State water

Keepit Dam UPGRADE

PROJECT APPLICATION REPORT

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Project Application Report

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State Water Corporation

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Glossary

Term or Abbreviation	Definition
Abutment	Area where a dam wall meets the side of a valley.
Air Space	The volume between a dam's full water supply level and the crest of the dam wall.
Alluvial	Deposited by river processes.
Alluvium	Sedimentary deposits from rivers.
Amphibian	A class of invertebrates intermediate in many characteristics between fish and reptiles which live most or part of their lives on land but most return to water to breed. An example would be frogs.
Annual Exceedance Probability (AEP)	The likelihood of a flood being exceeded in any given year. For example, a flood with an AEP of 1 in 100 has a 1 in 100 chance of being exceeded in any given year.
Aquatic	Existing or growing in water.
Arboreal Mammals	Tree dwelling mammals.
Australian Height Datum (AHD)	The standard reference level used to express the relative elevation of different features. A height given in metres AHD is essentially the height above sea level.
Backwater	An area inundated by water from a river but outside the general flow of the river.
Benefit Cost Ratio (BCR)	The ratio of the benefits derived from a project to the costs of constructing and operating the project.
Benthos	Organisms that live on the bottom of a waterbody.
Catchment	The land surface area that drains into a reservoir or to a specific point in a river system.
CEMP	Construction Environmental Management Plan.
Dam	A structure across a river which impounds water.
dB(A)	Unit of sound measurement electronically weighted to approximate the sensitivity of human hearing to sound frequencies.
Decibel (dB)	Unit of sound measurement which is proportional to a base 10 logarithmic scale.
Design Flood	A flood where the levels at all points along the river have the same chance of occurrence. It is estimated using hydrologic and hydraulic computer models.
DIPNR	Department of Infrastructure Planning and Natural Resources.
Environmental Impact Statement (EIS)	A formal description of a project and an assessment of its likely impact on the physical, social and economic environment. It includes an evaluation of alternatives and a justification of the project. The EIS is used as a vehicle to facilitate public comment and as the basis for analysing the project when seeking approval under relevant legislation.

Term or Abbreviation	Definition
EP&A Act	The NSW *Environmental Planning and Assessment Act 1979.*
EPBC Act	The Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999*.
Exotic	Not native.
Floodplain	That part of a river valley, adjacent to the river channel, over which a river flows in times of flood.
Freeboard	The vertical height between the maximum flood level in a reservoir and the crest of a dam wall.
Full Supply Level (FSL)	The water level in a reservoir when it is at its full water supply storage capacity. It only rises above this level during floods and the excess water is discharged from the reservoir.
Gauging Station	Location at which hydrological characteristics, including flow rate, velocity and depth, are measured and recorded.
Hydrograph	A graph showing the variation over time of water levels or flow.
In Situ	In its original location.
Invertebrates	Animals without backbone.
Left Abutment	Area where the dam wall meets the left-hand side of a valley, while the observer is looking downstream.
Leq	The Leq level is the average noise energy during a measurement period.
Levee	An elevated bank flanking the channel of a river and standing above the level of the floodplain. Levees can be natural or constructed. The latter are designed to keep rivers within a defined channel and protect overbank areas from flooding.
LEP	Local Environmental Plan.
Design Flood Level (DFL)	The peak water level experienced at a particular location during a flood.
Maximum Design Earthquake (MDE)	The earthquake which would generate the most critical ground movements from among those loadings to which the structure might be exposed.
Megalitre (ML)	One million litres.
Net Present Value	The net difference between the present day value of future benefits and the present day value of future costs.
OEMP	Operational Environmental Management Plan.
Potable Water	Water of a quality suitable for human consumption.
Probable Maximum Flood (PMF)	The largest flood likely to occur.
Probable Maximum Precipitation (PMP)	The maximum rainfall statistically likely to occur.
R.L.	Reduced Level. Level relative to some datum.

Term or Abbreviation	Definition
Right Abutment	Area where the dam wall meets the right-hand side of a valley, while the observer is looking downstream.
Riparian Habitats	Areas along the river or creek banks and their immediate environs inhabited by plants and animals.
Riverine	Of or pertaining to a river.
Scouring	Erosion of materials by the passage of water.
Spawning	The release of gametes or eggs by fish as part of their reproductive cycle.
Spillway	A channel to convey overflow water from a reservoir to the downstream watercourse in a controlled manner.
SEPP	State Environmental Planning Policy.
Stratification	The separation of water in a lake into horizontal layers of different temperatures.
Terrestrial	Existing or growing on the land.

Summary

Introduction

State Water Corporation ("State Water") is the proponent of the Keepit Dam Upgrade ("the proposal") – a project which would resolve existing safety concerns with the dam which may occur during very large to extreme flood or earthquake events (see Section 2). Other aspects incorporated into the proposal would improve the environmental performance of the dam.

Keepit Dam is located on the Namoi River, upstream of the confluence with the Peel River, between the townships of Tamworth and Gunnedah in the north-east of NSW.

This document:

- *Supports an application for a concept approval for the upgrade of Keepit Dam under Part 3A, Section 75M(1) of the Environmental Planning and Assessment Act 1979 (EP&A Act) in accordance with the Minister for Planning's authorisation on 25 January 2006.*
- *Describes a number of key aspects of the upgrade including:*
    - *The existing Keepit Dam and the need and objectives of an upgrade;*
    - *The options assessment process conducted to date, the three short-listed options for upgrading the safety of Keepit Dam and other improvements proposed;*
    - *A preliminary environmental assessment of the proposal that identifies its marginal impacts (relative to those existing) across a range of environmental issues; and*
    - *Further investigations proposed as part of the formal Environmental Assessment in order to allow decision makers and the community to be properly informed of the key issues and impacts, and a preferred upgrade option to be determined by the Minister for Planning.*
- *Seeks environmental assessment guidelines under Section 75F(3) of the EP&A Act for the purposes of any additional environmental assessment that may be required under Sections 75F(5) and 75H(1) of the EP&A Act.*

The proposed Keepit Dam upgrade

The three dam safety options under consideration for the upgrade of Keepit Dam are as follows:

- *Option B1 — Raising of the main and subsidiary dam walls by 3.2 metres and construction of two additional spillways (total width 600 metres) with seven release plugs with sill levels 3.0 metres below full supply level, at the right-hand abutment of the main dam wall and at the subsidiary dam wall and installation of three saddle dams. There would be a temporary 30% loss of storage when the additional spillways operate.*
- *Option D2 — Raising of the main and subsidiary dam walls by 4.3 metres and construction of three additional spillways (total width 600 metres) with seven release plugs with sill levels 1.3 metres below full supply level at the right-hand abutment of the main dam wall, the Sailing Club and Boat Ramp saddles and installation of one saddle dam. There would be a temporary 15% loss of storage when the additional spillways operate.*

- *Option D3 (preferred option subject to environmental impacts precluding the other two less costly options) — Raising of the main and subsidiary dam walls by 5.5 metres and construction of three additional spillways (total width 600 metres) with seven release plugs with sill levels 0.3 metres above full supply level at the right-hand abutment of the main dam wall, the Sailing Club and Boat Ramp saddles and installation of two saddle dams. There would be no loss of storage when the additional spillways operate.*

All options also include subject to confirming its cost effectiveness, a proposed multi-level offtake which will allow the dam operator to select the level of the offtake within the storage water column. This will facilitate discharges from levels other than the bottom of the storage and thereby provide the dam operator greater control over the temperature of water releases, improving the downstream aquatic environment for up to 100 kilometres along the Namoi River.

A detailed description of the options, the multi-level offtake, and other construction and operational aspects is provided in Section 4.

Baseline conditions for assessment of incremental impacts of the proposal

A detailed analysis of extreme flood hydrology information as well as the existing operation of the dam was undertaken (See Section 3 and Appendix B) to determine a baseline for the assessment of overall benefits and incremental environmental impacts which might result from the upgrade.

Regarding upstream inundation, the adopted baseline is inundation to a level of 1.2 metres above existing full supply level of the storage. This level (RL 330.8 AHD) is the maximum operating level which can occur under current operating rules for small to medium size floods. It should be noted that under very large to extreme floods, upstream inundation levels can occur up to RL 335.4 AHD (5.8 metres above full supply level), which is the level at which the existing main dam wall is estimated to fail.

Regarding downstream conditions, the dam failure scenario which would occur unless the proposal was implemented, was adopted as the baseline for environmental assessment.

Environmental assessment

The options development and assessment process has been ongoing for several years and a substantial amount of environmental information already exists concerning the relative performance of the options. A preliminary environmental assessment undertaken on the short-listed dam safety options is presented in Appendix E. This assessment, after discussions with key stakeholders, has identified the following key environmental issues which are considered to require further detailed consideration and are proposed to be undertaken as part of the formal environmental assessment process:

- *The inundation of upstream areas above the adopted baseline level and consequent environmental effects, eg. heritage and flora and fauna issues.*
- *The proposed discharge of floodwaters through new downstream spillways and consequent environmental effects, eg. heritage and flora and fauna issues.*
- *Differential downstream erosion and sedimentation (and consequent environmental) effects.*
- *Further assessment of the feasibility and cost effectiveness of a fish lift or other ameliorative measures elsewhere in the catchment including trade-offs as*

sought under Section 218 of the Fisheries Management Act 1994 by the Department of Primary Industries, Fisheries.

- *A review of the 2002 heritage assessment of Keepit Dam, considered as an item of local heritage significance, in the context of any changes proposed by the upgrade.*

The results of further investigations of these issues and any other requirements advised under Section 75F(3) of the EP&A Act will be documented in the Environmental Assessment.

The preliminary environmental assessment also included the following other environmental aspects:

- *Topography, soil and spoil management*
- *Surface water quality and groundwater management*
- *Visual*
- *Aquatic ecology*
- *Noise and vibration*
- *Air quality*
- *Planning and land use*
- *Business impacts and effects on community facilities*
- *Waste minimisation and management*
- *Land contamination*
- *Risks and hazards*
- *Traffic*
- *Energy use and greenhouse gas emissions*
- *Cumulative impacts.*

The preliminary environmental assessment indicated that these environmental aspects are unlikely to significantly affect the environment, could be satisfactorily managed through the preparation and implementation of standard construction management measures or are unlikely to distinguish between the performance of the options. These environmental issues would be addressed in detail through State Water's draft Statement of Commitments to be included in the Environmental Assessment.

Based on the preliminary environmental assessment conducted, the key environmental issues and aspects of the Environmental Assessment are presented in Section 6.

These key areas reflect the required outcome of the approval process which, in this instance, is to select a preferred upgrade option from the short-list of options. The primary objective of the Environmental Assessment therefore is to provide relative performance information on the environmental issues which distinguish the options as well as being sufficient for determination by the Minister for Planning of the preferred upgrade.

1. Introduction

1.1 Purpose and structure of this report

The purpose of this report is to:

- Support an application for a concept approval for the upgrade of Keepit Dam under Part 3A, Section 75M(1) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) in accordance with the Minister for Planning's authorisation on 25 January 2006.
- Describe a number of key aspects of the upgrade including:
  - The existing Keepit Dam and the need and objectives of an upgrade
  - The options assessment process conducted to date, the three short-listed options for upgrading Keepit Dam and other improvements proposed
  - A preliminary Environmental Assessment of the proposal that identifies its incremental impacts (relative to those existing) across a range of environmental issues
  - Further investigations proposed as part of the formal Environmental Assessment in order that decision makers and the community can be properly informed of the key issues and impacts and a preferred upgrade option determined by the Minister for Planning.
- Seek environmental assessment guidelines under Section 75F(3) of the EP&A Act for the purposes of any additional environmental assessment that may be required under Sections 75F(5) and 75H(1) of the Act.

The structure of the report is as follows:

- Section 1 - Introduction including project objectives, need and background
- Section 2 - Description of Keepit Dam and its surrounds
- Section 3 - Extreme event assessment
- Section 4 - Consideration of alternatives
- Section 5 - Key features of short-listed options
- Section 6 - Environmental Assessment focus

Appendices to this document contain a range of more detailed information supporting the application including:

- Appendix A - Statutory context and approvals process
- Appendix B - Extreme flood hydrology information
- Appendix C - Options development and assessment process

- Appendix D - Minutes from the planning focus meeting
- Appendix E - Preliminary environmental assessment of key issues/aspects
- Appendix F - Concept design drawings of dam safety upgrade options

1.2 Project objectives

The objectives of the upgrade project were determined through a workshop process involving State Water and a Community Reference Panel (CRP). The objectives which have been progressively reaffirmed during the course of the project are to:

- Improve dam safety
- Reduce downstream flooding
- Improve environmental outcomes
- Support sustainable regional economic development.

The existing dam safety concern is the fundamental driver for the upgrade. Other objectives considered potential opportunities which could be valuable, as part of the upgrade.

1.3 Project need

The need for the upgrade is driven by the extreme consequences if the Keepit Dam were to fail as a result from very large to extreme natural events, specifically floods or earthquakes, and the fact that the dam cannot withstand such events.

While such extreme events typically have a very low likelihood of occurrence, if dam failure occurs it dramatically compounds consequences.

For Keepit Dam, failure would potentially put more than 10,000 people at risk within the flood plain from upstream of Carroll to Wee Waa and involve a potential major loss of life (in excess of 100). It would result in catastrophic downstream flooding with direct damage and loss estimated to be in the order of $1.7 billion dollars. The irrigation industry, which is highly dependent on Keepit Dam and worth more than $300 million per annum, and the whole regional economy, would be devastated.

