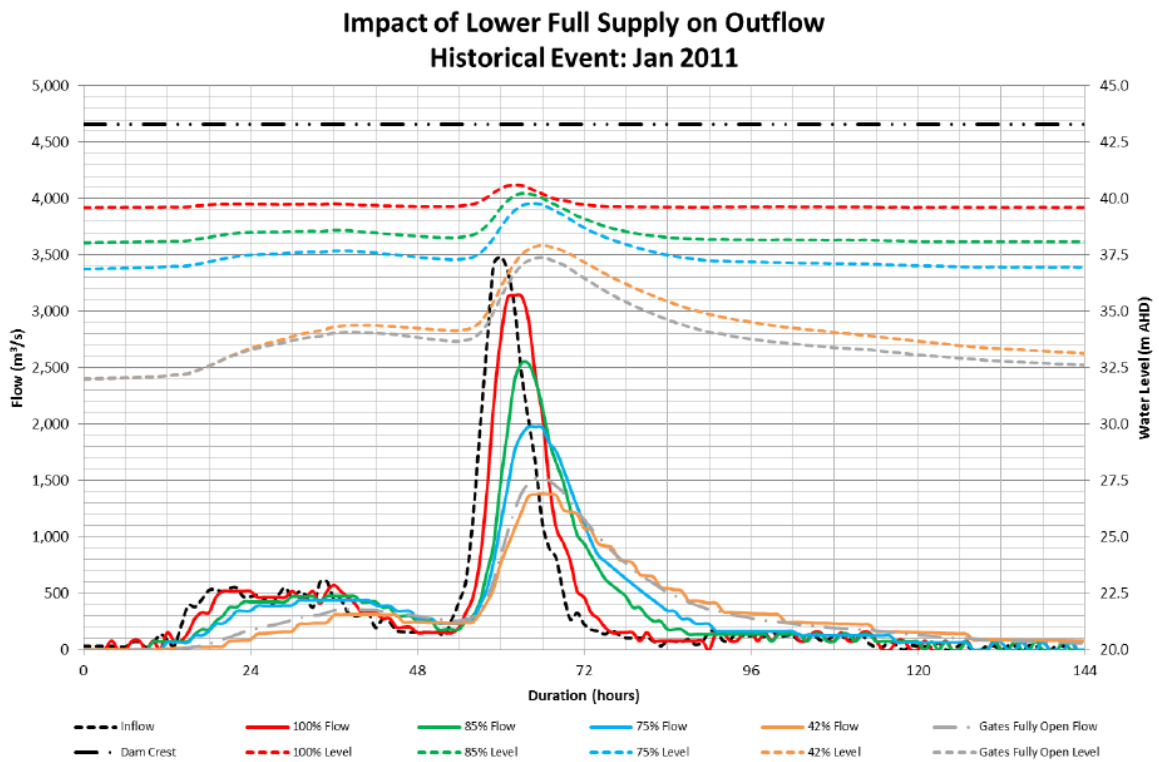
- peak outflows reduce as the FSV is reduced
- peak outflows reduce as the threshold for triggering flood releases is also lowered.

**Table 7.3: Peak outflows from North Pine Dam – historical flood events**

Supply Volume (%FSV)	Operation	Peak Outflows (m <sup>3</sup> /s)				
		January 2011	January 2013	January 1974	March 1989	February 1999
100	Alternative 1 (Revision 7 Flood Manual)	3,140*	1,550*	1,470	1,390*	1,000*
85	Alternative 2 (flood release 100% FSV)	3,100	1,380	1,390	1,390	1,000
	Alternative 3 (flood release 85% FSV)	2,540	1,090	1,170	1,320	890
75	Alternative 2 (flood release 100% FSV)	3,140	500	1,180	1,390	890
	Alternative 3 (flood release 75% FSV)	1,980	890	1,040	1,200	830
42	Alternative 2 (flood release 100% FSV)	1,790	500	1,230	1,230	500
	Alternative 3 (flood release 42% FSV)	1,380	560	810	1,050	640
	Alternative 4 (no gate control)	1,530	670	900	1,060	680

Note : \* Peak outflow based on simulation of dam being at 100% FSV at the commencement of the flood event. Outflow may be different to that recorded (refer Chapter 3, Table 3.3) due to different starting dam level and to different gate operating tables in the revision of the Flood Manual that was in force at the time of the historical flood event.

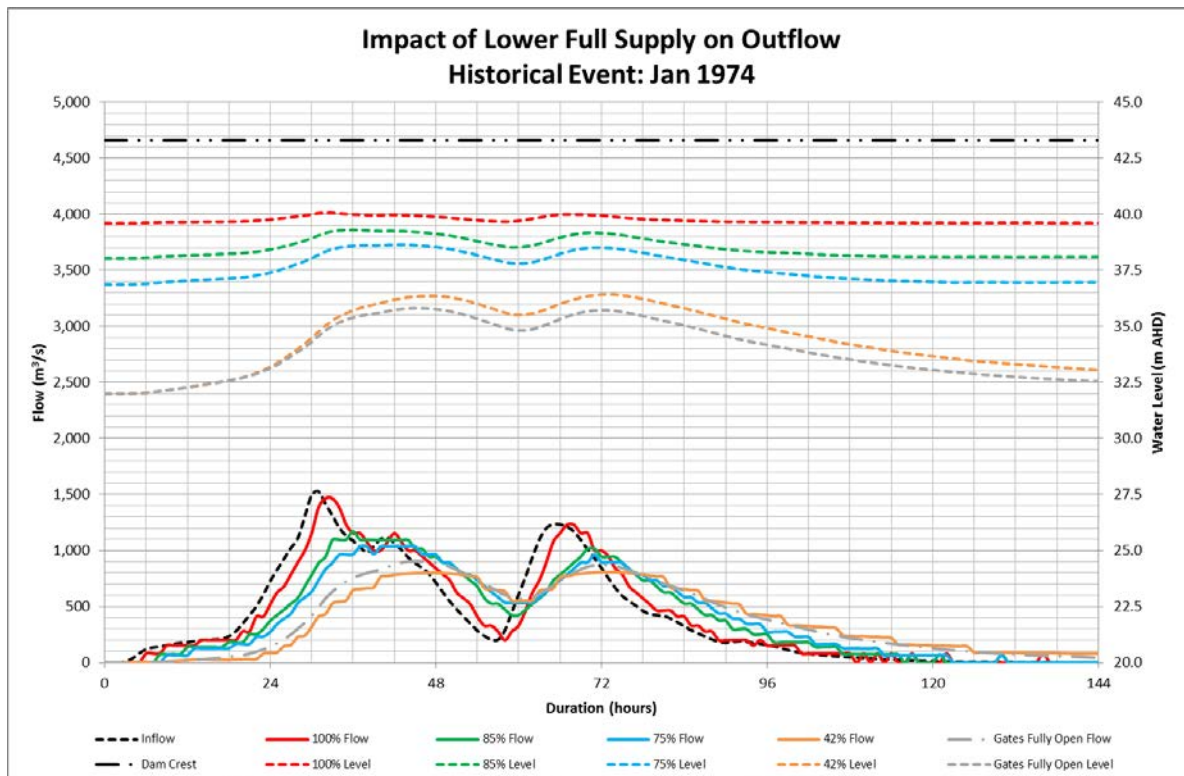
Source: Seqwater 2013a, Appendix D, Table D.6



Source: Seqwater 2013a, Figure 11.4

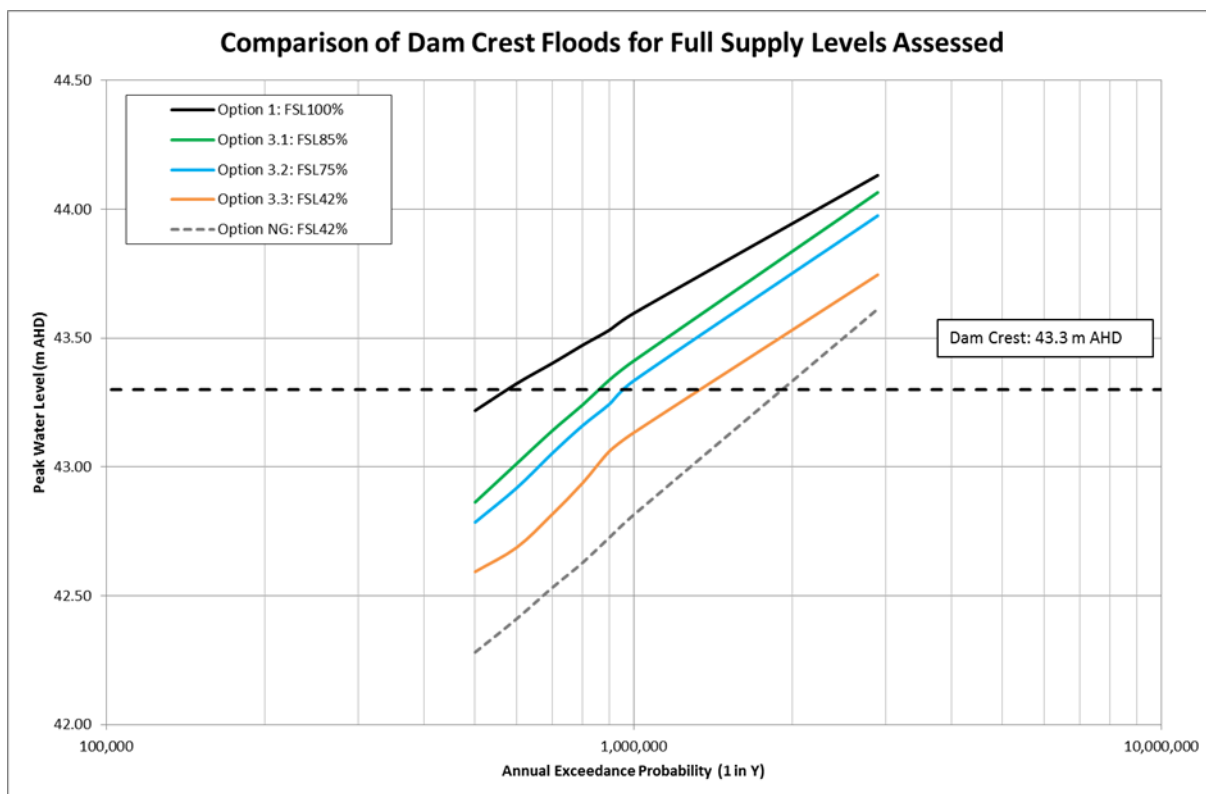
**Figure 7.9** Impact of lower dam levels on 2011 flood outflows (operational alternative 3)

Figures 7.9 and 7.10 illustrate the modelled changes in dam outflows and dam levels associated with a lowering of the dam supply volume for the January 2011 and January 1974 floods.



Source: Seqwater 2013a, Appendix D

**Figure 7.10** Impact of lower dam levels on 1974 flood outflows (operational alternative 3)



Source: Seqwater 2013a, Figure 11.1

Figure 7.11 Peak North Pine Dam water levels for dam overtopping assessment

### 7.5.5 Dam overtopping assessment

Because the flood events used to produce Figure 7.6 were selected from the perspective of providing dam outflows for the purposes of undertaking downstream flood assessments rather than dam overtopping safety assessments, Seqwater undertook specific overtopping assessments using appropriately selected flood events summarised in Table 7.2.

The modelling results for dam overtopping safety assessment based on the hydrology developed by Seqwater rather than MBRC are presented in Figure 7.11. The predicted peak water levels are for very large flood events. Extreme events much larger than have been experienced historically may still overtop the dam crest (EL 43.28 mAHD).

The lowering of the dam levels reduces the probability of a dam crest flood (EL 43.28 mAHD) due to the increased flood storage available.

The modelling results for operational alternative 3 demonstrate that lowering of the dam reduces the probability of overtopping from approximately 1 in 570,000 AEP for 100% FSV under the Revision 7 Manual operating rules to approximately 1 in 940,000 for 85%FSV and progressively reducing to 1 in 1,900,000 AEP for 42% FSV with free flow over the spillway. Therefore, structural safety of the dam is improved by lowering of the level in the dam.

This overtopping assessment does not form part of an Acceptable Flood Capacity (AFC) assessment in accordance with the dam safety regulations but demonstrates the relative dam safety associated with the FSV options. Dam safety is discussed in Chapter 8.

The 1 in 2,900,000 AEP events in Table 7.2 are the PMPDF events that had been derived by Seqwater for assessment of the AFC. The 12 hour duration PMPDF event was the critical duration PMPDF event determined by Seqwater for dam overtopping assessment and has a greater peak inflow than the 24 hour duration Probable Maximum Flood (PMF) determined by MBRC.

## 7.6 Conclusions

The results of the hydrologic assessment highlighted the following key conclusions:

- Peak outflows for any given event reduce as the FSV is reduced. (This benefit occurs due to the increased flood storage available to manage floods.)
- Peak outflows for any given event reduce as the threshold for triggering flow releases is also lowered. (This is the result of the earlier commencement of releases.)
- A lower dam level decreases the probability of overtopping of the dam crest during a flood event. (This benefit occurs due to the increased flood storage available to manage floods.)
- A lower dam level increases the duration of inundation of Youngs Crossing. (This impact occurs as the reduction in peak outflow from the dam results in longer duration of outflow from the dam.)
- Retention of the current FSL release level for lower dam levels provides a minor benefit to reduce peak outflow for small floods only. Once the volume of the flood exceeds the detention storage made available by reducing the dam levels, the flood attenuation benefit diminishes rapidly. For historical events, this mode of operation was found generally to yield higher outflows for lowered dam levels than with corresponding lowered release levels.
- Retention of the current FSL release level for lowered dam levels generally has a minor impact on the duration of outflow that would inundate Youngs Crossing when compared to the corresponding lowered dam level scenario.

## Chapter 8 – Dam safety

Assessment of the safety of North Pine Dam was a key consideration required under QFCoI Final Report recommendation 17.3 for a range of operational options and over a range of flood events.

This chapter:

- outlines the minimum dam safety requirements that must be met by the operator of North Pine Dam
- discusses the implications of the operational strategy options outlined in Chapter 6 on dam safety
- discusses whether operational strategy changes can result in dam safety improvements sufficient to defer capital costs needed to comply with the current schedule for dam safety upgrades outlined in the AFC Guidelines (DEWS 2013b).

The structural safety of the dam is the paramount objective of dam flood operations. Dam failure could have catastrophic consequences due to the magnitude of damage that would be caused downstream, and also due to the loss of a water supply source.

Analysis of options under in this study was on the basis that the existing safety level of the dam will not be lowered.

### 8.1 Legislation

Under the provisions of the Act, North Pine Dam is a Category 2 referable dam. A Category 2 dam is one where the population at risk is greater than 100 people.

DEWS administers the Act, regulates dam safety in Queensland and publishes the guidelines with which owners (of referable dams) must comply:

- *Queensland Dam Safety Management Guidelines* (DNRM 2002)
- *Guidelines for Failure Impact Assessment of Water Dams* (DEWS 2012)
- AFC Guidelines (DEWS 2013b).

The Act (Part 2, Chapter 4) requires the dam owner (in this case Seqwater) of a referable dam to prepare and maintain a flood mitigation manual for the dam which must meet the requirements set-out in the Act.

A flood mitigation manual needs to document:

- flood mitigation objectives for dam operations and their importance relative to each other
- operational strategies required to achieve the objectives, and
- operational procedures to be followed under each strategy.

The purpose of a flood mitigation manual is to provide sufficient information and guidance to support appropriate decisions on how best to release water from a dam during flood events (i.e. in line with the flood mitigation objectives).

## 8.2 Dam failure and acceptable flood capacity

The most likely cause of failure for North Pine Dam is overtopping. The dam consists of a mass concrete gravity section – which can withstand limited overtopping without damage – and earth-fill embankments on abutments – which are likely to washout rapidly if overtopped and cause failure of the dam and severe flooding downstream. A significant urban population is located close to the embankment wall of the dam. The prevention of overtopping of North Pine Dam is thus of paramount importance.

The consequences of failure of North Pine Dam are potentially catastrophic and include:

- around 15,600 people put at risk (depending on the failure scenario) with a potential loss of life estimated to be in the order of 700
- total direct damage costs to the community previously estimated to be of the order of \$2.7 billion
- intangible costs of a potentially similar magnitude
- the loss of a significant the water supply source for SEQ

As a result, North Pine Dam is classified as an ‘Extreme’ Hazard Category dam (i.e. the population at risk is greater than 1,000) and therefore should be able to safely pass the largest possible flood that can occur in its catchment – known as the Probable Maximum Flood (PMF) – without failure. Hence, North Pine Dam’s AFC should be the PMF.

In 2012, an assessment of North Pine Dam carried out for Seqwater (URS 2012) determined that around 63% of the PMF can be passed by the dam spillway before overtopping of the dam crest occurs. This spillway inadequacy has arisen due to major increases in the estimates of these extreme floods since the dam was designed.

At 63% of the PMF, North Pine Dam is less than the 65% AFC minimum required to be met by October 2025 under Section 4 Table 3 (reproduced in Table 8.1 below) of the AFC Guidelines. The 63% estimate is dependent on systems recently put in place to provide backup hydraulic gate operations (at lake levels flooding the electrical systems) and security for locking of gates in the fully open position.

**Table 8.1 Schedule for dam safety upgrades based on AFC guidelines**

Tranche	Required minimum flood discharge capacity	Date by which the required minimum flood capacity is to be in place for existing dams
1	25% AFC <sup>1</sup>	1 October 2015 <sup>2</sup>
2	65% AFC	1 October 2025 <sup>2,3,4</sup>
3	100% AFC	1 October 2035 <sup>2,3,4</sup>

Notes: 1 Or with at least 1:2,000 AEP for erodible dam embankments (whichever is the bigger flood)

1. As a guide, it is expected that up to about five years may be required to complete a flood discharge capacity upgrade for dams greater than 10 metres in height, and two years will be required to complete a spillway upgrade for smaller dams. However, each case will be considered on its merits.
2. In each case the required discharge capacity will need to be reassessed just prior to the undertaking of final spillway upgrade works to ensure that the required acceptable flood capacity has not changed and that the planned spillway capacity is still consistent with the specified upgrade program
3. The timing of the tranches will be confirmed once the acceptable flood capacity, and related assessments have been completed for all or most of the known referable dams

Source DEWS 2013b, Table 3

The current level of safety of North Pine Dam depends primarily on the proper operation of the spillway gates, which are used to control release rates and maximum water levels in the dam. The contributing catchment delivers rapid flooding requiring timely operation of the dam gates. At the current FSL, there is a limited margin for error or delay in initiating gate openings.

Under the Flood Manual’s current operating rules, North Pine Dam is estimated to be overtopped during floods larger than a 1 in 200,000 to 300,000 AEP event. This estimate is based on the DEWS AFC Guideline which requires one of the gates to be considered out of action, and is consistent with the basis of the 63% AFC estimate.

The above highlight the importance of ensuring that any options for establishing a formal flood mitigation function for North Pine Dam do not further compromise the dam’s current ability to pass rare to extreme floods through the reservoir and possibly improve the margin of safety for such operations (refer Seqwater 2011a).

### 8.4 2011 Flood

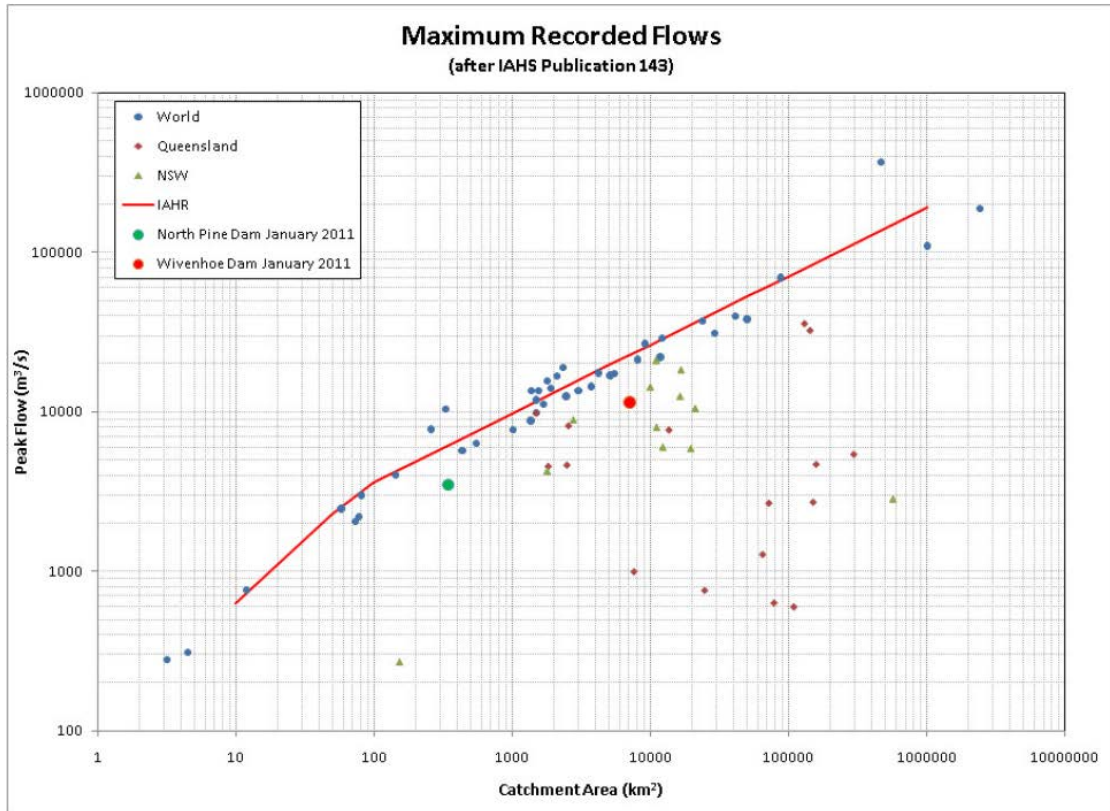
The January 2011 flood event was the largest flood event that the dam has experienced and hence the most significant from a dam safety perspective. The event began at 8:00 am on 6 January and finished at 5:00 am on 14 January 2011.

**Table 8.2 2011 flood event statistics**

2011 Flood Event Statistics			
Peak Inflow (m³/s)	Peak Outflow (m³/s)	Peak storage level in Dam (mAHD)	Time and Date
3,480	2,850	41.11	11 January 2011 2.00 pm

Source Seqwater 2011a

The International Association for Hydro-Environment Engineering and Research (IAHR Publication 143) publishes a list of maximum recorded flows for Australian and international catchments. This data is plotted in Figure 8.1. The North Pine inflow peak is also plotted on this graph and it shows the peak inflow during the January 2011 Flood Event is quite a large event when compared with maximum recorded flows for national and international catchments of similar area. The peak inflow is approximately half the envelope maximum.



Source Seqwater 2011a, Figure 9.8.1

Figure 8.1 Maximum recorded flows for Australian and international catchments

The 2011 event resulted in a re-appraisal of the potential extreme flood events that could occur in the dam catchment (URS 2012) and the likely consequences for the dam. The PMF is estimated to be approximately 11,000 m<sup>3</sup>/s (URS 2012).

## 8.5 Dam safety assessment

Changes to gate operating procedures have the potential to adversely affect the AFC of North Pine Dam if they restrict gate discharge to provide a greater degree of flood mitigation. However, on the basis of preliminary sensitivity modelling of options for this study by Seqwater (which indicated no significant difference in overall peak flood levels downstream of the dam for more rapid gate openings), the options assessed involve only reductions in FSVs and trigger levels for commencement of flood releases, and do not include the gate opening rates in the Flood Manual.

Lowering the level of North Pine Dam generally provides significant dam safety benefits assuming five gates are operational. The modelling results (Chapter 7) demonstrate that lowering of the dam reduces the probability of overtopping from approximately 1 in 570,000 AEP for 100% FSV under the Flood Manual operating rules to 1 in 840,000 AEP for 85% FSV, 1 in 940,000 AEP for 75% FSV, 1 in 1,340,000 AEP for 42% FSV and 1 in 1,900,000 AEP for 42% FSV with uncontrolled flow over the spillway.

The assessment of the probability of overtopping the dam undertaken as part of the dam flood operations assessment reported in Chapter 7 is not a definitive dam safety analysis. For example, it assumed all five gates operating rather than the assumption that only four gates are operating as required by the ‘standards based’ methodology for determining spillway adequacy. However, it does indicate that lowering the level of North Pine Dam for flood mitigation purposes has dam safety benefits by reducing the probability of dam crest overtopping and adverse flood impacts from large and rare flood events.

A previous review of North Pine Dam’s AFC for Seqwater (URS 2012) based on the assumption of one gate inoperable (as required by the ‘standards based’ methodology) gave the results shown in Table 8.3 and Figure 8.2. These indicate that the maximum lowering of the FSV possible (without undertaking major spillway works) of 42% FSV (i.e. spillway fixed ogee crest level EL 32 mAHD) with lifting of the gates clear provides the greatest improvement to the AFC, increasing it from 63% to 85% of the PMF..

**Table 8.3: North Pine Dam – dam crest flood capacity versus FSV**

FSV (%)	Description	Flood Capacity (% of PMF)
100	<ul style="list-style-type: none"> <li>EL 39.6 mAHD</li> <li>Existing gate operations</li> <li>4 out of 5 gates operable</li> </ul>	63
75	<ul style="list-style-type: none"> <li>EL 36.88 mAHD</li> <li>Revised gate operations settings</li> <li>4 out of 5 gates operable</li> </ul>	71
50	<ul style="list-style-type: none"> <li>EL 33.43 mAHD</li> <li>Revised gate operations settings</li> <li>4 out of 5 gates operable</li> </ul>	75
42	<ul style="list-style-type: none"> <li>EL 32.0 mAHD</li> <li>5 spillway bays fully effective</li> </ul>	85

Source: URS 2012, Tables 5.1 and 8.2

The results also suggest (Figure 8.2) that a lowering below 94% FSV to say 90% FSV would likely achieve the ‘tranche 2’ (65% PMF) requirement outlined in Table 8.1.

Reduction of the FSL will also provide increased margin of safety to avoid gate overtopping. If gates are damaged due to overtopping, ability to pass larger flood events without failure is compromised resulting in much higher probability of failure during subsequent events.

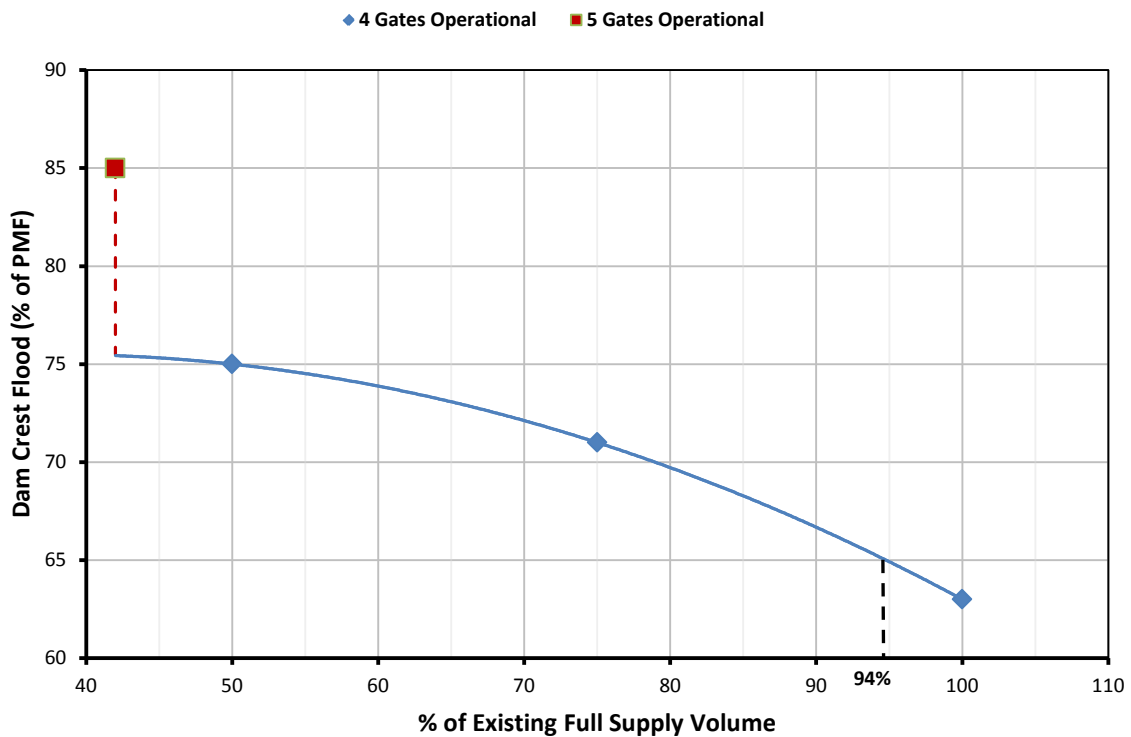


Figure 8.2 North Pine Dam – dam crest flood capacity versus FSV from Table 8.3

## 8.6 Upgrade options

The Seqwater AFC study (URS 2012) considered a range of conceptual upgrade options to comply with the AFC requirements for North Pine Dam. The conceptual upgrade options included:

- Lowering of the FSL
- Modification of the existing spillway
- Construction of an auxiliary spillway
- Raising the crest level of the dam.

The AFC study found that lowering of the FSV to the fixed crest spillway level does not enable the dam to pass the PMF event safely, but does enable North Pine Dam to satisfy the 65% PMF interim AFC requirement with no capital cost.

The AFC study also found that raising the embankment crest level by 1.5 m combined with modification of the existing gates or construction of an auxiliary spillway appeared to be the most suitable option to enable the dam to pass the PMF safely. Options to modify the existing spillway without raising the crest level were found to require significantly larger works and were considered less suitable. A dam crest raising of 1.5 m is the estimated maximum that can be achieved without causing additional upstream flooding. Preliminary estimates indicate that a full dam upgrade will be in the hundreds of millions of dollars.

## 8.7 Conclusions

North Pine Dam is an extreme hazard dam. Based on the standards based methodology (AFC test) for spillway adequacy outlined in the AFC Guidelines, it will ultimately be necessary to augment the dam to allow it to safely pass the PMF (which has an estimated AEP of around 1 in 2,900,000 (URS 2012)).

An assessment of the probability of overtopping the dam was undertaken as part of the dam flood operations modelling for this study (see Figure 7.11 and Seqwater 2013a). It was estimated that the maximum flood event that North Pine Dam can currently pass with all gates operational has an AEP of approximately 1 in 570,000. With only four gates operational (as required by the guidelines), the probability of the maximum event the dam can pass without overtopping may be in the order of 1 in 200,000 to 300,000 AEP.

Table 8.1 indicates that North Pine Dam at the current FSL is a tranche 2 augmentation required by 2025.

Lowering of the FSV of North Pine Dam for flood mitigation purposes would reduce the magnitude of dam crest overtopping and adverse flood impacts from large and rare flood events.

There may be some potential to delay upgrade work for North Pine Dam to 2035 if the FSV of the dam is lowered below 94% FSV to say 90% FSV.

Further investigation of options to meet dam safety requirements is needed, as significant works to upgrade spillway capacity will ultimately be required.

## Chapter 9 – Notifications and warning of flood releases

This Chapter discusses the effectiveness of the existing flood warning systems for residents located immediately downstream of the North Pine Dam and whether systems allow residents to take timely action to minimise the potential impacts of flood releases from North Pine Dam.

Generally, MBRC and BoM and Seqwater have robust warning and notification systems in place to warn community and stakeholder agencies of the potential negative impacts of flooding in all its forms. These are aligned within the Queensland Disaster Management Arrangements (QDMA) structure.

North Pine Dam is relatively uncommon in being a large water supply dam that is located immediately upstream of residential dwellings. During extreme events, residents in close proximity to the dam require more urgent warnings than those who are further downstream and are not at immediate risk. For North Pine Dam it is estimated that up to approximately 30 residential dwellings may require these urgent warnings.

The Queensland Government has recently introduced new legislation which sets statutory criteria for preparing Dam Safety Emergency Action Plans (EAPs) in Queensland. The legislative standards and regulator's guidelines aim to ensure that dam owners place a premium on notification processes that are negotiated with stakeholders, the community and Local and District Disaster Management Groups. Queensland's legislation builds upon and is consistent with the Australian Emergency Management Guidelines and Manuals for providing warning and notification for floods affected by dams (AG 2009).

Accordingly, responsible government agencies and entities aim to provide timely and appropriately detailed warning messages and notifications to those potentially impacted.

