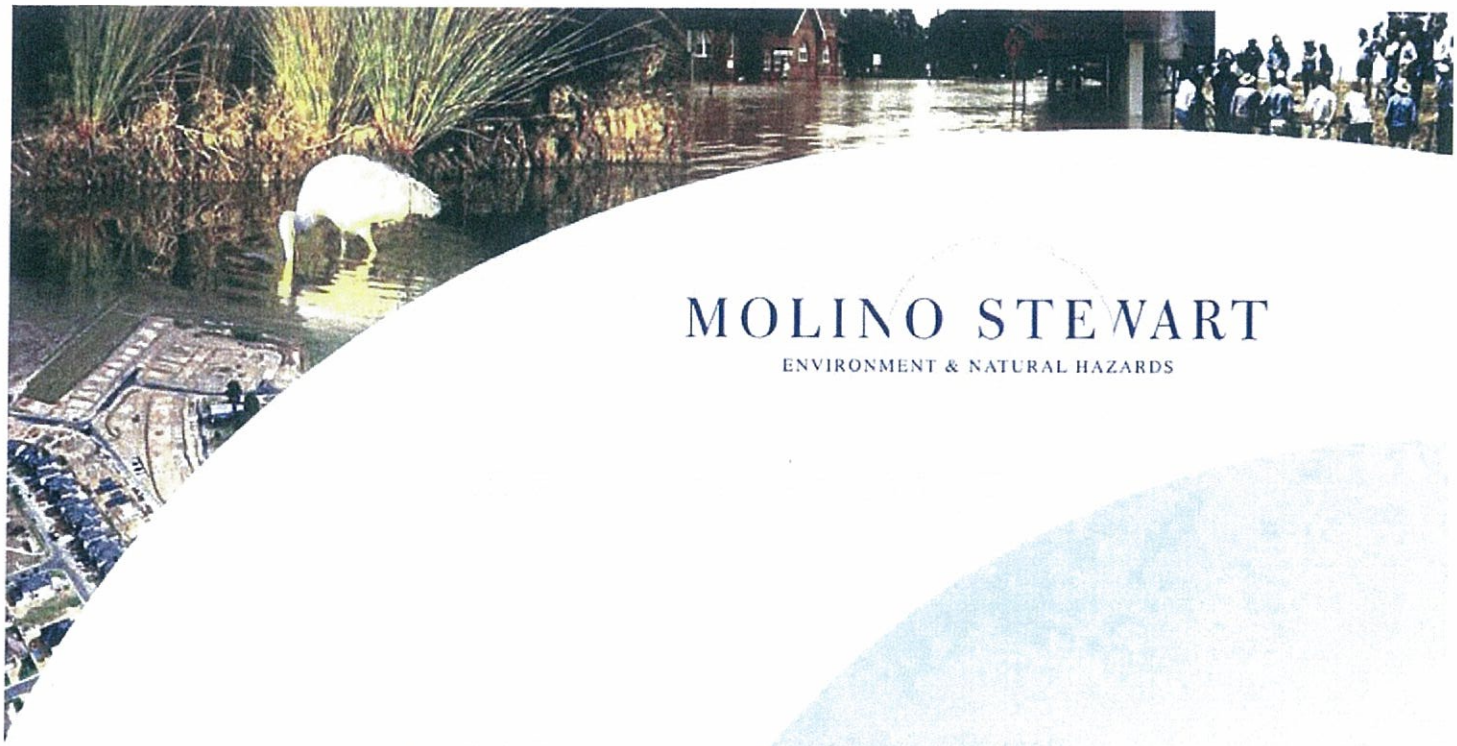

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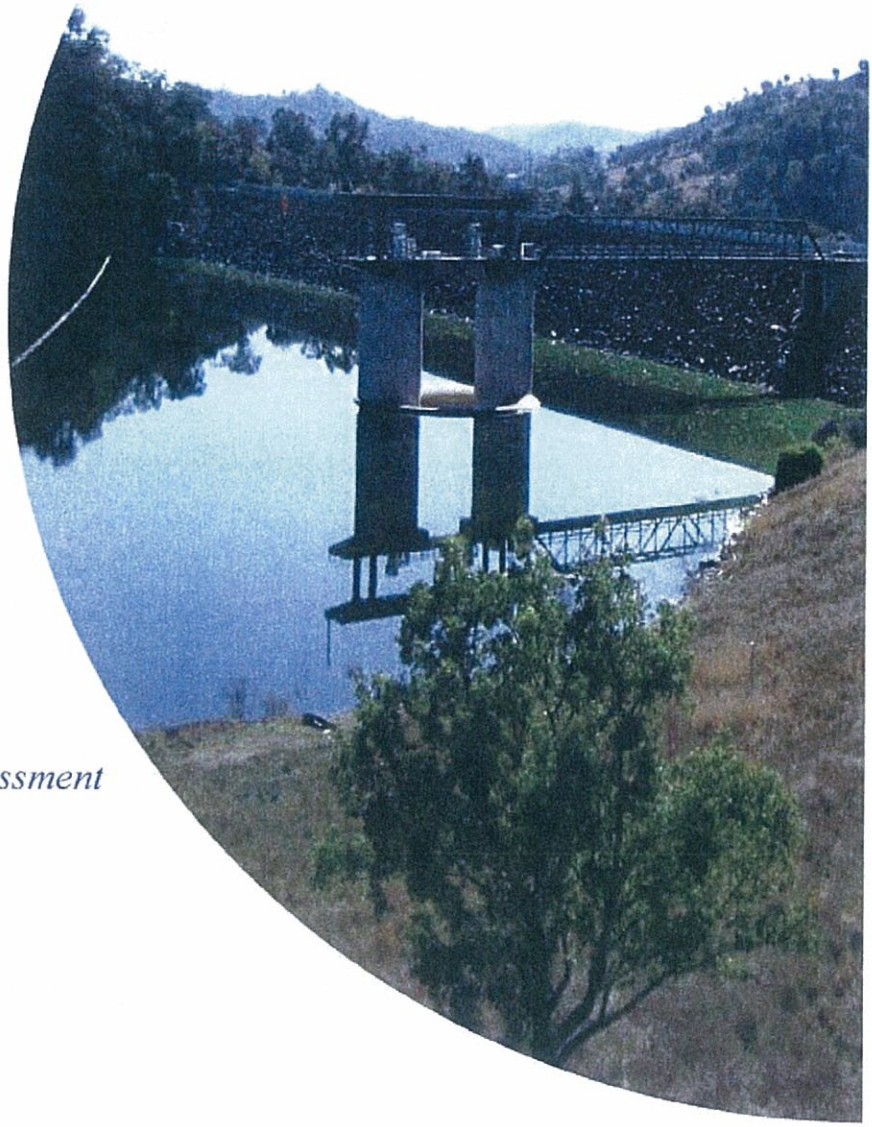
ENVIRONMENT & NATURAL HAZARDS