As the owner and operator of the dam, State Water Corporation (State Water) is responsible for ensuring the dam complies with the requirements of the NSW Dams Safety Committee. From a duty of care / due diligence perspective, dam safety should follow the guidelines promulgated by the Australian National Committee on Large Dams and satisfy acceptable corporate risk management. The NSW Dams Safety Committee classified Keepit Dam as an extreme consequence dam in 1995 based on the magnitude of damage and loss of life that would result if the dam failed. Under this classification Keepit Dam is required to withstand extreme event occurrences.

Investigations and interim works have been undertaken since 1995 to ensure the day to day safety of Keepit Dam and reduce the risks associated with large events.

A further upgrade remains to be completed within a reasonable period which has been identified as 2009, about five years since the completion of the interim works, to secure the long-term safety of Keepit Dam from these very large to extreme events.

1.4 Background

1.4.1 Planning and assessment process

In July 2005, the *Environmental Planning and Assessment (Infrastructure and Other Planning Reform) Act 2005* was enacted which introduced an alternative planning assessment and approval process for major infrastructure projects. One of the purposes of the reform was to make the planning and assessment process for major infrastructure projects more flexible. Another aim was to streamline the assessment and approval process. Further details of the Part 3A amendments to the EP&A Act is contained in *Appendix A*.

On 25 January 2006, the Minister for Planning authorised a concept plan for the Keepit Dam Upgrade under *Part 3A, Section 75M(1) of the EP&A Act*. The authorisation of a concept plan under Part 3A provides for the general nature and form of a proposal to be investigated in an environmental assessment while also recognising that many of the details upon which an environmental assessment is based are often subject to ongoing design development processes. A concept approval process therefore can facilitate an approval while preserving the rigour of the environmental assessment process through the application of approval conditions that may or may not require further assessment or details of a particular issue to be submitted at a later stage.

State Water proposes the following planning, assessment and approval process for the proposal in accordance with Part 3A of the EP&A Act:

- Obtain environmental assessment requirements from the Department of Planning for the environmental assessment following the Planning Focus Meeting held on 3 February 2006.
- Prepare a formal Environmental Assessment to meet the necessary requirements including appropriate consultation with key stakeholders (including CRP) to adequately understand and effectively address the requirements.
- Lodge the Environmental Assessment and draft Statement of Commitments for pre-exhibition by key agencies and review by the Department of Planning.
- Exhibit the Environmental Assessment and invite submissions from the public.
- Assess submissions, including appropriate consultation with key agencies, and prepare a Submissions Report which recommends a preferred proposal by State Water.
- Lodge the Submissions Report, including the preferred proposal, with the Department of Planning.

- Assessment by the Department of Planning.
- Determination by the Minister for Planning.

The proposed planning and assessment process is illustrated in *Figure 1.1*.

State Water proposes to refer the Keepit Dam upgrade to the Director General of the Commonwealth Department of Environment and Heritage, for their consideration under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

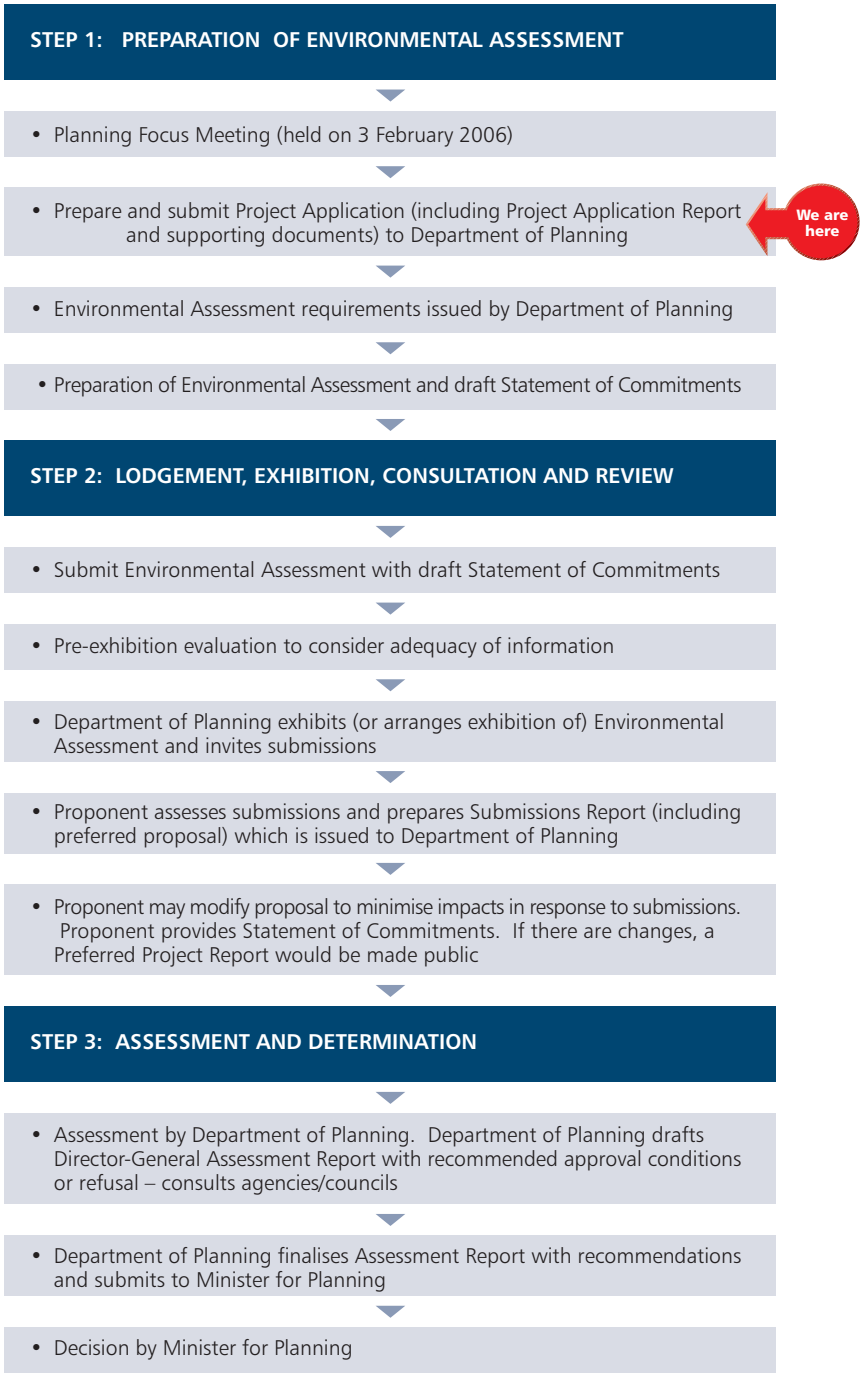

Figure 1.1 **Approvals process under Part 3A of the Environmental Planning and Assessment Act**

1.4.2 Dam safety improvements

Current detailed technical investigations on the most appropriate means of upgrading the dam commenced some four years ago. During this period, the following interim dam safety (temporary precautionary) measures have been undertaken to reduce short-term safety risks while the long-term solution was developed and implemented:

- A detailed risk assessment of Keepit Dam (as part of a larger portfolio risk assessment study of State Water major dam assets).
- The upgrade of power supply and provision of backup power sources to improve the reliability of the existing spillway gate operations.
- Installation of remote spillway gate controls at the Keepit Dam offices.
- A condition assessment leading to increased major periodic maintenance requirements (particularly for the gates and gantry crane) and some minor protection works from large floods, such as extension of the existing parapet wall, installation of a shear bearing plate to prevent the spillway bridge from sliding downstream and plugging of potential large flood entry points into the dam wall galleries.
- Improvements to flood routing by modifying storage operational procedures.
- Installation of an early warning system to notify emergency services and affected downstream residents of situations where the security of the dam may be at risk.
- Temporarily lowering the height of the subsidiary dam wall by an average of 3.5 metres and the installation of 17 release plugs allowing large flood waters to flow over the subsidiary wall in preference to the main dam wall failing. This work has reduced overall downstream flood risks in the event of a large flood event.

While these measures have been effective in reducing the risk of failure of the main dam wall from approximately 1:2,800 to 1:30,000 Annual Exceedance Probability (AEP), they do not meet the requirements of the NSW Dams Safety Committee for extreme consequence dams or satisfy duty of care / due diligence which requires Probable Maximum Flood (PMF) and Maximum Design Earthquake (MDE) protection.

Detailed investigations by State Water have assessed dam performance, benefits and impacts under a range of very large to extreme event scenarios and involving a large complex range of possible upgrade options.

Major effort has occurred in developing a range of potential dam upgrade options in conjunction with relevant government agencies and the community. A Community Reference Panel was set up by State Water in 2002, chaired by the Mayor of Gunnedah Shire Council and comprising a broad cross-section of the community, including adjacent landholders, various regional and local interest groups, local and state government agencies and State Water representatives (refer *Section 1.4.4*). The CRP has been the primary advisory body to State Water and has helped to guide the direction of technical studies, community consultation and input related to the options development and

assessment process to date. Input has also been sought at a number of key stages from the wider community and government.

As a result of the substantial technical investigations, concept design, community and departmental consultation and options assessment processes completed to date, State Water has arrived at a short-list of three dam safety upgrade options which are to be the subject of formal environmental assessment in accordance with the requirements of Part 3A of the EP&A Act.

The three options short-listed for the upgrade of Keepit Dam are as follows:

- Option B1 — Raising of the main and subsidiary dam walls by 3.2 metres and construction of two additional spillways (total width 600 metres) with seven release plugs with sill levels 3.0 metres below full supply level, at the right-hand abutment of the main dam wall and at the subsidiary dam wall and installation of three saddle dams. There would be a temporary 30% loss of storage when the additional spillways operate.
- Option D2 — Raising of the main and subsidiary dam walls by 4.3 metres and construction of three additional spillways (total width 600 metres) with seven release plugs with sill levels 1.3 metres below full supply level at the right-hand abutment of the main dam wall, the Sailing Club and Boat Ramp saddles and installation of one saddle dam. There would be a temporary 15% loss of storage when the additional spillways operate.
- Option D3 — Raising of the main and subsidiary dam walls by 5.5 metres and construction of three additional spillways (total width 600 metres) with seven release plugs with sill levels 0.3 metres above full supply level at the right-hand abutment of the main dam wall, the Sailing Club and Boat Ramp saddles and installation of two saddle dams. No loss of storage when the additional spillways operate.

Refer Section 4 for more details.

1.4.3 Other improvements

A brief outline, of the other objectives involving the wider regional and system context which could be potential opportunities and may have been worthwhile as part of the upgrade is set out below:

Reduced downstream flooding

Downstream flood mitigation of very large to extreme flood events is inherent in the proposed dam safety upgrade options and as such is considered as part of the evaluation criteria for selecting dam safety options. Achieving reductions in flooding for smaller floods was considered but was found to not be readily related to works required to address very large to extreme events. The main influences for smaller floods revolve around flood operating rules and the resultant environmental impacts rule changes could make. As such rules and possible changes were common to any of the safety upgrade options, it was determined that any such consideration of smaller flood mitigation should be a separate exercise to the upgrade and only if warranted. None of the upgrade options will change the current rules for the management of small to medium floods.

Improved environmental outcomes

The Namoi riverine system is considered to be highly regulated and significantly degraded, based on a number of environmental indicators. This degradation is the result of the construction of Keepit and Split Rock Dams and associated irrigation / agricultural / land management practices and a whole range of other human influences involving urban, industrial and rural development.

A number of potential environmental improvements were identified and investigated in varying detail to determine their appropriateness and cost-effectiveness, as part of the overall upgrade project. The potential improvements, extensively investigated, were:

- Reducing cold water pollution — Better aligning the temperature and water quality of discharged water from the dam with those of natural river waters. Investigations considered the potential for 'multi-level offtake', whereby the existing intake tower at the dam would be modified to allow withdrawal of stored water from any level within the storage column but in particular the warmer higher level water. Currently Keepit Dam only has low level offtakes resulting in cold water releases particularly during the spring and summer months – key fish breading periods. (Discharges from Keepit Dam reduce the natural temperature of the water in the Namoi River downstream for a distance of up to 100 kilometres due to thermal stratification in the storage and the release of cold water from the lower levels of the dam.)

- Outcome of investigations and key consultation — a multi-level offtake to be included as part of the upgrade, subject to key stakeholders agreeing to its cost effectiveness and funding being secured.

- Improving stored water quality — Establishing whether there is a need and capability, including the use of de-stratification techniques, to reduce algae and nutrients and the removal of sedimentation within the storage.

  Outcome of investigations, expert workshops and key consultation – de-stratification which is the only identified realistic water quality improvement mechanism, was considered to have far too high a cost and doubtful effectiveness in such a large storage as Keepit to be a viable option at this stage. If water quality conditions deteriorated and overall cost effectiveness of de-stratification improved in the future it could be readily considered and added as a separate exercise. With respect to sedimentation, loads were considered relatively low and overall, it is not a significant issue at present. There were considered no feasible options at this stage to remove sediment or prevent build-up and associated water quality impacts. No stored water quality improvement options were therefore included in the upgrade proposal.