### 9.1 Queensland's disaster management arrangements

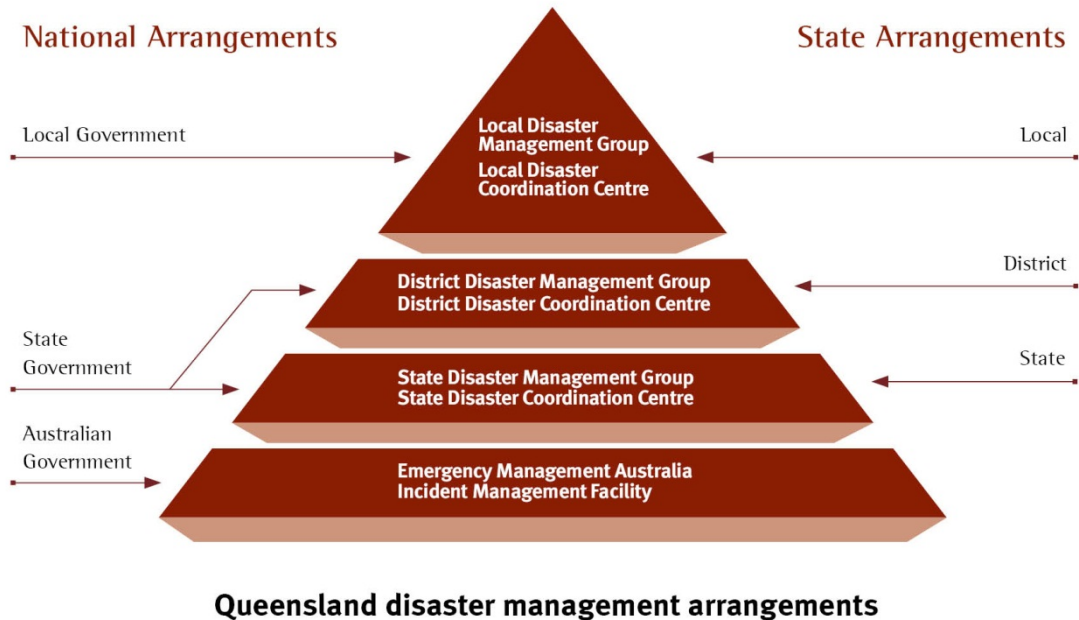
The Queensland Disaster Management system is a multi-tiered system of committee and coordination centres at state, district and local levels. Within this system the whole-of government disaster management arrangements are based on partnerships between government, government-owned corporations, non-government organisations, commerce and industry sector and local community.

The disaster management arrangements in Queensland are made up of several key management and co-ordination structures through which the functions of disaster management for Queensland are achieved (See Figure 9.1).

The principal structures that make up Queensland's disaster management arrangements (QDMA) are:

- disaster management groups operating at local, district and state levels which are responsible for the planning, organisation, co-ordination and implementation of all measures to mitigate/prevent, prepare for, respond to and recover from disasters
- co-ordination centres at local, district and state levels that support disaster management groups in co-ordinating information, resources and services necessary for disaster operations

- state government functional agencies through which the functions and responsibilities of the state government in relation to disaster management are managed and coordinated; and State government threat-specific agencies responsible for the management and coordination of combating threats.



Source: EMQ 2013

**Figure 9.1** Queensland disaster management structure

The QDMA is activated using an escalation model from ‘Alert’ to ‘Lean Forward’ to ‘Stand Up’ and to “Stand Down”. The levels of activation are as follows:

- ‘Alert’ – A heightened level of vigilance due to the possibility of an event in the area of responsibility. No action is required however the situation should be monitored by someone capable of assessing the potential of the threat.
- ‘Lean Forward’ – An operational state prior to ‘Stand Up’ characterised by a heightened level of situational awareness of a disaster event (either current or impending) and a state of operational readiness. Disaster co-ordination centres are prepared but not activated.
- ‘Stand Up’ – The operational state following ‘Lean Forward’ whereby resources are mobilised, personnel are activated and operational activities commenced. Disaster co-ordination centres are activated.
- ‘Stand Down’ – Transition from responding to an event back to normal core business and/or recovery operations. There is no longer a requirement to respond to the event and the threat is no longer present.

The movement of disaster management groups through this escalation phase is not necessarily sequential; rather it is based on flexibility and adaptability to the location and event.

Activation of the response arrangements may occur when there is a need to:

- monitor potential threats or disaster operations
- support or co-ordinate disaster operations being conducted by a designated primary agency
- co-ordinate resources in support of disaster operations and recovery operations at local or district level; and
- co-ordinate State-wide disaster response and recovery activities.

Activation does not necessarily mean the convening of disaster management groups; rather the provision of information to disaster management group members regarding the risks associated with a pending hazard impact.

## 9.2 Regulatory standards for notifications and warnings

The Queensland Government established statutory criteria and standards under the Act for emergency situations at referable dams. A referable dam is a large dam that would put lives at risk if it were to fail and the regulatory criteria and standards are required to be formalised in the form of an EAP for that referable dam.

The primary reason for an EAP is to minimise risk posed by a dam failure or downstream release hazards. Such risks can arise from a number of scenarios which can include failure of elements of the dam, failure of the complete dam structure or risks to people or property as a result of water releases from an uncontrolled or controlled spillway. In order to maximise preparedness for such events, provision is also made for taking into account circumstances which may develop into the failure of a dam. Although emergency action planning provides for all potential risks, for the purposes of this report the focus will be placed on notifications and warnings during flood events.

Prior to the statutory requirements under the Act, EAPs were non-statutory and required as part of dam safety conditions on the development permit for the dam. Recommendation 17.31 of the final report of the QFCoI (QFCoI 2012) was that the Queensland Government should legislate to oblige each owner of referable dam to have an emergency action plan approved by the appropriate Queensland Government agency. The Act has now been amended to contain the requirement for all referable dams to have an EAP approved by the chief executive (of DEWS).

Recommendation 4.16 of the Interim Report of the QFCoI (QFCoI 2011) was that dam operators should plan to contact people identified in their emergency action plans about dam outflow in sufficient time for them to be able to respond to the information. In cases where there may be insufficient time to notify affected people through existing emergency management systems, due to the close proximity of these people to the dam, the dam owner may need to notify them directly.

The Act requires that EAPs state when and how the owner of the dam must notify the relevant entities of an emergency condition. Relevant entities include persons whose safety or property may be threatened by the emergency condition. An emergency condition includes a downstream release hazard in relation to a dam is reasonably foreseeable hazard to persons or property that could be potentially be caused or aggravated by a release of water from a dam's spillway or a controlled releases of the water from the dam.

To assist dam owners in the development of emergency action plans the Department of Energy and Water Supply released a Provisional Guideline (DEWS 2013c). This guideline also assists Local and District Disaster Management Groups to understand their role in the preparation of the EAPs.

### **9.3 Roles of responsible organisations in flood warning**

The QFCoI found in its Interim Report that flood warning is the responsibility of BoM, local Governments and dam owners.

BoM provides the prediction of flooding and the conditions likely to give rise to floods. Local Governments provide the warning of the likely impacts of floods on local communities and dam operators have a responsibility for providing notifications and warnings to those communities immediately downstream of the infrastructure.

#### **9.3.1 Bureau of Meteorology**

In conjunction with MBRC and Seqwater, BoM operates a flood warning system for the North Pine and South Pine Rivers, based on the network of rainfall and river height stations.

BoM prepares and issues flood warnings on a river basin scale. Warnings are generally in terms of minor, moderate or major flood events at reference gauges. BoM does not issue specific flood warnings for the North Pine and South Rivers because of the relatively fast nature of flooding in these areas.

BoM provides flood forecasting and warning services in cooperation with agencies from State and Local Governments. MBRC does liaise directly with BoM during a flood event.

BoM does not:

- issue flash flood warnings (described as situations where the rain-to-flood time is less than 6 hours) for specific locations or individual creeks
- predict the extent to which the increased river height levels will cause an inundation of floodplains
- interpret the impact of any predicted flood levels or expected flooding on people or infrastructure, or
- disseminate targeted information to individuals or communities who are likely to be affected by any expected flooding.

#### **9.3.2 Seqwater**

Seqwater has a role in providing notifications and advice about North Pine Dam releases to the community and agency stakeholders. This role has been expanded since the January 2011 flood event in response to the recommendations of the Queensland Floods Commission of Inquiry (QFCoI Interim Report Chapter 4 and Final Report Chapter 17 Recommendations).

Seqwater has four key documents which establish the procedures and processes for providing warning to State agencies, Stakeholders and the community during flood events in the North Pine River. These documents include:

- the North Pine Dam 2013 EAP (Seqwater 2013d)
- Communications Protocol for Releases from Seqwater's Gated Dams (Wivenhoe Dam, Somerset Dam, North Pine Dam and Leslie Harrison Dam) (Seqwater 2013e)
- the Flood Manual (Seqwater 2013b)
- Bulk Authority Emergency Response Plan, Whole of Supply Chain Response, 2013 (Seqwater 2013f).

In general and for North Pine Dam, Seqwater is aligned within the Queensland Disaster Management Arrangements Structure to provide advice and information to the Moreton Bay Region LDMG as well as the relevant SEQ service providers and SEQ water supply system emergency stakeholders.

The Flood Manual (Section 1.3 Role of Seqwater) states that Seqwater does not have responsibility for:

- forecasting flood levels along the Pine River during Flood Events
- interpreting forecast flood levels to provide local information on areas likely to be inundated or providing local flood warnings to residents (this being the responsibility of Local Government and the Local Disaster Management Group (LDMG)).

The North Pine Dam EAP and the Communications Protocol for Releases from Seqwater's Gated Dams (Communications Protocol) are the two documents that provide the procedures and processes for notifications and external communications about releases from North Pine Dam. Both the Flood Manual and the Emergency Response Plan provide some guidance for notification and external communications but are not the definitive documents.

### ***North Pine Dam EAP – notifications***

Under the current standards and guidelines for EAPs Seqwater is only expected to provide information as to timing and volume of dam outflows during a flood event. Predictions as to river heights or inundation areas are the responsibility of others within the disaster management framework. It is the responsibility of residents close to the dam to be aware of how flood flows will affect their property and have in place appropriate plans or courses of actions in the event of floods.

Seqwater's established Communications Protocol (Seqwater 2013e) defines the communication arrangements in the event of a dam release from one of Seqwater's gated dams, to assist in the effective, coherent and timely coordination of information to stakeholder agencies and the public. A stakeholder agency in this instance includes federal, state and local governments. The Communications Protocol is implemented when the conditions for a potential dam release eventuate. Seqwater will send a message to stakeholder agencies advising of such conditions existing. The EAP identifies the various conditions that lead to a dam release occurring.

To maintain the consistency with the QDMA Seqwater has established levels of activation for when the Communications Protocol is implemented. Different floods call for different frequency of communication. A slow rising flood may require less frequent provision of information, while a rapidly rising flood may require very regular communication.

Under the Communications Protocol Seqwater rely on various communications mediums to provide information to the public and stakeholder agencies. Formal notifications are made using the Dam Release Situation Reports. These situation reports are generally issued as soon as practical after the mobilisation of the Flood Operations Centre and then on an ongoing basis at 7:00am and 7:00pm. Should an unexpected escalation in a flood event occur the situations reports by issued at other times.

Seqwater provides projected North Pine Dam outflow hydrographs to stakeholder agencies operating flood modelling systems. Updated hydrographs are emailed when a significant change is made to the North Pine Dam Release Plan. Agencies currently receiving this information are: BoM and MBRC. This allows those agencies to undertake assessments of projected inundation extents and heights during a flood event.

In accordance with the QFCoI recommendations, Seqwater also provide information to subscribers using the Dam Release Notifications via email, SMS or recorded messages. These notifications are made if a dam release is occurring, about to occur or there has been a significant change to releases. Information about releases can be accessed through a dam release hotline as well as using Seqwater's web and social media updates. The dam release notification network, hotline and web and social media updates are mediums by which the general public can maintain situational awareness during a flood event.

The further downstream the population is from North Pine Dam, the more appropriate it is that they are warned through other less direct means than personal contact.

The Act requires the EAP, for each emergency condition, to state when and how the owner of the dam must notify the relevant entities of emergency conditions including the order of priority in which the relevant entities are to be notified.

In the case of North Pine Dam, Seqwater and the Moreton Bay Region LDMG have an agreed understanding of their respective roles in a flood event and the type and frequency of information Seqwater will provide to the Moreton Bay Region LDMG and residents at risk from the emergency condition. This is of critical importance to help ensure that residents are notified in a timely manner and that they know from whom, and how, to access information other than flow.

In accordance with the current requirements the definition of who may be covered by the term "immediately downstream from the dam" is a matter that requires negotiation and resolution between Seqwater and the Moreton Bay Region LDMG. However, as an indicative example, *Emergency Management Planning for Floods Affected by Dams* (AG 2009), page 18 notes:

*'Warning time for evacuation needs to be considered in time blocks of not less than one hour to ensure that action plans can be realistically implemented.'*

Given the size of the total population at risk downstream of North Pine Dam and the urgent need to notify a small number of residents immediately downstream of North Pine Dam, the notification process should have regard to:

- the likely rate of development of emergency conditions,
- the time required to provide adequate notification to all stakeholders and affected parties, and
- the time required for those notified to act effectively on the notification.

Consideration should be given in association with the relevant disaster management group as to how those messages should be given.

Depending on the location and extent of the impacted area and the number of notifications that may need to be issued; the issuing of notifications should always consider a combination of the effectiveness of:

- a) word of mouth or personal visits
- b) personalised phone or SMS contacts
- c) local mass communications media
- d) sirens or other direct means of localised warnings

Multiple means of communications may be required in order to maximise the chance of the notification being received in sufficient time to adequately respond.

The frequency and content of notifications will depend on the emergency condition identified and the way it develops with time. The notification messages should be consistent with the approved disaster management standards and local disaster management plan.

### **9.3.3 Moreton Bay Regional Council**

In accordance with the Disaster Management Act 2003 (QLD) and the Queensland Local Disaster Management Guideline, it is a role of the LDMG to provide the public with hazard awareness, household preparedness and emergency planning information about events and recommended actions. Broadcast radio is the primary vehicle for public information in most events, however emergency service agencies are now increasingly also using more contemporary mass communication mediums such as social networking sites, subscription services or emergency alert notifications.

The Moreton Bay Region LDMG is established under the QDMA and has the role of coordinating the management of the wider community consequences as a direct or indirect result of severe weather. It also establishes priorities to guide response and recovery efforts. The main objective of the Moreton Bay Region LDMG is to ensure risk to life and property is reduced to acceptable levels by coordinating the actions of all agencies contributing to the event.

After the January 2011 flood event, MBRC developed and released its 'Moreton Alert' warning system. This system is accessed on the MBRC website.

A letter to 1,500 potentially affected residents notifying them of the 'Moreton Alert' warning system was sent out in September 2011. This system allows residents to register a property address and advise MBRC on the contact method they wish to receive warnings.

MBRC has developed a range of alerts which have escalating alert message status:

- 'Be Alert' – flood conditions may lead to minor damage in and around local rivers.
- 'Watch and Act' – occupants should monitor river levels and if necessary implement personal emergency plan.
- 'Emergency' – there is a risk of severe damage to properties in and around local rivers making evacuation of some properties necessary.

There are 2 different alert groups for sending out the warning:

- close to the river
- above the river

MBRC is alerted to release rates from Seqwater and also monitors dam level heights at North Pine Dam. Under this system, the Moreton Bay Region LDMG provides warning messages to residents.

#### **9.4 Warning time for downstream residents**

For the majority of residents living downstream of North Pine Dam, the timing of flood release notifications and the level of detail is appropriate for them to take action. This assumption considers that residents are receiving notifications from both Seqwater and the Moreton Bay Region LDMG and are therefore able to cross reference information detail to make an informed decision.

There are, however, a small number of residential dwellings which are located in very close proximity downstream of the North Pine Dam. In these circumstances the situation can be that, although they may be notified very quickly by Seqwater's voluntary Flood Release Notification Service, the messages may not be sufficiently detailed for action to be taken. Conversely, a more detailed message may be received from the Moreton Alert System however the timing is likely to be too late. This is due to the time it takes for the Moreton Bay Region LDMG to receive relevant information from Seqwater, interpret the information then send out the warning to residents. In an extreme flood event, it is possible that, by the time the residents are warned of the release by the LDMG, they are already being impacted by the flood waters and the opportunity to take action has been lost (see Figure 9.2).

It is possible that during the 'Alert' and 'Lean Forward' notifications, the LDMG and Flood Operations Centre may not be activated. There can also be the situation where it may be necessary to bypass both the 'Alert' and 'Lean Forward' activation levels, as discussed in section above on 'Seqwater communications protocol – notifications'.

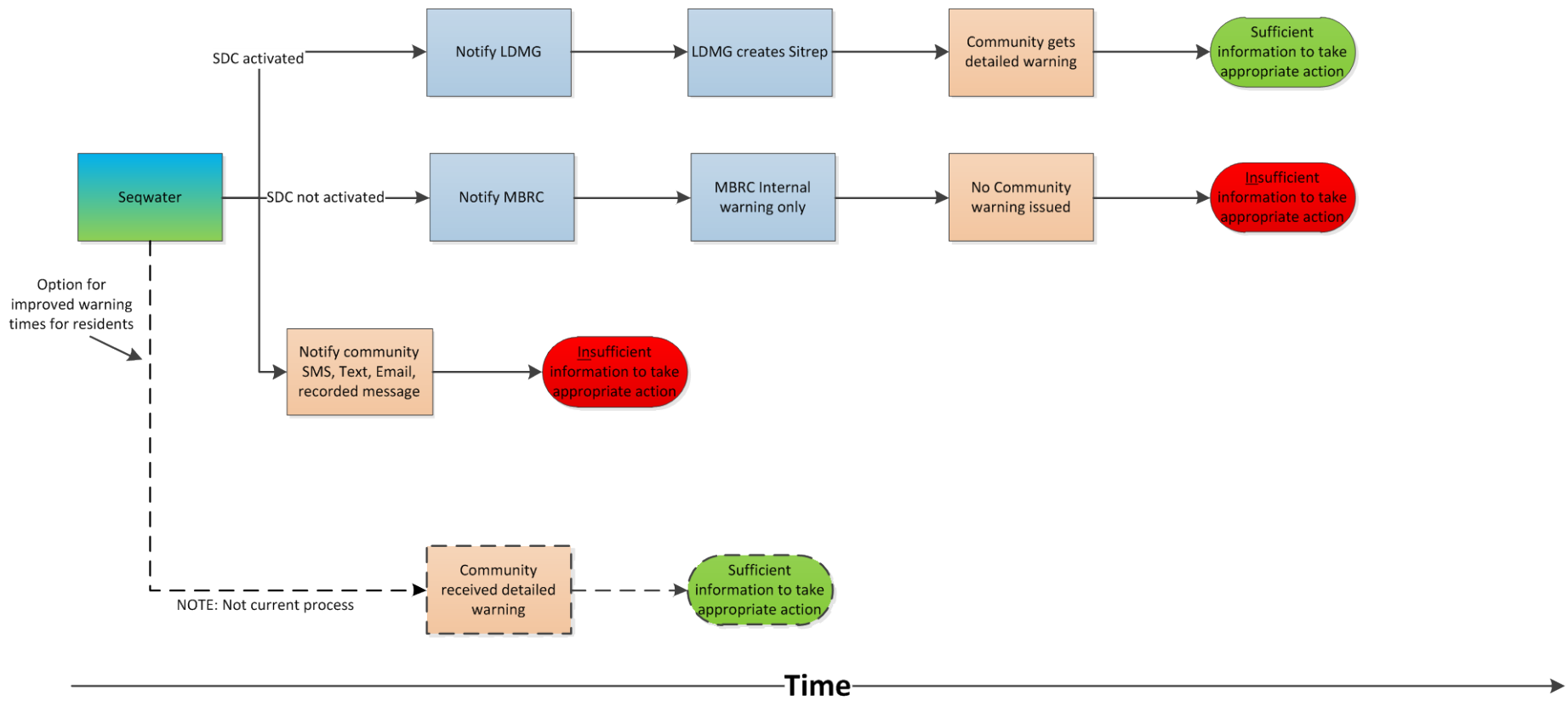


Figure 9.2: Flood releases warning time for downstream residents

## 9.5 Conclusions

Generally, MBRC, BoM and Seqwater do have robust warning and notification systems in place to warn community and stakeholder agencies.

The legislative standards in the Act and the regulator's Provisional Guideline for Emergency Action Planning for Referable Dams aim to ensure that dam owners place a premium on notification processes that are negotiated with stakeholders, the community and Local and District Disaster Management Groups.

North Pine Dam is relatively uncommon in being a large water supply dam located immediately upstream of and in close proximity to residential dwellings. During extreme events, residents in close proximity to the dam require more urgent warnings than those who are further downstream and are not at immediate risk. Seqwater does provide notifications directly to downstream residents and has in place detailed and rigorous plans, processes and procedures to deliver those notifications.

However, it is a notification system that relies on subscription to the service by the resident. This may not be a reliable notification service for those who may be affected within minutes of a significant flood release occurring. It would be preferable for a system that targets those located within the affected area through an unsubscribed emergency alert notification.

Seqwater, the Queensland Government, stakeholders, the community and the local and district disaster management groups will need to negotiate an acceptable outcome to ensure that those at risk from dam flood releases are warned by a nominated agency in a timely manner to take appropriate action. It is possible that in order to achieve this outcome amendment to legislation, guidelines and emergency management and action plans may be necessary.

As a guide for those involved in the negotiation the BoM states the following about a flood warning message:

*'A flood warning message provides information on what a flood prediction will mean to the target audience and what the audience should do.'*

*Warning messages are the critical link in communicating information on expected flooding. They provide the signal for those at risk to take action before the flood arrives or reaches particular levels.*

*Message construction should be based on the needs of those at risk and should be in language familiar to those expected to take action. The critical issues are:*

- *ensuring messages are forward-looking and provide helpful information and advice,*
- *persuading those at risk they should respond and within an appropriate time frame, and*
- *ensuring messages include the predicted severity (height) of the flood, describe its likely consequences and indicate the actions people should take.'*

The key elements that should be considered by those devising any warning message to those residents downstream are as follows:

- Can the dam operator warn those residents more quickly than any the emergency management agencies?
- Does the message provide enough information to inform those at risk to take action before the dam release arrives or reaches a particular level?
- Does the message persuade those at risk to respond and within an appropriate timeframe?

## Chapter 10 – Floodplain risk assessment

Assessment of the implications of urban and rural inundation was one of the considerations required under QFCoI Final Report recommendation 17.3 for a range of operational options and over a range of flood events. MBRC undertook the Floodplain Risk Assessment (FRA) with a view to characterising the flood behaviour and the resultant impacts and flood risks within the floodplain below North Pine Dam for the different dam operating scenarios.

The three dam operational strategy options summarised in Table 6.3 were analysed using scenario assessments outlined in Chapter 7. These incorporate lowering of North Pine Dam to various levels below the current FSL combined with different triggers for the commencement of flood releases.

The flood impacts were assessed for:

- property inundation
- residential buildings above floor flooding
- non-residential buildings above floor flooding and facility infrastructure inundation
- road access and potential isolation, and
- damage to bridge infrastructure.

These inundation assessments provided the basis for flood damage estimations by MBRC and those outlined in Chapter 15 and also provided input to the assessments presented in Chapter 12 on bridge and crossing submergence impacts.

### 10.1 Scope of the assessment

The FRA was undertaken by MBRC and drew heavily on work that had been undertaken for Council's RFD project that was completed in April 2013. The RFD project was a detailed flood investigation covering the entire Moreton Bay Regional Council area and provides high quality flooding information. The information in the database is used to predict where and how flooding may occur.

The RFD Lower Pine River basin study area extended from North Pine Dam and Sideling Creek Dam through to the mouth of the Pine River and included the South Pine River catchment. The FRA study area excluded those areas of the RFD Lower Pine River model that were considered to be unaffected by flooding in the North Pine River. Consequently, the NPDOS FRA study area was trimmed from the RFD Lower Pine River area at the following locations:

- Whiteside Creek tributary at the North Pine River backflow extent
- Yebri Creek tributary at Anzac Avenue
- One Mile Creek and Todds Gully tributaries at Youngs Crossing Road
- Four Mile Creek tributary at Gympie Road
- Coulthards Creek and Conflagration Creek tributaries at the railway line
- South Pine River at the railway line.

The extent of the FRA study area is shown on Figure 10.1.

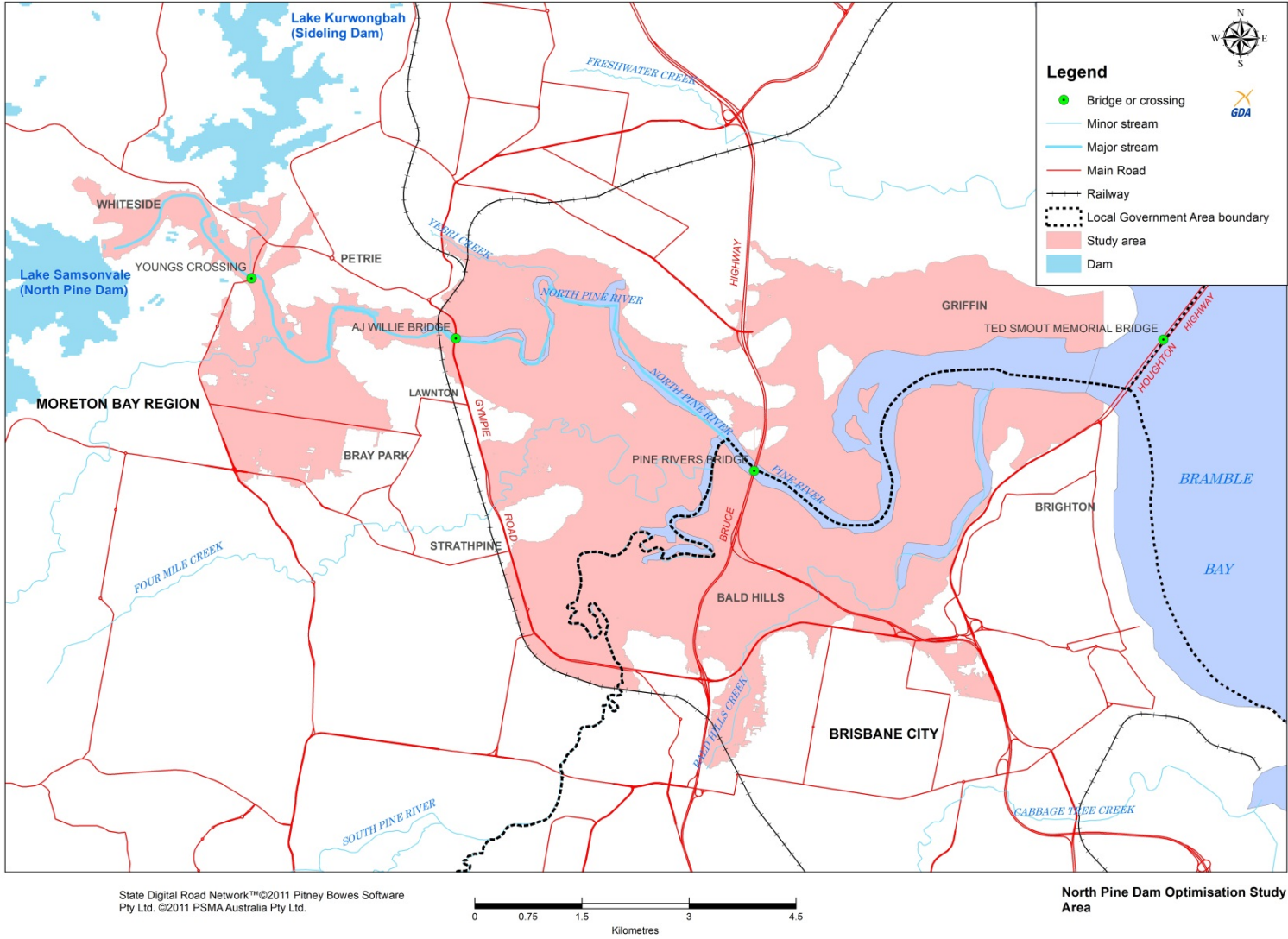
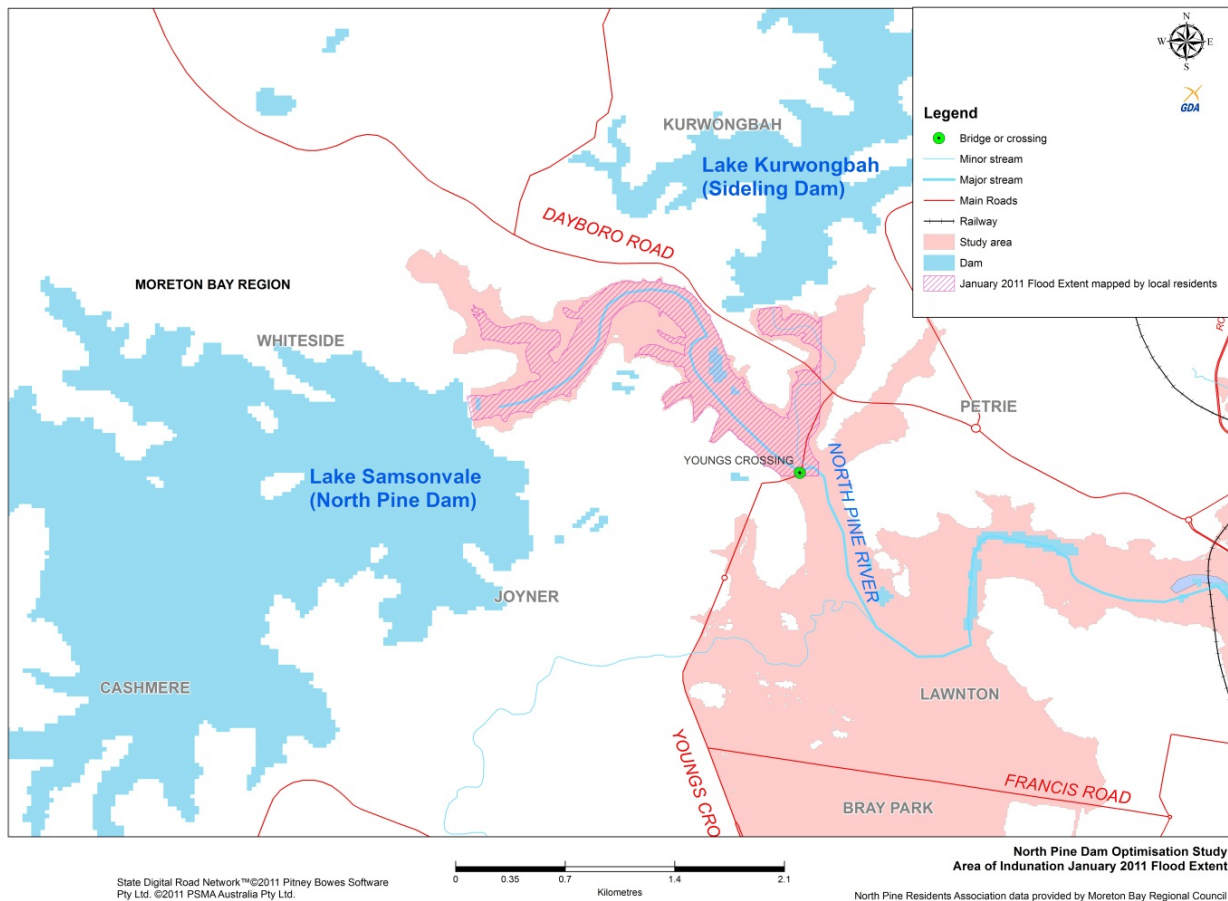


Figure 10.1 Floodplain risk assessment area

The lower Pine Rivers floodplain also includes parts of the outer northern Brisbane suburbs of Bald Hills, Bracken Ridge and Brighton. The relevant property data for those areas was obtained from BCC for inclusion in the assessment.

The study area used for floodplain risk assessment under the North Pine Dam Optimisation Study extends beyond the extent of flooding for the January 2011 flood event that was mapped by the North Pine Residents Association. The map of the January 2011 flooding was provided to MBRC by the local residents following the flood. Figure 10.2 shows the extent of January 2011 flooding in the area immediately downstream of the dam.



**Figure 10.2** January 2011 flood extent as mapped by local residents

For the RFD, Council adopted the following modelling software for all its catchments:

- hydrology – WBNM (Watershed Bounded Network Model) used to calculate the inflow hydrographs for the hydraulic model
- hydraulics – TUFLOW a dynamically-linked 2D/1D hydrodynamic numerical model used to estimate flood level, flood extent and other properties of flow.

A coupled hydrologic and hydraulic model was constructed for each of the 14 catchments across the Moreton Bay Regional Council area. The three catchment models of most relevance to this study are:

- Upper Pine River
- Sideling Creek
- Lower Pine River.

## 10.2 Hydrology

For all design events used to assess the dam operational scenarios under NPDOS associated with the lowering of the levels in the dam, local inflows downstream of the dam were assumed to be equivalent to a one exceedance per year inflow.

This probability was selected in order to avoid the influence of concurrent flood peaks from tributaries which could mask the impact of the North Pine dam outflow on overall peak levels. This also more closely reflects the observed rainfall and flood behaviour observed during the January 2011 flood event as well as the likely spread of flood magnitudes that will actually occur in the North Pine River since:

- The critical storm duration for the minor creeks below North Pine Dam is different (shorter) than the main arm.
- The substantial spatial separation between the upper and lower catchments which makes a single storm event with the same intensity and duration across the entire catchment improbable.

Nevertheless, a sensitivity analysis using a more substantial concurrent inflow condition was undertaken in order to confirm the likely impact of this assumption on the study results. To test the sensitivity of these results to a larger concurrent flood downstream of the dam, a 1% (1 in 100) AEP flood event was modelled in all three catchments simultaneously. This analysis indicated that there is very little change to the flood extent in the upper floodplain with the exception being an area of shallow breakout within the Todds Gully tributary. Although there is a distinct visible increase in the flood extent in the lower floodplain, it is mainly observed in undeveloped areas.