- Providing fish passage — Removing restrictions on fish passage through modification or replacement of existing ineffective fishways downstream of Keepit Dam at Mollee and Gunidgera weirs and consideration of a fish lift past the main dam wall.

  Outcome of investigations, expert workshops and key consultations –fish passage improvements past Mollee and Gunidgera downstream

weirs would be considered in the overall Namoi River Fishway Strategy downstream of Keepit Dam being developed in conjunction with Namoi Catchment Authority and Department of Primary Industries (Fisheries).

Until recently, fish passage past Keepit Dam was not going to form part of the upgrade. This position was due to the time and high cost of research required to resolve the outstanding issues identified during investigations associated with the environmental value of a fish lift (the only realistic option identified) at Keepit Dam and potential difficulty and cost of achieving, in particular, downstream passage. Consideration of the outstanding issues including an appropriate level of research was proposed to continue and if able to be resolved, then a fish lift could be reconsidered.

However at the Planning Focus Meeting in February 2006 and at a workshop on 3 March 2006, the Department of Primary Industries (Fisheries) identified that more recent research and data on fish passage generally should help resolve these outstanding issues at Keepit Dam without major further research.

In addition DPI has formally advised on 14 April 2006, that under Section 218 of the *Fisheries Management Act 1994*, State Water should evaluate the current impact the dam has on the fish passage and investigate and assess the value of potential ameliorative measures as part of the Environmental Assessment. The ameliorative measures may involve either construction of a fish lift at the dam or other measures to improve fish passage elsewhere in the catchment. Therefore State Water will further develop the assessment of providing fish passage as part of the Environmental Assessment.

- Providing environmental flows — Improving the health of the downstream river environment by providing variable water releases to the Namoi River through either potentially increasing full supply level (FSL) to store water during high flood flows for later release and / or increasing the outlet capacity allowing pulsing of releases.

  Outcome of investigations, expert and value management workshops and key consultations – increased FSL concept would not be pursued as part of the upgrade. The main reasons for not pursuing this opportunity as part of the upgrade is a complete understanding of the long-term pros and cons of the proposal could not be scientifically identified within the timeframe of the project and support by key environmental agencies that would manage such a concept could not be obtained. The lack of support was due to these key environmental agencies concern that environmental value, impacts and management processes had not been sufficiently demonstrated and overall the concept was not consistent with current environmental policies. Support for the concept was, however, indicated by local community groups and regional organisations and so it is proposed that the upgrade would not prevent consideration of the concept sometime in the future.

  Current on-farm water infrastructure and capture requirements are considered to limit irrigator's ability to manage more variable delivery of flows. This aspect, coupled with the decision to no longer pursue the increased FSL concept as part of the upgrade, means

consideration of increasing the outlet capacity of Keepit Dam is also not appropriate for the upgrade.

Supporting sustainable regional economic development

In addition to overall reduction of impacts and associated regional benefits achieved by dam safety and possible environmental improvements, other regional development opportunities identified were as follows:

- Improving the reliability of dam operations and the delivery of water – potential to improve was found to be difficult in view of the large distance downstream of the main irrigation demand centres and need for changes in on-farm infrastructure. As a result limited opportunity was identified. During consultation with irrigator representatives, strong indication was given that the few days a year that irrigation demands challenged release capacity was considered acceptable, particularly as there was generally a temporary/emergency back-up by "cracking" open a gate.

- Increasing the capacity of the existing hydropower generation station – found to be not viable with no change in full supply level proposed.

- Enhancing the recreational quality of Lake Keepit – varying opportunities exist depending on what upgrade option is selected and the associated impacts on the recreational facilities. Such opportunities will be fully explored in conjunction with the Lake Keepit State Park Trust and other organisations around the rim of the storage as part of finalising detailed mitigation measures.

  Overall outcome of the other improvements and in particular environmental enhancements is as follows:

- A proposed multi-level offtake subject to confirming its cost effectiveness which will allow the dam operator to select the level of water to release from within the storage, This will facilitate discharges from levels other than the bottom of the storage and thereby provide the dam operator greater control over the temperature of water releases improving the downstream aquatic environment for up to 100 kilometres along the Namoi River.

- Further assessment on the feasibility and cost effectiveness of a fish lift or other ameliorative measures elsewhere in the catchment including trade-offs as sought under Section 218 of the *Fisheries Management Act 1994 by Department of Primary Industries.*

1.4.4 Consultation conducted

Attachment 1 of *Appendix C* outlines the meetings held by State Water with stakeholders during the course of the options assessment process to date. The principal advisory body to State Water has been a Community Reference Panel (CRP), established in 2002 with representatives from the following organisations / interest groups:

- Mayor of Gunnedah Shire Council (Chair)

- Namoi Water

- Downstream landowners

- Local community groups
- Lake Keepit State Park Trust
- Department of Natural Resources
- Department of Primary Industries, Fisheries
- Department of Environment and Conservation, EPA
- NSW Dams Safety Committee
- State Emergency Services
- State Water.

Newsletters and fact sheets concerning the dam upgrade process have also been produced and made available at State Water offices, State Government departmental regional offices, municipality offices, schools, Lake Keepit State Park and on State Water's website. Media releases have also been placed in local newspapers at key decision points in the options development and assessment process and input invited. Other community and stakeholder consultation has been conducted in conjunction with the following events:

- Ag-Quip (August 2002, 2003 and 2004) – displays discussed the project need including dam safety and possible environmental improvements opportunities, interim works and potential long term solutions.
- Ag-Quip (August, 2005) – dsicussed short-listed options and the proposed multi-level offtake.

Community consultation on the short-listed options and proposed multi-level offtake was undertaken for a period of three months between June and August 2005. This included more than 20 community and key stakeholder presentations, nine landowner meetings and an environmental workshop comprising representatives of the then Department of Infrastructure, Planning and Natural Resources, the Department of Environment and Conservation and the Department of Primary Industries (Fisheries).

The Planning Focus Meeting held on 3 February 2006 was attended by representatives of the following agencies:

- Department of Planning
- Gunnedah Shire Council
- Tamworth Regional Council
- Department of Natural Resources
- Department of Environment and Conservation
- Department of Primary Industries (Fisheries)Department of Lands
- Namoi Catchment Management Authority
- NSW Dams Safety Committee
- State Water.

Issues raised in the planning focus meeting included:

- Details of the extreme flood hydrology and frequency of occurrence
- Options assessment information
- Economic and financial analysis results
- Construction details and proposed mitigation
- Provision of fish passage past the dam
- Environmental offsets
- Part 3A planning and assessment process.

The minutes of the planning focus meeting are provided in *Appendix D*.

Subsequent to the Planning Focus Meeting, a series of further consultations has occurred with the key agencies regarding environmental assessment requirements and the Community Reference Panel. This consultation will continue as part of the preparation of the environmental assessment report.

One particular consultation with the NSW Heritage Office, held on 17 March 2006, has resulted in advice stating that to ensure no unforeseen concerns arise, a review of the Keepit Dam heritage assessment which was undertaken in 2002, as part of the development of State Water's s170 Heritage Register should be undertaken. While no change is expected to the current rating, that is having local heritage significance, the review will provide another check that potential heritage impacts and any applicable mitigation measures proposed as part of the upgrade options have been effectively identified and assessed.

2. Description of Keepit Dam and its surrounds

Keepit Dam is situated between the townships of Gunnedah and Tamworth in the north-east of NSW. It is on the Namoi River, approximately 13 kilometres upstream of its confluence with the Peel River. The regional location of Keepit Dam is shown in *Figure 2.1*.

The main dam comprises a combined concrete gravity structure with gated spillway and an earth and rock-fill embankment. The spillway consists of six radial gates, each 14.94 metres wide and 11.3 metres high. Floods discharging from the gated spillway in the main dam wall flow directly into the Namoi River downstream of the dam.

A subsidiary dam, which comprises an earth and clay core embankment is located to the south-east of the main dam. The subsidiary dam wall has been recently modified to function as a temporary auxiliary spillway but only as an interim measure to reduce the short-term safety risks of the main dam as described in *Section 1.4*. Location of the main dam and subsidiary dam walls and an aerial view of Lake Keepit, the lake formed by the impoundment of waters at Keepit Dam, are shown on *Figure 2.2*.

Key specifications of the existing Keepit Dam are as follows:

Age	46 years (in 2006)
Storage capacity	425,000 megalitres (ML)
Total length of main dam wall	533 metres
Maximum height of main dam wall	55 metres
Maximum depth of stored water	43 metres
Upstream catchment area	5,700 square kilometres
Length of subsidiary dam wall	914 metres
Maximum height of subsidiary wall	11 metres pre-interim works (or 7.5 metres with interim works)
Storage full supply level	329.6 metres AHD
Design flood level (DFL)	333.5 metres AHD
DFL maximum spillway discharge	10,475 cubic metres per second
Dam crest level annual exceedance probability	1:2,800 AEP pre-interim works and best estimate 1:30,000 AEP post-interim works
Upstream area inundated at full supply level	4,370 hectares

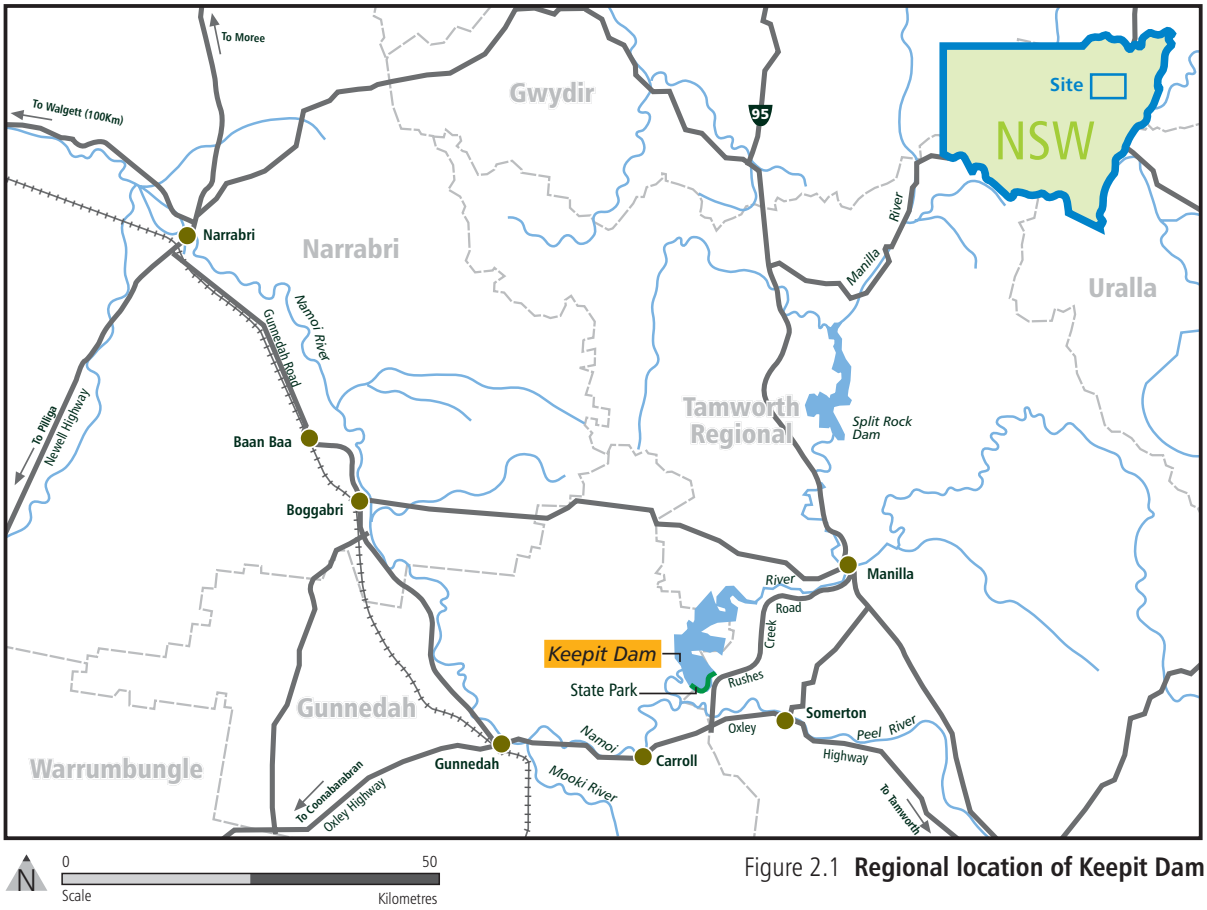

Figure 2.1 **Regional location of Keepit Dam**

Source: StateWater

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Figure 2.2 **Aerial view of Lake Keepit and location of the main dam and subsidiary dam walls**

Figure 2.3 shows the key land uses and ownership around the southern end of Lake Keepit which include:

- A State Water office, workshop, depot and employee housing.
- Various recreational facilities within Lake Keepit State Park which includes a caravan park, five hole golf course, boat ramp, sailing and fishing clubs, gliding club, camping ground, kiosk and other facilities. These facilities are generally located on the western side of Lake Keepit between the main dam wall and the subsidiary dam wall with the exception of the gliding club and camping ground located on the eastern side.
- Lake Keepit Sport and Recreation Centre, which is located approximately 2.7 kilometres north-east of the main dam wall, and includes cabins, a conference centre and a swimming pool.
- A further caravan park, (Ski Gardens/Pelican Point) is located on the north-east end of Lake Keepit.

Ownership of the land for the existing dam and storage and the area affected by the potential upgrade options is considered primarily with the Water Administration Ministerial Corporation, State Water and private landowners. The Water Administration Ministerial Corporation is a statutory body representing the Crown enacted under the Water Management Act 2000. Land under State Water infrastructure is currently being transferred from the Ministerial Corporation to State Water and further transfers associated with the land under the storage and around the rim may occur in the future. Much of the Ministerial Corporation land is leased or managed by other Government departments / agencies. Lands occupied and managed by the Lake Keepit State Park Trust are under an additional legal encumbrance Section 25A Crown lands Consolidated Act 1919 which allows such lands to be managed and administrated by the Department of Lands (on behalf of the Crown). In addition, State Parks shall be read as a reference to a National Park under National Parks and Wildlife Act 1974.

The existing dam and the proposed upgrade works are in the Shire of Gunnedah. Only operational impacts and road access are in the Tamworth Regional Council area.

The primary use of the water stored in Lake Keepit is for irrigated agriculture (97%), although other uses also include town water supplies, stock watering and mining. Lake Keepit also supports a variety of other functions including hydroelectric power generation and recreational uses such as caravanning, boating, fishing and other tourism (e.g. camping, bushwalking and bird watching) and educational facilities.

The largest operational (irrigation) discharges from the dam occur during the irrigation season from September to March, with a discharge in January (the sustained peak of irrigation demand) order of 3,000 megalitres per day. Maximum discharge through the outlet structure is approximately 4,000 megalitres per day and may be called upon for a few days each year. In the event of difficulty achieving high discharge levels, a gate can be slightly opened provided water is above gate sill level (22% storage capacity). However, this arrangement, which has limited control, must only be temporary or for an emergency to prevent damage to the gate seal. Minimum flows through the outlet arrangement outside the irrigation season are approximately 10 to 20 megalitres per day.

Discharge from the storage is controlled via two low level, fixed outlet pipes through the dam wall drawing off at approximately 24 metres below full supply level. One outlet pipe (capacity 1,800 megalitres per day) serves a small hydroelectric power station (6 megawatt owned and operated by Eraring Energy). The other outlet pipe and valves (capacity 2,200 megalitres per day) provides for additional irrigation supplies.

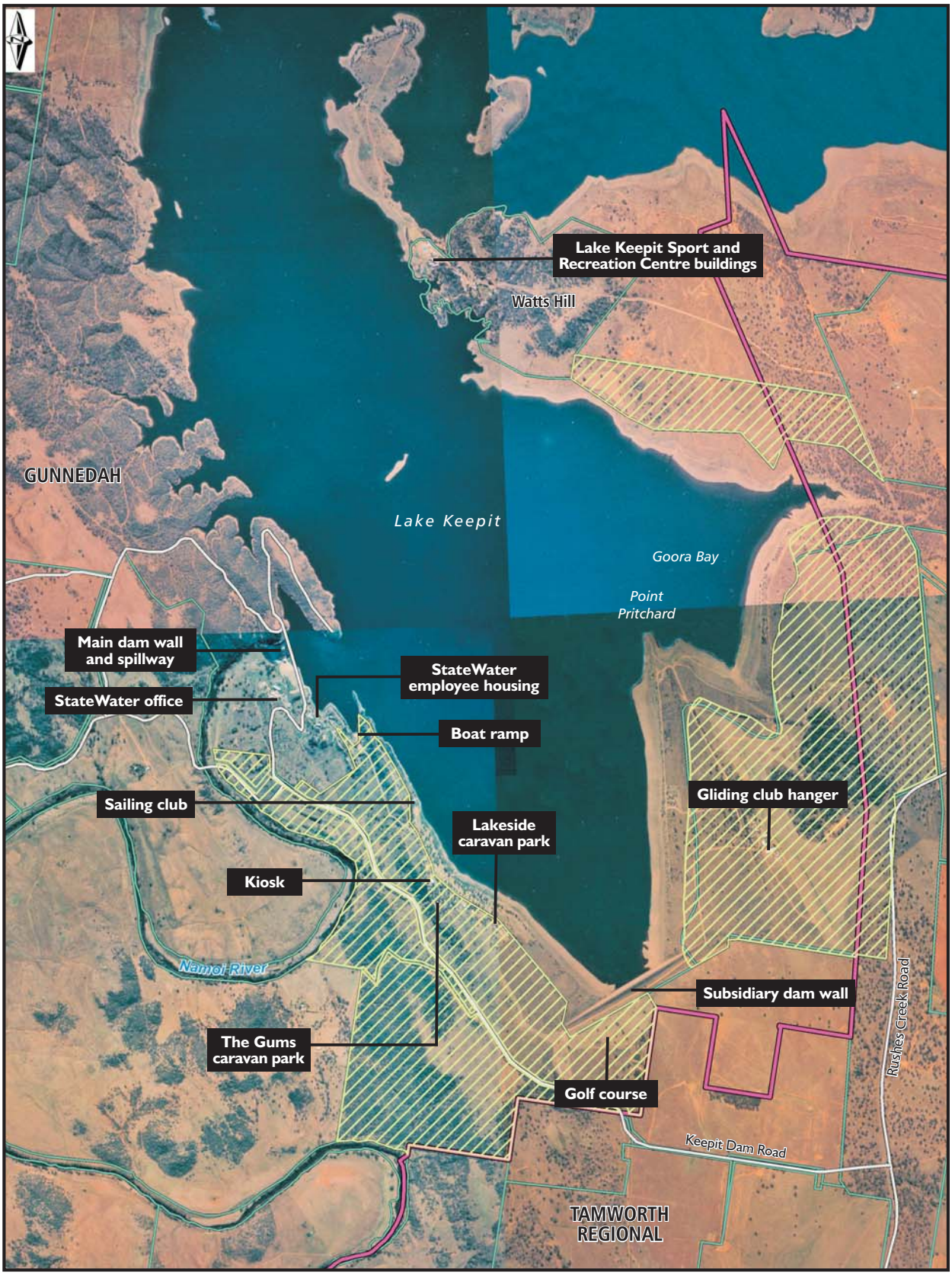


Figure 2.3 **Key landuses and ownership**

3. Extreme event assessment

3.1 Extreme earthquakes

Several earthquakes of magnitude 7 on the Richter scale have occurred in Australia since European settlement. The 1989 Newcastle earthquake (magnitude 5.6) provided a reminder that large damaging earthquakes can occur in NSW. Seismologists advise, that although Australia is often referred to as a relatively 'stable' continental, major earthquakes up to magnitude 7.5 can be expected to occur. As with extreme floods, extreme earthquakes have a very low probability of occurrence (order of 1:10,000 annual exceedance probability - AEP) and it is impossible to predict their actual magnitude, location or timing.

The gravity concrete and spillway sections of the main dam wall are considered unable to maintain adequate stability during a maximum design earthquake and therefore remedial measures are required. The only realistic upgrade is the installation of post- tension cables which is also the same solution for protection from extreme flood surcharging.

3.2 Extreme flood hydrology

3.2.1 Overview

Inadequate flood capacity is not unique to Keepit Dam or dams in NSW, but is a problem faced by dam owners worldwide. As a combined result of a better understanding of extreme rainfall events and improved flood prediction techniques, current estimates of extreme floods are in many cases significantly higher than when the dams were originally designed.

Understanding the magnitude and nature of an extreme flood is an essential precursor to identifying feasible dam safety options. A large amount of information has been generated over the past four years on this aspect of the project. The following information is a snapshot of the key findings of these processes and their implication for the upgrade. This information is supported by hydrographs, upstream and downstream flood mapping, velocity profiles, frequency information, cross-sections, floodwater flow depths and other information, provided in *Appendix B*.

3.2.2 Characteristics of Keepit Dam and a Probable Maximum Flood

- Main wall overtopping was estimated to occur at the 1:2,800 Annual Exceedance Probability (AEP) storm (pre-interim works). The interim works are designed to help protect the main dam wall by providing temporary additional spillway capacity over the subsidiary wall into the Peel River. This would operate during a storm of frequency greater than 1:1,800 AEP. The main wall with the interim works is now estimated to be protected up to floods of 1:30,000 AEP.
- The spillway capacity required at Keepit Dam to safely pass floodwaters from a Probable Maximum Flood (PMF) storm is approximately four times the capacity of the existing gated spillway or approximately 40,646 cubic metres per second.

- The overall duration of inflows during a PMF storm is approximately 120 hours.
- The total volume of water in a PMF storm is approximately eight-and-a-half times the existing storage capacity of Keepit Dam.
- The frequency of a PMF cannot be estimated but the Probable Maximum Precipitation Design Flood (PMPDF) (which equates to some 25% less in peak inflows) is 1:175,000 AEP. The frequency of a PMF has for economic analysis been assumed to 1:500,000 AEP but potentially it could be lower than this figure.

3.2.3 Existing flood operational procedures

Current flood operating procedures (rules) for Keepit Dam spillway gates will not change for any of the upgrade options proposed.

In broad terms all existing gates are progressively opened, as the flood increases, to maintain the maximum upstream flood surcharge at no more than one metre above Full Supply Level (FSL) or RL 330.6 AHD. All gates are lifted clear at about 1.2 metres above FSL (or RL 330.8 AHD) when it is obvious the one metre maximum flood surcharge can no longer be controlled by the gates and the upstream flood surcharge will continue to rise. At this point, the existing spillway becomes a free-flowing fixed crested ogee weir and no more operating rules apply until the upstream flood water surcharge recedes back to one metre above FSL, when gates can be lowered and the upstream surcharge once again can be controlled.

All three proposed options upgrades do not affect existing spillway flood flows until the upstream flood surcharge reaches RL 332.0 AHD or 2.4 metres above FSL (a large flood with a frequency of occurrence of less than 1:1,800 AEP). At this surcharge height, the first release plug activates in the additional right hand abutment spillway. Accordingly there is no requirement to amend existing flood operation rules.

3.2.4 Adopted baseline inundation

The adopted baseline for upstream inundation is a level of 1.2 metres above existing full supply level of the storage. This level (RL 330.8 AHD) is the maximum operating level which can occur under current operating rules for small to medium size floods, as explained in Section 3.2.3. It should be noted that under very large to extreme floods, upstream inundation levels can currently occur up to RL 335.4 AHD (5.8 metres above full supply level), which is the level at which the existing main dam wall is estimated to fail.

Regarding downstream conditions, the dam failure scenario, which would occur unless the long-term upgrade was implemented, is considered the baseline for environmental assessment.

3.3 Flood modelling results relevant to environmental issues

- The largest flood on record for the Namoi River over the past last 108 years of records occurred in 1955 and is considered to have an annual exceedance probability (AEP) of approximately 1:100.

- Keepit Dam is characterised by a large catchment and relatively small storage. Discharges from Keepit Dam contribute only about 21% of total average flows in the Namoi River catchment. This effectively limits the extent to which the dam can be used to provide downstream flood mitigation.
- Modelling indicates that floodwater depth at Gunnedah varies between the three options by only about 300-500 millimetres – this is within the range of accuracy of the modelling and highlights the size of very large to extreme floods relative to the size of the storage at Keepit Dam and, therefore, its inherent inability to provide flood mitigation of extreme floods.

3.3.1 Upstream flooding impacts

All three short-listed options comprise design flood level raising (dam wall raising) ranging from 3.2 metres (Option B1) to 5.5 metres (Option D3). There are a range of facilities and activities around the storage rim. Such facilities would be affected to varying degrees from rising flood waters in the event of extreme flooding and include the Sailing and Fishing clubs, two caravan parks and parts of the State Sport and Recreation Area to the north-east of the main dam wall. The rise of floodwaters into these areas is expected to be slow and to provide sufficient time to:

- Allow native fauna and stock to move to higher ground; and
- Implement an emergency and evacuation plan which would be prepared jointly by State Water and the State Emergency Service prior to the commencement of operations of the upgrade works.

It is estimated that the maximum duration of upstream inundation above existing flood operating procedures (RL 330.8 AHD) would vary between approximately two and 38 hours depending on the option selected and the level of the land (refer *Appendix B*).

Existing flood surcharge of up to RL 335.4 AHD occurs between two and 25 hours for very large to extreme floods.

Table 3.1 provides the approximate areas of upstream inundation which currently occurs and specific to each option above RL 330.8 AHD - current maximum flood operating level. These are also shown on *Figure 3.1*.