As indicated in Chapter 7, the range of design flood events selected for analysis is shown in Table 10.1.

**Table 10.1: Design flood events utilised in floodplain risk assessment**

AEP	Critical Duration (hours)
5% (1 in 20)	12
1% (1 in 100)	12
0.2% (1 in 500)	24
0.1% (1 in 1,000)	24
0.05% (1 in 2,000)	24
PMF	24

These events represent an appropriate range to allow assessment of frequent flooding (smaller than 1% (1 in 100) AEP) along with dam safety and emergency management strategies (larger than 1% (1 in 100) AEP). Critical storm durations for the RFD were selected based on the hydraulic models results, rather than hydrologic model results. This means that the critical duration was selected based upon the maximum flood levels rather than flows.

## 10.3 Hydraulic modelling

### 10.3.1 Model

TUFLOW is a hydrodynamic numerical model used to predict flood behaviour. The TUFLOW hydraulic model of the lower Pine Rivers basin that had been developed for the RFD project was truncated at the locations listed below:

- One Mile Creek
- Four Mile Creek
- Coulthards Creek
- Conflagration Creek
- South Pine River

and then used to predict flood behaviour for the operational Options 1 and 3 outlined in Chapter 6.

### 10.3.2 Inflow and boundary conditions

The outflow hydrographs from North Pine Dam that had been modelled by Seqwater together with the RFD outflows from the Sideling Creek Dam were the two major external inflows into the Lower Pine River hydraulic model for each design flood event and dam operating scenario.

Other external inflows that resulted from the model being trimmed at large creek and river tributaries and local inflows within the Lower Pine River hydraulic model extent were obtained from the Lower Pine River hydraulic model.

Sensitivity tests were undertaken in the RFD project for the downstream boundary conditions. It was found that higher tide levels increased peak flood levels within the most downstream part of the floodplain only. This includes the area generally downstream of the Bruce Highway, which is predominantly undeveloped. The modelling results demonstrated that flood behaviour within the urbanised area of the Lower Pine River floodplain, between North Pine Dam and the Bruce Highway is not influenced significantly by tidal conditions and associated water levels at the mouth of the river in Bramble Bay.

Therefore, similar to previous flood modelling by MBRC, the mean high water spring (MHWS) tide level was adopted for the modelling for all design flood events.

## 10.4 Flood impact assessment of options

### 10.4.1 Scope of the impact assessment

The assessment of the predicted flood impacts for each modelled FRA scenario included:

- flood affected properties (areas external to habitable buildings)
- residential building above floor flooding
- non-residential building above floor flooding and facility infrastructure flooding
- road access and potential isolation, and
- bridge damage.

Data from the BCC areas has also been incorporated into the data sets for the flood impact and risk assessments.

The outputs from the Lower Pine River hydraulic modelling were combined with information obtained from property databases, transport and access information and flood damages cost data for the assessment of flood impacts.

Council undertook a field survey of all buildings within the study area where the property was predicted to be flooded by flood events up to and including the 0.1% (1 in 1,000) AEP flood event. Floor levels for those properties above the level of the 0.1% (1 in 1,000) AEP flood event where this accurate data was not available were estimated by applying an average floor height, based on the building type, to the average ground level within the building footprint obtained from aerial survey data. Residential buildings were assumed to be single storey, low set houses having floor levels 300 mm above ground level, except where council was able to confirm otherwise.

All sheds, garages and small (<50 m<sup>2</sup>) buildings were excluded from the analyses as they were deemed to be outbuildings rather than separate dwellings or business premises.

The population at risk from above floor flooding has been calculated using 2.8 persons per residential building (2011 Census for Moreton Bay Regional Local Government Area) and using an average of 5.4 persons per non-residential building, as was used in the RFD risk study (Molino Stewart, 2013).

The assessment of the potential flood impacts on road and railway crossings was undertaken by reviewing the flood modelling results against the GIS roads data, which includes the BCC roads within the study area. A road/railway crossing has been designated as being impacted, for the purposes of this investigation, if the modelled flood data indicated any flooding at the crossing. Potential areas of isolation were identified from the modelled PMF extent to represent the 'worst case' condition.

The flood modelling results were utilised to determine the duration of flooding for all crossings apart from Youngs Crossing. Youngs Crossing over the North Pine River has an extremely high likelihood of flooding and prolonged durations of flooding that extend well beyond the model simulation periods. Therefore the analysis of historical flow records (refer to Section 12.3.2) was used to determine both the frequency and duration of flooding for Youngs Crossing.

It was assumed that structural damage to any of the road or rail bridges over the river had the potential to occur when the flood level reached 1 m above the deck of the bridge.

## 10.4.2 Properties and buildings impacted

The numbers of properties, residential and non-residential buildings and populations at risk for various FSVs of North Pine Dam are summarised in Table 10.2 and presented graphically in Figures 10.3, 10.4 and 10.5 respectively.

**Table 10.2: Properties and buildings impacted and populations at risk**

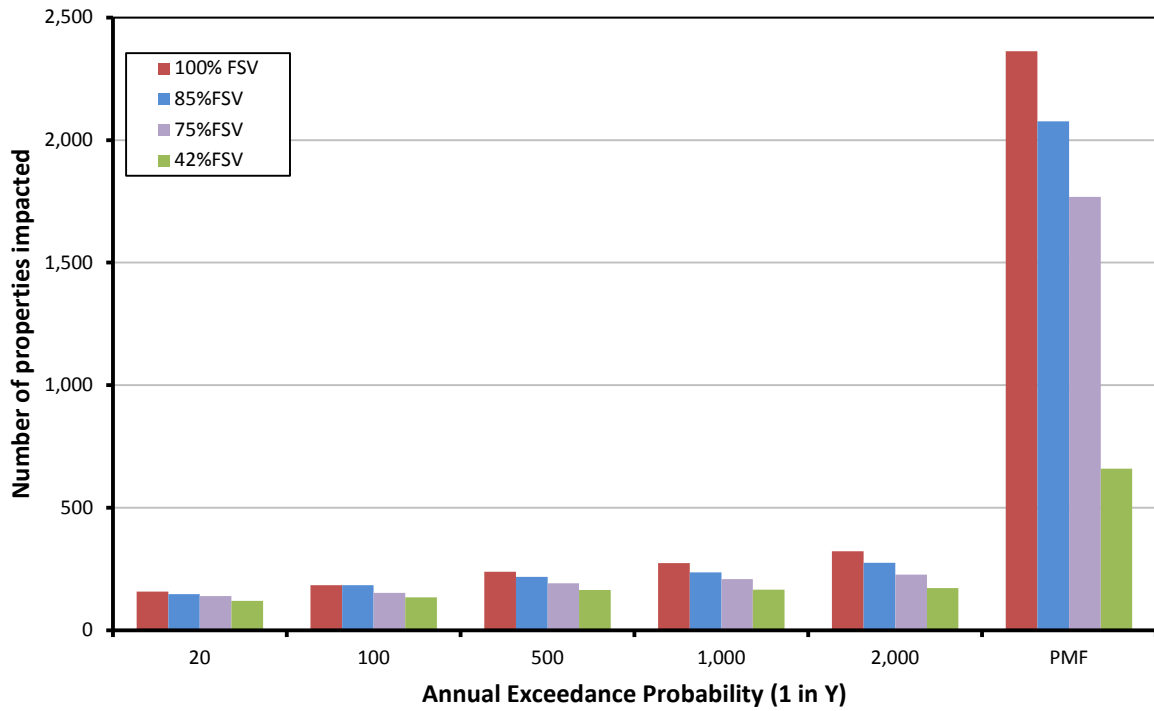
Supply Volume	Flood Affected	Flood Event Likelihood (AEP)					
		5% (1 in 20)	1% (1 in 100)	0.2% (1 in 500)	0.1% (1 in 1,000)	0.05% (1 in 2,000)	PMF
100% FSV	Properties <sup>1</sup>	158	184	239	274	322	2,363
	Buildings <sup>2</sup>	1	6	20	24	36	1,525
	Population at Risk <sup>3</sup>	5	27	69	83	119	4,434
85% FSV	Properties <sup>1</sup>	148	184	218	236	275	2,076
	Buildings <sup>2</sup>	1	1	11	20	24	1,200
	Population at Risk <sup>3</sup>	5	5	41	69	83	3,487
75% FSV	Properties <sup>1</sup>	140	153	192	209	227	1,768
	Buildings <sup>2</sup>	1	1	5	9	15	915
	Population at Risk <sup>3</sup>	5	5	24	36	52	2,684
42% FSV	Properties <sup>1</sup>	120	135	165	166	173	659
	Buildings <sup>2</sup>	1	1	1	1	3	241
	Population at Risk <sup>3</sup>	5	5	5	5	16	758

**Notes:**

1. Number of properties affected includes residential and non-residential (i.e. commercial and industrial). A property was considered affected if at least 10% of the registered parcel intersected the relevant flood extent. In most cases any buildings on the property are not affected.
2. Number of buildings affected is based on above habitable floor level flooding. Includes residential, non-residential and facility infrastructure (e.g. hospitals, schools, police stations, electrical sub stations, council community facilities).
3. Population at risk is based on the number of people at risk from above habitable floor level flooding.

Sources: MBRC 2013a, Tables 4.2 and 4.3

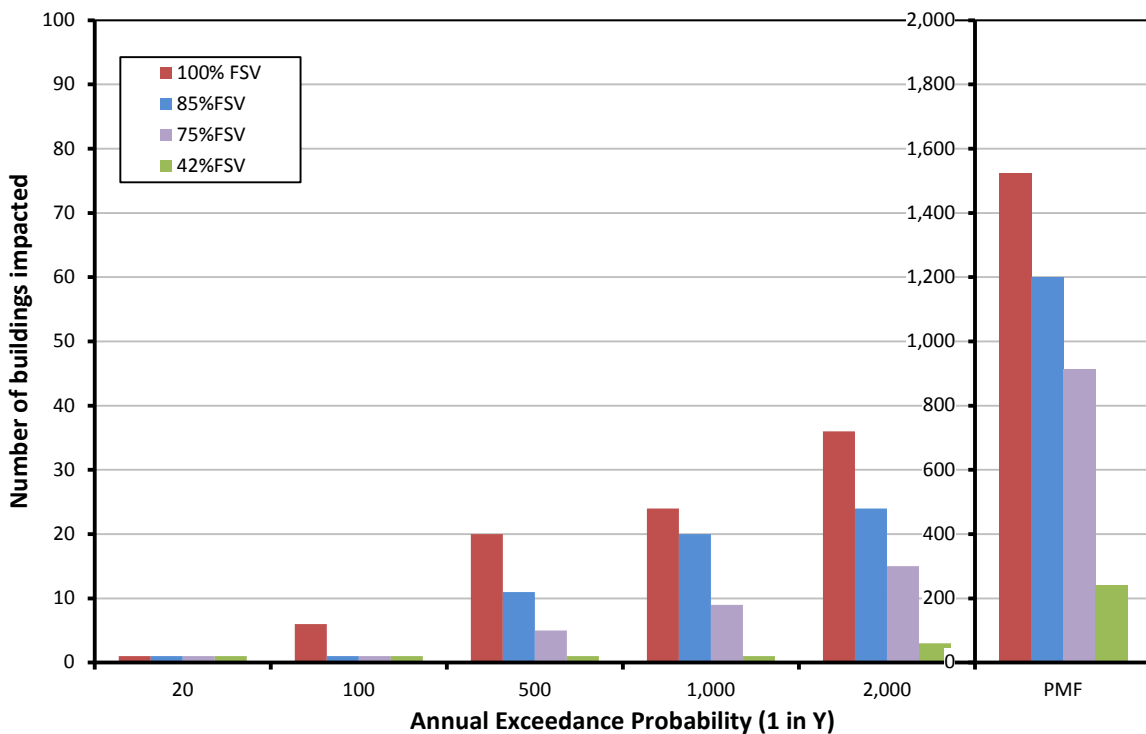
The results presented in Table 10.2 indicate that with the dam operating at 100% FSV (i.e. existing FSL of EL 39.60 mAHD) there are 184 properties predicted to be impacted by flooding external to habitable areas by the 1% (1 in 100) AEP flood event. Of these, only 6 buildings (two residential and four non-residential) are affected by above habitable floor level flooding. An additional 138 properties (i.e. a total of 322) are estimated to be impacted by the 0.05% (1 in 2,000) AEP flood event. Of these, only 36 buildings are affected by above habitable floor level flooding. A total of 2,363 properties are estimated to be impacted by the PMF flood event.



Note: Properties affected includes residential and non-residential (i.e. commercial and industrial).

Source: MBRC 2013a, Table 4.2

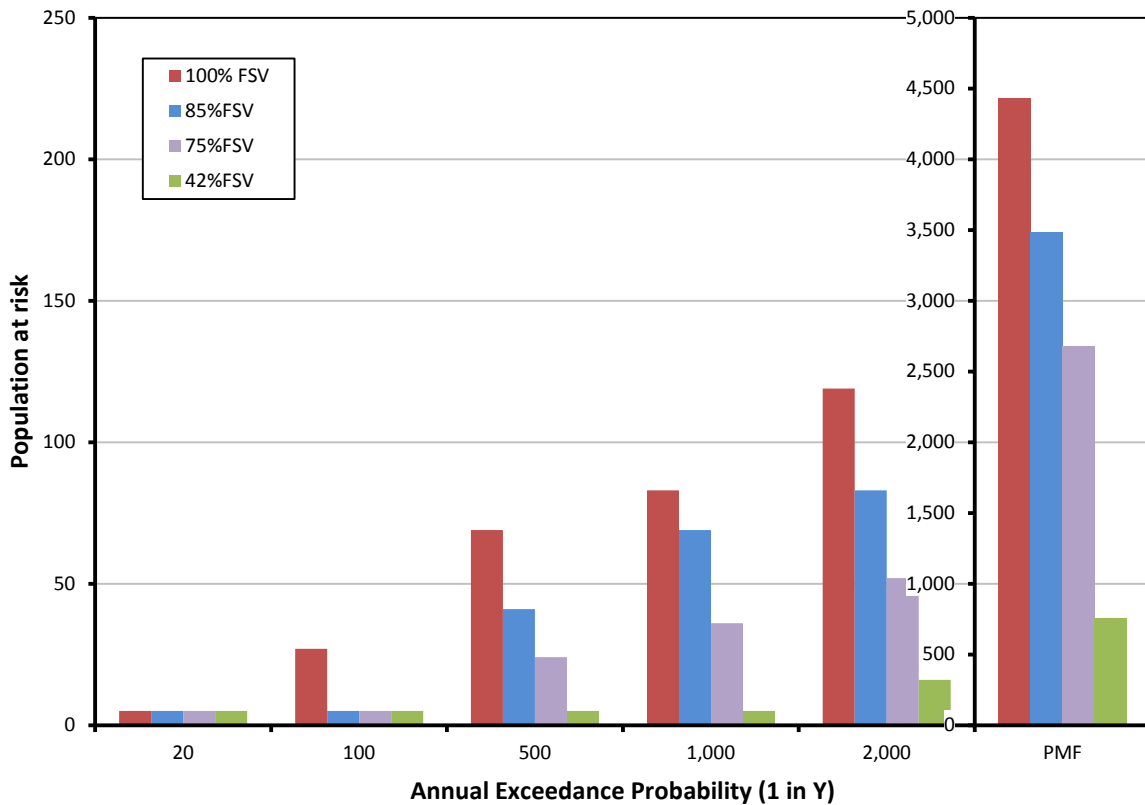
Figure 10.3 Properties impacted by external flooding



Note: Includes residential, non-residential and facility infrastructure (e.g. hospitals, schools, police stations, electrical sub stations, council community facilities)

Source: MBRC 2013a, Table 4.3

Figure 10.4 Buildings impacted by above habitable floor level flooding



Note: Population at risk is based on the number of people at risk from above habitable floor level flooding.

Source: MBRC 2013a, Table 4.3

**Figure 10.5 Population at risk from above habitable floor level flooding**

Figure 10.3 shows that the number of properties impacted by flooding does not vary significantly for flood events up to 1 in 2,000 AEP. A step change in the number of properties impacted occurs for the PMF flood event.

Most of the buildings impacted by flooding above habitable floor level downstream of North Pine Dam are only impacted by rare extreme flood events (i.e. significantly larger than the January 2011 flood event).

The 1% (1 in 100) AEP flood event is MBRC's current planning standard in relation to residential buildings downstream of the dam.

Lowering the dam level to 42% FSV significantly reduces the number of impacted properties and buildings and the population at risk in a PMF flood event. Smaller reductions in impacts occur when the dam levels are lowered to 75% FSV.

### 10.4.3 Road access and bridge impacts

MBRC identified 13 major road and rail crossings within the study area. The majority of the major road/railway crossings within the floodplain have a very low likelihood of flooding (i.e. the likelihood of these crossings being impacted by flooding is less than 0.05% (1 in 2,000) AEP).

Youngs Crossing, Gympie Road at A.J. Wyllie Bridge and Dayboro Road have less flood immunity. The A.J. Wyllie bridge crossings on Gympie Road and Youngs Crossing Road in Petrie have a likelihood of flooding in the order of 0.6% (1 in 160) AEP and in the order of two exceedances per year respectively. Dayboro Road has a likelihood in the order of 0.2% (1 in 500 AEP) of being flooded in any one year.

There are also 26 minor road crossings within the study area, most of which have a low likelihood of flooding. Fifteen have an immunity to floods with an annual likelihood less than 0.05% (1 in 2,000 AEP).

Only two minor road crossings for areas, which do not have alternative access, have an annual likelihood of flooding greater than a 5% (1 in 20 AEP). These two minor crossings are located at Vores Road, Whiteside in the Moreton Bay Region and Wyampa Road, Bald Hills in Brisbane City. Both these crossings can be flooded by events not related to North Pine Dam releases; Vores Road by local flooding of Whiteside Creek and Wyampa Road due to flooding downstream of the dam (including the South Pine River) and / or due to storm tide inundation. Lowering the dam level of North Pine Dam does not reduce the likelihood of flooding for these two crossings.

The major and minor road and rail crossings and estimated persons isolated for the flood option scenarios modelled are summarised in Table 10.3.

**Table 10.3 Number of major and minor road crossings flooded and population isolated**

Supply Volume	Description	Flood Event Likelihood (AEP)					
		5% (1 in 20)	1% (1 in 100)	0.2% (1 in 500)	0.1% (1 in 1,000)	0.05% (1 in 2,000)	PMF
100% FSV	No of major crossings flooded	1	1	3	3	3	11
	No of minor crossings flooded	6	7	10	11	11	26
	Population Isolated <sup>1</sup>	160	160	860	969	969	7,054
85% FSV	No of major crossings flooded	1	1	1	3	3	11
	No of minor crossings flooded	6	6	7	10	11	26
	Population Isolated <sup>1</sup>	160	160	160	860	969	7,054
75% FSV	No of major crossings flooded	1	1	1	1	2	10
	No of minor crossings flooded	6	6	6	6	8	26
	Population Isolated <sup>1</sup>	160	160	160	160	160	7,004
42% FSV	No of major crossings flooded	1	1	1	1	1	5
	No of minor crossings flooded	6	6	6	6	6	13
	Population Isolated <sup>1</sup>	160	160	160	160	160	2,229

Note: 1. Isolated population figures refers to the isolation of properties by road not necessarily that the buildings are impacted by the flood event above the habitable floor level. The isolated population figures are accordingly significantly higher than the population at risk figures for the corresponding flood event presented in Table 10.2.

Source: MBRC

#### 10.4.4 Property isolation

Isolation of properties refers to situations where road access to properties is cut before the properties are flooded by a particular flood event. A significant proportion of these isolated properties have houses with habitable floor levels well above the flood event which cuts road access. Other mitigating measures that can reduce the risks from isolation include having adequate supplies (food and drinking water), emergency power supplies (e.g. back-up generators) and access to local medical facilities if required.

Five areas were identified as having the highest risk of isolation due to flooding. These were:

- Vores Road, Whiteside.
- Kirri Avenue, Petrie
- Pine Valley Drive, Lawnton
- Wyampa Road, Bald Hills and
- Dohles Rocks Road, Griffin

These areas of isolation represent approximately 2% of the buildings and population at risk due to isolation during a PMF event.

The areas most vulnerable to property isolation are Vores Road immediately downstream of the dam and Wyampa Road downstream of the Bruce Highway. The Kirri Avenue, Dohles Rocks Road and Pine Valley Drive areas have an existing annual likelihood of isolation ranging 0.2% to 0.3% (1 in 500 to 1 in 330 AEP).

Lowering the dam levels of North Pine Dam reduces only marginally improves property isolation risks associated with Vores and Wyampa roads. Lowering of dam levels significantly reduces the likelihood of isolation for the Kirri Avenue, Dohles Rocks Road and Pine Valley Drive areas.

The Youngs Crossing is the most flood-prone transport route within the study area. However, no people are isolated by its submergence. The impact of the submergence of Youngs Crossing is discussed in Chapter 12 – Bridge and Crossing Submergence.

The modelling results showed that the majority of the roads are flooded for relatively short durations under existing conditions, yielding only marginal reductions in durations of flooding for the lowered dam levels.

### 10.5 Conclusions

The relatively low numbers of buildings affected by floods up to and including the 0.05% (1 in 2,000) AEP design flood event demonstrates that the management of the lower Pine Rivers floodplain through the adoption of modern appropriate flood planning controls has been effective in minimising the impacts of flooding in the affected area to date.

The hydraulic modelling results indicate that lowering the level in North Pine Dam will:

- achieve relatively minor reductions in the numbers of properties and buildings flooded habitable floor level and the populations at risk for the 0.05% (1 in 2,000) AEP design flood and smaller events.
- provide marginal reductions to the likelihood of flooding for most of the major and minor road and railway crossings which already have a low flooding risk.

# Chapter 11 – Water Supply Security

North Pine Dam was designed and constructed for urban water supply for the northern suburbs of Brisbane and parts of Moreton Bay Regional Council areas. This chapter summarises the results of the water supply security investigations (DEWS 2014) undertaken for NPDOS and the Wivenhoe and Somerset Dams Optimisation Study by DEWS with modelling input from Seqwater. This chapter presents the results of analyses undertaken to determine the impacts of lowered FSVs of both North Pine and Wivenhoe dams as well as adjustments to the availability of manufactured water.

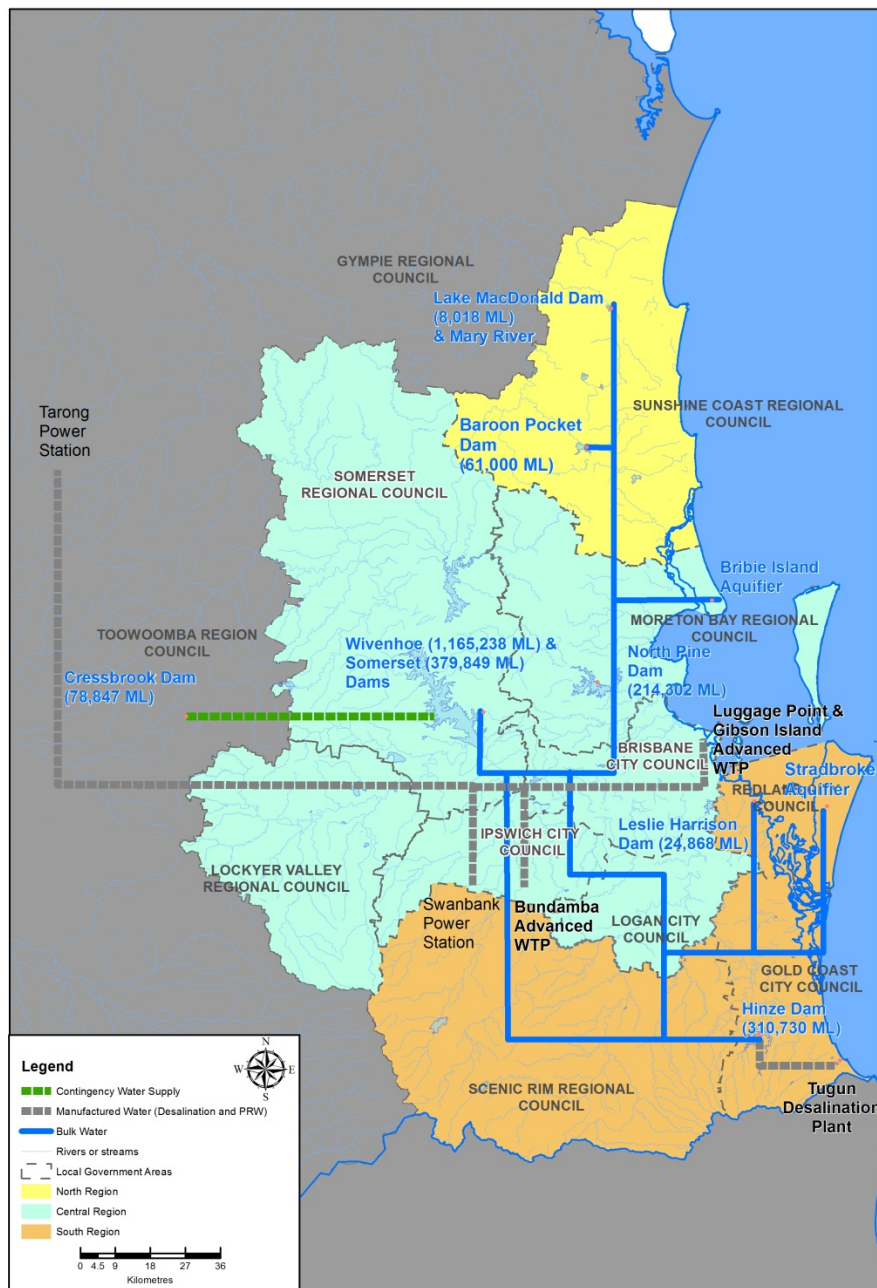


Figure 11.1 SEQ water supply system

## 11.1 SEQ water supply system

Water supply security for SEQ is achieved through the networked water supply system, shown in Figure 11.1, which is operated by Seqwater and enables water to be moved where and when it is needed. Consequently, it is necessary to consider the combined impacts on water supply security of operational measures being considered in the North Pine Dam and Wivenhoe and Somerset Dams Optimisation Studies. Both studies involve operational options with lowered FSVs of dams with consequential potential impacts on water supply system yields.

Water supply to the region is sourced from 12 SEQ water storages within three sub-systems:

- Southern System – Hinze Dam and Little Nerang Dam
- Central System – Leslie Harrison Dam, Somerset Dam, Wivenhoe Dam, North Pine Dam and Lake Kurwongbah
- Northern System – Ewen Maddock Dam, Cooloolabin Dam, Wappa Dam, Baroon Pocket Dam and Lake Macdonald.

At full supply, North Pine Dam has a storage capacity of around 214,300 megalitres. This is equivalent to approximately 10% of the total volume of the SEQ water storages. Surface water supplies are supplemented (when required) by two manufactured water assets:

- GCDP, and
- WCRWS.

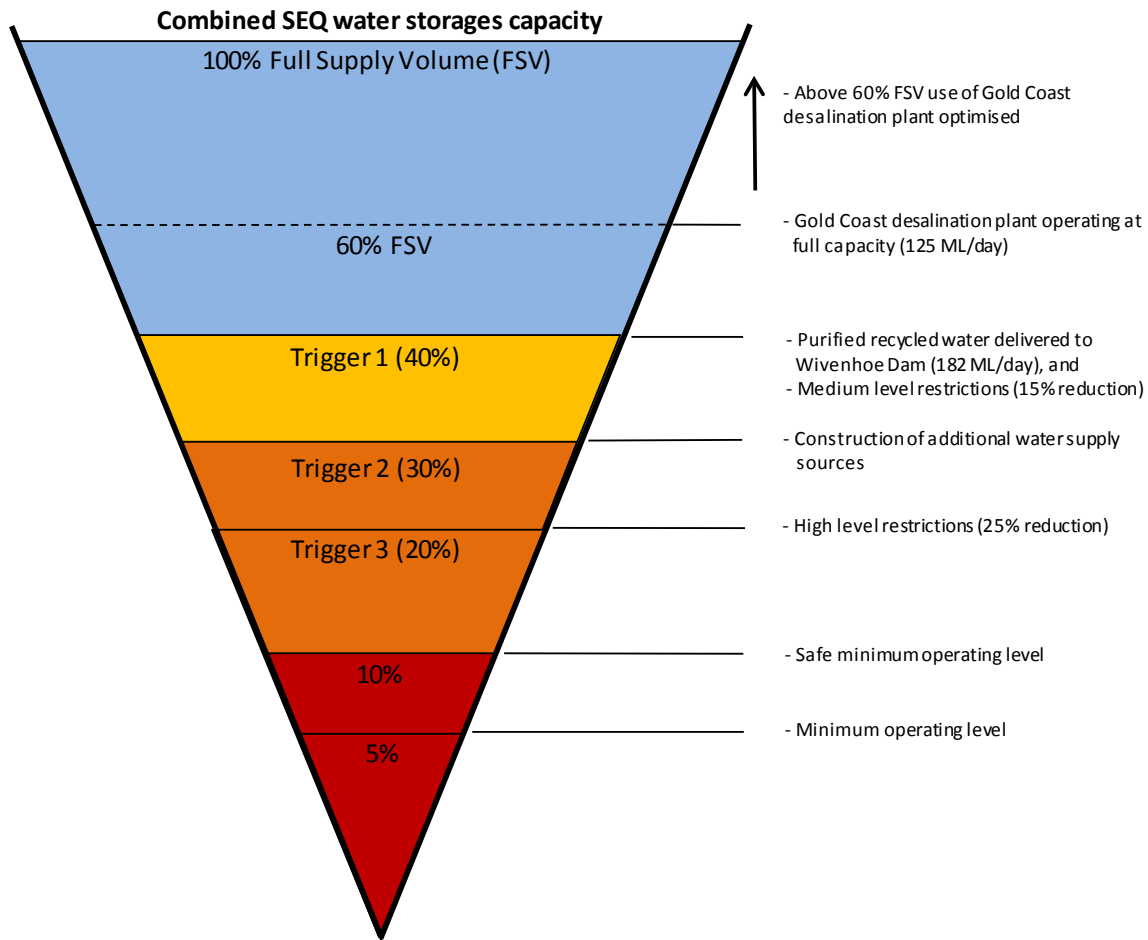
The GCDP at Tugun is currently operated in standby mode. It is brought into full production (supplying up to 125 ML/day) when the combined capacity of the SEQ water storages reach 60%. This is an operational trigger determined by Seqwater, however the plant is able to operate at full capacity during water supply emergencies.

The WCRWS consists of advanced water treatment plants (AWTPs) at Luggage Point, Gibson Island and Bundamba which can supply purified recycled water to the SEQ water supply system. Under the System Operating Plan (SOP), a subordinate legislation plan, the WCRWS is required to be fully operational when the combined capacity of the SEQ water storages reaches 40%. Currently the WCRWS is being shut down into care and maintenance mode with the ability to be recommissioned and operated at full capacity should the 40% trigger be reached.

The current combined storage trigger volumes for demand restrictions and changes in operation of the manufactured water assets are summarised in Figure 11.2.

The SEQ water supply system supplied around 282,000 ML in the 2012–13 financial year.

DEWS is currently undertaking a review of the desired level of service objectives outlined in the SOP; following which the revised LOS objectives will be prescribed in regulation. Seqwater must then develop a detailed water security program within 12 months. The water security program will include how future infrastructure needs, demand management and responding to drought conditions are addressed. The water security program will also detail how water security will be maintained for those SEQ communities that are not directly connected to bulk water supply system (such as Boonah and Beaudesert). It is anticipated that Seqwater will consider the outcomes of this report when developing their water security program.



Source : Adapted from QWC 2010, Figure 3.1

**Figure 11.2: Current triggers for changes to operations**

## 11.2 Modelling

Seqwater has undertaken modelling to assess the implications of options to lower the FSVs at North Pine Dam on the water supply security for SEQ. The modelling scenarios included options to lower the FSV in North Pine Dam separately as well as in combination with lowering the FSV in Wivenhoe Dam. Additional modelling was undertaken by Seqwater to assess scenarios where no manufactured water (GCDP and/or WCRWS) was available.

The modelling provided two outputs:

- the effect on system yield and therefore system augmentation dates
- the effect on the likelihood of reaching combined storage trigger levels associated with changed system operation and restrictions.

### 11.2.1 WATHNET model

WATHNET is a suite of programs capable of simulating the operation of a wide range of water supply headworks and transfer systems serving urban, industrial, irrigation and in-stream demands. The model contains assumptions about infrastructure - including pipeline capacities, storage capacities and behaviour (including evaporation), and manufactured water - and water demands across the region.

Modelling of the behaviour of the Seqwater supply system storages was based on synthetically generated potential inflow sequences that have the same statistical characteristics as the historical record. It included 10,000 synthetic inflow sequences, each 117 years in length; along with the historic record.

The purpose of such modelling was to assess the potential impacts of climate variability on water supply security beyond that which has been experienced historically.

### 11.2.2 Modelling cases and assumptions

The WATHNET hydrologic model was used to assess various scenarios considering the lowering of the FSV in North Pine Dam alone and in combination with a lowering of the FSV in Wivenhoe Dam were analysed. The scenarios are listed in Table 11.1.