Table 3.1 Approximate area of upstream inundation above RL 330.8 AHD

Option	Area of inundation (hectares)
Existing to RL 335.4 AHD	1,340
Option B1	2,000
Option D2	2,250
Option D3	2,500

The increased inundation of these areas from very large to extreme floods, would also have an effect on a number of rural properties and on some environmental issues including heritage and terrestrial flora and fauna. These impacts are discussed further in *Appendix E.*

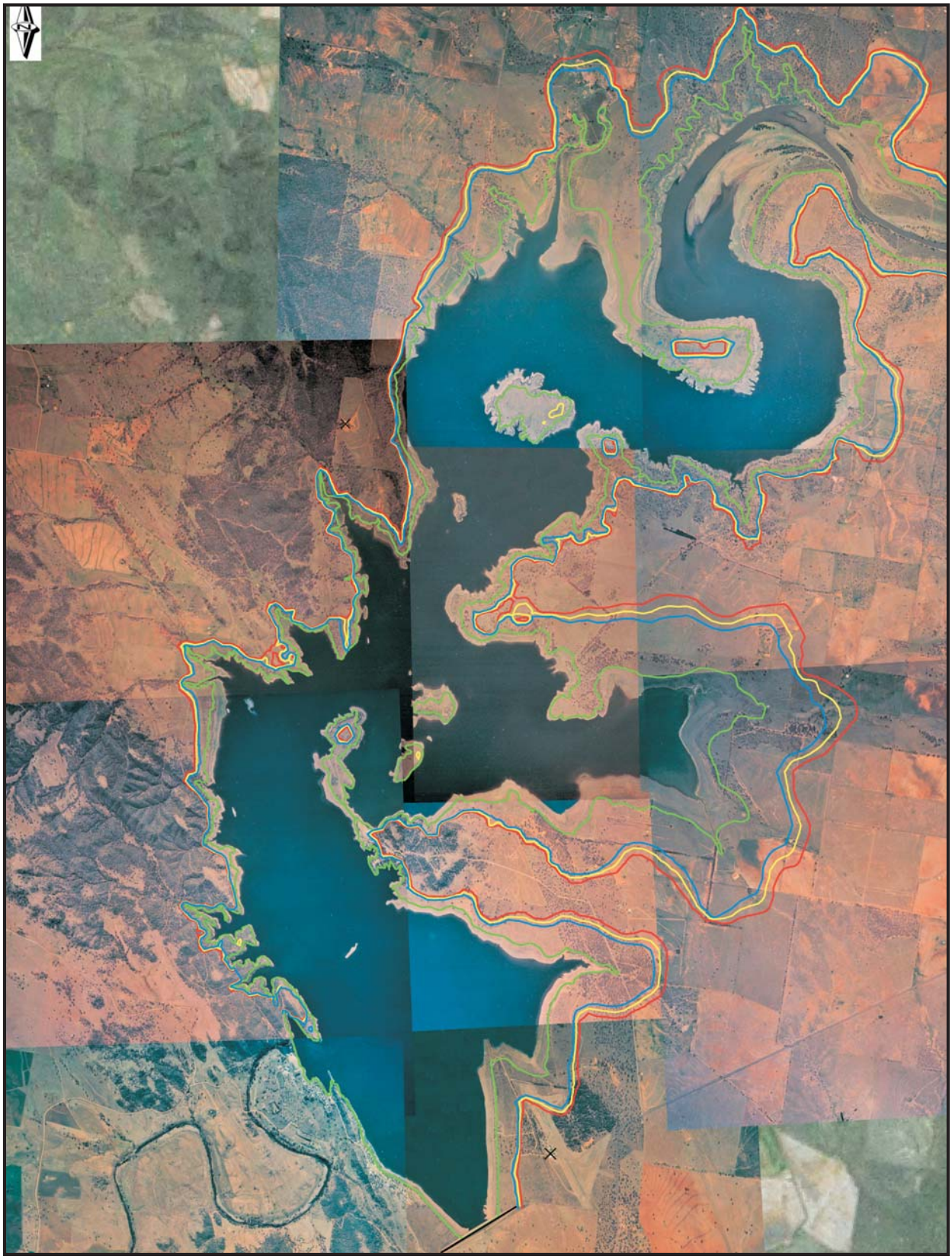


Figure 3.1 **Upstream flooding inundation**

3.3.2 Downstream flooding impacts

There are two key aspects of downstream flooding relevant to the comparative effect of the three short-listed options: the extent of flood inundation and the velocity of floodwaters between the dam walls and the confluence of the Namoi and Peel Rivers.

There is very little difference in flooding downstream of the confluence of the Namoi and Peel Rivers. Option B1 is potential slightly greater flood 300 to 500mm than the other options.

Extent of flood mitigation

Figure 3.2 shows the influence of the upgrade options relative to the dam failure scenario which is the adopted baseline for environmental impacts. The figure shows that mitigation of downstream inundation would be achieved by all options.

Floodwater velocities

The velocity of flood waters was calculated at a number of representative locations along the Namoi and Peel Rivers, identified in *Table 3.2* and shown in *Figure 3.3*.

The key differences between the options is that Option B1 results in high floodwater discharges from the subsidiary dam wall and an increase in floodwater velocities in the lower Peel River. All options would result in high floodwater velocities downstream of the various spillways in the Namoi River to the confluence with the Peel River. Option B1 would result in a lower velocity in this section of the Namoi River as a result of the increased impact on the Peel River.

Environmental impacts to areas where new spillways discharge to the receiving waters of the Namoi and Peel Rivers will occur. Option B1 has the greatest potential impact. The impacts would include potential further destruction and loss of terrestrial flora and fauna and heritage sites and are discussed further in *Appendix E*.

It is important to note that there is very little difference in downstream inundation impacts between options, for large floods with a frequency of occurrence between 1:1800AEP to 1:10,000 AEP when the first additional (right hand abutment) spillway operates.

Figure 3.2 **Downstream flooding inundation**

Table 3.2 PMF floodwater velocities (metres/second)[1]

	Location[2]									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**		
Option	Immediately downstream of the right hand abutment spillway	At the Hakea	Between the Hakea and the confluence of the Namoi and Peel Rivers	Gorge (downstream of the confluence of the Namoi and Peel Rivers)	Immediately downstream of the subsidiary dam wall	Peel River between the subsidiary dam wall and the Namoi River	Boat ramp spillway	Sailing club spillway	Peel River upstream of the subsidiary dam wall	Namoi River at Carroll
Option B1	8.5	3.1	2.9	8.9	8.5	4.4	0	0	2.0	2.2
Option D2	8.3	3.6	3.6	8.8	0	2.5	8.3	8.3	2.0	2.2
Option D3	8.1	3.6	3.6	8.8	0	2.6	8.0	8.1	2.0	2.2
Dam failure[3]	0	8.1	5.8	10.7	0	2.7	0	0	2.0	2.8

Source: SKM 2005

Notes:
[1] Velocities relate to the probable maximum flood.
[2] Locations refer to those shown on *Figure 3.3*.
[3] Prior to interim works, and without any dam safety upgrade works.

Source: StateWater

Figure 3.3 **Reference sections for floodwater velocities**

4. Consideration of alternatives

The alternatives development and assessment process is set out in detail in *Appendix C*.

The development and assessment of dam safety upgrade options was undertaken in a series of stages and over an extended period of time (see *Figure 4.1*). This provided a clear decision trail, while taking account of the wide range of values and opinions represented by the members of the Community Reference Panel and other project stakeholders. Some of the considerations raised in consultation and which contributed to the extended duration of study included:

- The large number of options and variations possible at a range of locations around the dam, with each requiring initial assessment to verify its achievement of the safety criterion.
- A wide range of issues and potential solutions requiring identification and assessment, in some cases including further studies with data collection and computer modelling to provide sufficient information for the decision-making process.
- The complexity and inter-relationship of many of the issues, requiring a wide variety of inputs and necessary reconciliation of sometimes conflicting views.
- The potential local and regional effects of the proposal and the decision to adopt a 'whole of system' approach to the effects of the works and potential environmental improvement options.
- A comprehensive, open and transparent consultation process taking account of all stakeholder views, with particular emphasis on community involvement and requiring consideration of a wide range of assessment criteria.
- An integrated development assessment and evaluation process requiring simultaneous consideration of many different issues, refinement of the options and the development of additional or modified options to address the implications of the specialist studies conducted.

Attachment 1 of *Appendix C* illustrates the extensive effort made to seek the opinions of a range of stakeholders and the community on the options performance, while *Attachment 2* provides a list of the technical inputs and reports produced to support the options assessment and development process. This comprised numerous technical reports and more than 150 consultative meetings over some four years.

The outcome of the above process was a short list of initially four dam safety options and one environmental improvement option. After consideration of all the consultation and potential funding limitations, the State Water Corporation Board removed one of the options (Option A3) because of its significant additional cost which was not considered commensurate with an increase in net environmental benefits.

Option D3 is currently the preferred option based on the overall consideration of benefits and impacts, but its adoption is heavily dependent on the greater environmental concerns and other local impacts precluding the other two less costly options (Options B1 & D2)

during the formal environmental assessment process. Option D3 adoption is also dependant on approval of funding

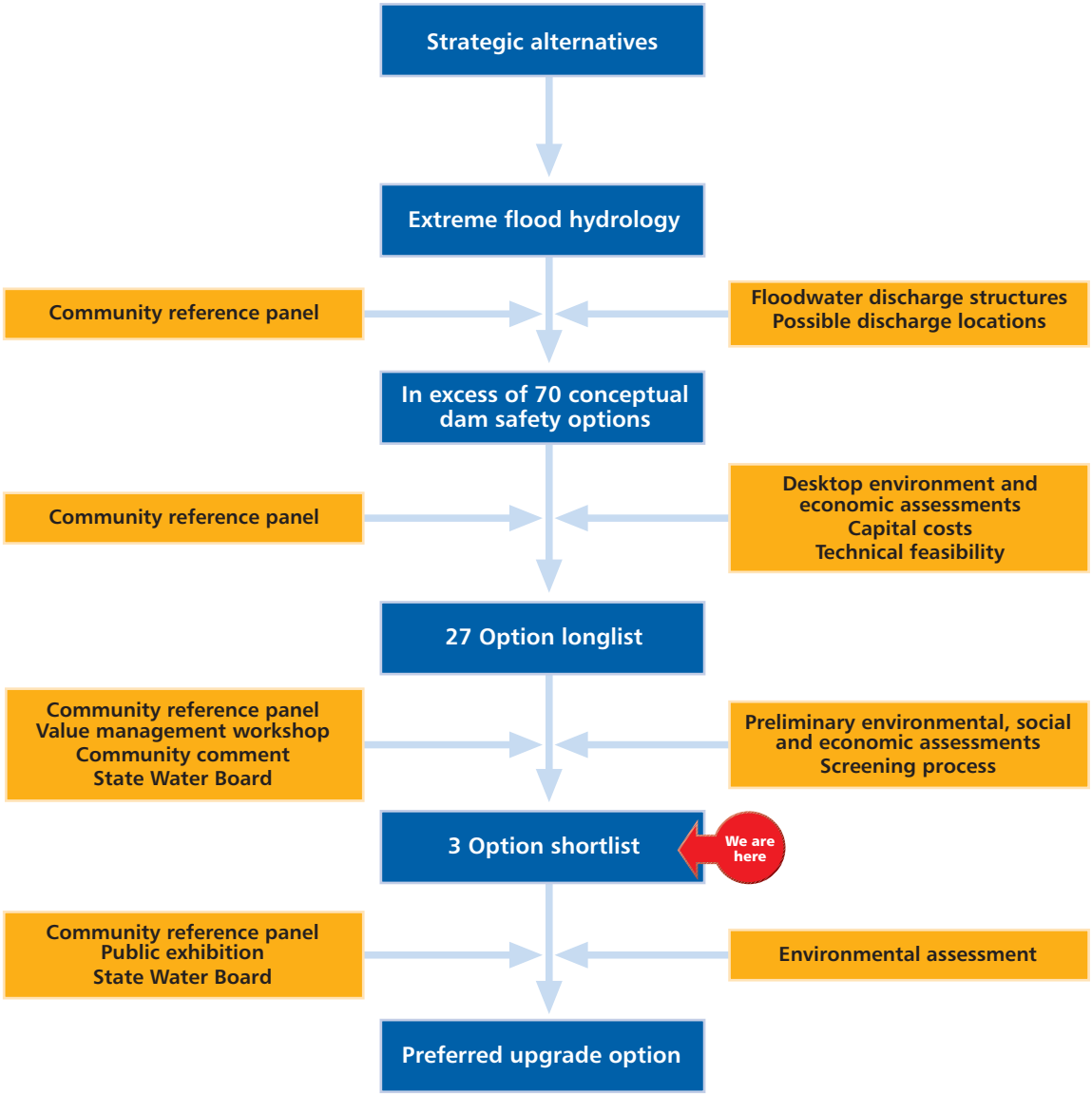


Figure 4.1 **Overview of options development and selection process**

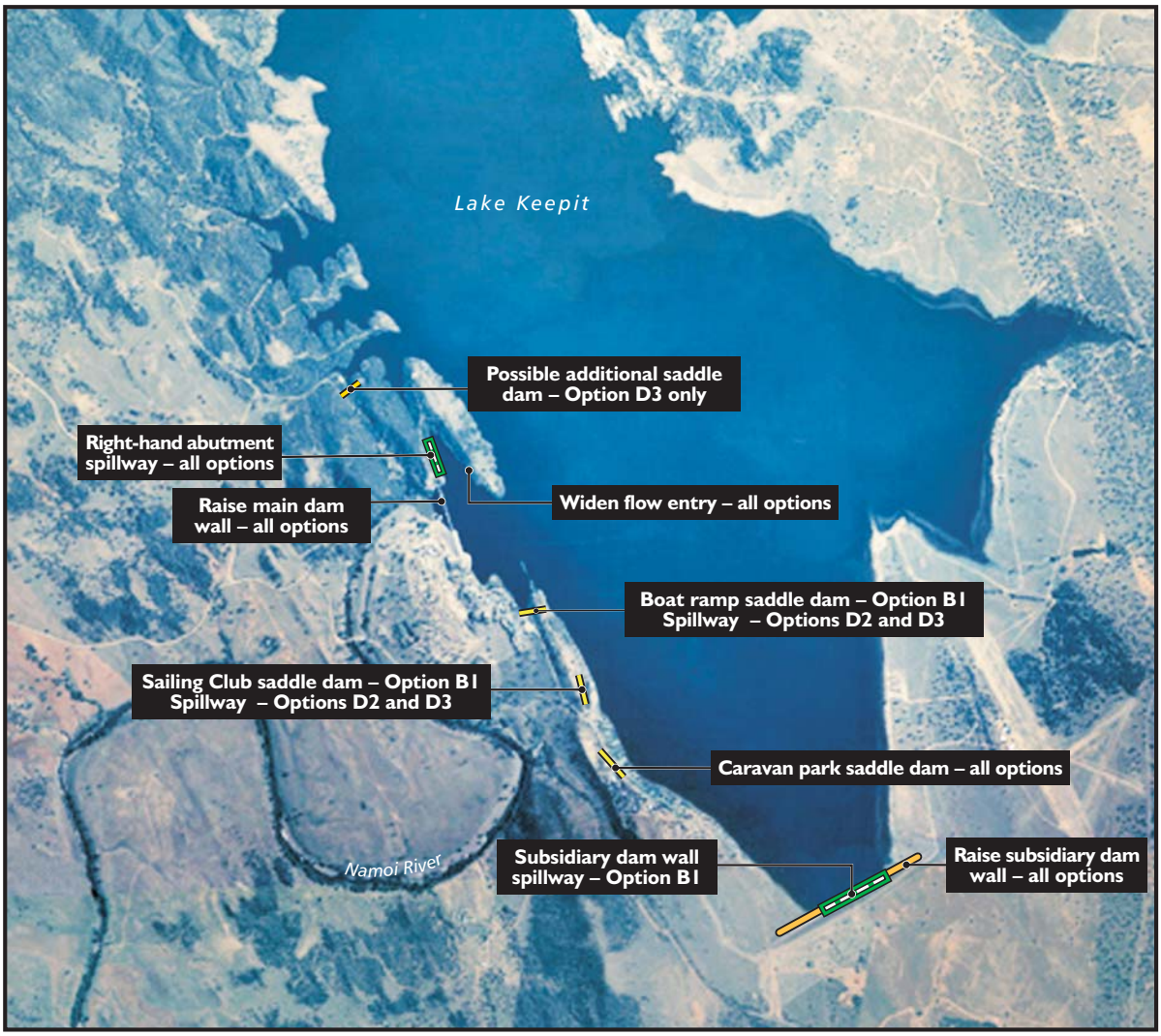
5. Key features of the short-listed options

Three short-listed options have been developed to achieve compliance with the requirements of the NSW Dams Safety Committee. The multi-level offtake is described separately, as this component could be implemented without effect on any of the three short-listed dam safety options.

The key features of the three dam safety short-listed options are summarised in *Table 5.1* and displayed in *Figure 5.1*.

Table 5.1 Key features of the dam safety short-listed options

Option	Main and Subsidiary wall raising	Spillway locations (and width)	Spillway discharge location(s)	Saddle dam locations	Temporary loss of storage
B1	3.2 metres	▪ Right-hand abutment (220 metres) ▪ Subsidiary dam wall (380 metres)	Namoi and Peel rivers	▪ Boat ramp ▪ Sailing club ▪ Caravan park	30%
D2	4.3 metres	▪ Right-hand abutment (220 metres) ▪ Sailing club & Boat ramp (total 380 metres)	Namoi River	▪ Caravan park	15%
D3 (currently preferred)	5.5 metres	▪ Right-hand abutment (220 metres) ▪ Sailing club & Boat ramp (total 380 metres)	Namoi River	▪ Caravan park ▪ Right-side saddle	Nil



Source: StateWater

Figure 5.1 **Key features of options**

5.1 Design and construction

Appendix F provides a series of detailed concept drawings for each of the three dam safety options and *figure 5.3* the concept drawing *of the* multi-level offtake improvement.

5.1.1 Main dam wall rising

All the short-listed options would require the height of the main dam wall to be raised by between 3.2 metres (Option B1) and 5.5 metres (Option D3). The dam wall raising would comprise the following tasks:

- Raising the bridge piers and deck to the required height
- Raising (and refurbishment as required) of the existing gantry crane
- Raising the spillway gate lifting gear
- Construction of a reinforced concrete wall (various height for each option)
- Installation of concrete dam wall post-tensioning
- Placement of additional rock fill / crest raising on the left-hand abutment.

Externally sourced rock fill will be required in addition to on site rock fill. Drilling, lifting, anchor installation, concrete and rock placement and access reinstatement will be the main activities.

These works are anticipated to be undertaken over a period of approximately 12 months.

5.1.2 Right-hand abutment spillway

All the short-listed options will require construction of an additional 220 metre-wide spillway (or narrower depending on the detailed design) at the right-hand abutment of the main dam wall. The spillway will comprise reinforced concreted sill, aprons and walls, grouted cut-off and earthen release plugs or concrete/steel release gates (to be confirmed during detailed design).

The sill and crest levels of the release plugs / gates at the right-hand abutment spillway vary between options. The sill level of release plugs / gates for Options B1 and D2 are lower than for Option D3 and below full supply level, meaning a temporary loss of storage during a very large to extreme flood event until the release plugs / gates are replaced. The crest levels of the release plugs / gates progressively increase in each option to ensure a progressive release of water as floods intensify. The right-hand abutment spillway is the first additional spillway to operate after operation of the existing spillway.

Drilling and blasting and bulk excavation of rock at the right-hand abutment would be required to create the additional spillway. Machinery would include drilling equipment, bulldozers, excavators, scrapers and off-site haul trucks. The works would begin from the downstream side of the main dam working progressively toward the storage in order to limit potential impacts on in-storage water quality. Standard construction

erosion and sediment control measures would be implemented before substantial construction began. Construction works would result in a public car park, road access across the dam wall via Keepit Dam Road and access out to the adjacent peninsula being unavailable for the duration of construction. The road is not often used and an alternative route via Orange Grove Road is available for through traffic. Access across the dam wall via Keepit Dam Road and to the car park and peninsula would be restored at the end of construction to at least the same standard of the existing facilities.

Following activation of a release plug or gate, floodwaters would pass through the spillway and partly along a rock channel for approximately 150 metres before discharging into the Namoi River immediately downstream of the existing spillway gates discharge point. The limited environmental impact and the quality and extent of rock in this location is considered acceptable to avoid the need for a concrete-lined discharge chute.

These works are anticipated to be undertaken over a period of approximately six to nine months.

5.1.3 Peninsula reshaping

For all options, the peninsula inside the dam immediately in front of the proposed right-hand abutment needs to be reshaped to increase the hydraulic capacity of the right-hand abutment spillway. The western edge of the peninsula needs to be removed to increase the size of the channel leading to the right-hand abutment spillway. Reshaping of the peninsula would be conducted by drilling and blasting and by excavation. Silt curtains would be setup across the peninsula entrance to limit the effects on in-storage water quality from these works.

These works would normally be undertaken in concurrence with the spillway works at the right-hand abutment, but this may need to be altered if storage levels were high.

5.1.4 Boat ramp and sailing club spillways

For Options D2 and D3, additional spillways are required to be constructed at the locations of the existing public boat ramp and the sailing club. The total width of spillways in both locations would be approximately 380 metres wide. The spillways will comprise reinforced concreted sill, aprons and walls, grouted cut-off and earthen release plugs or concrete/steel release gates (to be confirmed during detailed design).

The sill and crest levels of the release plugs / gates at the boat ramp and sailing club spillways vary between Options D2 and D3. The sill level of release plugs / gates for Option D2 is lower than for Option D3 and below full supply level, meaning a temporary 15% loss of storage during a very large to extreme flood event until the release plugs / gates are replaced. The crest levels of the release plug / gates progressively increase in each option to ensure progressive release of water as floods intensify. The sailing club and then the boat ramp additional spillways are the last to operate in an extreme flood.

Drilling and blasting and bulk excavation of rock would be required to create the additional spillways. Machinery would be similar to that

required for the right hand abutment. The existing boat ramp would need to be relocated as part of the works as would the sailing club subject to finalising the location of the spillway relative to the proposed Sailing Club building. New “like for like” or modified facilities would be provided as agreed in negotiations with the relevant parties. The access road to the existing boat ramp and sailing club would also have to be relocated.

Following operation of either the boat ramp or the sailing club spillways, flood water would flow for about 200 to 400 metres, across Keepit Dam Road before merging with the Namoi River approximately two kilometres downstream of the main dam wall.

Because of the close location of these works to the existing caravan park, it is proposed that the main works would be undertaken during the off-peak (winter) season when tourism at the State Park is at its lowest. The off-peak season lasts for approximately seven months of the year, which would be sufficient to substantially complete the main works.

Due to the impracticality and infrequency of operating these spillways (less than 1:10,000 AEP) no concrete-lined discharge chute is proposed.

5.1.5 Subsidiary dam spillway

Option B1 requires a 380 metre wide spillway to be installed into the subsidiary dam. The centre section of the existing earthen subsidiary dam would be excavated / removed and a spillway built comprising reinforced concreted sill, aprons and walls, grouted cut-off and earthen release plugs or concrete/steel release gates (to be confirmed during detailed design). Construction of the subsidiary wall spillway would require using a combination of scrapers, bulldozers, off-site haul trucks and excavators. In view of the much poorer foundation strength, far more extensive grouting and concrete works will be required than at the other spillway locations to prevent failure of the spillway foundations under flood flows.

The sill level of all release plugs / gates for Option B1 is the lowest of all options and well below full supply level, meaning a temporary 30% loss of storage during a very large to extreme flood event until the release plugs / gates are replaced. The crest levels of the release plug / gates progressively increase to ensure progressive release of water as floods intensify.

The subsidiary dam additional spillway is the last to operate in an extreme flood.

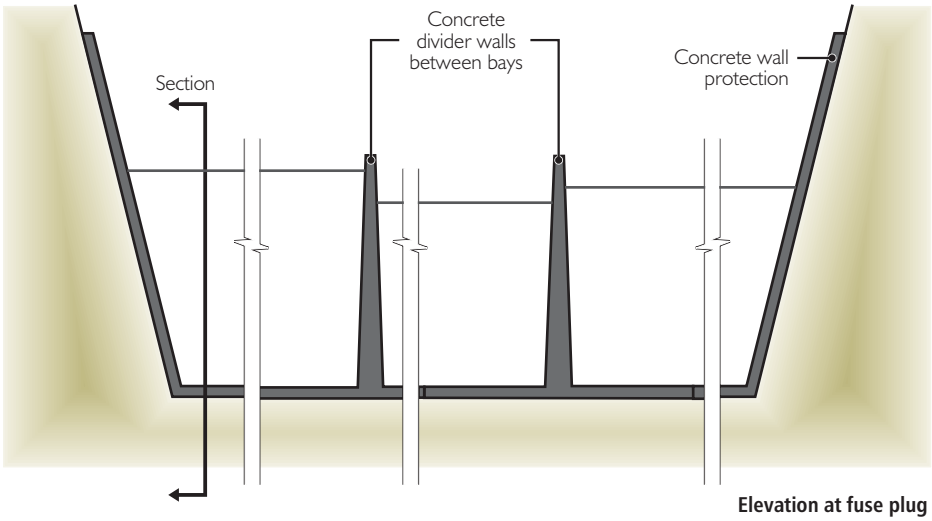
Following operation of the subsidiary wall spillway, flood water would pass across an access road to the State Park camping area and across the golf course and sewage treatment plant. This would require replacement of both, then approximately 2 to 2.5 kilometres over highly erodable grazing land to the Peel River. Flood waters would then flow approximately five kilometres downstream to the Namoi River confluence.

Construction of the subsidiary wall spillway is anticipated to last approximately six to nine months.

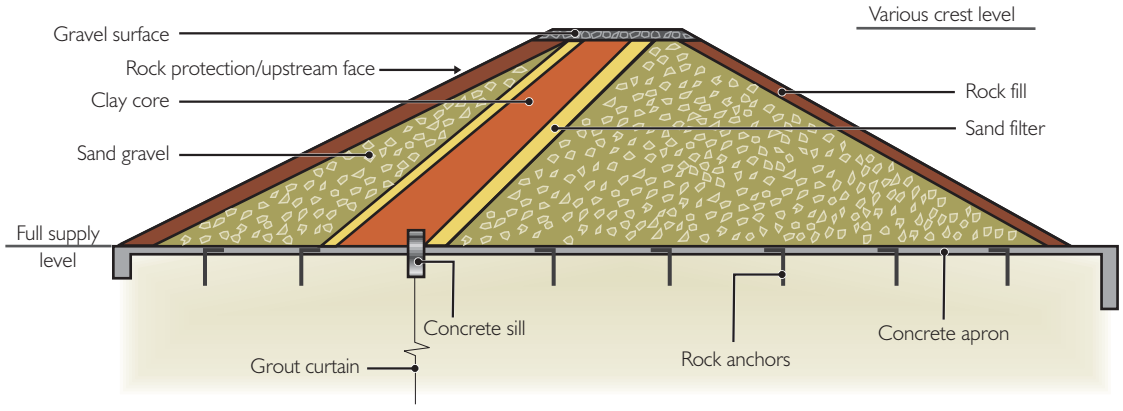
5.1.6 Release plugs / gates (technically called fuse plugs/gates)

A release plug is a feature common to dams around the world. It is installed in new or existing spillways and is comprised of a non-permeable downstream sloping clay core supported with selected gravel fill. Under normal circumstances, it acts just like a dam wall and retains water upstream. When the plug is overtopped during a flood event, the plug is designed to erode at a relatively rapid but reasonably predicable rate. As the supporting gravel fill is removed, the clay core collapses and the whole plug washes away. Reinforced concrete foundations at a specified depth (or sill level) and side walls ensure that the design volume and flow rate of water is released and the shape and integrity of the spillway remains. Banks of release plugs may make up a spillway and each can be designed to activate individually according to the size of a storm. A release plug may take up to six months to be replaced following its release and replacement can only occur after flood waters have stopped flowing through the spillway. A typical detail of an earthen release plug is shown in *Figure 5.2*.