**Table 11.1 Water security assessment modelling cases**

North Pine Dam (% FSV)	Wivenhoe Dam (% FSV)			
	100	85	75	60
100	X	X	X	
85	X	X		X
75			X	
42	X			X

The modelling was based on the infrastructure existing in 2012.

The demand projections were based on the ‘most likely’ forecast demand scenario. The projected most likely demand is estimated to exceed the system yield within 20 years. Consequently the modelling results have been generated for a planning horizon of 20 years to 2033.

Demand restrictions (refer Figure 11.2) were assumed to be applied to all SEQ regions during the modelling as follows:

- 15% reduction to average regional total urban use when the SEQ water storages fall to 40% and applied until a return to the 50% threshold; and
- 25% reduction to average regional total urban use when the SEQ water storages fall to 20% but revert to 15% when 30% is reached.

The following manufactured water availability was modelled:

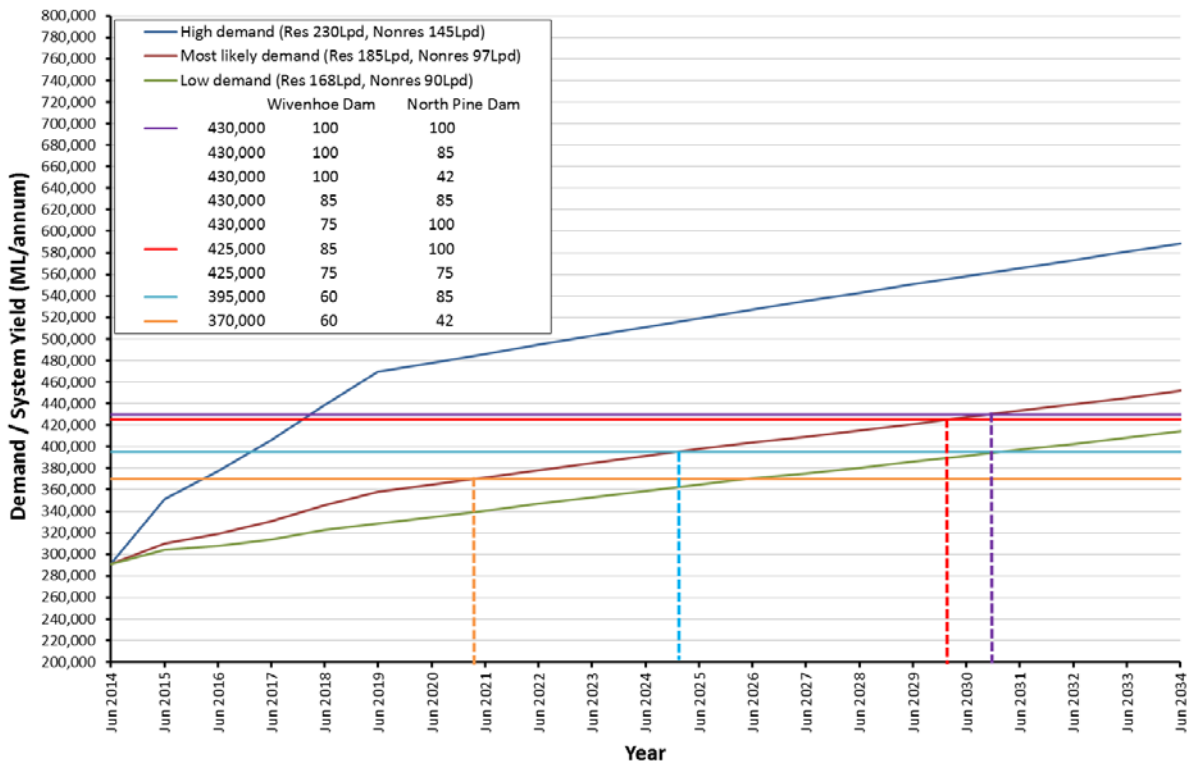
- WCRWS and GCDP available
- only GCDP available
- only WCRWS available
- no WCRWS or GCDP available.

All modelling has been based on a permanent lowering of FSVs. Temporary lowering of the FSVs would have less impact on water supply security.

### 11.2.3 Modelling results

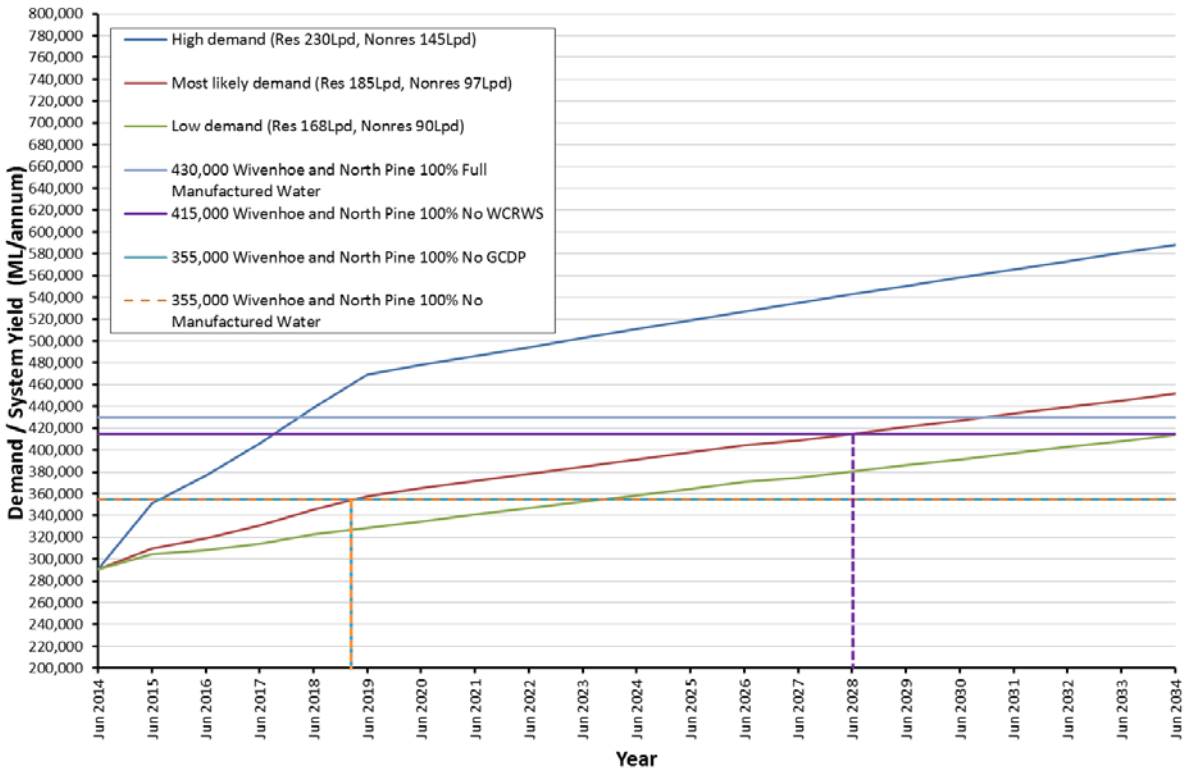
Figures 11.3 and 11.4 summarise:

- the impacts of lowering the FSVs of North Pine and Wivenhoe dams , and
- reducing the availability of manufactured water.



Source: DEWS 2014

Figure 11.3 Modelled water security scenarios



Source: DEWS 2014

Figure 11.4 Supply demand balance - effect of manufactured water

The estimated system yield for SEQ, based on achieving the level of service objectives (outlined in the SOP) for the assumed most likely demand scenario (i.e. based on a total per capita demand of 285 litres/person/day), is 430,000 ML/year. This yield takes into account water available from the surface water storages, combined with GDCP and WCRWS operated as needed. The estimated total system yield is sufficient to satisfy the most likely projected demand (refer Section 11.2.2), for SEQ until around 2031.

Figure 11.3 indicates that the system yield impacts are minor providing North Pine and Wivenhoe dams are not lowered below 75%. The critical factor in the SEQ water supply system assessment undertaken is the risk of supply shortfalls occurring on the Sunshine Coast as a result of Baroon Pocket Dam reaching dead storage in the modelling. If the indicator of supply failure was changed from a local shortfall in supply to a regional shortfall such as reaching a percentage of the total SEQ water storage capacity, then the results may be different with the impacts of lowering the dams likely to be more noticeable. Such modelling has not been undertaken. For the immediate future, lowering of North Pine Dam will have small impacts so long as there are no water quality issues.

North Pine Dam (which contributes approximately 10% of the total system volume) has an estimated average annual contribution of around 25,000 ML, which is just 6% of the total system yield. The historical no failure yield of North Pine Dam is around 39,000 ML/year at 100% FSV and 25,500 ML/year at 42% FSV.

This combined with recognition of the potential water quality issues at low levels in the dam indicates that the modelling may understate the potential consequences on system yield when the dam levels are lowered.

The uncertainties about water supply security may impact decisions to declare temporary FSLs for flood mitigation purposes.

Without the WCRWS (Figure 11.4), the total system yield reduces to 415,000 ML/year. This yield reduces further if neither WCRWS nor GCDP are available, to 355,000 ML/year.

If the WCRWS was not available to be fully operational at the 40% trigger, the timeline for augmentation of supply in SEQ would be brought forward from 2031 to 2028 and the likelihood of reaching the 30% trigger would be increased. Modelling indicated that the cumulative probability of reaching 30% within the next 20 years would approximately double (but be less than 5%) if Wivenhoe and North Pine dams are lowered to 85% FSV. Having neither the WCRWS nor the GCDP would roughly triple the cumulative probability of reaching the 30% trigger by 2033 (but the probability is less than 7%). Construction would need to commence about three years in advance of when the supply was needed to allow sufficient time for commissioning and testing.

Increases in the frequency of use of manufactured water supplies are an increase in bulk water supply costs. These additional costs are described in Chapter 15 and included in the options assessment.

The results of the cumulative probability of SEQ water storages reaching system trigger levels under current operations when the FSVs of North Pine and Wivenhoe dams are lowered are summarised in Table 11.2. The base case for comparative purposes was 100% FSV in both dams.

**Table 11.2 Cumulative probability of SEQ water storages reaching trigger levels – various North Pine and Wivenhoe dams FSVs (with manufactured water available)**

SEQ water storages combined capacity trigger levels	Response strategy	Year	Modelling Cases (North Pine %FSV / Wivenhoe %FSV)						
			100/100	85/100	42/100	85/85	75/75	85/60	42/60
			60%	GCDP (125 ML/d)	2018	2.60%	3.00%	6.00%	7.70%
		2023	13.00%	14.70%	23.30%	28.40%	48.10%	75.60%	92.20%
		2033	43.5%	46.70%	60.10%	67.40%	85.00%	97.40%	99.80%
40%	WCRWS (182 ML/d) <sup>1</sup>	2019	0.01%	0.04%	0.02%	0.10%	0.10%	0.70%	1.30%
		2023	0.80%	0.80%	0.80%	1.60%	3.00%	6.10%	8.90%
		2033	7.60%	8.30%	7.70%	12.40%	18.00%	27.90%	35.90%
30%	Construction of Additional Supplies <sup>2</sup>	2018	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.02%
		2023	0.06%	0.07%	0.10%	0.20%	0.30%	0.40%	0.50%
		2033	1.40%	1.40%	1.90%	2.20%	3.00%	4.10%	5.40%

Notes:

1. WCRWS brought on line in addition to GCDP
2. Additional supplies assumed to be 125 ML/d desalination plants

Source : Seqwater

The implications of variable availabilities of manufactured water for addressing shortfalls were only assessed for scenarios where both dams were maintained at either 100% FSV or 85% FSV. These are summarised in Table 11.3.

**Table 11.3 Cumulative probability of SEQ WATER STORAGE reaching trigger levels – various North Pine and Wivenhoe dams FSVs and manufactured water availability**

Manufactured Water Production	Year	Probability of reaching 60% combined SEQ water storages capacity		Probability of reaching 40% combined SEQ water storages capacity		Probability of reaching 30% combined SEQ water storages capacity	
		100/100	85/85	100/100	85/85	100/100	85/85
		Full Manufactured Water available	2018	2.6%	7.7%	0.01%	0.1%
	2023	13%	28.4%	0.8%	1.6%	0.06%	0.2%
	2033	43.5%	67.4%	7.6%	12.4%	1.4%	2.2%
Without GCDP (i.e. WCRWS is only manufactured water available)	2018	2.3%	8.2%	0.05%	0.2%	0.00%	0.01%
	2023	13.2%	29.2%	1.3%	2.9%	0.2%	0.4%
	2033	44.2%	68.3%	10.6%	17.7%	2.8%	4.5%
Without WCRWS (i.e. GCDP is only manufactured water available)	2018	2.6%	9.2%	0.02%	0.1%	0.00%	0.01%
	2023	14.2%	30.6%	0.9%	2.0%	0.2%	0.4%
	2033	45.8%	69.7%	8.6%	13.9%	2.5%	3.7%
Without GCDP and WCRWS (i.e. no manufactured water available)	2018	2.7%	9.5%	0.1%	0.3%	0.01%	0.01%
	2023	14.8%	31.6%	1.6%	3.6%	0.4%	0.7%
	2033	46.8%	70.6%	11.9%	19.5%	4.2%	7.0%

Source : Seqwater

There are only small changes in the cumulative probabilities in Table 11.3 between manufactured water being available and not available. This is due to several factors such as:

- the cumulative probabilities for reaching the thresholds for initiating manufactured water production and construction of new sources of supply assuming the current high levels in the dams.
- the current demands being well below the SEQ water supply system yield, and to a lesser extent
- the system operating rules incorporating triggers for restrictions and manufactured
- water production.

Figure 11.4 indicates that without the WCRWS and the GCDP, supplies in SEQ would need to be augmented around 2019. A future decision to actually augment supply would be based on consideration of the SEQ water supply system yield as in Figure 11.4 and the levels in the dams at the time. If the SEQ water storages are relatively full, typically, it can take between eight to ten years to deplete them. Obviously, the least cost solution will be to defer capital expenditure until it is needed.

### 11.3 Water quality

As raised in Section 3.5 of Chapter 3, North Pine Dam is prone to algal blooms when the dam is at low levels. Algal blooms can be caused by numerous species and generally result in water quality problems (i.e. discoloured water, surface scums, unpleasant tastes and odours).

Water contaminated by blue-green algae is generally considered to be a health risk to water users, thus making it potentially unsuitable for water supply - without at least additional (usually more expensive) treatment.

The water supply security implications of this have not been specifically analysed / modelled for this study, however algal blooms could affect North Pine Dam during a critical supply period - as was experienced during the Millennium Drought – reducing the contribution to the total system yield by North Pine Dam to zero and increasing reliance on manufactured water sources.

This tends to mitigate against adopting a major lowering of North Pine Dam for flood mitigation purposes.

### 11.4 Conclusions

Overall, the modelling results indicate that small reductions in the FSV of North Pine Dam down to 85% FSV or 75% FSV have minimal impact on the performance of the bulk water supply system. The modelling might produce slightly different results and better reflect the importance of the North Pine Dam supply if the indicator of supply failure is changed from a local shortfall in supply to a regional shortfall.

A substantial lowering of the FSV of North Pine Dam would increase the likelihood of algal blooms such as was experienced during the Millennium Drought.

Reducing North Pine Dam to the dam spillway crest level (i.e. 42% FSV) would most likely have greater impacts than the modelling indicates due to water quality issues increasing the likelihood of triggering water restrictions and the use of manufactured water. The modelling is not able to reflect the potential water quality impacts.

Despite its small contribution to the total system yield, North Pine Dam plays an important role in minimising costs associated with supply distribution to the northern Brisbane metropolitan areas and the Sunshine Coast. A small lowering of North Pine Dam is predicted to have a small impact on the drawdown of Sunshine Coast storages. However a substantial reduction of North Pine Dam to 42% FSV could increase the frequency that the northern SEQ sub-region is subject to water supply shortfalls, bringing forward the need to augment the bulk supply or distribution system to the northern areas.

## Chapter 12 – Bridge and Crossing Submergence

The QFCol Final Report recommendation 17.3 required consideration of bridge and crossing submergence in the assessment of operational options for North Pine Dam. This chapter presents the results of assessments on the duration of road closures and traffic delays due to bridge and crossing submergence as a result of changed operations of North Pine Dam as outlined in Chapter 6 – Operational Strategy Options.

This Chapter has been compiled to provide the basic input information for incorporation into the integrated assessment of options (Chapter 15) based on assessments by:

- MBRC on flood impacts
- DSITIA on the estimated historical flooding of Youngs Crossing
- Seqwater on the duration of flooding by large floods
- DTMR on traffic re-routing caused by bridge and crossing closures.

The impacts on bridge and crossing submergence discussed below include:

- the frequency and duration of bridge and crossing closures as a result of flood releases from North Pine Dam, and
- delays resulting from the diversion of traffic around closed bridges and crossings.

Traffic impacts have focused only on road traffic impacts given the very low likelihood of flooding of the North Coast Railway Bridge at Petrie.

Assessments by MBRC (Chapter 10 – Floodplain Risk Assessment) demonstrate that the likelihood of damage to major road and bridges (including the A.J. Wyllie Bridge due to bridge submergence) is a rare occurrence. Chapter 10 also includes MBRC's assessment of the impacts and risks of isolation and access to people resulting from the flooding of minor roads and crossings as part of the assessments conducted on floodplain risk.

### 12.1 January 2011 Flood

The January 2011 flood event had significant impacts on major transport routes downstream of North Pine Dam. Road access was severely affected. Youngs Crossing was closed for over two weeks and most notably the lower northbound A.J. Wyllie Bridge (Gympie Rd at Petrie) was overtopped and irreparably damaged and has since been upgraded (rebuilt to a higher level). The Bruce Highway bridges at Murrumba Downs were unaffected by the January 2011 flood.

The North Coast Railway Bridge across the North Pine River at Petrie was not affected by the flood and remained open during the flood. Passenger rail services were however disrupted by the termination of northbound services at Strathpine station due to flooding farther north and especially due to flooding at Petrie station.

### 12.2 Infrastructure

The principal transport bridges and crossings of the North Pine and Pine Rivers downstream of the dam along with estimated bridge and crossing submergence flow rates are summarised in Table 12.1.

**Table 12.1 Principal transport bridges and crossings downstream of North Pine Dam**

Description	Bridge / Crossing Submergence Flow Rate (m <sup>3</sup> /s) <sup>2</sup>	Likelihood of discharge from the dam causing the submergence flow <sup>2</sup>
Youngs Crossing – North Pine River	8 to 10	≈ 2 EY <sup>1</sup>
North Coast Railway / Petrie Bridge– North Pine River	>2,800	≈ 0.05% (1 in 2,000) AEP
A.J. Wyllie Bridges, Petrie (north and southbound bridges on North Pine River)	1,500 -1,750	≈ 0.6% (1 in 160) AEP
Bruce Highway, Murrumba Downs (north and southbound bridges – Pine River)	>3,500	<0.05% (>1 in 2,000) AEP

Note:

1. EY = Exceedances per year
2. Flows are the calculated flows at the bridge or crossing correlated with the likelihood of discharge at the dam.
3. It should be noted that the flows downstream of the dam attenuate due to the floodplain storage.

QFCoI Interim Report recommendation 2.29 recommended that MBRC investigate options for the upgrading of Youngs Crossing including a cost benefit analysis. MBRC has proposed the construction of the West Petrie Bypass, including high level bridges over the North Pine River and Sideling Creek, to replace the existing low level Youngs Crossing and to improve the traffic flow in the Petrie area. MBRC has produced a business case which was released in August 2013 for the West Petrie Bypass project addressing QFCoI Interim Report recommendation 2.29.

DTMR is currently undertaking planning studies of the West Moreton corridor between Caboolture and Brendale, and of the South Moreton corridor. These studies will compare alternative options to the West Petrie Bypass. Both studies are due for completion in 2014.

## 12.3 Dam operations

### 12.3.1 Impact of dam operations on bridges and crossings

The nominal flow capacity of the Youngs Crossing bridge is 8 to 10 m<sup>3</sup>/s, resulting in the bridge being closed due to submergence several times each year. The outflow from North Pine Dam through one (1) gate open to the first setting is sufficient to close the crossing to traffic. Consequently, the crossing is frequently closed by low flow releases from North Pine Dam to maintain the FSL following minor rainfall events. Uncontrolled overflows from Sideling Creek Dam during minor events can also close the crossing.

The A.J. Wyllie bridges are infrequently affected by flood releases and are generally only impacted by moderately large flood events with a less than 1 in 160 chance in any one year (0.6% AEP). The North Coast Railway Bridge at Petrie and the Bruce Highway bridges have a less than 1 in 2,000 chance of being flooded in any one year (0.05% AEP). This represents a flood larger than the January 2011 flood event.

Given the high likelihood of flooding of Youngs Crossing, lowering the dam level does not appreciably reduce the likelihood of flooding of the crossing, i.e. it is still frequently flooded. The length of the duration of flooding is however significantly increased for the case of the dam level lowered to 42% FSV (refer to Chapter 7 and the following Section 12.3.2).

Lowering the dam level to 85% FSV does reduce the likelihood of flooding of A.J. Wyllie bridges to a less than 1 in 500 chance in any one year (0.2% AEP). A further lowering to 75% FSV reduces the likelihood of flooding to a less than 1 in 1,000 chance in any one year (0.1% AEP).

The likelihood of flooding of the North Coast Railway Bridge at Petrie and the Bruce Highway bridges is already low and would not benefit from lowered dam levels.

### 12.3.2 Frequency and duration analysis

Most of the major and significant transport routes are generally unaffected by flood releases from North Pine Dam with only one flood within the last 125 years (January 2011) having impacted the existing A.J. Wyllie bridges (Gympie Rd) at Petrie.

The exception is Youngs Crossing which due to its low level is frequently flooded by releases from North Pine Dam up to several times in any one year. The flood events considered under the North Pine Dam Optimisation Study are far too large for an accurate assessment of the impacts on Young Crossing. The smallest flood considered for floodplain risk assessment purposes was the 5% (1 in 20) AEP event which is many times greater than the flow capacity of the crossing.

To gain a better understanding of what the impacts of the changed operations for North Pine Dam have on Youngs Crossing, a historical analysis was undertaken of all flows (not just the larger design floods assessed for floodplain risk assessment purposes).

DSITIA has developed a daily flow model (IQQM) for the Pine Rivers catchment as part of water resource planning for the Moreton basin. This model has daily flow information from January 1889 to June 2011 with data sourced from river gauging station information (i.e. river levels) and synthesised data for those periods of the records where only rainfall records existed. DSITIA has re-run the flow model for the lowered dam levels being considered. The results of this analysis are presented in Table 12.2.

The results show that the total length of flooding and frequency of flooding for the crossing do not change significantly for lowered dam levels down to 75% FSV.

Lowering the dam level down to the existing fixed crest level at 42% FSV significantly increases the duration of flooding and consequently the length of closure for Youngs Crossing.

The analysis by DSITIA shows that without the dam, the number of closure events for Youngs Crossing would double and the length of closure would be significantly longer.

The modelling of flood operation options predicted that Youngs Crossing would be closed for less than 48 hours for most flood events, excluding the 42% FSV option.

MBRC recognises that there are competing objectives to be considered in the operation of North Pine Dam and seeks a dam operations solution that minimises the duration of closures of Youngs Crossing, preferably to less than 48 hours, with minor releases for drain down carried out during non-peak traffic periods.

**Table 12.2 Number and duration of flood events at Youngs Crossing from IQQM flow examination of the historical record from January 1889 – June 2011<sup>2</sup>**

	Dam level (mAHD)	No of Events	Median Event Duration <sup>1</sup> (days)	Total Length of Flooding (days)	Longest Event Duration Period (days)
With Dam <sup>3</sup>	39.60 (Existing)	223	3 (9)	1,104	49 (17/2/1956 – 5/4/1956)
	38.04 (85% FSV)	228	4 (9)	1,172	49 (17/2/1956 – 5/4/1956)
	36.88 (75% FSV)	227	4 (10)	1,223	49 (17/2/1956 – 5/4/1956)
	32.00 (42% FSV)	240	10 (22)	2,828	69 (14/2/1950 – 23/4/1950)
Pre- Dam		480	4 (10)	2,396	41 (20/1/1971 – 1/3/1971)

Notes:

1. The median duration means that 50% of flood events that have flooded Youngs Crossing (in the historical record) have durations longer than the number stated and 50% have shorter durations. The duration quoted in brackets is the 90th percentile flooding duration, i.e. 90% of the flooding events for that particular case would be less than or equal to that duration length.
2. IQQM daily flow simulation is based on the period of 1/1/1889 to 30/6/2011, i.e. 122.5 years of historical record. IQQM flow reporting location is notionally Youngs Crossing (AMTD 17.1 km North Pine River) just upstream of confluence with Sideling Creek (i.e. excludes Lake Kurwongbah flows) with the exception of the pre-dam flows which are reported at the dam wall (AMTD 20 km North Pine River).
3. 'With Dam' dam spills cases based on a supply simulation with the dam level starting at the nominated dam level. Includes supply losses for evaporation and assumes that the current Seqwater future forecast constant demand rate is being extracted from the dam. Demand rate is 155 ML/day for the EL 39.60 mAHD (100% FSV), EL 38.04 mAHD (85% FSV) and EL 36.88 mAHD (75% FSV) dam level cases and 62 ML/day for dam level EL 32 mAHD (42% FSV). These demand rates are close to the maximum allowable water use allocated in the Moreton ROP (c.f. 162 ML/day for EL 39.60 mAHD, EL 38.04 mAHD, and EL 36.88 mAHD dam level cases and 65 ML/day for the EL 32.00 mAHD dam level case).

## 12.4 Traffic modelling

### 12.4.1 Modelling scenarios

Traffic modelling was carried out by DTMR (DTMR 2013).

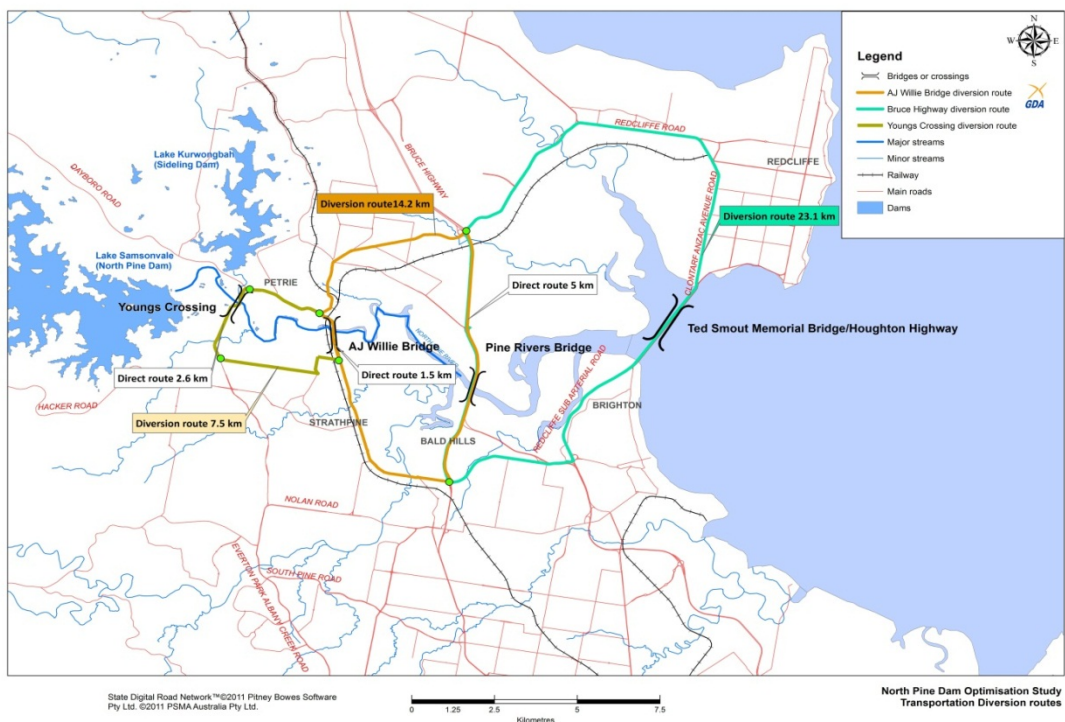
Three scenarios were modelled as shown in Table 12.3. Each scenario was modelled for two traffic volume cases, the 2010 base case and a future growth case for 2026.

**Table 12.3 Traffic modelling scenarios for NPDOS**

Scenario	Description
1 (Base Case)	All three road crossings/bridges open to traffic (i.e. Youngs Crossing, A.J. Willie bridges and Bruce Highway bridges open)
2	Two road crossings/bridges open to traffic (i.e. Youngs Crossing closed, A.J. Willie bridges and Bruce Highway bridges open)
3	Only Bruce Highway open to traffic (i.e. Youngs Crossing and A.J. Willie bridges closed)

### 12.4.2 Traffic diversions

For the purposes of determining the impacts of traffic delays due to diverted traffic as a result of closed river crossings, the diverted traffic routes were determined for all three closure scenarios. These are shown in Figure 12.1.



**Figure 12.1 Map showing diverted traffic routes considered in assessment of traffic delays**

### 12.4.3 Closure impacts of Youngs Crossing

The 2010 traffic model data provided by DTMR indicates morning and afternoon peak hour flows for Youngs Crossing of approximately 850 and 1270 vehicles per hour respectively. This is predicted to increase to approximately 1700 and 3080 vehicles per hour respectively by 2026. Youngs Crossing Road carries approximately 40% of the volume of traffic of Gympie Road and only 10% of the traffic of the Bruce Highway.

When Youngs Crossing Road is closed to traffic due to flooding, traffic needs to be diverted. The total length of the diversion is estimated to be approximately 7.5 km, compared to the direct route using Youngs Crossing Road of 2.6 km. The additional trip time is estimated to be approximately 10 minutes.

DTMR has undertaken traffic modelling using 2010 data and forecast data for 2026 to predict the impact of closure of Youngs Crossing Road on traffic within the southern Moreton Bay Region. The 2010 model data indicates that up to 12,000 vehicles per day would be displaced when Youngs Crossing Road is closed due to flooding. The morning peak period modelling indicates that most traffic would simply divert to Gympie Road (3280 vehicles per hour). The results for the afternoon/evening peak period indicate there are significant area wide traffic impacts due to the diversion of Youngs Crossing Road traffic to other congested routes. Both the northbound Gympie Road (2060 vehicles per hour per lane) and the northbound Bruce Highway (1995 vehicles per hour per lane) would be operating near capacity.

The results for 2026 conditions are similar in pattern though greater in magnitude due to traffic growth, with the key routes in the base networks being very congested without any road closures. The 2026 model data indicates that more than 30,000 vehicles per day would be displaced when Youngs Crossing Road is closed due to flooding. The modelling predicts major area wide diversions during both peak periods, with major diversion to Gympie Road, with lesser diversion to the Bruce Highway (basically both routes would be at capacity). Given that both Gympie Road and the Bruce Highway would be at capacity there would be further secondary diversion via the Houghton Highway during both peak periods, and in the afternoon/evening period, around Lake Samsonvale via Mount Samson Road, Winn Road and Samsonvale Road.

It should be noted that some additional river crossing capacity (i.e. increased number of lanes) would be required prior to 2026 irrespective of whether Youngs Crossing was open or closed. This is required based on traffic growth (i.e. two traffic lanes for Youngs Crossing would be insufficient for the 2026 case even if both were open).

### 12.4.4 Combined closure impacts of Youngs Crossing and Gympie Road

The 2010 model data indicates that approximately 42,000 vehicles per day would be displaced if both Youngs Crossing Road and Gympie Road were closed.

At 2026 the number of vehicles affected is predicted to increase to more than 70,000 vehicles per day if both routes are closed. DTMR indicated that the implications that this would have on the Bruce Highway and other Pine River Crossings, and the South Moreton network would be unsustainable without major augmentations.

## 12.5 Conclusions

MBRC recognises that there are competing objectives in the operation of North Pine Dam. MBRC has advised it seeks an appropriate balance between environmental protection including river bank stability, minimising traffic disruption and minimising urban flood damage. MBRC seeks a dam operation solution that will minimise periods of closure of the low flow capacity Youngs Crossing to no greater than 48 hours. Where only small releases are necessary (i.e. shorter closure periods), MBRC's preference is these continue to be during non-peak traffic periods and that appropriate notice for staff to effect the road closure is provided.

The results of the assessments completed show that:

- the frequency and duration of flooding for the crossing do not change significantly for lowered North Pine Dam levels down to 75% FSV.
- lowering the dam to the existing fixed crest level of 42% FSV significantly increases the duration of dam releases, flooding and consequently the extent of closure of Youngs Crossing.
- without North Pine Dam the frequency of closures of Youngs Crossing would double and the duration of closures would be significantly longer.

The large numbers of vehicles impacted and resultant relatively high costs of traffic diversions (refer Chapter 15) for existing conditions suggests that the upgrading of road infrastructure, including high level bridges, in the West Moreton transport corridor is desirable independent of any possible changes to the dam level and or to the flood operation of North Pine Dam.

Both MBRC and DTMR are considering potential options for improving traffic movement in the West Moreton corridor.

MBRC has produced a business case for the replacement of Youngs Crossing with a high level river crossing as part of their investigations of the West Petrie Bypass project. This was released by council in August 2013. The West Petrie Bypass project has an estimated capital construction cost of \$125.5 million.