A release gate is a similar concept to a release plug only these may be made of either concrete or steel. The operational principals are similar to release plugs. Release gates can be made to smaller widths and much finer differentials in crest levels making them much more flexible in minimising pulse flows than release plugs. Release gates are often considered more flow efficient, reliable and potentially require less maintenance than release plugs but are normally more expensive to build. While the concept options and drawings have been developed based using release plugs; final choice between release plugs and release gates will be made as part of determining the detailed design of the upgrade.



Elevation at fuse plug



Section

Source: StateWater

Not to scale

Figure 5.2 **Typical detail of an earthen release plug**

5.1.7 Subsidiary dam & saddle dams

All the short-listed options would require the subsidiary dam wall to be raised by between 3.2 metres (Option B1 – either side of the centre located spillway) and 5.5 metres (Option D3). The works would require raising the clay core and supporting gravel zones using bulldozers, scrapers, off-road haul trucks and compaction equipment. The access road to the camping area and glider club will require relocation.

The clay core of the subsidiary dam wall would either be provided from stock piled interim works materials on the north-eastern side of the subsidiary wall or on-site borrow pit sources near the proposed sailing club spillway. Gravel fill would be provided from existing spoil stockpiles and crushed rock from the excavation of the right-hand abutment or sailing club spillways. On site and possible externally sourced, further rock armour would also be placed on the upstream face of the subsidiary dam wall.

All options would require the additional construction of an earthen saddle dam at the rear of the caravan park to match the height of the raised main dam wall. Option B1 would require two other saddle dams at the sailing club and boat ramp. Option D3 may, subject to detailed design, require an additional smaller saddle dam at the right-side saddle north of the right-hand abutment.

Saddle dam construction would essentially comprise bulk earthworks using bulldozers, scrapers, off-road haul trucks and compaction equipment. Fill from spillway crushed excavation and clay from on-site borrow pits is expected to be adequate. Rock armour would also be added to the upstream faces likely sourced from bulk excavation works on-site and externally.

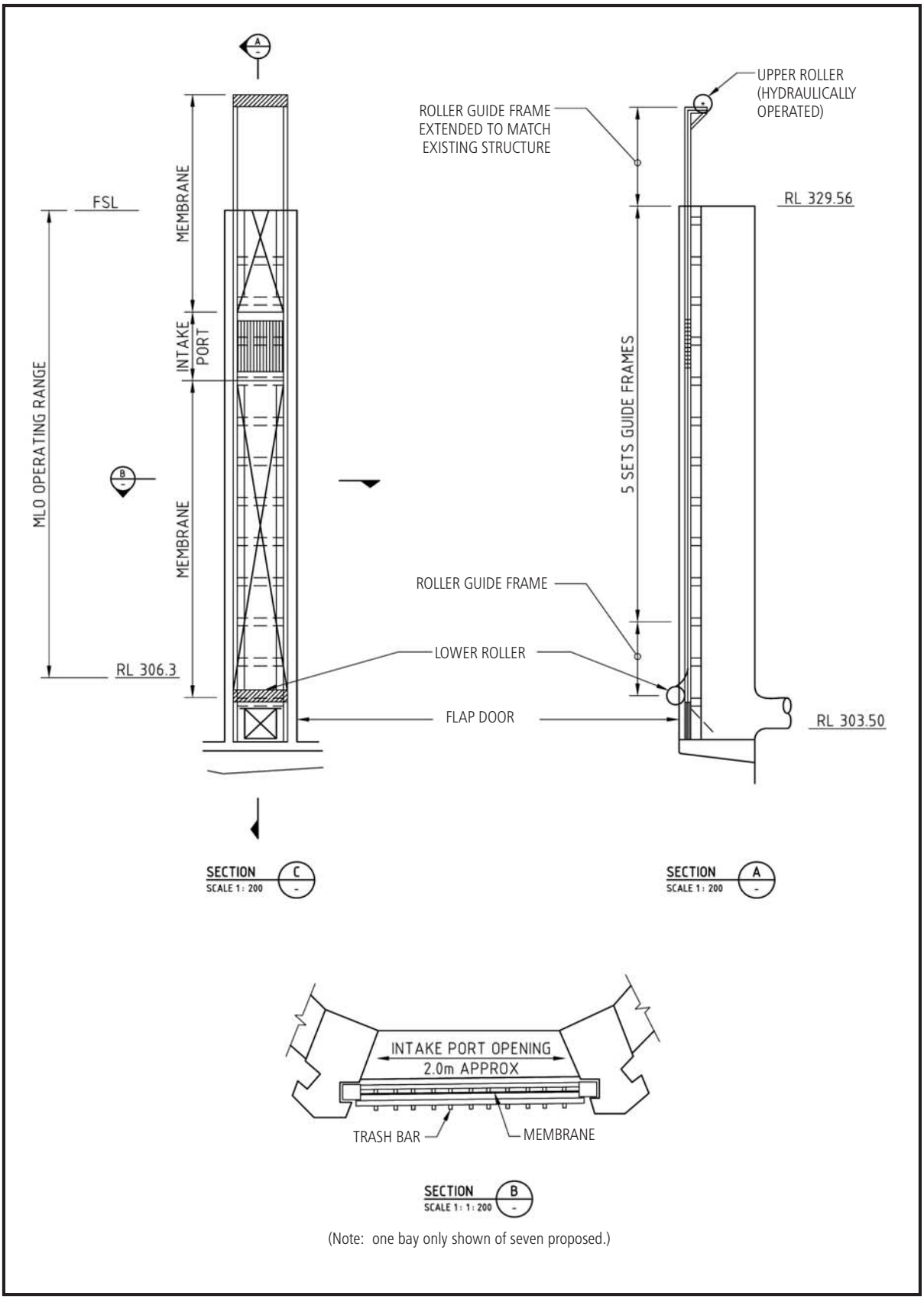
Option B1 would involve the construction of a saddle dam at the rear of the caravan park, and thus the relocation of one row of caravans (up to 8 vans), an amenities block and associated services of the Gums Caravan Park. Taller embankments associated with options D2 and D3 would require the relocation of up to two rows, or 15 caravans, and an amenities block and associated services. The caravans would be relocated to a location agreed with the Lake Keepit State Park Trust in consultation with caravan owners, possibly to the south west of the Gums Caravan Park. A new amenities block will be required.

To assist with understanding of all potential impacts on the Lake Keepit State Park and negotiate mitigating measures, a detailed master plan is proposed to be developed in conjunction with the State Park Trust and local clubs. The plan will help determine key works required and their timing in relation to overall strategic planning of the Lake Keepit State Park Trust. It will also assess issues of disruption and mitigation / offset measures – both during construction and from possible operational impacts in the longer-term.

5.1.8 Multi-level offtake

All the short-listed options propose to modify, the existing outlet at the dam to facilitate the multilevel release of water subject to final cost effectiveness which will be identified in the environmental assessment report, This multilevel offtake will allow the dam operator to release outflows at a appropriate temperature and control algal discharges.

An evaluation of various types of multi-level offtake structures has been undertaken and a 'roller door' concept, which uses the trash rock slots in the existing intake structures, is considered the most cost effective (see *Appendix C*). Detailed operating procedures for the multi-level offtake will need to be developed from temperature and algal data currently being collected, to maximise the effectiveness of the structure. A conceptual design of the multi-level offtake is shown in *Figure 5.3*.



(Note: one bay only shown of seven proposed.)

Figure 5.3 **Concept design of the multi-level offlake**

5.1.9 Ancillary facilities

A concrete batching and crushing plant is anticipated to be required on-site and is proposed to be located immediately downstream of the left-hand abutment near the existing State Water works depot.

The source of the clay borrow pit to be used in the dam wall core (likely to be near the sailing club spillway) will be subject to detailed site investigations following appointment of a construction contractor. Should the on-site suitable material not be sufficient in volume or quality, external sources will be used.

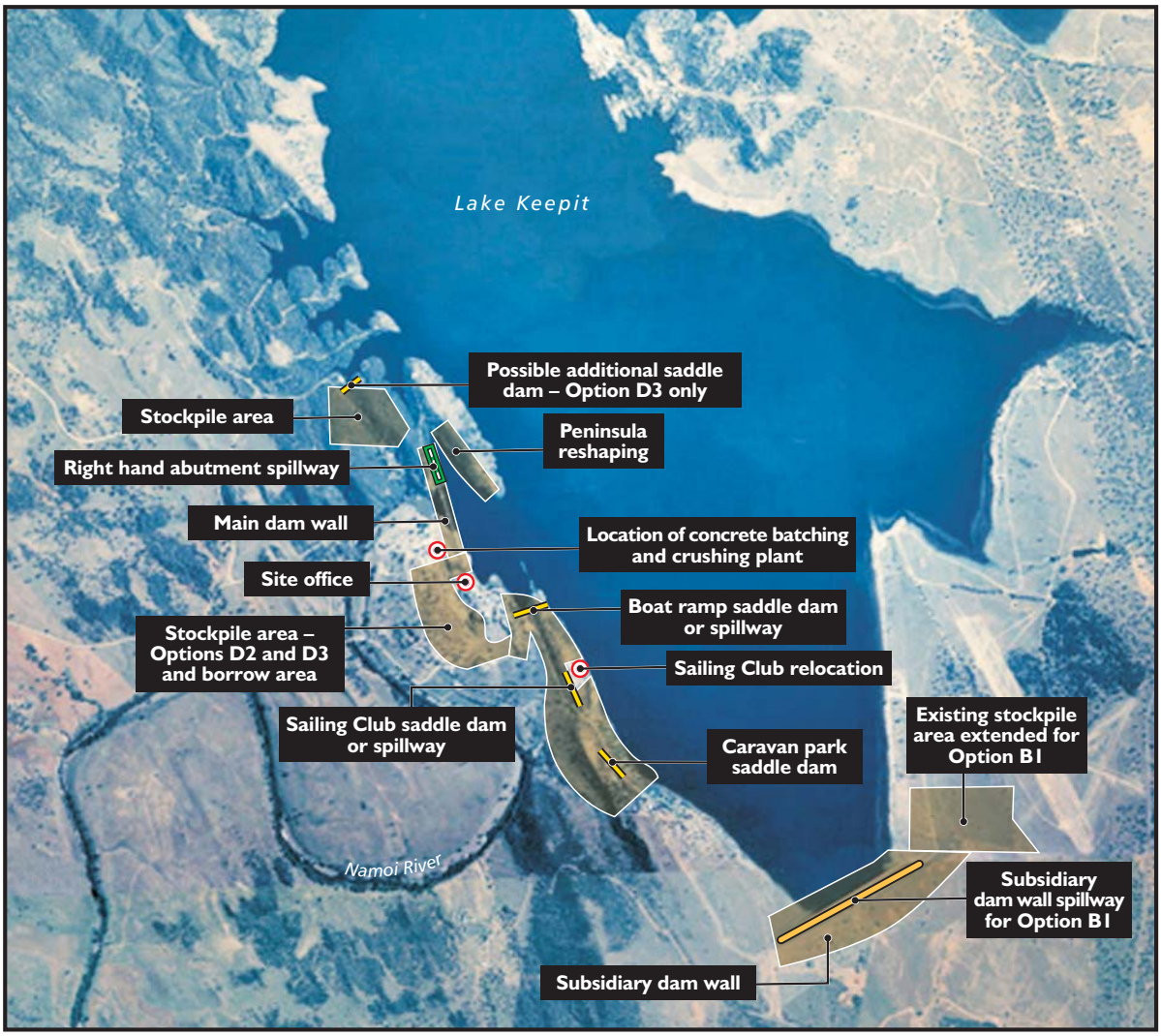
The balance of earthworks not used in the embankment construction is anticipated to be about 400,000 cubic metres of spoil excess. Excess spoil would be deposited in one of two locations indicated on *Figure 5.4*. The first location is in a valley on the hillside facing the downstream Namoi River. The alternative site is located to the west of the boat ramp behind the State Water village. There is also an existing spoil stockpile area to the east of the subsidiary dam wall which may continue to be used.

The existing State Water staff village will be in close proximity to some of the works. An agreement with staff and their families on possible disruption offsets is proposed.

5.1.10 Construction workforce and timing

It is anticipated the maximum and average number of construction workers will be 70 and 30 respectively. The overall duration of construction is expected to be 2.5 years.

While up to the construction contractor, it is anticipated that the construction workforce will stay in Gunnedah and at the Lake Keepit State Park Caravan Park. Other townships, caravan parks, facilities and Tamworth may also provide accommodation. It is also anticipated that the existing kiosk facilities at the State Park will a major source of food and drinks and other incidental supplies for workers during the construction period.