DTMR is currently undertaking a planning study of the West Moreton corridor between Caboolture and Brendale and a planning study to compare options for an east or west bypass of Petrie. Both studies are due for completion in 2014. The studies will investigate alternative alignments to what is being proposed in the West Petrie Bypass project.

Decisions on whether bridges and crossings should be raised require a wider consideration of transport planning and budgetary matters with bridge and crossing submergence being just one consideration. These considerations go beyond the scope of the North Pine Dam Optimisation Study and are best dealt with by MBRC and DTMR in consultation.

## Chapter 13 – Downstream bank slumping and erosion

Riverbanks are dynamic zones that are continually changing in response to the interactions between flow and sediment transport and other factors affecting channel geometry. Natural levees, river terraces and river channels are formed by fluvial processes over very long periods of time and can be changed by flood events.

Changes in the channel geometry that may influence the rate and volume of bank erosion are influenced by several factors, including:

- riverbank material and form
- riparian vegetation
- adjacent land-use
- flow regime, and
- bed load transport in the system.

The trajectory of the stream channel, in terms of incision or aggradation, is a major influence on the erosion processes, and rates and needs to be established to understand the long-term interaction of flow and sediment transport.

### 13.1 Desktop study

A desktop study (titled *Bank slumping, erosion, and flora and fauna – Desktop study for Wivenhoe and Somerset Dams Optimisation Study (WSDOS) and North Pine Dam Optimisation Study (NPDOS)*) was undertaken to:

1. identify relevant degradation processes and associated flood event impacts for bank slumping, erosion and flora and fauna recognising that such effects are affected by the historical sequence (including frequency) of flood events, other natural process and the impact of human activities
2. outline dam flow release strategies that would mitigate impacts on bank slumping, erosion and environmental (flora and fauna) having regard to the rising and falling stages (including magnitude and duration) of a flood event
3. identify any specific recommendations that can be made relating to the releases from Wivenhoe and North Pine Dams, and
4. outline possible future sampling, survey and monitoring activities that could be undertaken to help refine the Wivenhoe and Somerset dams and North Pine Dam manuals of operational procedures for flood mitigation beyond the current WSDOS and NPDOS.

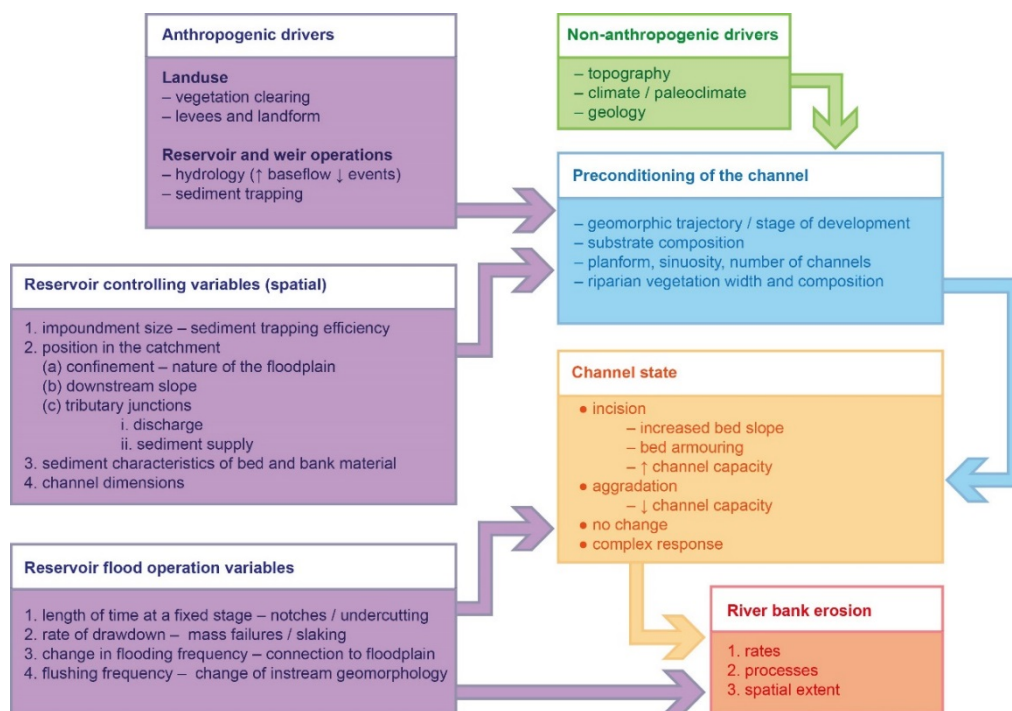
A four stage approach was devised in order to structure the analysis of the Mid-Brisbane and North Pine River systems:

- Step 1: Evaluate the initial trajectory of the stream pre-reservoir by understanding how both anthropogenic and non-anthropogenic drivers have pre-conditioned the channel. This includes factors that influence the sediment yield, hydraulics and hydrology of the channel and may include measures of land clearance, sand and gravel extraction, catchment topography, geology and climate.
- Step 2: Assess if there has been any alteration in the trajectory caused by the imposition of the reservoir. Any changes should be set against other anthropogenic disturbances in the catchment.

Step 3: Identify the existing riverbank erosion processes operating in the channel. The processes already operating provide an indication of how the channel is responding to its current condition, and provides a baseline for comparison.

Step 4: Assess the consequences of dam release strategies on the system. This may be in terms of the rate, spatial extent or process of erosion, or a combination of all of these.

To aid with the analysis of the impacts of flow regulation by the dam on riverbank erosion, a conceptual model (Figure 12.1) was devised.



Source: DSITIA 2014

Figure 13.1 A framework for investigating the effects of reservoirs on downstream riverbank erosion

## 13.2 Bank erosion

A Seqwater (2013g) review of bank erosion in the North Pine River downstream of North Pine Dam focused on the reach between the dam and Youngs Crossing but also considered the downstream section from Youngs Crossing through to the South Pine River junction. The riverbank erosion observed in the reach between the dam and Youngs Crossing during a site inspection following the January 2013 flood event is summarised in Table 13.1 (refer also Figures 13.2 to 13.5).

The extent of the erosion is just over half the downstream distance of the survey. Under natural conditions it would be expected that erosion would occur on the outside of meander bends, and it would be expected that the outer bend for the extent of site 5 would have an eroding bank. During extreme events, such as the 2011 and 2013 flooding, erosion would be expected.

**Table 13.1 Observed riverbank erosion – North Pine River 2013**

Site	Distance from Dam (km)	Description	Vegetation	Erosion Process	Length Affected (m)
1	0.4	Relatively straight section, on left bank	Low density trees with grass	Planar failure	150
2	0.5	Relatively straight section, on left bank	Low density trees with grass and shrubs	Fluvial entrainment	10
3	0.55	Relatively straight section, on left bank	1 stand depth of trees with grass and shrubs	Wet flow	15
4	0.55-1.2	Outside of meander bend, on left bank	Low density, clearance for access to river	Wet flow and fluvial entrainment	750
5	1.2-2.0	Outside of meander bend, on left bank	Native, intact	Fluvial entrainment and cantilever failure	800

A site visit on 25 September 2013 did not reveal further bank erosion problems in the reach down to the South Pine River.



Source: DSITIA 2014, Figure 46

**Figure 13.2 Aerial photograph - Seqwater assessment sections**



Source: DSITIA 2014, Figure 47

**Figure 13.3**      **Site 01 - Planar erosion**



Source: DSITIA 2014, Figure 48

**Figure 13.4**      **Site 04 - Wet flow erosion**



Source: DSITIA 2014, Figure 49

**Figure 13.5**      **Site 05 - Cantilever matt grass caused by fluvial entrainment undercutting the base of the bank**

### 13.3 Bank slumping and erosion assessment

The North Pine River system currently has insufficient information available to make any inference of the pre-dam trajectory. Based on the limited sediment data available for Lake Samsonvale, it is considered that sand was the coarsest sediment being transported to the lower reaches prior to the construction of North Pine Dam.

There is limited data available on riverbank sediment composition, both in terms of size fraction and stratigraphy. An investigation of a 3 km reach downstream of North Pine Dam from Grant Street through to Youngs Crossing indicates that they are a combination of dispersive clays, silts, sands and organics in the banks (Seqwater 2013g).

The efficient trapping of bedload combined with little change to the high flows and lack of tributary bedload inputs suggests that the areas downstream of North Pine Dam are susceptible to a high degree of change. However, the presence of a macro-channel and coarse, out of regime, bed sediment could mitigate the impacts of the dam. Without survey data on the bed level variations, it is not possible to be certain if there has been any major change in the riverbed in response due to the North Pine Dam and other instream structures.

Areas downstream of North Pine Dam appear to be experiencing bank erosion typical for a naturally eroding stream that has experienced a flood. Planar failures, wet flows and fluvial entrainment all appear to be occurring, but with a limited spatial extent close to the reservoir. The poor riparian vegetation cover, and flow obstructions such as wooden steps into the water, may have decreased the shear strength or increased the shear stress respectively.

The hydrological conditions that have resulted from the reservoir operations have not seriously altered the downstream river reaches. The lowered baseflow may increase aggradation, and the release of water at a sustained level pre-wet season or rapidly pulsing flows, due to night time releases, may cause undercutting of the banks. The pulsing of flows is likely to be more of an issue on cohesive bank sediments, as wetting and drying of the surface may weaken the surface. This may be countered by the ability of vegetation to grow further down the banks with the reduction of baseflow. Following a wet season it is suggested that evidence for this type of undercutting be investigated immediately downstream of the dam.

### 13.4 Key Findings

River form stability comparisons should not assume a no erosion case as the reference point as riverbanks are dynamic zones that are continually changing in response to complex interactions between flow regimes, sediment transport, riverbank material and form, riparian vegetation and land-use.

Based on the review of available data, the North Pine River system appears insensitive to changes to these complex interactions. In addition, the effect of the dam and release strategies relative to other anthropogenic disturbances in the systems (e.g. vegetation clearing, sand and gravel extraction) appears to be minor.

Release strategies which maintain a constant level for long durations are likely to have a greater impact on downstream bank erosion than varied flow levels. A fixed release discharge may cause notching or undercutting at low levels, or completely saturate the bank at higher levels.

Pulsed (night time) discharges from the dam should be reduced if the river banks are of a cohesive nature

## 13.5 Future work

Due to the limited data on reference conditions, and current rates of change in bed levels and planform, a conceptualisation of downstream geomorphic processes in relation to dam operations cannot be completed with any certainty. There is insufficient information to be able to document the change in bank erosion rates and processes over time.

In order to be able to do this, a strategic monitoring program would need to be undertaken. This may be a combination of field measurements and remotely sensed data collection. Repeat cross-sectional surveys are preferred and not just observations as these are not easily quantifiable and do not include the riverbed if it is submerged. After large flood events high resolution aerial photography and LiDAR would enable a quantification of deposition and erosion, as well as delineation of erosion processes.

Knowledge of the size and texture of bank material and its critical shear strength are necessary to understand the impact of pulsed flows and pre-wet season dam drawdown discharges.

## Chapter 14 – Downstream flora and fauna

North Pine Dam has significant impacts on the flow regime in the Pine River. The mean annual flow (MAF) at the river mouth is estimated to be approximately 68% of all catchment inflows. Smaller floods (less than a 20% (1 in 5) AEP) are substantially impacted, whereas larger floods are impacted to a lesser degree. The impact on these flows lessens moving downstream from North Pine Dam towards the mouth of the Pine River. The low flow regime has been impacted considerably. Whereas the Pine River at Youngs Crossing was previously a near perennial stream, now there is no flow approximately 17% of the time. This impacts on the quality of refuge waterholes in the riverine reach between the dam and the tidal reach. The lack of flows to the estuary causes hyper-saline conditions at times and limits connectivity between the riverine and estuarine reaches.

The general hydrologic effect of a dam during flood events is to reduce the peak of the hydrograph, and taper it down to a lower level of water release from the dam until the floodwaters have been discharged to the desired level. Dams can capture all the runoff from small streamflow events. This can alter the flow regime, including the magnitude, frequency, duration and timing of flow events, the rate of change during a flow event, as well as the degree to which these characteristics are temporally and spatially variable.

In addition to these changes, the drawdown operations of North Pine Dam on the tail end of a flood along with level reductions to achieve declared temporary FSLs has resulted in the introduction of artificial high-flow pulse (sequences of night time) releases to minimise disruption to traffic flows due to the closure of Youngs Crossing.

### 14.1 Desktop study

A desktop study (titled Bank slumping, erosion, and flora and fauna – Desktop study for Wivenhoe and Somerset Dams Optimisation Study (WSDOS) and North Pine Dam Optimisation Study (NPDOS)) was undertaken to:

- identify relevant degradation processes and associated flood event impacts for bank slumping, erosion and flora and fauna recognising that such effects are affected by the historical sequence (including frequency) of flood events, other natural process and the impact of human activities
- outline dam flow release strategies that would mitigate impacts on bank slumping, erosion and environmental (flora and fauna) having regard to the rising and falling stages (including magnitude and duration) of a flood event
- identify any specific recommendations that can be made relating to the releases from Wivenhoe and North Pine Dams, and
- outline possible future sampling, survey and monitoring activities that could be undertaken to help refine the Wivenhoe and Somerset dams and North Pine Dam manuals of operational procedures for flood mitigation beyond the current WSDOS and NPDOS.

## 14.2 Ecological consequences

There are ecological consequences associated with the changes to the flow regime as a result of building and operating a dam. There can be modification of riparian vegetation which is fundamental to the establishment of healthy instream ecosystems. Riparian vegetation provides a number of beneficial roles in aquatic ecosystems including: shading of channels and temperature regulation, primary production, carbon and nutrient cycling, and the direct provision of habitat via the input of woody debris. Flow characteristics directly control instream water quality and habitat conditions, and mediate ecological processes, such as spawning and the dispersal of water-dependent biota.

The changes to the flow regime may result in:

- modification of the physical properties of the upstream and downstream habitat
- reduction in instream and riparian vegetation due to the loss of bed and bank material
- the reduction of flow-cues associated with critical life cycle of events (i.e. spawning and recruitment) of some species
- reduction of downstream freshwater influence and subsequent loss of brackish water habitat for estuarine species, and
- reduction of sediment and nutrient export to estuaries.

## 14.3 Flora and fauna assessment

The focus of this assessment has been on the flows which can be impacted through the operation of the dam.

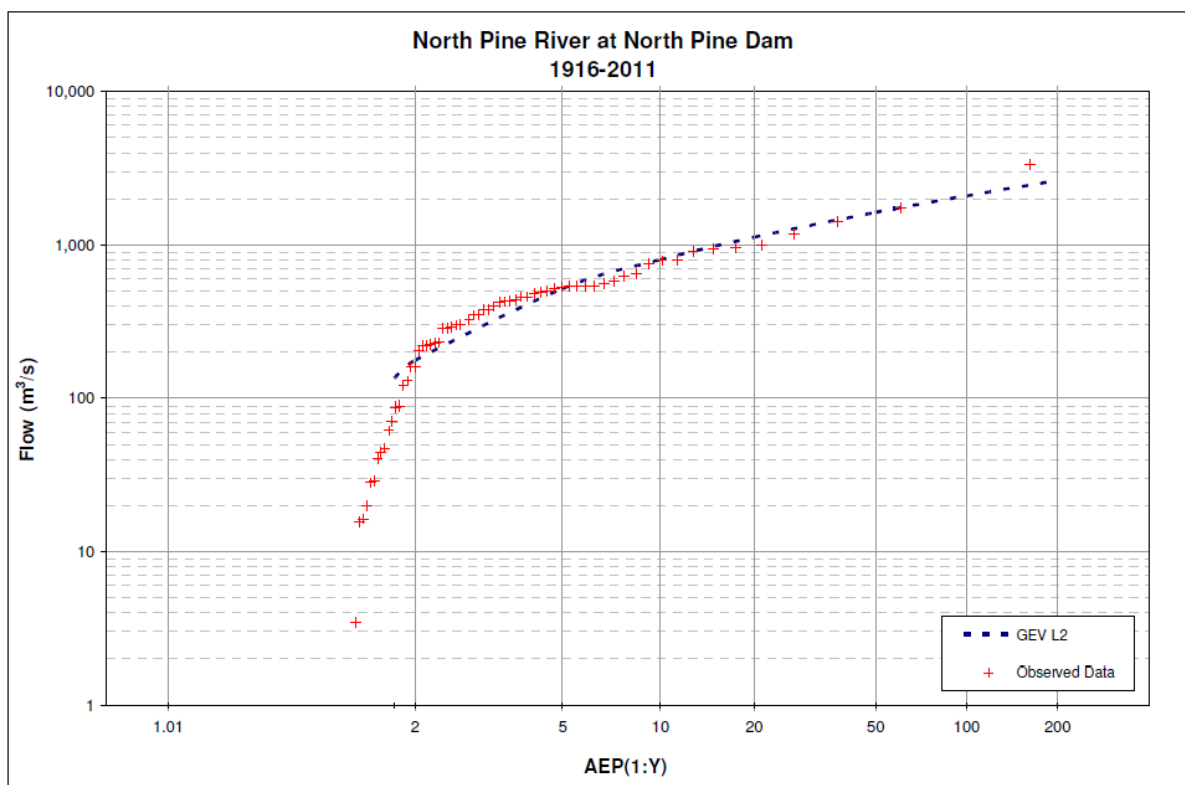
The Flood Manual (Seqwater 2013b), Section 3.5 states:

*'Near the conclusion of a Flood Event, consideration is to be given to minimising the impacts on riparian flora and fauna. In particular, strategies aimed at minimising harm to fish populations in the vicinity of the Dam structures are to be instigated, provided such procedures do not adversely impact on other flood mitigation objectives.'*

On 27 February 2013, Seqwater sought an exception to the above conditions to allow a peak release of 500 m<sup>3</sup>/s in order to minimise impacts on the downstream community of operational releases. The Flood Manual allows up to a 500 m<sup>3</sup>/s release under the small flood procedure as a flow that causes limited impacts downstream (the main impact being the closure of Youngs Crossing, which is inundated at a flow of about 10 m<sup>3</sup>/s). Releasing up to 500 m<sup>3</sup>/s meant that releases to manage the dam near FSL could be made overnight, allowing Youngs Crossing to be reopened the next day and thus limiting impacts downstream.

A flood frequency analysis for the North Pine River at North Pine Dam indicates that a flow of 500 m<sup>3</sup>/s occurs about once every 5 years (20% AEP).

The Flood Manual (Seqwater 2013b) (Section 6.4) now includes procedures for the release of water stored above a declared temporary FSL for the dam. Section 6.4 restricts the release rates for draining down to the temporary FSL to 300 m<sup>3</sup>/s unless higher rates of release are required because of an impending rainfall event.



Source: Seqwater 2011a, Figure 9.6.2

Figure 14.1 Flood frequency at North Pine Dam (no dam analysis case)

### 14.3.1 Riparian vegetation

The latest cross section available (1976 – HYDSTRA – Section 760017) indicates that releases of approximately 500 m<sup>3</sup>/s inundate the downstream cross section by approximately 5.3 m with a velocity of approximately 1 m/s. This is a similar peak inflow of a 20% (1 in 5 year) AEP event (refer Figure 14.1). Such flows maintain the stream channel by causing scouring in the main river channel and anabranch, inhibiting regrowth of seedlings in the low flow channel. This may provide a function of minimising the impact of vegetation channel encroachment downstream of North Pine Dam, which has had to be cleared in the past by Seqwater. A site visit on 16 September 2011 detected impacts from the January 2011 flooding; however there were signs of riparian regeneration especially the native bottlebrush and exotic camphor laurel. Debris from the flood was still evident.

### 14.3.2 Aquatic habitat (macrophytes, riffles, pools)

Discharges of approximately 500 m<sup>3</sup>/s are sufficient to cause scouring of and ‘cleansing’ of riffles and movement of sediment in pools. If this occurs in drier years, flood releases of this magnitude could cause clear-water erosion, whereby the cleaner water causes mobilisation and removal of existing sediment. The downstream reach below North Pine Dam has been impacted by previous droughts and the capture of inflows by the dam. This has caused sedimentation in pools and channel encroachment. However, much of this was cleared during the January 2011 flood. Dam releases may provide a useful function in maintaining downstream habitats. However if the timing of releases is during the peak growth period for aquatic macrophytes, the scouring effect of the releases could cause significant reduction of density and abundance. There was very little evidence of macrophytes during the September 2011 visit which suggests no or very little macrophyte recovery from the January 2011 flood.

### 14.3.3 Fish

Increased discharge allows connectivity between the freshwater and estuarine habitats. This is beneficial to species such as Australian Bass, which have been found to be in limited numbers (through the DNRM Environmental Flows Assessment Program monitoring). In addition, dam releases create brackish habitat in the upper Pine River and increases the productivity potential in the upper estuary, providing for juvenile nursery habitat for species such as banana prawns, sea mullet and limited habitat for Australian Bass larvae. The benefits of these releases are very short-lived (in the order of 10 days).

It is unknown whether fish are able to pass through the structure during releases of these magnitudes (of approximately 500 m<sup>3</sup>/s), therefore risks to fish from downstream stranding may not be able to be assessed. If Queensland lungfish and other fish can pass through the structure, there may be high mortality from the passage. Seqwater may need to enact their fish transfer operations more frequently if fish become trapped immediately downstream of the storage. If fish were not able to pass downstream, there would still be fish that would become trapped immediately downstream of the dam and would have to be relocated or provided with minimum stream flow to exist until flows recommence. Queensland lungfish spawning (unsuccessful) has been observed in North Pine Dam. Eggs and juveniles which have resulted from spawning in the storage at this time, potentially in areas in the upstream reaches where inflow occurs, may become desiccated through the rapid drawdown.

### 14.3.4 Turtles

It is unknown the extent or numbers of species of freshwater turtle species residing in the limited riverine habitat of the Pine River.

## 14.4 Key findings

Some potential aquatic ecosystem impacts associated with hydro-peaking (pulsed night time releases) and dam operations include:

- stranding of fish and other aquatic fauna
- washing away of instream macro-invertebrate populations when flow rises
- rapid and frequent change in habitat condition and availability.

In small, and potentially isolated systems with limited opportunities for recruitment due to altered patterns of connectivity such as North Pine River downstream of the dam, long term impacts on community composition may occur over time.

Stepped ramp-down of dam releases could be implemented to provide cues to fish and other fauna of dropping flows before full dewatering of habitat occurs. This will reduce the potential for fish stranding under 'hydro-peaking' (pulsing) operations.

## 14.5 Future work

Monitoring of aquatic ecosystem response to flow management is currently conducted under the DNRM Environmental Flows Assessment Program according to the environmental provisions of the Water Resource (Moreton) Plan 2007 (This program provides valuable information on how aquatic ecosystem components and processes respond to the managed flow regime including the impacts of water infrastructure such as dams and weirs. Over time, the program will inform improved management responses to minimise environmental impacts.

## Chapter 15 – Integrated assessment of options

This chapter outlines the integrated assessment undertaken as part of NPDOS to evaluate the relative benefits and costs of the different operational options identified in Chapter 6.

It presents, at a high level, the methodology and the results of the assessments undertaken to provide indicative overall costs for dam lowering scenarios and an overall integrated assessment of the options.

To satisfy the requirements of QFCoI Final Report recommendation 17.3, the integrated assessment of the operational options, requires trade-off between:

- the damage and impacts associated with flooding
- the water supply security costs associated with increased production of manufactured water and the need to bring forward infrastructure upgrades
- the ability to reduce dam safety risks and improve flood mitigation while any necessary upgrades of the dam are planned and executed, and
- the ability to minimise disruption to the community by reducing the cost of traffic rerouting resulting from the submergence of bridges, crossings and roads.

Strategies for minimising bank slumping and erosion and flora and fauna impacts identified in Chapters 13 and 14 are confined to small flows/floods less than 500 m<sup>3</sup>/s on the rising and falling stages of a flood.

The integrated assessment of options includes two phases:

1. an assessment of the Net Present Costs (NPCs) (sections 15.1 to 15.6) of the tangible damages and impacts of floods for each operational option (refer Aurecon 2013, Aurecon 2014 for more comprehensive details), and
2. a high level assessment of the overall implications of the considerations raised in the QFCoI Final Report recommendation 17.3 (Section 15.7).

Net Present Costs have been estimated for tangible flood inundation damages and impacts and brought forward costs of water infrastructure and manufactured water production.

As shown in Figure 15.1 in order to develop the NPCs, this Chapter brings together the results of work outlined in:

- Chapter 7 – Dam Operations Assessment
- Chapter 10 – Floodplain Risk Assessment
- Chapter 11 – Water Supply Security
- Chapter 12 – Bridge and Crossing Submergence

### 15.1 Integrated assessment

An Integrated Assessment Methodology was developed to allow comparison of the relative costs and benefits of dam operations being investigated under NPDOS. The primary focus of the analysis are the trade-offs between flood mitigation and water supply security and transport disruption due to bridge and crossing submergence.

To allow a direct comparison between the operational alternatives/options, the benefits and costs were quantified using a consistent and comparable framework of analysis. The most

common way of doing this is by estimating the dollar value of the benefits and costs of each option, along with when they occur into the future and combining them in a NPC analysis.

The total NPC is the accumulation of costs that can be directly attributed to, or modified by the proposed operations. For this study, integrated assessments incorporated:

- flood damages – spatially distributed property damage directly related to inundation during a flood (or water release) event
- flood impacts – impacts associated with loss or disruption of a service (e.g. transport) due to a flood event
- water supply impacts – costs directly or indirectly resulting from changes to a flood mitigation or water supply strategy
- direct infrastructure and other capital costs associated with implementation of a strategy.

### 15.1.1 Assessment scope and limitations

The results presented in this chapter are for comparison of the operational options listed in Table 15.1.

**Table 15.1 Operational options subject to net present cost assessment**

Option	Dam Level		Flood Release Level		Description
	%FSV	mAHD	%FSV	mAHD	
1	100	39.60	100	39.60	Existing situation with the dam at its current full supply volume
3.1	85	38.04	85	38.04	Dam level and flood release level lowered to 85% FSV
3.2	75	36.88	75	36.88	Dam level and flood release level lowered to 75% FSV
3.3	42	32.004	42	32.004	Dam level and flood release level lowered to 42% FSV

Operational options listed in Table 15.2 were not analysed because either operational performance would not be as good as those in Table 15.1 or be similar.

**Table 15.2 Operational options not subject to net present cost assessment**

Option	Dam Level		Flood Release Level		Description
	%FSV	mAHD	%FSV	mAHD	
2.1	85	38.04	100	39.60	Lower dam level to 85%FSV with the flood release level at 100% FSV
2.2	75	36.88	100	39.60	Lower dam level to 75%FSV with the flood release level at 100% FSV
2.3	42	32.004	100	39.60	Lower dam level to 42%FSV with the flood release level at 100% FSV
4 No Gates	42	32.004	42	32.004	Gates lifted to the fully open position (that is, no gate control)

The results of this integrated assessment are indicative only as there are significant uncertainties in the damages and impacts (Aurecon 2013, Section 5.7) and water supply cost estimates due to the methodology applied and limitations of the available data.

The adopted Integrated Assessment Methodology is a simplified approach, assuming that flood impacts, and consequently damage costs, can be directly related to one or two key flood characteristics within a defined area, and that key flood characteristics can be provided directly from hydrologic and hydraulic models. This simplification allows the hydraulic and damage assessments to be conducted independently to develop a damages or impacts rating curve.

### 15.1.2 Methodology

Figure 15.1 outlines the five main phases used to calculate the NPC of tangible flood damages and impacts costs and water supply infrastructure and operational costs associated with each operational option. The phases of assessment to produce the estimate of NPCs associated with each option were:

1. Phase 1 – Average annual flood damage costs to buildings and infrastructure (flood damages were calculated for residential and non-residential buildings and transport infrastructure except bridges)
2. Phase 2 – Average annual impact costs due to traffic delays and bridge damage (the delays relate to traffic rerouting due to bridge and crossing submergence)
3. Phase 3 – Additional infrastructure capital costs due to the bringing forward of water supply augmentation timelines as a result of lowering the FSV of the dam including consideration of the potential for deferring dam safety spillway upgrades
4. Phase 4 – Additional bulk water operational costs due to the lowering the FSV of the dam, and
5. Phase 5 - Economic assessments to calculate the NPC.

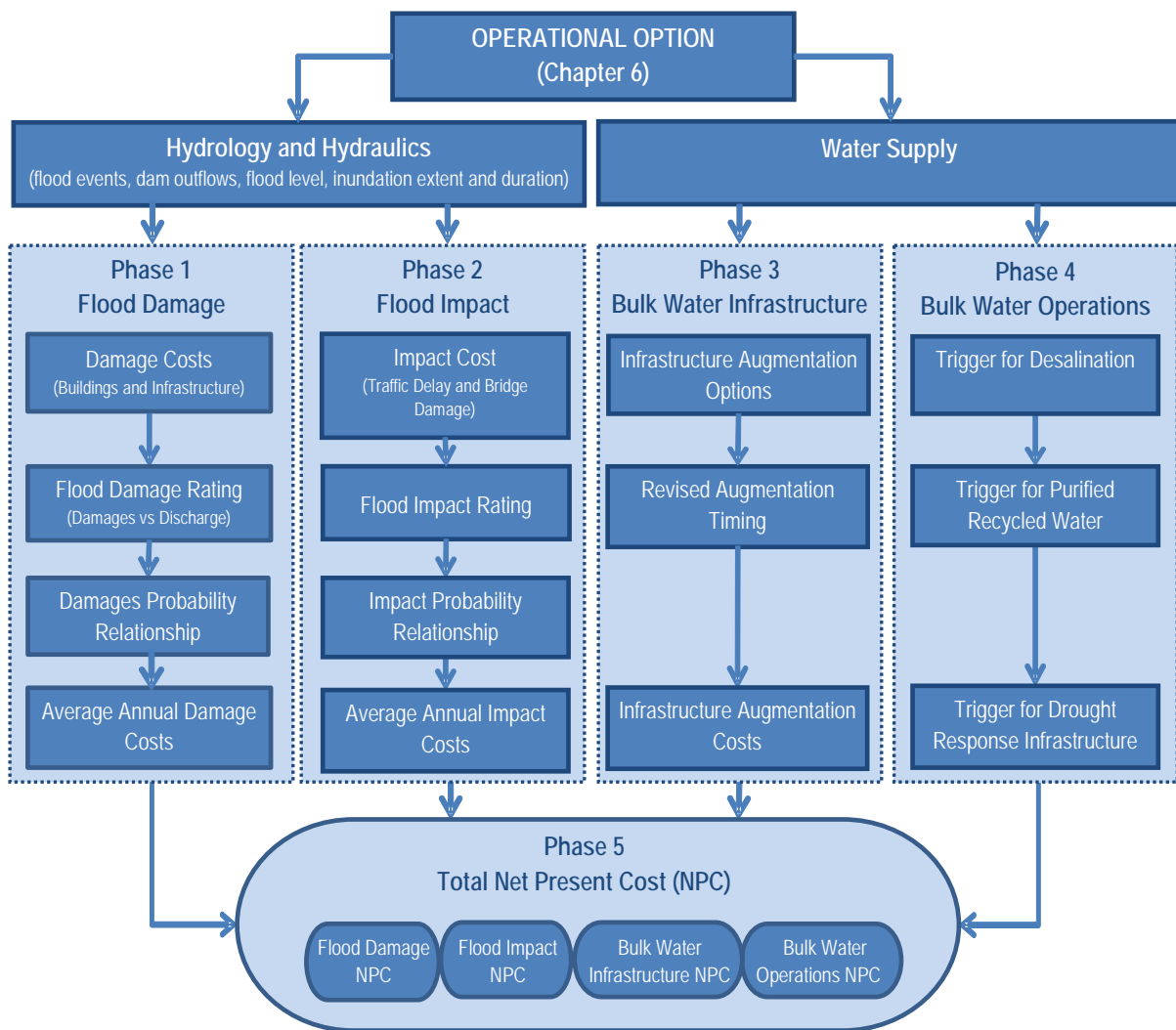


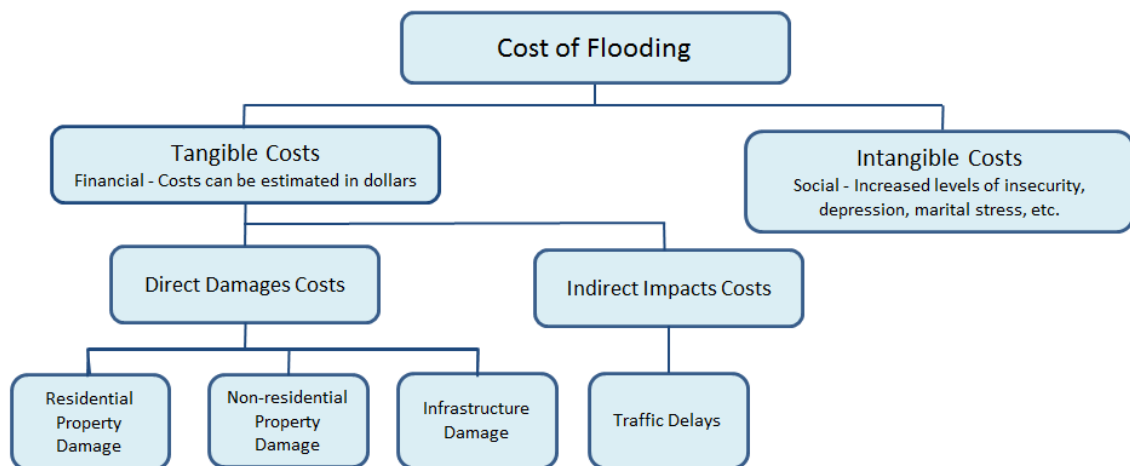
Figure 15.1 Methodology for assessing the net present costs of options

### 15.1.3 Flood Damages and Impacts

The impacts and costs of flooding vary with location within a floodplain (including depth and velocity of water as well as duration of flooding) and the susceptibility to damage by flood water of the type of property or infrastructure (that is, houses, roads, bridges, commercial properties, etc.).