Source: StateWater

Figure 5.4 **Construction details**

5.2 Operation of the proposal

There would be no change to the existing flood operational procedures for Keepit Dam up until a large flood of approximately 1:1,800 AEP occurs. At this point, the first release plugs / gates in the right-hand abutment spillway would activate. If the rate of floodwater inflow to the dam continues to exceed outflow, further release plugs / gates will continue to breach.

If the rate of floodwater flow into the dam continues to exceed its release, the remaining safety mechanisms will operate depending on the option implemented. For Option B1, the release plugs/gates in the subsidiary dam spillway would start to activate at a flood frequency of approximately 1:10,000 AEP. At the same frequency, for Options D2 and D3, the additional spillway at the sailing club would instead start to activate, followed by the boat ramp spillway at extremely large floods of less than 1:100,000 AEP. Dam storage levels would continue to rise to the maximum height of the PMF flood. Top of Dam walls provide for a further 600mm freeboard for wave and any potential coincidental actions.

The implementation of all options would need to be accompanied by the development of specific emergency management procedures for occupants of the Lake Keepit State Park, the Sport and Recreation Centre and the Ski Garden Caravan Park. For Option B1 only, special emergency management procedures would need to include the lower Peel River landowners and associated State Park road access.

Installation of a multi-level offtake which is likely to be one of the last upgrade works to occur, will see the current low level draw-off changed to draw-off at the most appropriate water quality (principally temperature) level. The new draw-off arrangements will be based on new operating rules which will be developed over the next two to three years based on algal, temperature and other water quality data currently being collected.

5.3 Land acquisition and other compensatory arrangements

Some private land (farming properties) which is not currently affected maybe affected during very large to extreme flood events after the upgrade. Similarly infrastructure and recreational facilities and rural properties downstream of the subsidiary dam for Option B1 will also be affected from such very rare events (less than 1:10,000 AEP).

The current approach by State Water which has been discussed with the various landowners and facilities managers who could be affected, is to consider fair compensation when and if damage / loss occurred. Compensation arising would be in the form agreed to be appropriate by the parties concerned.

Depending on the final option selected and the outcomes of negotiations, some private land may need to be acquired immediately below the subsidiary wall.

5.4 Costs, Finance / Economics & Funding

5.4.1 Capital Cost

The estimated capital costs of the options are shown below in *Table 5.2*. As mentioned previously, this includes estimates for necessary relocation / reinstatement of facilities, but not costs that may be incurred after very large to extreme event which operates the proposed upgrade works.

Table 5.2 Estimated capital costs of options

Option	Estimated capital cost (March 2005) ($ million)
Option B1	56.0
Option D2	62.0
Option D3	67.0
Multi-level offtake	3.0

Assuming of the economic analysis of the options is provided in *Appendix E.2* revised costs and resulting changes to the economic analysis will be presented in the Environmental Assessment report taking into consideration inflation since March 2005, better unit costing / contract pricing from recent similar upgrades and finalisation of environmental assessment requirements.

5.4.2 Finance and Economics

A financial and economic analysis was prepared in accordance with NSW Treasury Guidelines, to investigate the merit of investment in the various upgrade options (Hassall and Associates 2005). The base case adopted was dam failure or no implementation of the proposal, with an assumed average failure frequency of 1:2,800 annual exceedance probability (AEP). By comparison, the performance of each option was considered in the context of the likelihood of occurrence of the probable maximum flood in the order of 1:500,000 AEP. The economic appraisal was undertaken for an assumed period of 100 years, consistent with the design life of the dam infrastructure.

The factors included in the consideration of costs and benefits resulting from dam wall failure included:

- infrastructure, buildings and commerce, including public, commercial and residential buildings, utilities, vehicles, emergency provision (e.g. temporary accommodation)
- social effects, including loss of life, tourism and recreational impacts
- agricultural losses in the year of failure and subsequent years.

The following factors were included as costs and benefits of the implementation of the various project options:

- capital, operating and maintenance costs

- the reinstatement costs of any spillway structures (e.g. release plugs)
- the costs of reprovision of any infrastructure, buildings and commerce potentially affected by inundation associated with the proposed wall raisings
- the benefits resulting from upgrading dam safety (or alternatively, the difference in damage costs between dam wall failure under the probable maximum flood and following implementation of the project options).

The latter item was assessed through comparison of flood mapping. This included consideration of the area of downstream floodwater inundation, floodwater depth and velocity in the region between Keepit Dam and Wee Waa. *Table E.3* presents a summary of the study results.

Table E.3 Financial and economic comparison

Option	Capital cost	Present value of costs	Present value of benefits	Net present value	Ratio of benefits to costs
B1	$56.0 million	$54.9 million	$14.7 million	-$40.2 million	0.268
D2	$62.0 million	$59.8 million	$15.7 million	-$44.1 million	0.263
D3	$67.0 million	$64.1 million	$16.6 million	-$47.6 million	0.258

Source: Hassall and Associates, May 2005

Note: 1. Figures rounded to nearest one hundred thousand

2. A negative net present value indicates there would be no return on investment.

3. A ratio of benefit to costs of less than 1.0 indicates the upgrade is not economically efficient.

For all the options, the project costs were predicted to exceed the project benefits, meaning that the proposed capital investment is not economically efficient. More specifically, while substantial benefits of the proposed upgrade have been identified (i.e. avoided damage costs associated with dam wall failure), these are tempered by the relatively high costs of all of the options and the extremely low/rare likelihood of the very large to extreme floods. Therefore, even a very large economic benefit becomes small relative to the extremely low likelihood of the event occurring. This is not an unusual or unexpected result for projects of this type, where the requirement for upgrade is dominated by the potential for major loss of life and overall catastrophic regional damage and loss, but with a very low likelihood of occurrence. The need to upgrade the dam is not based on economic efficiency measures, but on compliance requirements by the NSW Dams Safety Committee and due diligence.

The results indicate that there is broadly little difference between the benefit to cost ratios for the three short-listed options. The results also indicate that the economic preference for the options is proportional to their capital cost and, therefore, Option B1 would have the highest economic benefit.

The financial (including capital cost of options) and economic assessment will be updated as part of the Environmental Assessment

5.4.3 Funding

Under current Independent Pricing and Regulatory Tribunal (IPART) pricing determinations, funding for the dam safety component of the Keepit Dam Upgrade is to be fully provided by the NSW Government. However funding for environmental upgrade compliance such as the multi-level offtake and any fish passage works is 50 / 50 NSW Government and State Water's Namoi Valley customers.

6. Environmental assessment focus

6.1 Main focus

One of the objectives of Part 3A of the EP&A Act is to facilitate the focused reporting of environmental impacts. In order to produce focused environmental assessment documents, environmental issues that have been addressed through the concept design, are likely to be of minor environmental consequence or can be satisfactorily managed through the application of standard mitigation measures. They may also be addressed through the preparation of a draft Statement of Commitments attached to the Environmental Assessment.

It is proposed that the Environmental Assessment for the proposed Keepit Dam Upgrade will focus on the assessment of key environmental issues (rather than all environmental issues) and those which will distinguish the performance of the options and assist with the selection of a preferred option.

Appendix E provides a preliminary environmental assessment of the incremental impacts associated with the upgrade options. The investigation of the incremental effects acknowledges the impacts caused by the operation of the existing dam infrastructure and distinguishes those which would result from the three short-listed options. These include both environmental benefits and impacts.

Figures E.1 and *E.2* show the incremental extent of upstream and downstream inundation respectively, relative to the baseline level of impact (refer Section 3.2.4) caused by the existing dam.

The incremental upstream impacts are inundation of areas above this baseline level and for each option, and are relative to the height of wall raising proposed.

The baseline relevant to downstream impacts is dam collapse and the hydraulic modeling undertaken for the assessment indicates that all of the upgrade options would significantly reduce the area of inundation downstream of the confluence of the Namoi and Peel Rivers, relative to dam failure. In fact all options would result in some mitigation compared with a PMF if the dam had not been constructed.

Flood inundation and associated impacts from the dam to the confluence of the Namoi and Peel Rivers varies between the options, particularly between Option B1 and Options D2 and D3 when very large floods with a chance of occurrence less than 1:10,000 AEP occur.

Modeling also indicated that the differential effect of the options beyond the confluence of the Namoi and Peel Rivers was estimated to be within the error margin of the hydraulic model and, therefore, no assessment of potential impacts beyond the confluence is considered necessary.

Appendix E indicates the key issues for the upcoming environmental assessment and the other environmental aspects considered. For the other environmental aspects, the Part 3A approvals process allows for their assessment to be brought forward in the approvals process by including preliminary assessment within the Project Application. Further

assessment requirements and mitigations measures would be set out in a draft Statement of Commitments attached to the Environmental Assessment. The draft Statement of Commitments will be developed in consultation with key stakeholders and attached to the Environmental Assessment for public exhibition.

6.2 Further environmental investigations

The preliminary environmental assessment presented in this report (refer to *Appendix E*), the Planning Focus Meeting held in February 2006 and subsequent consultation with key environmental agencies indicate the following key environmental issues would require further detailed consideration as part of the Environmental Assessment of the Keepit Dam Upgrade:

- The inundation of upstream areas above the adopted baseline level and consequent environmental effects, eg. heritage, flora and fauna issues.
- The proposed discharge of floodwaters through new downstream spillways and consequent environmental effects, eg. heritage, flora and fauna issues.
- Differential downstream erosion and sedimentation (and consequent environmental) effects.
- Further assessment on the feasibility and cost effectiveness of a fish lift or other ameliorative measures elsewhere in the catchment, including trade-offs as sought under Section 218 of the *Fisheries Management Act 1994* by Department of Primary Industries.
- A review of the 2002 heritage assessment of Keepit Dam, considered as an item of local heritage significance, in the context of any changes proposed by the upgrade.

The preliminary environmental assessment also indicates that the proposal is unlikely to have significant impacts on all the other environmental aspects. Any impacts could be readily managed through the preparation and implementation of environmental management plans for the construction and operation of the proposal by State Water and its construction contractor. It is proposed that these issues be addressed and managed through the draft Statement of Commitments for the proposal, which would determine the requirements of these environmental management plans.

6.3 Key areas

Subject to the outcomes in *Section 6.2 (Further environmental investigations*) and refinement of existing information, the proposed key areas to be highlighted in the Environmental Assessment are outlined in *Table 6.1* below.

Table 6.1 Proposed key areas of the environmental assessment

Environmental issue	Key highlights
General	
Hydrology	▪ Summarise hydrology of PMF (as per this document) ▪ Document upstream and downstream flood limits of the options
Need and alternatives	▪ Summarise project need and alternatives development process (as per this document)
Stakeholder Consultation	▪ The existing Community Reference Panel and consultation directly with key agencies would be maintained throughout the preparation of the Environmental Assessment. Key issues raised and the responses from the project team would be documented
Statutory context and approvals process	▪ The permissibility and statutory context of the proposal and the approvals process under Part 3A would be documented
Environmental Assessment	
Terrestrial ecology - upstream inundation and between new spillways and receiving waters	▪ Habitat-based assessment combined with targeted field surveys for threatened species and populations in upstream inundation areas ▪ Field investigations and documentation of species within the flow path between new spillways and inundation levels which would otherwise result from dam failure ▪ Description and documentation of potential impacts
Heritage - upstream inundation and between new spillways and receiving waters	▪ A desktop predictive model within the inundated areas based on landforms and topography. ▪ Field truthing of identified sites subject to inundation and additional areas of high potential archaeological significance. ▪ Consultation with aboriginal groups to determine the significance of any finds and mitigation measures required. ▪ Field investigations of flow path between new spillways and inundation levels which would otherwise result from dam failure
Erosion and sedimentation	▪ Establish an panel of experts to review information relevant to the erosion and sedimentation effects of the options resulting from a very large to extreme flood event ▪ Estimate erosion potential and sediment loads mobilised in an extreme flood from the upstream Keepit catchment ▪ Investigate the effect of the storage in controlling and passing sediments downstream ▪ Investigate the incremental effects of Option B1 relative to the other options locally ▪ Consider the regional effects of all options of erosion

Environmental issue	Key highlights
	and sedimentation on various aspects including heritage resources, terrestrial and aquatic flora and fauna, agricultural lands and regional development opportunities
Aquatic ecology	▪ Desktop assessment of likely species in storage and in the Namoi and Peel Rivers between the dam and the confluence of these two rivers. ▪ Focussed field investigations to confirm desktop assessment results ▪ General description of existing Namoi riverine conditions and the improvements resulting from implementation of the multi-level offtake. Information relevant to maximising beneficial outcomes.
Fish lift or other ameliorative measures elsewhere in the catchment including trade-offs	▪ Further assessment and consultation on the feasibility and cost effectiveness of a fish lift at the dam or other measures ▪ Identify potential cost effective options
Keepit Dam heritage assessment	▪ Review the Keepit Dam heritage assessment with respect to the upgrade options proposed
Land use and property (including compensation issues)	▪ Identify all properties likely to be affected as a result of the upgrade and document approach to compensation
Draft Statement of Commitments	▪ Covers all other environmental aspects

7. References

Department of Commerce 2005, *Design Concept for Three Alternative Options for Provision of Multi-Level Offtake Facilities*

Parsons Brinckerhoff 2005, *Preliminary assessment of erosion potential of upgrade options*

Parsons Brinckerhoff 2005, *Draft Keepit Dam Upgrade Options Comparison Report*