The methodology adopted for NPDOS is based on those tangible costs that are traditionally used in floodplain management studies and for which data and generally accepted estimation techniques are available. Flood damages and impacts are typically described as tangible (i.e. those that can be assigned a dollar value) and intangible (i.e. those that cannot be expressed in dollars).

Tangible costs are further classified as direct damages (such as to houses and property) and indirect impacts (such as traffic delays associated with flooding of crossings and bridges) - see Figure 15.2. Other indirect costs (e.g. loss of production and loss of income) have not been included in this assessment.



**Figure 15.2 Flood damage and impact costs**

Intangible costs have not been quantified. Some intangible costs have been addressed via the considerations outlined in QFCoI Final Report recommendation 17.3 discussed in the earlier Chapters and summarised in Section 15.7.

Flood damage (residential, commercial property and road infrastructure) and impacts (traffic travel delays and bridge damage) costs are dependent on the severity of a particular flood event. Floods are relatively rare events and the severity and occurrence of future flood events cannot be predicted. The procedure for producing an NPC associated with flooding involves estimating the damage and impact costs resulting from a range of flood events from very likely/minor damage to very unlikely/major damage. A probabilistic assessment can then be used to estimate average annual costs of damages and impacts.

Generic damage and impact rating relationships for cost versus discharge (discharge being a measure of the extent of flood inundation) were developed to enable assessment of the differential effects of operational options downstream of the dam. The hydrologic and dam operations assessments (outlined in Chapters 7) and the hydraulic assessments (outlined in Chapter 10) provided the basis for calculating flood damages and impacts determined mainly from the depth and duration of inundation.

The effect of the proposed operational options is primarily the alteration (generally a reduction) of the probability of achieving the downstream flows on the cost-discharge relationship. Thus, for each operational option, a damage-probability and impact-probability relationship can be established.

For each operational option, an estimate of the average annual damages and impacts costs can be calculated by integrating the area under the relevant damage probability and impact probability relationships/curves.

#### **15.1.4 Water supply**

Two water supply aspects have been investigated in the integrated assessment:

1. bulk water infrastructure augmentation costs including those that are triggered when the total volume stored within SEQ water storages reduces to 30% combined capacity, and
2. operational costs mainly associated with the increased production of manufactured water.

This assessment seeks to identify the differential costs associated with changes to water supply infrastructure augmentation timeframes and operational costs under each operational option when compared to the current situation (Option 1).

As stated in Chapter 11, North Pine Dam has a capacity of around 214,300 ML - which is equivalent to approximately 10% of the total volume of the SEQ water storages - and contributes 6% of the total system yield. However, despite this, North Pine Dam plays an important role in minimising the distribution costs of supplying water to the northern areas of Brisbane, Moreton Bay and the Sunshine Coast.

Reducing the water supply storage capacity of North Pine Dam has the potential to affect the planning and delivery (and cost) of water across the SEQ water supply system. This is due to a reduction in water supply security and strategically located sources of supply, potentially increasing manufactured water use and the need for earlier capital investment in new water supply sources and water transport infrastructure.

Bulk water costs comprise proposed future upgrades of supply sources within the SEQ water supply system (assumed to be predominantly desalination plants). The operational costs relate to water manufacture or augmentation works undertaken in response to combined capacity of the SEQ water storages reaching defined trigger levels during drought periods. Operational costs associated with manufactured water production have been calculated and weighted based on the probability of occurrence.

The infrastructure cost impact of the different operational options involving lowered FSLs of the dams was calculated as the difference between the NPC of:

- the adjusted timelines for the construction of infrastructure due to changes in the capacity of the water supply storages under each operational option (Options 3.1, 3.2 and 3.3), and
- the currently proposed augmentation schedule for Option 1.

Infrastructure and operational costs have been determined on the basis of information supplied by Seqwater.

Some significant challenges exist in estimating the differential costs of options, including:

- the uncertainty of any assessments given that the level of service objectives for the region are under review which will inform the preparation of a new water security program by Seqwater
- the need to consider the potential lowering of the FSVs of both North Pine Dam and Wivenhoe Dam conjunctively
- deriving a methodology for the appropriate apportionment of differential capital and operating cost associated with the potential conjunctive lowering of the FSVs of the dams
- the estimates of costs beyond the first augmentation of supply currently proposed in 2031 under the Option 1 scenario
- the estimating of differential operational costs based on probability of triggering of manufactured water production (that is, when the total water storage in the SEQ water supply system falls to 60% (GCDP), 40% (WCRWS) and 30% (new augmented supply) of the total SEQ water storages)
- determining an appropriate analytical period to capture relevant costs.

Under most scenarios for lowering North Pine Dam and Wivenhoe Dam (assuming manufactured water is available and the most likely demand scenario outlined in Chapter 11), the first augmentation occurs in 2031. The second augmentation occurs in the mid-2040s. Hence, it is appropriate to evaluate scenarios over 20 years and 40 years to account for the shorter and medium term effects. The consultants (Aurecon 2014) also investigated a longer term scenario of 60 years.

Analysis has also been undertaken to determine the impact of not having supply from the WCRWS and not having any manufactured water (both WCRWS and GCDP water) available.

### **15.1.5 Potential dam safety capital costs savings**

As noted in Chapter 8 – Dam Safety, North Pine Dam currently cannot pass the Probable Maximum Flood (PMF) for its catchment with only four gates operating without overtopping. On this basis, its current capacity is estimated to be approximately 63% of PMF (URS 2012). The AFC Guidelines require that North Pine Dam be upgraded to at least 65% PMF by 2025.

The conceptual upgrade options to comply with the AFC requirements for North Pine Dam considered in a 2012 report to Seqwater (URS 2012) included:

- lowering of the FSV
- modification of the existing spillway
- construction of an auxiliary spillway
- raising the crest level of the dam.

The report indicates that lowering of the FSV would enable North Pine Dam to satisfy the 65% PMF interim AFC requirement with no capital cost. As indicated in Figure 8.2, and subject to further analysis, the lowering may only need to be around 94% of its current FSV.

Given that the dam spillway upgrade is likely to cost several hundreds of millions of dollars, it is likely to factor into considerations about the operation of the dam in the short to medium term. Section 15.6 includes an indicative assessment of the potential benefits of being able to defer a dam spillway upgrade by 10 years.

## **15.2 Phase 1 - Flood damages**

### **15.2.1 Identification and quantification**

In identifying flood damages, the outputs from the Lower Pine River hydraulic modelling were combined with information obtained from property databases, transport and access information and flood damages cost data for the assessment of flood impacts.

Moreton Bay Regional Council (MBRC) undertook a field survey of all buildings within the study area where the property was predicted to be flooded by events up to and including the 1 in 1,000 AEP flood event.

For properties above the level of the 1 in 1,000 AEP flood event, MBRC used available data (where considered accurate), or estimated floor levels established by applying an average floor height based on the building type, to the average ground level within the building footprint, obtained from aerial survey data. Residential buildings were assumed to be single storey, low set houses having floor levels 300 mm above ground level, except where Council was able to confirm otherwise.

## 15.2.2 Residential (building and property) flood damage

The methodology adopted for NPDOS to estimate residential flood damages is consistent with that used in other SEQ and national studies. This methodology utilises damage versus flood depth relationships for five different building types:

- fully detached, single storey (FDSS) buildings
- fully detached, double (and more) storey (FDDS) buildings
- fully detached, high set (FDHS) buildings
- multi-unit, single storey (MUSS) buildings, and
- multi-unit, double (and more) storey (MUDDS) buildings.

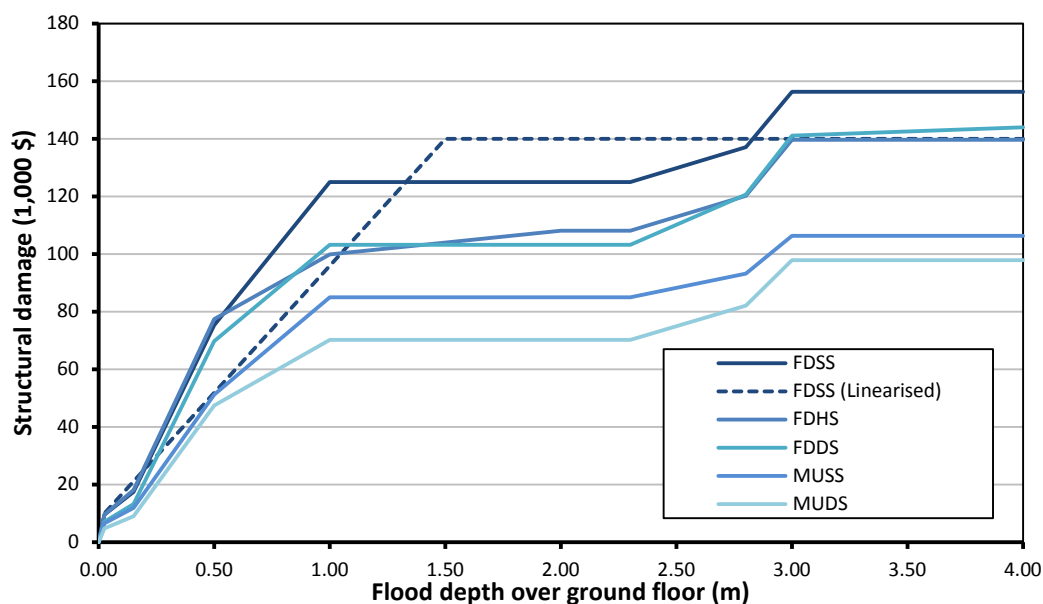
For each building type, damages are estimated in terms of:

- structural damages on the building
- internal damages on the furniture and other equipment, and
- external damages, on all properties around the building.

The estimated structural damage versus flood depth relationship for the five building types above is shown in Figure 15.3. Figure 15.3 also shows the adopted FDSS simplified relationship (dashed) for assessment purposes.

For each building type, based on the local flood situation, four different cases can be distinguished:

- Flood level < ground level: no damages
- Flood level > ground level and flood level < floor level: external damage (based on flood depth over ground)
- Flood level > floor level and flood level < eave level: external damage (based on flood depth over ground) and internal + structural damage (based on flood depth over floor), and
- Flood level > eave level: maximum damage.



Source: Based on Aurecon 2013, Figure 7

Figure 15.3 Residential stage damage curves for structural damage – adopted curve for study

No allowance was made for changes to damages through changes in warning time.

### **15.2.3 Non-residential (building) flood damage**

The adopted methodology for non-residential building damage was based on ANUFLOOD (1983). The ANUFLOOD approach has been applied in several flood damage studies without significant changes and characterises non-residential properties by two aspects – their size and a ‘value class’.

While size can be readily assessed by the building footprint from spatial information, the value class was estimated considering the correlation of its primary use with one of five value categories (very low, low, medium, high and very high value).

Details of the non-residential building damage methodology are available in the consultant’s report (Aurecon 2013, Section 5.3).

### **15.2.4 Flood damage to roads and rail**

Damage to roads caused by inundation is generally considered to comprise an initial repair cost, followed by additional costs for the subsequent accelerated deterioration of the road. Costs estimates figures are generally provided as a unit cost per kilometre of road inundated for different road types. This study has estimated direct damage costs to inundated roads using the methodology and unit costs described in DNRM (2002) – which were sourced from the Victorian Rapid Appraisal Method (Aurecon 2013, Section 5.4).

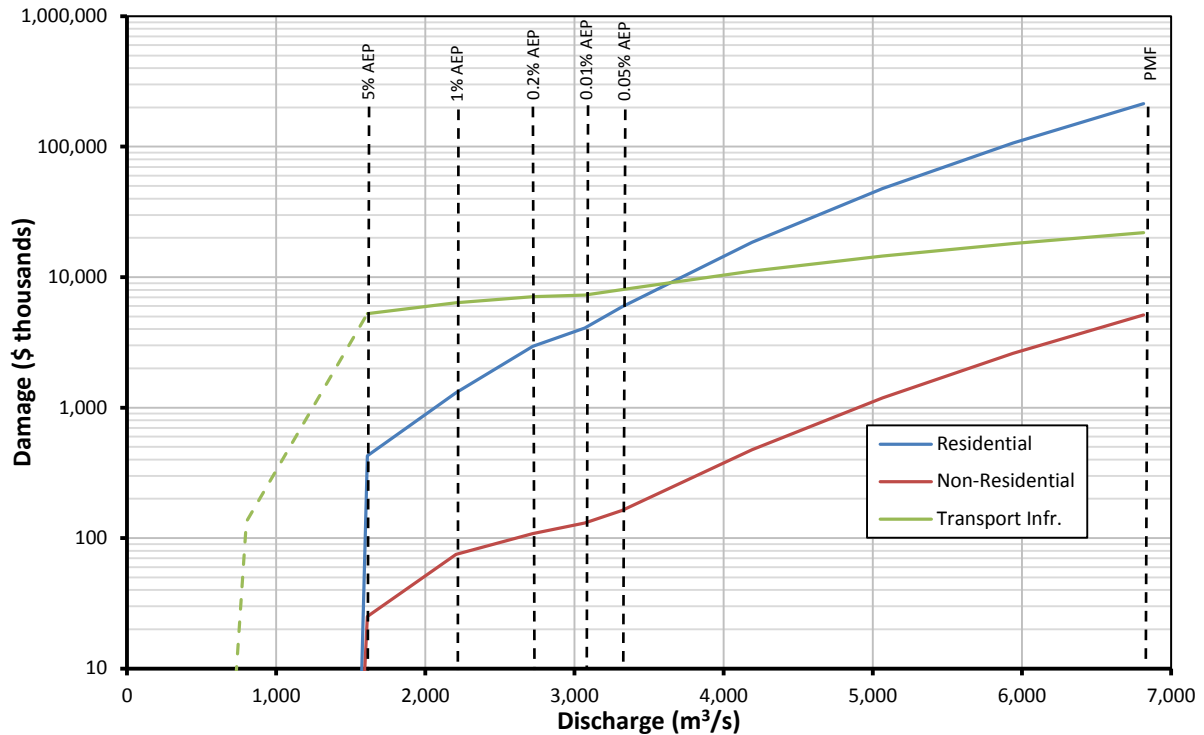
The spatial extent of transport infrastructure (road and railway) in the downstream floodplain potentially affected by dam operational options has been determined by identifying all road and rail assets located within each flood extent and calculating their total length. The unit costs method described above were then applied to estimate direct damage values.

### **15.2.5 Flood damages rating curve**

From the above assessments, flood damage rating curves (damage versus discharge) were able to be developed for the downstream floodplain for each damage category (i.e. residential, non-residential and transport infrastructure) and differing peak flood discharges (and AEPs). Flood damage rating curves were developed using flood mapping and GIS information provided by MBRC.

Figure 15.4 shows the generic damage rating curves for the North Pine floodplain area for residential and non-residential buildings and transport infrastructure.

The figure also includes the probabilities for flood events under Option 1 operating conditions. Relatively few properties are affected up to the 1 in 100 AEP flood event; however flood damages increase exponentially for larger flood events.



Source: Aurecon 2014, Figure 2

**Figure 15.4 Flood damage rating curves for downstream areas (Option 1)**

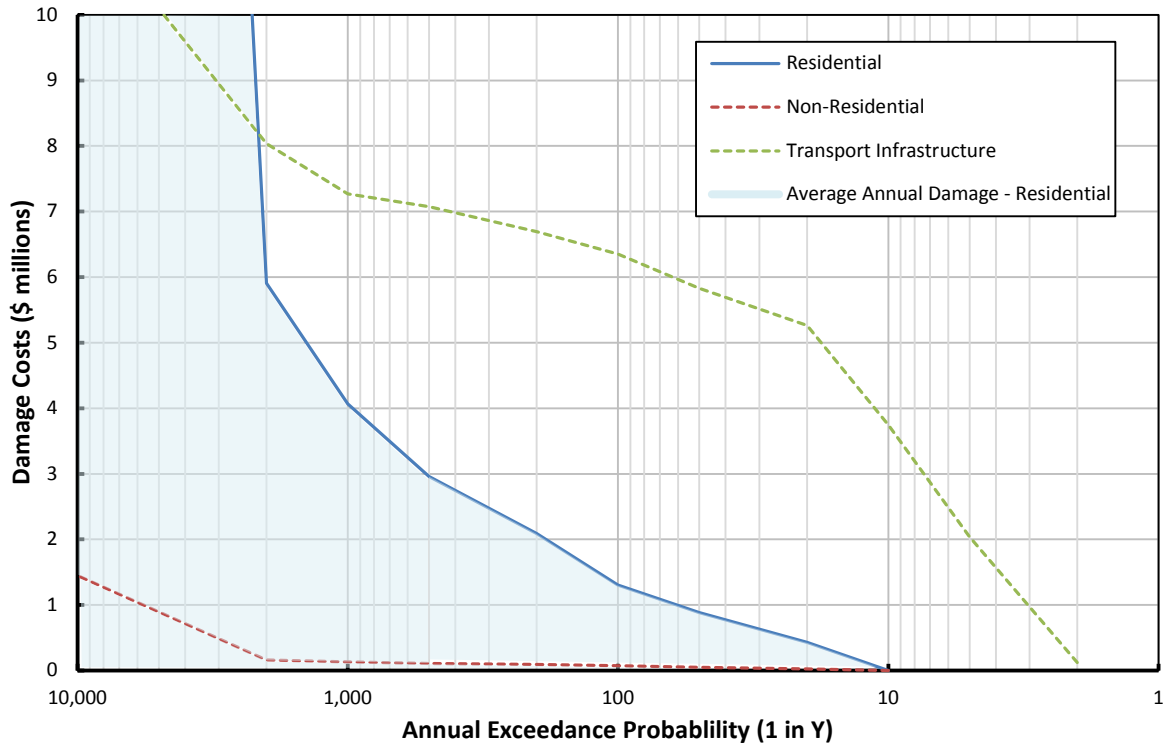
Damage cost has been plotted logarithmically to allow the three damage costs to be plotted together. This illustrates that for the downstream floodplain, transport infrastructure costs are typically an order of magnitude higher than residential property damage costs – which are generally a further order of magnitude greater than non-residential damage costs.

Similar to Option 1, the discharge probabilities associated with other operational options could be shown on the damage rating curve above.

The damage rating curve is then used to enable generation of a damage probability curve for each option.

## 15.2.6 Average annual flood damages (Phase 1)

Average annual costs are estimated by integrating the area under the damage probability curve. Figure 15.5 illustrates this for the existing conditions (Option 1).



Source: Aurecon 2014, Figure 3

**Figure 15.5** Flood damage costs for downstream areas (Option 1)

Calculated average annual flood damage costs for residential and non-residential properties and transport infrastructure for each of the four dam supply volumes under Option 3 operations (lower dam and flood release levels) are provided in Table 15.3. These results show that average annual flood damage costs for Option 1 are relatively low.

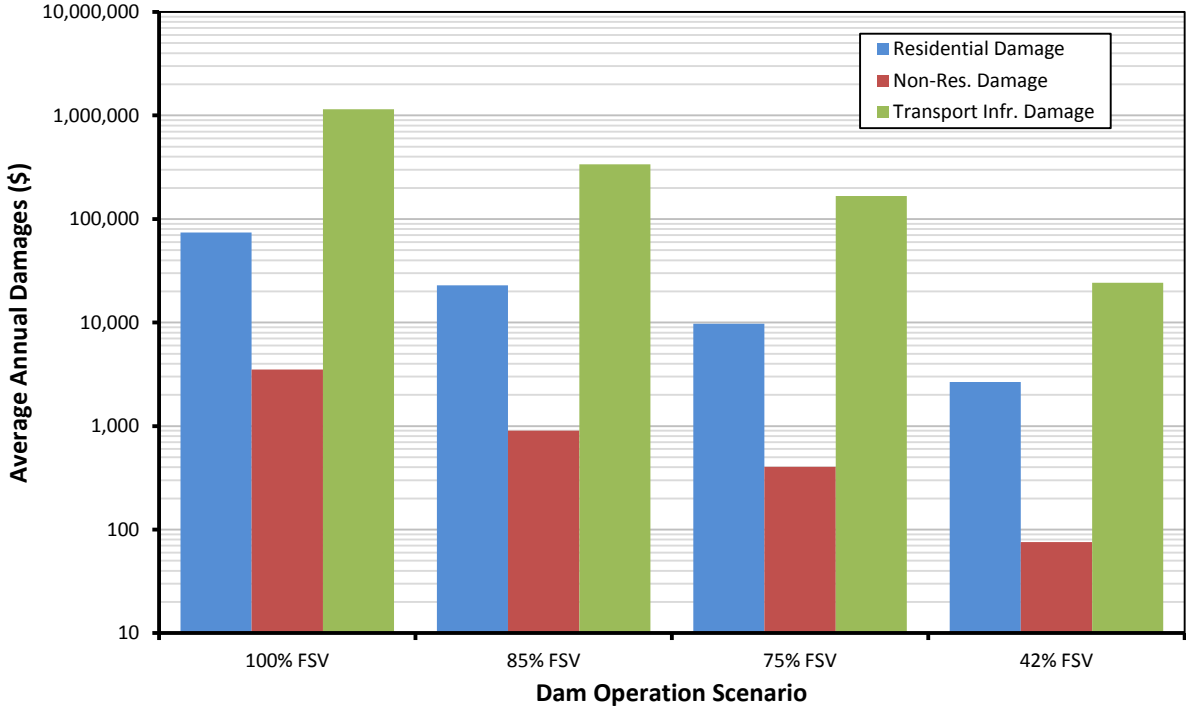
**Table 15.3** Average annual flood damage costs for downstream areas

Flood Damage	North Pine Dam Supply Volume			
	100% FSV	85% FSV	75% FSV	42 FSV %
Residential	\$73,916	\$22,824	\$9,714	\$2,671
Non-residential	\$3,527	\$906	\$405	\$76
Transport Infrastructure	\$1,145,222	\$337,071	\$166,401	\$24,249
<b>TOTAL</b>	<b>\$1,222,664</b>	<b>\$360,801</b>	<b>\$176,520</b>	<b>\$26,996</b>

Source: Aurecon 2014, Table 5

A reduction in FSL is effective in mitigating expected damage costs, with reductions of nearly one and two orders of magnitude respectively for the 75% and 42% FSV scenarios. Similar to the damage rating curve, damage cost has been plotted logarithmically in Figure 15.6 to allow the three damage costs to be shown together. These estimates show that transport infrastructure costs are dominant in the North Pine catchment, being one and two orders of magnitude greater than residential and non-residential damage costs respectively.

A reduction in FSL is effective in mitigating expected damage costs, with reductions of nearly one and two orders of magnitude respectively for the 75% and 42% FSV scenarios. Similar to the damage rating curve, damage cost has been plotted logarithmically in Figure 15.6 to allow the three damage costs to be shown together. These estimates show that transport infrastructure costs are dominant in the North Pine catchment, being one and two orders of magnitude greater than residential and non-residential damage costs respectively.



Source: Aurecon 2014, Figure 4

Figure 15.6 Average annual flood damage costs for downstream areas

### 15.3 Phase 2 - Flood impacts (bridges and crossings)

There are three road crossings of the Pine Rivers that are potentially affected by North Pine River floods downstream of the Dam:

- Youngs Crossing
- Gympie Road Bridge, and
- Bruce Highway Bridge.

In addition to delays caused by flood waters cutting bridge access, there is further potential for structural damage to a bridge once flows exceed a given threshold. This threshold varies for each bridge.

#### 15.3.1 Flood impacts and flood damage to bridges

Flood impacts (Aurecon 2014, Section 4.2) resulting from the closure of Gympie Road and Bruce Highway have been calculated by estimating the number of vehicles impacted by the closure, the average lost time per vehicle due to diversion via alternate routes and the cost per vehicle per hour of delay.

Closure times for crossings are a function of:

- the duration of flooding above the bridge deck level as calculated from discharge hydrographs (provided by Seqwater and MBRC), and
- the time required to close, clean, repair and reopen the bridge prior to and after the flood.

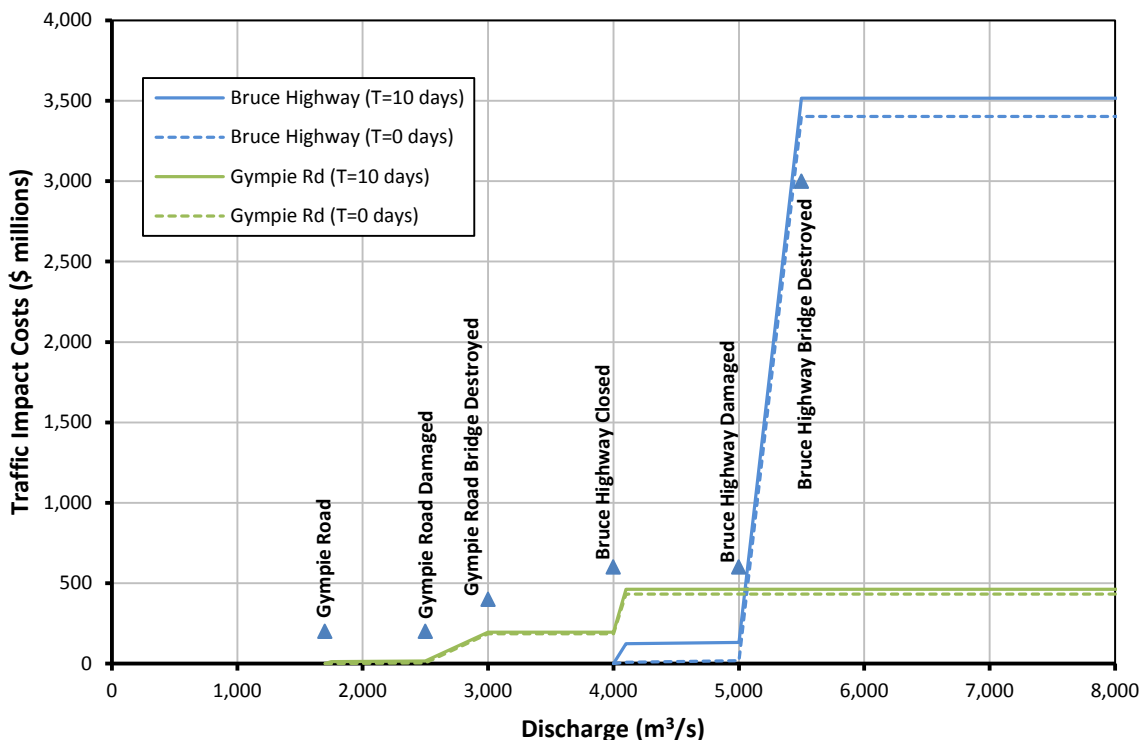
The costs of repair and/or reconstruction following flows exceeding thresholds of structural damage have also been considered.

A three-stage impact rating has been developed comprising:

- flood levels reaching the bridge deck and subsequent closure to traffic with minimal structural damage
- onset of structural damage at a higher discharges
- complete bridge failure requiring subsequent reconstruction.

The resulting Option 1 impact rating is shown in Figure 15.7. Figure 15.8 shows the same information as an impact costs versus exceedance probability relationship.

Delay impacts comprise lost time/additional travel time due to the need to divert traffic via alternate routes. No allowance has been made for secondary impacts on the local community resulting from the short or long-term closure of the bridges. The corresponding flood impact probability curve for Option 1 (base case) is shown in Figure 15.8.



Source: Aurecon 2014, Figure 8

**Figure 15.7** Flood impact rating curves for downstream areas (Option 1 - traffic diversion and delay and bridge repair / reconstruction)

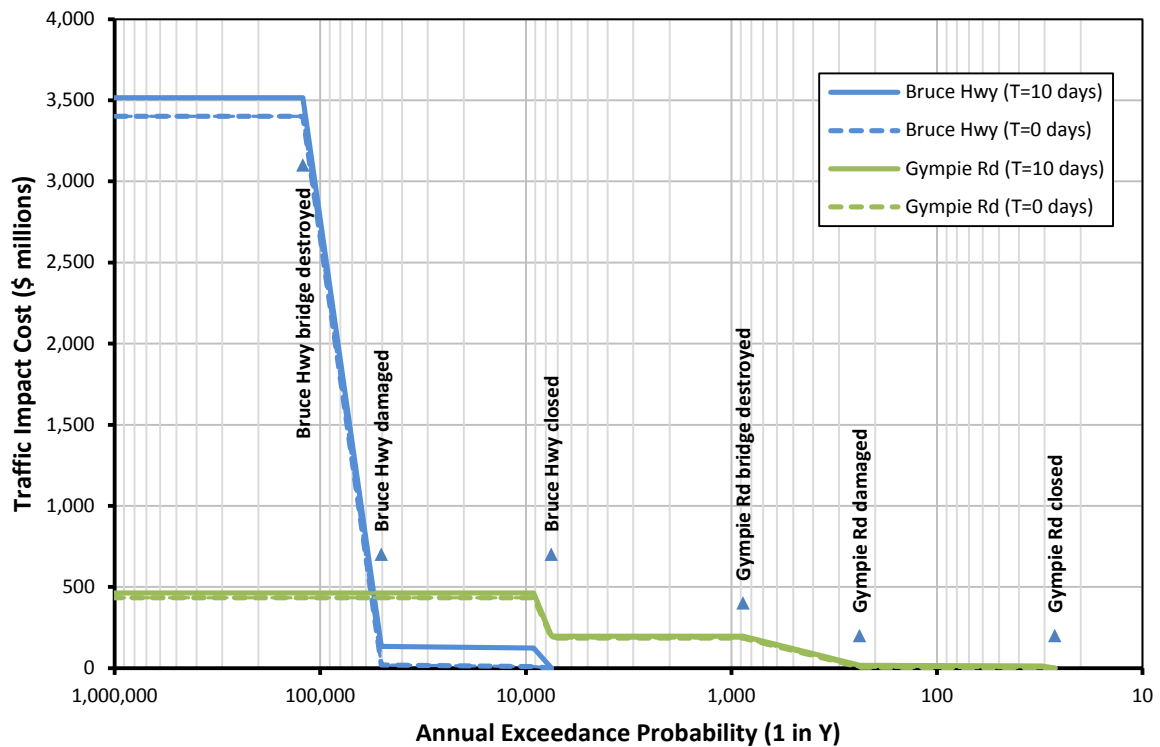


Figure 15.8 Flood impact probability curve for downstream areas (Option 1 - traffic diversion and delay and bridge repair / reconstruction)

### 15.3.2 Flood impacts at Youngs Crossing

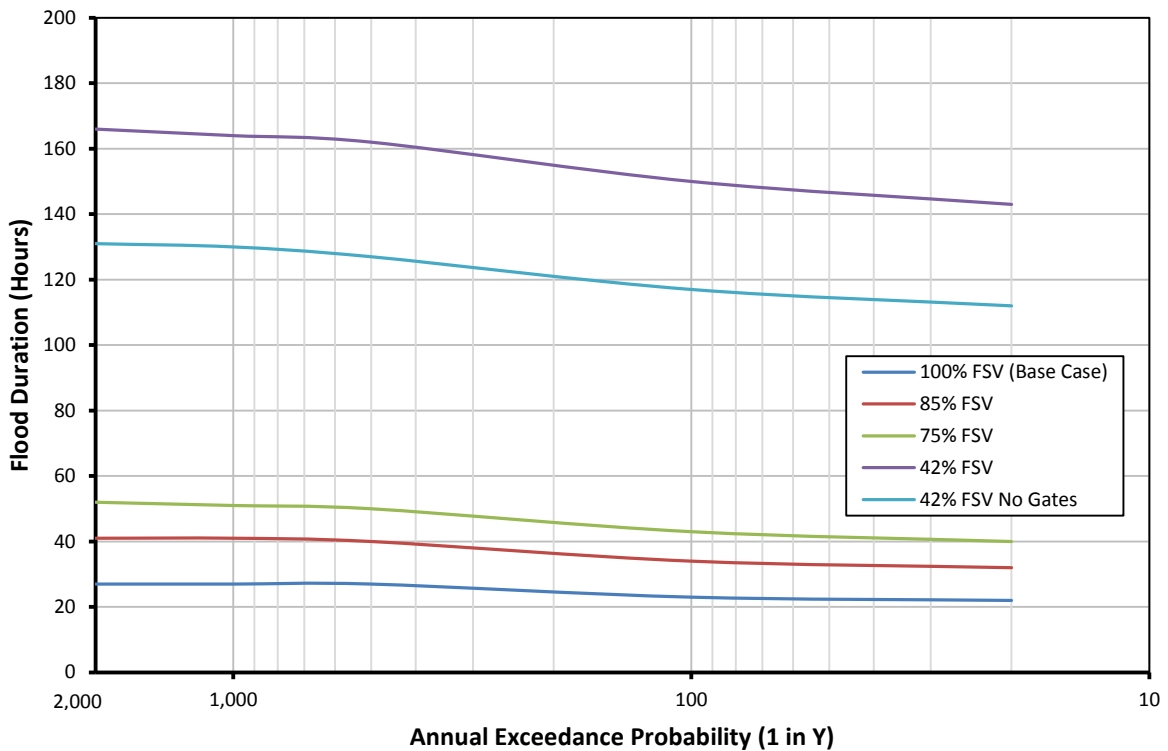
The flow capacity of Youngs Crossing is very low, at around 10 m<sup>3</sup>/s. This means that Youngs Crossing can be cut frequently (sometimes several times each year). Due to the frequency of inundation at Youngs Crossing, it is not possible to use traditional techniques that use annual probabilities to convert estimated closure cost to an average annual value based on design flood events.

Modelling undertaken by DSITIA using the IQQM<sup>3</sup> model has been used to estimate closure times for Youngs Crossing. This estimate is based on the average number of days per year that average daily discharges exceed the flow capacity of Youngs Crossing thereby requiring alternate routes to be used and causing increased travel distances/time (see also Section 12.3.2).

This approach may not identify shorter duration closures such as flow events that cut the crossing but do not result in the average daily flow rate exceeding the threshold of closure. Conversely, events that are identified on the basis of the averaged daily flow rate as exceeding this closure threshold, while closing the crossing for less than a day, are rounded up to a full day closure. Considering that over 70% of the flood events exceed the daily average for 2 or more days, this estimate is considered a reasonable indication of average annual closure time.

Chapter 7 (refer Figure 15.9 below) indicates that whilst lowering the FSV of North Pine Dam reduces the peak discharge in the North Pine River, it increases the duration of inundation of Youngs Crossing.

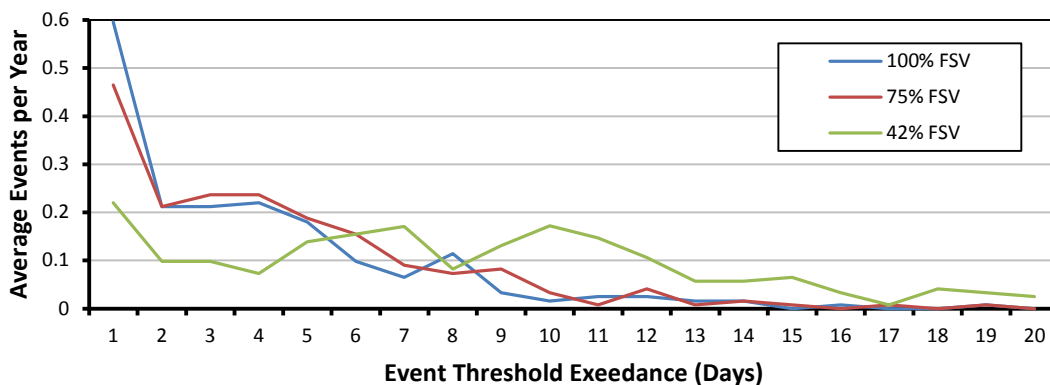
<sup>3</sup> IQQM is the Integrated Quantity and Quality Model for water resources planning.



**Figure 15.9** Youngs Crossing inundation durations

The IQQM modelling (Figure 15.10) also suggests that the duration of flood events with an average daily discharge greater than the Youngs Crossing closure threshold increases as the dam levels are lowered. For example, reducing the FSV for North Pine Dam to 42% results in a minor increase in the average number of flow events exceeding the closure threshold of Youngs Crossing per year (1.9 to nearly 2.1), however the average number of days Youngs Crossing is closed per year more than doubles (8.2 to 20.4). Additionally, the frequency of short duration closures reduces as the FSV of the dam is reduced and the frequency of long duration closures increases.

Notably, the costs associated with the closure of Youngs Crossing as a result of regular small flow events in the North Pine River outweigh the costs of closures associated with infrequent large events.



Source: Aurecon 2014, Figure 10

**Figure 15.10** Durations and frequencies of Youngs Crossing closures

### 15.3.3 Average annual flood impacts

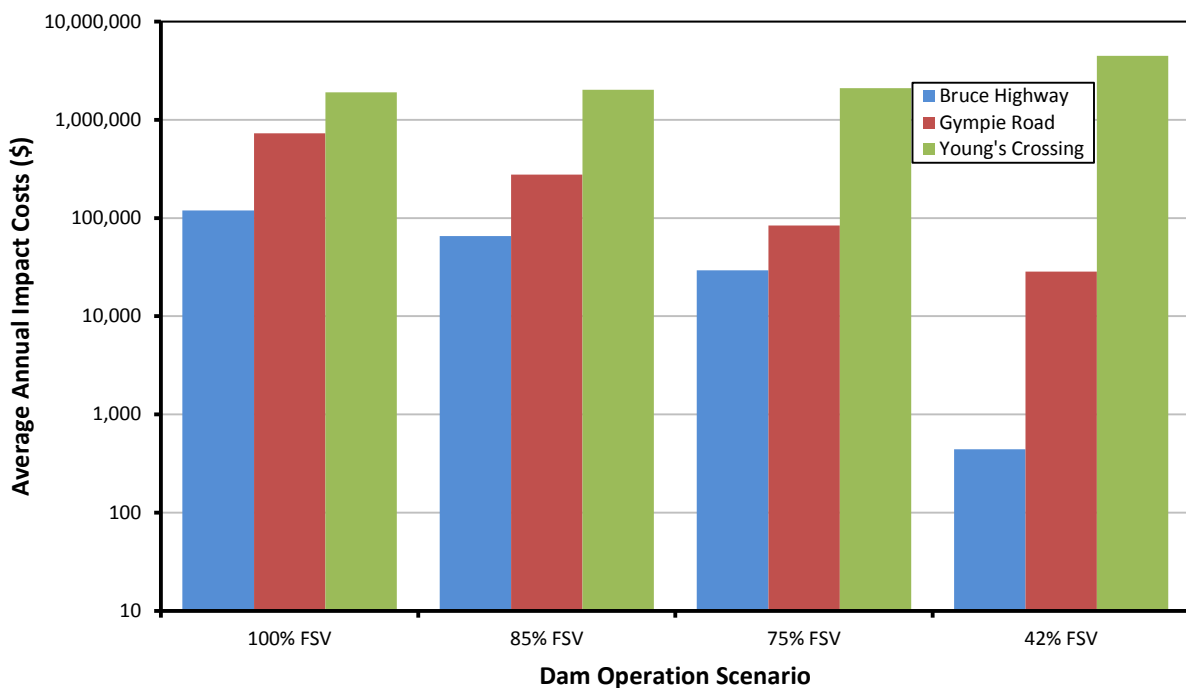
Average annual flood impact costs for the Gympie Road and Bruce Highway crossings have been calculated using a similar methodology to flood damage. Average annual flood impact costs, along with the costs of Youngs Crossing closure, are shown in Table 15.4 and Figure 15.11.

It should be noted that estimates of average annual impact costs for Gympie Road and, in particular, the Bruce Highway should be treated with caution as the impacts increase significantly once the bridge is heavily damaged, and the exact AEP of which is difficult to accurately predict. Nevertheless, the impact costs for these structures also exhibit a significant reduction as the FSV is reduced.

**Table 15.4** Average annual flood impact costs for downstream areas

Flood Impact	North Pine Dam Supply Volume			
	100% FSV	85% FSV	75% FSV	42% FSV
Bruce Highway	\$119,930	\$65,469	\$29,291	\$443
Gympie Rd	\$729,737	\$276,301	\$83,957	\$28,517
Youngs Crossing	\$1,904,135	\$2,018,944	\$2,100,587	\$4,474,170
<b>TOTAL</b>	<b>\$2,753,802</b>	<b>\$2,360,714</b>	<b>\$2,213,835</b>	<b>\$4,503,129</b>

Source: Aurecon 2014, Table 10



Source: Aurecon 2014, Figure 9

**Figure 15.11** Average annual flood impact costs for downstream areas

## 15.4 Phase 3 - Bulk water supply infrastructure

The current bulk water supply strategy is based on a staged augmentation of existing water supply infrastructure with desalination plants. Costs associated with each augmentation stage include initial construction of supply infrastructure as well as ongoing costs of operation. Under the current strategy for SEQ, the next source augmentation is proposed to be a desalination plant located in the northern SEQ sub-region (i.e. Sunshine Coast) followed by another desalination plant located in the central SEQ sub-region (i.e. close to Brisbane).

Construction and operational costs and currently proposed implementation dates for augmentation have been supplied by Seqwater and converted to 2013 dollar values for use in the analysis, as shown in Table 15.5.

**Table 15.5 Current bulk water supply augmentation timing and costs**

Item	Capital Cost (\$M)	Time to Build (Years)	Date of Implementation	Operation Cost (\$M/a)
<b>Augmentation Stage 1</b>			2031	
• Desalination Plant	1100	3		61.9
• Network Connection	166.8	1		13.9
• Associated pipe upgrades	21.5	1		0.5
<b>Augmentation Stage 2</b>			2044	
• Desalination Plant	1100	3		61.9
• Network Connection	145.8	1		4.1
• Associated pipe upgrades	174.2	1		0.7

Source: Aurecon 2014, Table 14

Modelling to determine changes to augmentation dates as a result of lowering North Pine Dam was based on the bulk water supply infrastructure existing in 2012 and the 'most likely' system demand projections (outlined in Chapter 11).

### 15.4.1 Infrastructure timing for options

Changes to bulk water supply infrastructure affect the water supply capacity of the SEQ water supply system and influence the timing of supply augmentations. Seqwater and Aurecon assessed the impact of a range of concurrent FSVs at Wivenhoe/Somerset and North Pine dams on the SEQ supply augmentation schedule.

Due to Wivenhoe, Somerset and North Pine dams forming part of an integrated system, the timelines for augmentation were based on the results of WATHNET modelling of system yield impacts and volumetric reductions in combined system storage. Although the capacity of North Pine Dam is significantly smaller than that of Wivenhoe and Somerset dams some minor impacts on the augmentation schedule are expected, particularly for significant reductions to the FSV of North Pine Dam down to 42% FSV and especially when concurrent with Wivenhoe Dam being reduced to 90% FSV or lower.

The adopted timings of augmentations of water supply for the purposes of this assessment are shown in Table 15.6.

**Table 15.6 Timing of bulk water supply augmentation**

		Wivenhoe Dam FSV							
		100%		85%		75%		60%	
		First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage
North Pine Dam FSV	100%	2031	2044	2031	2039	2031	2036		
	85%	2031	2044* (2043)	2031	2039* (2038)			2025	2031*
	75%					2030	2036* (2035)		
	42%	2031	2044* (2041)					2021	2027*

Notes:

1. \*Modelling has not been undertaken for these scenarios to determine the yield. Consequently, the dates have been inferred and could be earlier than stated
2. First and second stage augmentation advice was provided by Seqwater except where inferred
3. Bracketed year is the timing adopted by Aurecon 2014 for analytical purposes

Source: Aurecon 2014, Tables 15 and 16

Seqwater also investigated the likely changes to the bulk water supply infrastructure augmentation schedule resulting from alteration to current manufactured water asset operations. Revised augmentation timings are listed in Table 15.7. Augmentation schedule changes have been provided for the first augmentation only. Timing of the second augmentation has been assumed to be unchanged from the current manufactured water timings.

**Table 15.7 Likely timing of water supply augmentation with alteration to manufactured water**

		No WCRWS		No Desalination		No Manufactured Water	
		First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage
Combined Dam FSV	100%	2028	2044*	2019	2044*	2019	2044*
	85%	2027	2038*	2019	2038*	2019	2038*

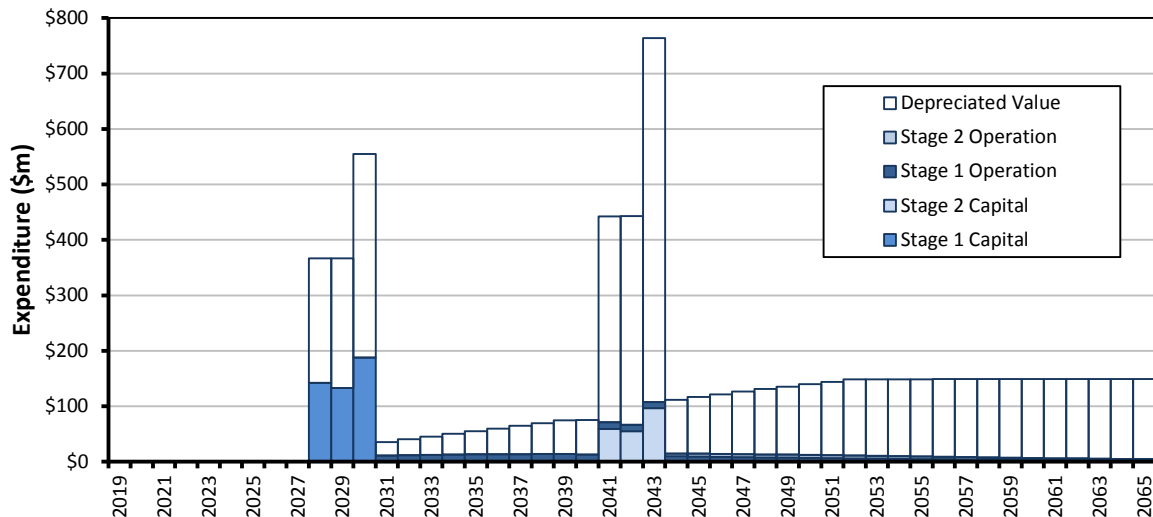
Notes: \* Timing of second augmentation has not been determined for these cases – assumed to be unaffected by manufactured water availability but this may result in an underestimate of the NPC of the water supply augmentation costs.

Source: Aurecon 2014, Table 17

### 15.4.2 Water supply infrastructure costs

Infrastructure costs have been assumed to consist of the NPC of proposed first- and second-stage augmentation infrastructure, including construction and operating costs for the duration of the analysis period.

Projected augmentation costs were discounted and accumulated into an NPC. Figure 15.12 illustrates the yearly distributions of discounted costs based on current estimates of augmentation timing assuming current infrastructure availability. Figure 15.12 highlights the decreased importance of long-term costs. Bringing forward the augmentation dates results in increased NPC of the augmentation.



Source: Aurecon 2014, Figure 15

Figure 15.12 Projected augmentation costs for current conditions ('average' discount rate = 7%)

## 15.5 Phase 4 Operational costs

As indicated in Section 15.1.3, operational costs consist of the costs of manufactured water production and for any infrastructure constructed in response to drought. These costs are an underestimation of the actual costs of operation, as the costs associated with manufactured water delivery and redistribution of other water supplies in the SEQ water supply system have not been included.

### 15.5.1 Water security strategy

To ensure reliability of supply to SEQ, a number of water supply thresholds have been identified which trigger augmentation of supply. Currently, these thresholds and strategies are as follows:

- at 60% combined capacity of the SEQ water storages, operation of the GCDP is increased to full capacity while the reservoir level remains below the trigger threshold
- at 40% combined capacity of the SEQ water storages, the GCDP continues to operate at full capacity and operation of the WCRWS is increased to full capacity while the reservoir level remains below the trigger threshold
- at 30% combined capacity of the SEQ water storages, the GCDP and WCRWS continue to operate at full capacity and immediate construction commences on drought response/contingency infrastructure (assumed to be a new desalination plant).

Availability of the GCDP and WCRWS for immediate drought response will depend on the policy adopted regarding the use of manufactured water. Modelling undertaken by Seqwater has assumed that the WCRWS is active and operating at sufficient capacity to supply power station demands. However, from 2014 the WCRWS will be decommissioned and placed under care and maintenance, with the ability to be re-commissioned at the 40% trigger. Consequently, Swanbank Power Station demands will need to be met from other supplies.

**15.5.2 Water restriction costs**

The cost impacts of water restrictions or the implications that these may have on the general community are difficult to address due to the lack of information. The Productivity Commission (2011) notes that the costs associated with water restrictions (many of which are hidden and potentially intangible) are borne by households, business, the community and government. These costs may include those associated with increased production, inconvenience and loss of amenity, compliance and enforcement. For the SEQ water supply system, restrictions are currently applied at the 40% combined capacity trigger.

Given the lack of current data, a simplistic approach to the economics of water restrictions has been adopted for this assessment. Studies indicate that water consumers are willing to pay relatively little to avoid low-level restrictions, but much greater amounts to ensure high-level restrictions are not imposed or are imposed very rarely. The range of estimated tolerable household costs is listed in Table 15.8.

**Table 15.8 Water restrictions cost estimates**

Restrictions	Cost / household	Annual Cost
Low level (10% reduction)	≈ \$15	\$9M
Medium to High level	\$160 – \$280	\$95M – \$165M

Note: The available data on the cost of water restrictions is limited with the above figures being used for preliminary assessment.

Source: Aurecon 2014, Table 26

It is important to note that willingness-to-pay values are based on public perception of cost and probabilities rather than an actual cost or probabilistic assessment, and it is therefore not necessarily appropriate to correlate these values to an actual impact cost.

For the purposes of this study, a cost of \$130M/a has been assumed. This relates to medium-level restrictions imposed to achieve a targeted reduction of 15%, initiated at the 40% trigger.

Costs associated with medium level water restriction (based on community perception-and-willingness to pay, as discussed above) comprise approximately 20% of current water security costs. Although the cost increases as the storage volume is reduced, the percentage contribution decreases down to 11% of total costs for the minimum supply volumes examined. As with the manufactured water costs, the significantly lower probability of triggering increased water restrictions means that they should have a greatly reduced contribution to overall costs. Given the uncertainty regarding the water restriction cost estimates, it is considered reasonable to neglect these costs.

### 15.5.3 Manufactured water costs

Manufactured water costs comprise the production costs for drought response and capital costs when new infrastructure is required. For the scenarios not specifically investigating alteration of manufactured water availability, the existing manufactured water options (GCDP and WCRWS) have been assumed to be in operational order and incur no significant infrastructure cost to increase to full production capacity. Re-commissioning costs have been supplied by Seqwater and have been applied to scenarios where the asset has been de-commissioned. For simplicity these costs have been calculated based on the average time between threshold trigger events. Production costs have been based on annual operating costs for the infrastructure provided by Seqwater and assume that the asset remains active for two months longer than the average duration that the water level remains below the threshold.

New drought response infrastructure is constructed when combined SEQ water storages capacity falls to 30%. The cost of bringing forward the next planned augmentation in response to drought is the difference in NPC resulting from the different construction timeframes of drought-response construction as opposed to the planned construction. This cost was assumed to not be incurred if the planned augmentation was already under construction or in the 5 years following construction where the plant was operating at less than full capacity. Production costs have also been applied, although it is noted that drought response infrastructure may not enter production as the average duration below the threshold (from the WATHNET modelling) is less than the time of construction. This is considered to have negligible impact on the estimates of NPCs as reaching the 30% threshold has a low probability and production costs are significantly outweighed by the infrastructure costs.

Adopted operational costs are summarised in Table 15.9. These costs are cumulative, as higher threshold infrastructure will already be in operation when lower threshold triggers are reached.

**Table 15.9** Manufactured water operating costs

Threshold	Infrastructure	Operating Cost	Average Duration	Infrastructure Cost
60%	GCDP	\$44.80M/a	9 to 10 months	\$18M to \$28.5M <sup>a</sup>
40%	WCRWS	\$66.80M/a	7 to 8 months	\$10.2M to \$33M <sup>a</sup>
30%	New DSP	\$64.48M/a	5 to 6 months	0 to \$1,000M+ <sup>b</sup>

Notes:

- a. Re-commissioning cost calculated based on average time between trigger events and applied only to Manufactured Water scenarios
- b. Bring-forward construction costs dependent on time between trigger and next planned augmentation

The NPC attributable to operations can be calculated as the sum of the present cost of the consequences of reaching a threshold in each year multiplied by the probability of the threshold being reached in each year.

## 15.6 Phase 5 - Net Present Costs

The Integrated Assessment Methodology (IAM) has been developed to allow consistent assessment and comparison of costs and benefits across multiple criteria. The IAM has identified impacts related to spatially distributed flood damage, site-specific flood impacts, bulk water supply infrastructure requirements and operations of the water supply.

These impacts have been assessed and compiled in the form of an average NPC. The NPC of a cost time series is the sum of the present values of costs. The present value is the future impact cost (or benefit) discounted to reflect its current value. Therefore, the NPC is dependent on the discount rate and the forecast period over which the likely costs are accrued. Sensitivity to these parameters has been tested using the combinations for short-term, medium and long-term horizons listed in Table 15.10.

**Table 15.10 Net present cost conditions**

NPC Horizon	Discount Rate (%)	Forecast period (Years)	NPC Multiplier
Short-term	9%	20	9.13
Medium-term	7%	40	13.33
Long-term	5%	60	18.93

Combined NPC for the medium-term horizon are provided in Table 15.11 and Figure 15.13. These costs are provided for North Pine Dam levels between 100% and 42% FSV (with Wivenhoe Dam at 100% and current manufactured water availability). These costs are indicative of those for Wivenhoe Dam at 85% or higher, which have relatively little impact on costs attributable to the North Pine region. Water infrastructure and security costs are presented relative to the current situation.

Notably, if the Seqwater second stage augmentation timing projections are assumed, reference to Table 15.6 shows there is no change over the existing scenario (Option 1). Consequently, the increases in water supply infrastructure capital costs in Table 15.11 and Figure 15.13 reduce to zero.

It is likely that the total NPC will ultimately fall somewhere between the totals shown in Table 15.11 and a NPC estimate without the water infrastructure costs. Estimated NPC without water infrastructure would not adequately reflect the importance of North Pine Dam to the performance of the SEQ water supply system but the extent to which water infrastructure and other costs such as water restrictions should be included is debatable.

Residential damage contributes less than 2% of the current total flood related damage costs. The largest contributors are all related to transportation infrastructure, with general flood-related damage to the road network and traffic interruption at Youngs Crossing as well as at Gympie Road, which has greater flood immunity but much higher traffic use.

Whilst reducing the water supply volume of North Pine Dam to 42% FSV significantly reduces flood damage cost, the increased traffic impact costs (mainly due to increased closures of Youngs Crossing) far outweighs the benefits of reducing flood damage costs. This suggests that significant reductions in the FSL of North Pine Dam will not be economically justifiable, even where water supply costs are not considered.

Reducing the FSV increases the projected bulk water supply infrastructure costs and drought initiated manufactured water costs (which are roughly 10% of the infrastructure costs). At 85% and 75% FSV, the increase in water supply infrastructure and manufactured water costs are approximately twice the decrease in flood related damage and impact costs, meaning that reduction of the FSV has an overall adverse effect on expected costs.

**Table 15.11 Influence of dam supply volumes on net present costs for the medium term conditions (\$M)**

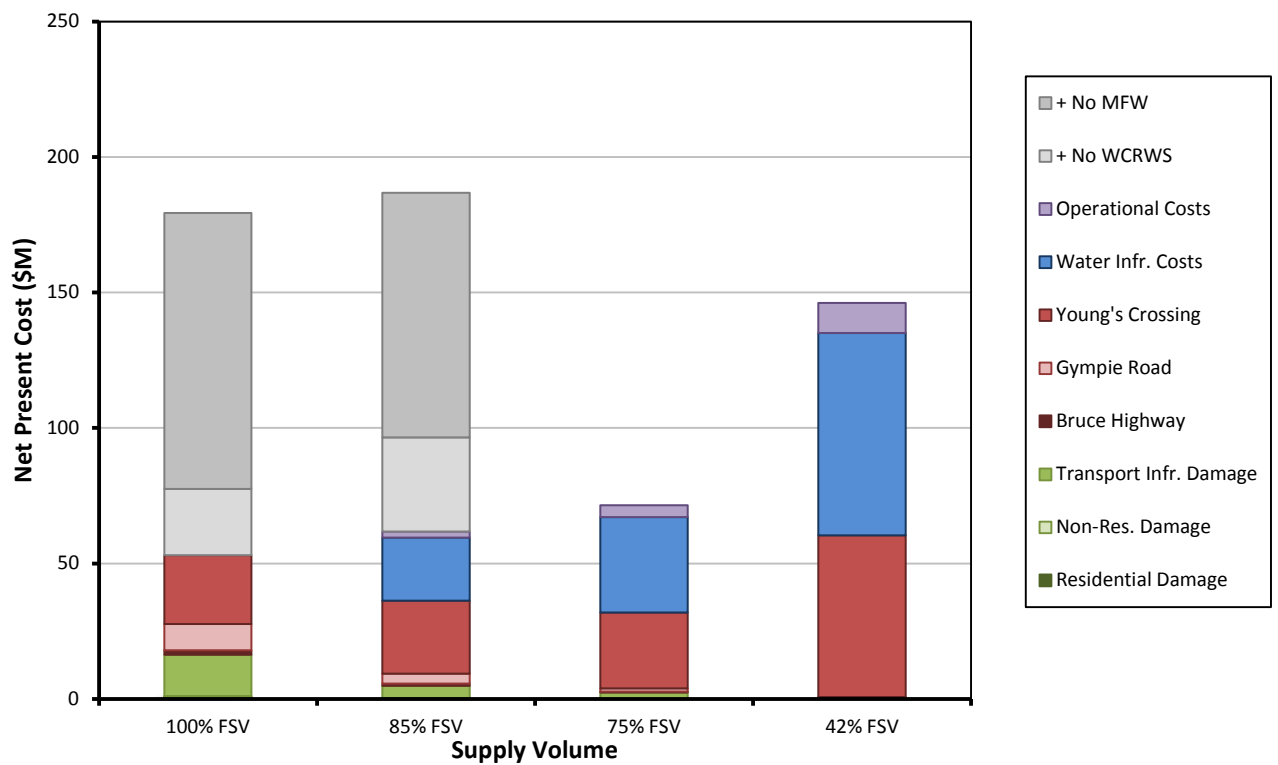
Damage / Impact Type	Wivenhoe Dam / North Pine Dam supply volumes (% FSV)			
	100% / 100%	100% / 85%	100% / 75%	100% / 42%
Residential Damage	\$0.99	\$0.30	\$0.13	\$0.04
Non-Res. Damage	\$0.05	\$0.01	\$0.01	\$0.00
Transport Infrastructure Damage	<u>\$15.27</u>	<u>\$4.49</u>	<u>\$2.22</u>	<u>\$0.32</u>
<b>Total Flood Damage</b>	<b>\$16.30</b>	<b>\$4.81</b>	<b>\$2.35</b>	<b>\$0.36</b>
Bruce Highway	\$1.60	\$0.87	\$0.39	\$0.01
Gympie Road	\$9.73	\$3.68	\$1.12	\$0.38
Youngs Crossing	<u>\$25.39</u>	<u>\$26.92</u>	<u>\$28.00</u>	<u>\$59.65</u>
<b>Total Flood Impact</b>	<b>\$36.71</b>	<b>\$31.47</b>	<b>\$29.51</b>	<b>\$60.03</b>
Water Infrastructure Costs	\$-	\$23.21	\$35.17	\$74.65
Operational Costs	\$-	\$2.32	\$4.37	\$11.11
<b>NET PRESENT COST</b>	<b>\$53.01</b>	<b>\$61.82</b>	<b>\$71.41</b>	<b>\$146.15</b>
<b>Total Benefit of Scenario</b>	<b>\$-</b>	<b>(\$8.80)</b>	<b>(\$18.39)</b>	<b>(\$93.13)</b>

Impact Type	No WCRWS		No MFW	
	100% / 100%	85% / 85%	100% / 100%	85% / 85%
Water Infrastructure Costs	\$21.53	\$52.66	\$119.77	\$136.84
Operational Costs	\$2.94	\$7.52	\$6.57	\$13.66
<b>NET PRESENT COST</b>	<b>\$24.46</b>	<b>\$60.18</b>	<b>\$126.35</b>	<b>\$150.50</b>
<b>Added Benefit of Scenario</b>	<b>(\$24.46)</b>	<b>(\$30.74) <sup>a</sup></b>	<b>(\$126.35)</b>	<b>(\$121.07) <sup>a</sup></b>

Notes: a. In excess of full manufactured water availability scenario. Refer to Aurecon 2014, Tables 22 and 30.

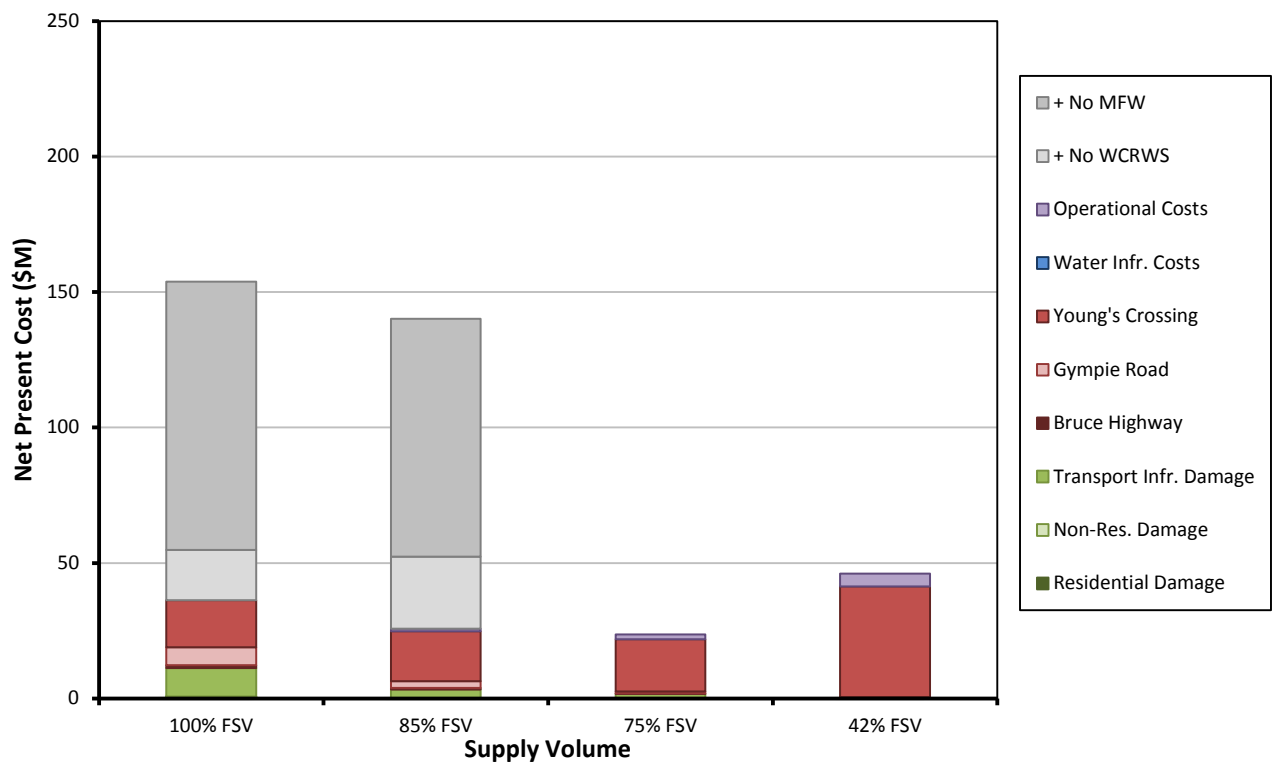
Source : Aurecon 2014, Table 33

Sensitivity to NPC assumptions has been examined using the short term and long term NPC assumptions from Table 15.10. Results for short-term conditions shown in Table 15.12 and Figure 15.14. Use of long-term parameters generally increases the NPC by around approximately 40%, however the general trends and conclusions are identical to the medium-term analysis discussed above.



Source: Aurecon 2014, Figure 35

Figure 15.13 Influence of dam supply volumes on NPCs for medium term conditions



Source: Aurecon 2014, Figure 36

Figure 15.14 Influence of dam supply volumes on NPCs for short-term conditions

**Table 15.12 Influence of dam supply volumes on net present costs for short-term conditions (\$M)**

Damage/Impact Type	Wivenhoe Dam / North Pine Dam supply volumes (% FSV)			
	100% / 100%	100% / 85%	100% / 75%	100% / 42%
Residential Damage	\$0.67	\$0.21	\$0.09	\$0.02
Non-Res. Damage	\$0.03	\$0.01	\$0.00	\$0.00
Transport Infrastructure Damage	<u>\$10.45</u>	<u>\$3.08</u>	<u>\$1.52</u>	<u>\$0.22</u>
<b>Total Flood Damage</b>	<b>\$11.16</b>	<b>\$3.29</b>	<b>\$1.61</b>	<b>\$0.25</b>
Bruce Highway	\$1.09	\$0.60	\$0.27	\$0.00
Gympie Road	\$6.66	\$2.52	\$0.77	\$0.26
Youngs Crossing	<u>\$17.38</u>	<u>\$18.43</u>	<u>\$19.18</u>	<u>\$40.84</u>
<b>Total Flood Impact</b>	<b>\$25.14</b>	<b>\$21.55</b>	<b>\$20.21</b>	<b>\$41.11</b>
Water Infrastructure Costs	\$-	\$-	\$-	\$-
Operational Costs	\$-	\$0.90	\$1.78	\$4.70
<b>NET PRESENT COST</b>	<b>\$36.30</b>	<b>\$25.74</b>	<b>\$23.60</b>	<b>\$46.05</b>
<b>Total Benefit of Scenario</b>	<b>\$-</b>	<b>\$10.56</b>	<b>\$12.69</b>	<b>(\$9.75)</b>

Impact Type	No WCRWS		No MFW	
	100% / 100%	85% / 85%	100% / 100%	85% / 85%
Water Infrastructure Costs	\$17.73	\$24.64	\$114.73	\$108.84
Operational Costs	\$0.83	\$2.88	\$2.74	\$6.44
<b>NET PRESENT COST</b>	<b>\$18.55</b>	<b>\$27.52</b>	<b>\$117.47</b>	<b>\$115.27</b>
<b>Added Benefit of Scenario</b>	<b>(\$18.55)</b>	<b>(\$26.08) <sup>a</sup></b>	<b>(\$117.47)</b>	<b>(\$113.84) <sup>a</sup></b>

Notes: a. In excess of full manufactured water availability scenario. Refer to Aurecon 2014, Tables 23 and 31.

Source : Aurecon 2014, Table 34

In the short-term analysis, NPCs are generally reduced, reflecting the fact that changes to bulk water infrastructure augmentation dates lie outside the assumed short-term forecast period of 20 years (i.e. first stage augmentation dates remain at 2031 for most cases) and hence no present cost is realised. Although there are some operational costs, these are not sufficient to offset the reduction in flood damage and impact.

Having regard to the short-term analysis (and the medium-term analysis, excluding bulk water infrastructure capital costs), it may be concluded that a moderate reduction in the FSV of North Pine Dam has the potential to offer some short-term benefits of reduced flood risk and enhanced dam safety outcomes. However, whether any practical benefit is realised would depend on the occurrence and severity of flooding that occurs in the respective timeframes.

These potential benefits are further supported by a simple assessment of the deferral of dam safety upgrades from 2025 to 2035 resulting from a reduced FSV. For example, the NPC of a deferral of \$50M is approximately \$10M while the likely cost of a dam spillway upgrade is likely to be in the hundreds of millions of dollars. This outcome further enhances the short-term advantages associated with a small lowering the FSL of the dam and may offset additional water supply upgrade costs.

Changes to the availability of manufactured water do not affect flood-related damages; however, as illustrated in Figure 15.13, a reduction or elimination of current manufactured water production requires future augmentation to be brought forward and increases drought risk, which adds a significant NPC. A reduction in water supply storage volumes, whether at Wivenhoe Dam or North Pine Dam, increases the frequency of reaching triggers for initiating manufactured water.

## 15.7 Integrated Assessment

To satisfy the requirements of QFCoI Final Report recommendation 17.3, the integrated assessment of the proposed operational options for North Pine Dam requires consideration of trade-off between:

- the damage and impacts associated with flooding
- the water supply security costs associated with increased production of manufactured water and the need to bring forward infrastructure upgrades
- the ability to reduce dam safety risks and improve flood mitigation while any necessary upgrades of the dam are planned and executed
- the ability to minimise disruption to the community by reducing the cost associated with the submergence of bridges, crossings and roads.

Strategies for minimising bank slumping and erosion and flora and fauna impacts identified in the key findings above have been confined to smaller floods less than 500 m<sup>3</sup>/s on the rising and falling stages of a flood.

Net Present Costs have been estimated for tangible flood inundation damages and impacts and bring forward costs of water supply infrastructure and manufactured water production. Where it has not been possible to quantify the costs, evidence has been presented throughout this report to inform qualitative assessment of the potential impact.

Based on the key findings in the earlier chapters, Option 2 (lowered dam levels with flood release at the current FSL) offers few advantages over Option 3 (lowered dam and flood release levels) other than slightly shorter duration closures of Youngs Crossing. Option 3 offers improved flood mitigation benefits over the whole range of flood events and FSV options analysed, whereas Option 2 only provides flood mitigation improvements over a range of smaller flood events similar to those experienced historically. Option 2, therefore, has not been considered further in the integrated assessment of the operational options. In essence, for smaller floods, the flood mitigation outcomes of Option 2 are similar to Option 3 while for larger floods Option 2 is similar to Option 1 (base case).

Indicative comparisons of the NPC for Option 1 compared to the reduced FSVs proposed in Option 3 have been summarised in Tables 15.11 and 15.12. These comparisons are detailed graphically in Figures 15.13 and 15.14. Table 15.13 provides a comparison of these options considering criteria outlined by QFCoI Final Report recommendation 17.3 relating to dam safety, urban flood mitigation and water supply matters along with an overall summary of the NPC. The assumptions informing these comparisons are outlined in the specialist reports underpinning NPDOS.

Table 15.13 summarises the implications of operational alternatives 1 and 3 and the associated options bringing together the findings of the previous Chapters, and highlights that reducing the FSV of North Pine Dam:

- improves dam safety outcomes
- reduces peak dam outflow rates for flood events
- reduces the inundation of residential and non-residential buildings and critical infrastructure such as bridges and roads, however the number of affected buildings is low and benefits are mostly gained in very large events
- results in only small reductions in inundation of the habitable floor levels as there is already a high level of flood immunity for the downstream areas
- does not impact the system yield of the SEQ water supply system but increases the likelihood of requiring desalinated water production and incurring increased operating costs
- increases the likelihood of triggering restrictions
- would not change the timing for the next augmentation of the SEQ water supply system (although longer term augmentation timings are affected)
- increases the likelihood that algal blooms will be triggered as occurred during the Millennium Drought of 2001 to 2007.

Table 15.11 also shows that:

- estimated average annual damages for residents is low
- estimated average annual damages for transport infrastructure is more significant
- estimated average annual impacts, mainly due to road closures and traffic rerouting, is substantial and would be greatest at a dam level of 42% FSV due to the increasing impact of submergence of Youngs Crossing - despite the declining impact on Gympie Road and Bruce Highway
- reducing the availability of manufactured water brings forward the timelines for augmentation of bulk water supplies.

Figures 15.13 and 15.14 illustrate the significant cost associated with rerouting traffic due to the inundation of river crossings, particularly with Youngs Crossing, as well as the sensitivity of the analysis to assumptions about water infrastructure costs. These figures demonstrate that most of the water supply costs arise from the need to implement second stage supply augmentations sooner than currently anticipated beyond 2031. The main cost of manufactured water being unavailable is the brought forward cost of capital expenditure to augment the supply capacity of the SEQ water supply system.

The limits of accuracy and uncertainties associated with the estimates and modelling underpinning the analysis mean that the flood mitigation benefits of lowering North Pine Dam from 100%FSV to either 85% or 75% FSV are marginal and accrue mainly due to reductions in transport infrastructure damage (local road damage). However, a small lowering of the dam to below 94% FSV to say 90% FSV would improve the dam's ability to pass extreme floods and downstream flooding in the short-term, without increasing costs, until Seqwater and upgrades the spillway capacity of North Pine Dam could be beneficial.

**Table 15.13 Implications of the operational options (Wivenhoe Dam at 100% FSV)**

Issue	Measure	Option 1	Option 3.1	Option 3.2	Option 3.3
		Existing	85% FSV	75% FSV	42% FSV <sup>1</sup>
Dam Design	Supply Level (mAHD)	39.6	38.04	36.88	32.00
	Volume (ML)	214,300	182,200	160,700	90,000
Dam Safety	Flood capacity of the dam	Increasing dam safety →			
	Approximate flood capacity (% PMF) <sup>2</sup>	63%	68% (interpolated)	71%	85%
	Dam crest flood probability (AEP)	1 in 570,000	1 in 840,000	1 in 940,000	1 in 1,340,000
Flood Mitigation	Dam outflows relative to inflows	Increasing reduction in dam outflows →			
	Reduction of PMF inflow (5 gates)	15%	20%	25%	43%
	Buildings flooded above habitable floor	Reducing flood inundation →			
	• 1.0% (1 in 100) AEP	6	1	1	1
	• 0.2% (1 in 500) AEP	20	11	5	1
	• 0.05% (1 in 2,000) AEP	36	24	15	3
	• PMF <sup>3</sup>	1524	1200	915	241
	Flooding of major / minor roads	Reducing submergence →			
	• 5.0% (1 in 20) AEP	7	7	7	7
	• 1.0% (1 in 100) AEP	8	7	7	7
	• 0.2% (1 in 500) AEP	13	8	7	7
	Damage and impact costs	Damage costs reduce, variable impact costs →			
	Residential average annual damage (AAD)	\$0.07M	\$0.02M	\$0.01M	\$0.01M
	Non-residential AAD	~\$0.0M	~\$0.0M	~\$0.0M	~\$0.0M
Transport infrastructure AAD	\$1.15M	\$0.34M	\$0.17M	\$0.02M	
Transport average annual impact (AAI)	\$2.75M	\$2.36M	\$2.21M	\$4.50M	
<b>Total AAD and AAI</b>	<b>\$3.98M</b>	<b>\$2.72M</b>	<b>\$2.39M</b>	<b>\$4.53M</b>	
Water Supply	System (level of service) yield (ML/a) <sup>4</sup>	435,000	435,000	435,000	435,000
	Timing of future supply augmentations	WCRWS and/or GCDP unavailability brings forward upgrades			
	• Existing SEQ water supply system	2031	2031	2031	2031
	• WCRWS <sup>5</sup> unavailable	2028	2028	2028	2028
	• WCRWS and GCDP <sup>6</sup> unavailable <sup>6</sup>	2019	2019	2019	2019
	Drinking water quality concerns <sup>7</sup>	Increasing risk of algal blooms in North Pine Dam →			
	Cumulative probability of desalination water production being required	Increasing likelihood desalination will be required → ↓			
	• Probability by 2018	2.6%	3.0%	3.5%	6.0%
	• Probability by 2023	13.0%	14.7%	16.3%	23.3%
	• Probability by 2033	43.5%	46.7%	49%	60.1%
Cumulative probability of restrictions <sup>8</sup>	Increasing likelihood restrictions will be required				
• Probability by 2033	7.7%	7.8%	8%	8.5%	
Estimated NPC Benefit	Medium term NPC analysis	-	(\$8.80M)	(\$18.39M)	(\$93.13M)
	Short term NPC analysis	-	\$10.56M	\$12.69M	(\$9.75M)

Notes:

1. The statistics for the no gates case generally provide slightly higher flood immunity and dam safety.
2. From *North Pine Dam Acceptable Flood Capacity Report* (URS 2012) prepared for Seqwater.
3. While there is considerable exposure to flooding in a PMF (probable maximum flood), this is the case throughout Queensland and the world.
4. Assumes that Wivenhoe Dam is not lowered.
5. Purified recycled water via the Western Corridor Recycled Water Scheme.
6. Gold Coast Desalination Plant
7. Potentially the SEQ water supply system augmentation schedule could be impacted due to drinking water quality issues and associated increased transport costs.
8. Probability of restrictions being triggered in the first 10 years is very low with or without manufactured water.

## Chapter 16 – Future Flood Risk Management

The focus of the North Pine Dam Optimisation Study has been to assess whether the operation of the dam can be optimised to improve downstream flood mitigation while not reducing current levels of dam safety.

This chapter discusses:

- the potential to operate North Pine Dam as a flood mitigation dam as required by the QFCoI Final report recommendation 17.9,
- possible future investigations that could lead to improvements to the Flood Manual, and
- other strategies to mitigate the impact of floods that could be considered.

This chapter does not provide significant detail regarding these strategies. Instead the intent is to simply place dam optimisation into the context of a suite of available floodplain management measures.

### 16.1 Potential to Operate as a Flood Mitigation Dam

QFCoI Final Report recommendation 17.9 requires consideration of whether North Pine Dam should be operated as a flood mitigation dam.

Most dams, including ungated dams, provide some passive flood mitigation by attenuation of the peak dam outflow relative to peak dam inflows. This occurs as flood water is temporarily stored in space above the normal water supply FSL which delays and reduces the peak outflow relative to peak inflow. For gated dams it may be possible to increase the flood mitigation by actively regulating the flood outflow and increasing the temporary storage of floodwater.

In order for a gated dam to be operated actively as a flood mitigation dam, two essential criteria need to be satisfied; there must be:

- adequate flood storage capacity above FSL; and
- sufficient time available to actively assess the flood conditions and regulate the flood outflow through the temporary storage of the floodwater.

In regard to the matter of sufficient time, it is noted that significant flooding in the North Pine River catchment can occur within 6 hours (sometimes shorter) to 12 hours of the commencement of heavy rainfall. This is not a lot of time available to assess the flood conditions including the collection of rainfall and streamflow information, analysis of weather forecasts, undertaking of predictive modelling and management of the dam gates.

#### 16.1.1 Operational alternative 1 – existing situation

North Pine Dam was not designed or intended to operate as flood mitigation dam. The existence of a Manual does not mean that North Pine Dam is a flood mitigation dam. The Flood Manual exists because there is a public interest to ensure that the radial gates are operated safely during flood events and to ensure the safety of the dam. The need for a flood mitigation manual is prescribed by legislation.

Under existing operations, there is limited opportunity to provide active flood mitigation by using the spillway gates to regulate outflows and increase the temporary storage of floodwater in the dam. This is due to:

- the limited available storage capacity between the current FSL at EL 39.6 mAHD and the dam crest level at EL 43.28 mAHD
- the need to have sufficient storage reserved for dam safety so that the probability of overtopping the dam crest is acceptably low.

### *Flood Storage Limitations Relative to Flood Volumes*

The absolute maximum available flood storage capacity above the current FSL to the dam crest level is approximately 90,000 ML. Not all of the flood storage to the dam crest level can be used for active flood mitigation because sufficient storage must be reserved for dam safety to ensure no increase in the probability of overtopping the dam crest.

As indicated in Chapter 3, Section 3.6, many historical flood events have produced flood inflow volumes that are significantly larger than 90,000 ML. Since 1988, there have been seven flood events with inflow volume exceeding 90,000 ML (URS, 2012 and Seqwater, 2013).

### *Dam Safety Aspects*

North Pine Dam is a Category 2 referable dam; hence the priority that must be placed on ensuring dam safety is an important constraint for how the available flood storage space in North Pine Dam can be used. This is now more significant than when North Pine Dam was originally designed, for a number of reasons.

When North Pine Dam was originally designed the largest known historical flood at the time was the February 1931 flood with an estimated peak flow of approximately 1580 m<sup>3</sup>/s. In the original design undertaken in the 1960s the maximum flood for the purpose of spillway design was estimated have a peak flow of approximately 4,400 m<sup>3</sup>/s (Webber 1974).

Since construction of North Pine Dam, the knowledge of the possibilities of extreme rainfall that may cause extreme floods has improved and BoM has published several revisions to the estimate of probable maximum precipitation (PMP). Additional data now available from actual flood events such as the January 2011 flood has also increased the understanding of the catchment response to intense rainfall. The most recent estimate of the PMF for North Pine Dam was approximately 11,000 m<sup>3</sup>/s peak inflow (URS, 2012). Under current legislative requirements (AFC Guidelines; DEWS 2013b) a spillway capacity upgrade for North Pine Dam is required by 2025.

To meet dam safety objectives, the spillway gates are required to be fully open when the reservoir level reaches EL 40.7 mAHD. At this level, the flood storage above the current FSL is approximately 25,000 ML (which is equivalent to approximately 71 mm of catchment average runoff). Therefore there is only a relatively small amount of temporary storage of flood water allowed while the spillway gates are being actively used regulate the dam outflow.

Having regard to the above, a range of possible lowered dam levels was been investigated to potentially increase flood storage to enable the dam to be operated as a flood mitigation dam. The additional flood storage available by lowering the dam to 85%, 75% and 42% of the FSV is 32,000 ML, 54,000 ML and 125,000 ML respectively.

## 16.1.2 Operating alternative 2 – lowered dam level with flood release at FSL

In Chapter 15, extended comparison of operational alternative 2 with operational alternative 1 was not undertaken as operational alternative 3 offered flood mitigation benefits that were better to operational alternative 2.

The modelling results indicate that under operational alternative 2 there is significant flood mitigation potential by lowering the dam to 42% FSV. Lowering the dam down to 75% FSV only provides flood mitigation benefit for smaller floods, with the benefits for extreme events (above that achieved under operational alternative 1 – existing situation) almost non-existent.

The assessment of the net present costs indicates that lowering the dam to 42% FSV results in the worst economic outcomes of the options considered. Even if alternative routes to Youngs Crossing are eventually provided, the medium to long term water supply implications mean there is very little economic benefit resulting from lowering North Pine Dam.

Hence, there is little incentive to implement operational alternative 2 and operate the dam actively during a flood event to mitigate downstream flooding.

## 16.1.3 Operating alternative 3 – lowered dam and flood release levels.

Operational alternative 3 is an operational option in which the flood release level is set at the adopted dam FSL. Hence while this option significantly reduces peak outflows relative to peak inflows, it is not an alternative under which the dam is actively operated during a flood event to mitigate downstream flooding. Nevertheless, the modelling results for operational alternative 3 indicate better flood mitigation outcomes to operational alternative 2 over the full range of flood events modelled. Operational alternatives 2 and 3 both generally provide better flood mitigation outcomes than operational alternative 1.

## 16.1.4 Summary – Potential to Operate as a Flood Mitigation Dam

In summary, it is not practical to operate North Pine Dam as an actively managed flood mitigation dam during floods to significantly reduce peak outflows relative to peak inflows. The evidence including the dam design characteristics, the rapid flooding experienced in the catchment, the dam operations and floodplain modelling results and the economic assessments all indicate that there is little value in operating North Pine Dam as an actively managed flood mitigation dam.

## 16.2 Future Investigations

### 16.2.1 Flood Operation Objectives

The primary objectives of the operational strategies in the Flood Manual, 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 dam near FSL at the conclusion of the flood event
- minimise impacts to riparian flora and fauna during the drain down phase of the flood event.

Under section 371F of the Act, the Minister may approve a flood mitigation manual only if the manual achieves an appropriate balance in relation to:

- (i) preventing failure of the dam, including, for example, by protecting the structural integrity of the dam
- (ii) minimising risk to property
- (iii) minimising disruption to transport
- (iv) maintaining the FSL for the dam after a flood event
- (v) minimising environmental impacts on the stability of banks of watercourses and on riparian flora and fauna.

The structural safety of North Pine Dam is the paramount objective of flood operations (including the safe operation of the radial gates) for two principal reasons:

- failure of the main embankment or one of the saddle dams has the potential to cause widespread damage and result in the loss of many lives with the population at risk estimated to be in the order of 15,600 within the urbanised areas downstream
- the loss of a significant water supply resource for SEQ (the most heavily populated region in the state) for an extended period of time.

The Flood Manual acknowledges that limited flood mitigation is achievable with the current FSV. The hydrologic modelling results demonstrate that, for the current FSV, the feasible reduction in peak flow is typically less than 6%.

Therefore peak flow reduction is not identified as a measure for minimisation of disruption resulting from inundation of urban and rural areas downstream of the dam. The Flood Manual identifies disruption to the community in areas downstream of the dam in terms of submergence of bridges and inundation of public areas and seeks to operate the dam such that the duration of inundation is not prolonged unnecessarily.

The local residents have raised concerns about the effectiveness of flood warning systems for releases from North Pine Dam during flood events. Given the proximity of residents downstream of North Pine Dam, further consideration could be given to flood warning linkages and emergency management as outlined in Chapter 9.

Whilst maintaining the FSV is desirable from a water supply perspective, there appears to be reasonable scope to extend releases below the FSV before shutting down. (Note: This is different to Section 3.4 of the Flood Manual in which operations seek to the lake level to the FSL at the conclusion of a flood event.) Providing the dam operator with flexibility to return to within prescribed levels less than the FSL prior to, during and following a flood event would provide increased scope for managing floods. This would enable aggressive operational strategies having regard to weather forecasts to be considered. Such strategies would be a modification of predetermined operations adopted in operational alternatives 1, 2 and 3. Objective criteria would need to be developed to take advantage of this increased latitude and would require the dam operator to apply judgement to make advance or increased releases in response to forecasts of potential imminent flood events by the BoM and in response to actual and forecast inflows to the dam during a flood event. As indicated in Chapter 4, Section 4.1.5. advice from BoM (BoM 2013 pers. comm., 30 August) stated that *'it's clear that further work is required to fully explore the use of rainfall information for dam management'*.

Allowing releases to below the FSL of the dam is inconsistent with the requirement under section 371F of the Act to maintain the FSL of the dam after a flood event which recognises the water supply role of North Pine Dam. This requirement directly impacts on the ability of the dam owner to undertake advance releases in response to forecasts for imminent and substantial rainfall. If advance releases are undertaken and forecasts rainfall does not eventuate, there is a risk the dam may not return to its FSL at the conclusion of a flood event. (Notably in the case of North Pine Dam, the water supply consequences currently would be minimal so long as the lake levels are not dropped excessively.)

Implementation of any options that require new or amended objectives that are not directly consistent with the statutory criteria will require legislative amendment.

Whilst minimisation of bank slumping and erosion impacts is omitted from the existing primary objectives, these issues could be considered along with the potential impacts on riparian flora and fauna. Additional investigations would be necessary to improve flood operations to minimise bank slumping and erosion impacts. Such improvements will be very difficult to achieve because of the complexities of the situation. The current shut down operations seek to minimise the risk of stranding fish, particularly lungfish, in areas that are separated from the river.

### **16.2.2 Forecast rainfall**

The development of better weather forecasting systems may enable more specific application of rainfall forecasts. However, this would place greater reliance on risk assessments and would require acceptance by all stakeholders (including the public) that dam operations won't always be optimal and that there may be less than optimal flood operations outcomes if the forecasts ultimately prove to be wrong.

### **16.2.3 Potential future investigation and research**

Potential future investigation and research includes:

- possible revision of the objective requiring retention of North Pine Dam near the FSL at the conclusion of a flood event to provide increased latitude for the management of floods and smaller inflows as water supply security is unaffected by a small lowering of the dam. (Such an outcome may require amendment of the Act in regard to flood mitigation manual requirements.)
- objective criteria to take advantage of this increased latitude (Seqwater would need to apply judgement to make advance or increased releases in response to imminent flood event rainfall forecasts by BoM and possibly in response to actual and forecast inflows to the dam during a flood event).
- an objective relating to bank slumping and erosion. (As there is insufficient information to be able to document the change in bank erosion rates and processes over time, a strategic survey and monitoring program would need to be undertaken.)
- stepped ramp-down of dam releases on the falling stage of a flood and to drain the dam down when declarations of temporary FSLs are made as:
  - constant rates of discharge for long durations are likely to have a greater impact on downstream bank erosion than a slightly varied flow level.
  - cues are needed reduce the potential for fish stranding especially under 'hydro-peaking' night time releases.

## 16.3 Flood information and awareness

It became clear following the January 2011 floods that the community has a generally low level of understanding of flood behaviour, particularly for large and rarely observed flood events. This is perhaps understandable given the limited amount of public flood information that has been made available in the past.

The QFCoI made a number of recommendations regarding the provision of flood information by councils including:

- As far as practicable, councils should maintain up-to-date flood information. (QFCoI Final Report recommendation 2.7)
- For urban areas where development is expected to occur, councils with the requisite resources should develop a flood map which shows 'zones of risk' (at least three) derived from information about the likelihood and behaviour of flooding. (QFCoI Final Report recommendation 2.13)
- Councils and the Queensland Government should display on their websites all flood mapping they have commissioned or adopted. (QFCoI Final Report recommendation 2.16)
- Flood maps, and property specific flooding information intended for use by the general public, should be readily interpretable and should, where necessary, be accompanied by a comprehensible explanatory note. (QFCoI Final Report recommendation 2.17)

Residents within the Pine River floodplain seeking to plan for their flood safety and better understand flood behaviour now have significant resources available. MBRC have made available through their public websites a comprehensive range of flood information products including flood maps, property flood reports and fact sheets.

## 16.4 Land use planning and development controls

Land use planning and development controls are an essential element in managing flood risk. The limited amount of flood risk that has been identified in the floodplain downstream of North Pine Dam indicates that this aspect has been well managed by councils in the past. There is only a small amount of development on the floodplain that would not comply with modern flood planning practice.

Strategic assessment of flood risk can steer inappropriate development away from sites in the floodplain that are subject to unacceptable hazard and/or sites with the potential to have significant impacts upon flood behaviour. It can also reduce potential damage to new developments on the fringe of the floodplain by identifying minimum development levels and flood emergency requirements.

The various aspects of land use planning and development controls that need to be addressed to support sensible future development include:

- appropriate land use zoning within the floodplain
- site accessibility during flood
- availability of safe refuge
- fill or excavation in the floodplain
- freeboard controls and suitable minimum development levels
- reliability of critical services during flood

- impact of new development on flood behaviour
- building materials and structural soundness of buildings in the floodplain.

Both BCC and MBRC ensure that their planning schemes give consideration to these aspects. BCC manages flood risk to its residents based on the principles set out in Council's Floodsmart Future Strategy.

Consequently, the flood risk in the North Pine Dam floodplain is unlikely to grow significantly.

## 16.5 Structural flood mitigation improvements

Structural flood mitigation improvements include physical modifications to floodplain infrastructure that reduce flood risk. In the context of the North Pine River floodplain this could possibly include:

- transport upgrades
- modification of structures
- acquisition of flood-prone property.

MBRC invests in such activities on a prioritised basis to ensure that community expenditure yields the best possible value for money.

Youngs Crossing is an important part of the area's north-south sub-arterial road network carrying approximately 12,000 vehicles per day across the river. This study has identified that closure of this particular road during flood represents the single largest floodplain infrastructure risk (flood impact and cost) downstream of the dam.

Both MBRC and DTMR are considering potential options for improving traffic movement in the West Moreton corridor. MBRC has produced a business case for the replacement of Youngs Crossing with a high level river crossing as part of their investigations of the West Petrie Bypass project. DTMR is currently undertaking planning studies of the West Moreton corridor between Caboolture to Brendale and the South Moreton corridor examining alternatives to the West Petrie Bypass project. These studies are due for completion in 2014.

At least two residential building structures have been voluntarily abandoned by their owners since the January 2011 flood and new dwellings constructed on higher ground within the same parcel. These voluntary floodplain risk management actions have reduced the risk profile for the North Pine River floodplain downstream.

While acquisition of flood-prone property is an option available to all councils, it is very unlikely this would be pursued given the low risks compared to other more heavily flood effected properties in the region.

## References

- AG 2009, *Emergency Management Planning for Floods Affected by Dams*, Manual 23, Attorney-General's Department, Commonwealth of Australia
- ANCOLD 2000, *Guidelines on Selection of Acceptable Flood Capacity for Dams*, Australian National Committee on Large Dams Inc.
- Aurecon 2013, *WSDOS / NPDOS Integrated Assessment Methodology - Project Methodology*, Brisbane, Queensland
- Aurecon 2014, *WSDOS / NPDOS Integrated Assessment Methodology - NPDOS Assessment Results*, Brisbane, Queensland
- CSIRO 2000, *Floodplain Management in Australia. Best Practice Principles and Guidelines*, SCARM Report No 73, CSIRO Publishing, Victoria
- DERM 2009, *Moreton Resource Operations Plan*, Department of Environment and Resource Management, Brisbane, Queensland
- DEWS 2012, *Guidelines for Failure Impact Assessment of Water Dams*, Department of Energy and Water Supply, Brisbane, Queensland
- DEWS 2013a, *North Pine Dam Optimisation Study, Addendum to Options Discussion Paper*, December 2013, Department of Energy and Water Supply, Brisbane, Queensland
- DEWS 2013b, *Guidelines on Acceptable Flood Capacity for Water Dams*, Department of Energy and Water Supply, Brisbane, Queensland
- DEWS 2013c, *Emergency Action Planning for Referable Dams*, Department of Energy and Water Supply, Brisbane, Queensland
- DEWS 2014, *NPDOS/ WSDOS Water Supply Security Report*, Department of Energy and Water Supply, Brisbane, Queensland
- DNR 1991, *North Pine Dam Flood Frequency Report*, Report No 5 (prepared as part of the Brisbane River and Pine River Flood Studies), Department of Natural Resources, Brisbane, Queensland
- DNRM 2002, *Queensland Dam Safety Management Guidelines*, Department of Natural Resources and Mines, Brisbane, Queensland
- DPC 2012, *Queensland Government response to Queensland Floods Commission of Inquiry Final Report*, Department of Premier and Cabinet, Brisbane, Queensland
- DSITIA 2013a, *Erosion, Flora and Fauna - Desktop study for Wivenhoe and Somerset Dams Optimisation Study (WSDOS) and North Pine Dam Optimisation Study (NPDOS) : Key Principles*, Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland
- DSITIA 2014, *Erosion, Flora and Fauna - Desktop study for Wivenhoe and Somerset Dams Optimisation Study (WSDOS) and North Pine Dam Optimisation Study (NPDOS) : Study Assessments*, Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland

DTMR 2013, *North Pine Dam Optimisation Study -Traffic Modelling Report*, Department of Transport and Main Roads, Brisbane, Queensland

EMQ 2013, *Disaster management arrangements*, Emergency Management Queensland, Brisbane, viewed 7 February 2014, <[http://www.disaster.qld.gov.au/About\\_Disaster\\_Management/DM\\_arrangements.html](http://www.disaster.qld.gov.au/About_Disaster_Management/DM_arrangements.html)>

IEAust 2003, *Australian Rainfall and Runoff, Volume 1*, Institution of Engineers Australia

Middelmann, M, Harper, B and Lacey, R 2001, Chapter 9 : Flood Risks In: Granger K and Hayne M, eds, *Natural hazards and the risks they pose to South East Queensland*, Geoscience Australia, Commonwealth of Australia

Molino Stewart 2013, *Moreton Bay Regional Council Floodplain Risk Management Study Phase 1*

MBRC 2013a, *North Pine Dam Optimisation Study Floodplain Risk Assessment (2 Volumes, Volume 1 – Main Report, Volume 2 – Figures)*, Moreton Bay Regional Council

MBRC 2013b, Flood Check, *Flood explorer*, Moreton Bay Regional Council, viewed 7 February 2014, <<http://flood.moretonbay.qld.gov.au/floodexplorer/>>

MBRC 2013c, *Flood Check Fact Sheet 5 – Understanding the likelihood of flood*, Moreton Bay Regional Council, viewed 7 February 2014, <<http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/living/floodplains/likelihood-of-floods.pdf/>>

Productivity Commission 2011, *Australia's Urban Water Sector: Productivity Commission Inquiry Report Volume 1*, No 55, 31 August 2011, Australian Government

QFCol 2011, *Queensland Floods Commission of Inquiry Interim Report*, August 2011, Queensland Floods Commission of Inquiry, Queensland Government

QFCol 2012, *Queensland Floods Commission of Inquiry Final Report*, March 2012, Queensland Floods Commission of Inquiry, Queensland Government

QWC 2010, *South East Queensland Water Strategy*, Queensland Water Commission, Brisbane, Queensland

Seqwater 2010, *Manual of Operations for Flood Mitigation at North Pine Dam – Revision 5*

Seqwater 2011a, *January 2011 Flood Event – Report on the Operation of North Pine Dam*, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2011b, *Manual of Operations for Flood Mitigation at North Pine Dam – Revision 6*, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2012a, *Manual of Operations for Flood Mitigation at North Pine Dam – Revision 7*, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2012b, *North Pine Dam Revised Design Flood Hydrology*, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2013a, *North Pine Dam Optimisation Study - Assessment of Flood Operations for Lower Full Supply Levels*, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2013b, *Manual of Operations for Flood Mitigation at North Pine Dam – Revision 8*, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2013c, *February – March 2013 Flood Event – Report on the Operation of North Pine Dam*, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2013d, *North Pine Dam Emergency Action Plan (EAP)*, 2013 Draft, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2013e, *Communications Protocol for Releases from Seqwater’s Gated Dams (Wivenhoe Dam, Somerset Dam, North Pine Dam and Leslie Harrison Dam)*, November 2013, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2013f, *Bulk Authority Emergency Response Plan, Whole of Supply Chain Response*, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2013g, *Stream Bank Condition Assessment 2013 – North Pine Dam*, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2014a, *Modelling Report for Water Security Implications WSDOS and NPDOS*, February 2014, Queensland Bulk Water Supply Authority, Brisbane

Seqwater 2014b, *NPDOS and WSDOS Manufactured Water – Modelled Report*, February 2014, Queensland Bulk Water Supply Authority, Brisbane

URS 2012, *North Pine Dam Acceptable Flood Capacity (AFC) Report*, Report prepared for Seqwater, URS

URS 2013, *Seqwater Dams Portfolio Risk Assessment North Pine Dam*, Report prepared for Seqwater, URS

Walland, D.J., Meighen, J., Xuereb, K.C., Beesley, C.A. and Hoang, T.M.T. 2003, *Revision of the Generalised Tropical Storm Method for Estimating Probable Maximum Precipitation*, HRS Report No. 8, Hydrology Report Series, Bureau of Meteorology Melbourne, Australia

Webber, W A L 1974, *Design and Construction of North Pine Dam*, Department of Local Government, Brisbane, Queensland

## Legislation

*Disaster Management Act 2003* (QLD)

*Water Act 2000* (QLD)

Water Resource (Moreton) Plan 2007

*Water Supply (Safety and Reliability) Act 2008* (QLD)



## Telephone enquiries

**Water:** 13 QGOV (13 74 68) business hours

**Energy:** 13 43 87 business hours

**Visit:** [www.dews.qld.gov.au](http://www.dews.qld.gov.au)