State water



Chaffey Dam Augmentation

Preliminary Environmental Assessment

MOLINO STEWART

Chaffey Dam Augmentation

PRELIMINARY ENVIRONMENTAL ASSESSMENT

for

State Water

by

Molino Stewart Pty Ltd

ACN 067 774 332

NOVEMBER 2011

MOLINO STEWART PTY LTD ABN 95 571 253 092 ACN 067 774 332
PO BOX 614, PARRAMATTA CBD BC, PARRAMATTA NSW 2124 TEL: (02) 9354 0300 FAX: (02) 9893 9806
www.molinostewart.com.au

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DOCUMENT APPROVAL

For Molino Stewart	
Name	Steven Molino
Position	Principal
For State Water	
Name	Jubrahil Khan
Position	Project Manager

EXECUTIVE SUMMARY

Chaffey Dam is located on the Peel River, approximately 43km by road to the southeast of Tamworth and each year it supplies approximately 9GL of potable town water to Tamworth and approximately 6.6GL of irrigation water to local landholders downstream.

The dam is classified as a high hazard dam because of the potential consequences should the dam fail. To comply with the current Australian National Committee on Large Dams (ANCOLD) and NSW Dams Safety Committee safety standards for high hazard dams, Chaffey Dam needs to pass a probable maximum flood (PMF) if the reservoir were full at the commencement of flooding.

State Water is proposing to increase the dam's storage capacity to provide more water for town and irrigation supplies and the opportunity will be taken as part of those works to provide sufficient freeboard to the dam crest so that the auxiliary spillway can safely pass a PMF.

In 2007 the Federal and NSW Governments announced commitment to fund the augmentation of Chaffey Dam. The Dam Safety Upgrade was to be fully funded by the NSW Government. An assessment into the long term options for the Chaffey Dam upgrades (GHD 2007) and a preliminary environmental assessment (PEA) (GHD 2008) were undertaken for three options. Option 3 was selected and included a dam safety upgrade to full compliance plus augmentation but was dependant on funding. Funding was not immediately available to undertake all works proposed for the safety upgrade. In the interim, works to enable partial compliance with safety standards with the installation of an auxiliary spillway were constructed to immediately improve dam safety and were completed in February 2011.

Since the completion of the PEA by GHD in 2008, further environmental studies at the site include an REF for the spillway and a detailed ecological study of the dam and its foreshores. The Federal and NSW Governments have now made funding available for the augmentation of water supply storage at Chaffey Dam from 62GL to 100GL and so it is proposed to raise the full supply level by 6.5m from 518.6m to 525.1m AHD. To ensure compliance with the Dam Safety Committee's requirements, the effective dam crest will need to be raised by up to 8.4m from 535.3m to 543.7m AHD. In addition the spillways will also need to be modified.

This preliminary environmental assessment undertaken by GHD and subsequent studies indicate that there are potential significant impacts on threatened and endangered species and items of indigenous and non-indigenous heritage.

The most significant ecological impact would be the loss or degradation of upstream environments that form a significant part of the endangered Booroolong Frog habitat. The areas around the dam are also important habitat for a number of other endangered/threatened species or priority species for conservation concern including the Border Thick-tailed Gecko, Speckled Warblers, Carpet Python and the Spotted-tailed Quoll.

Further field assessments and consultation with specialist ecologists is recommended as a guide to further assess whether the proposal is likely to result in a significant impact on other endangered and threatened species.

There are potentially significant heritage impacts arising from the disturbance of indigenous and non-indigenous cultural heritage sites by inundation from the increases in full supply level. Detailed heritage surveys of the proposed inundation area would be required to further describe impacts and allow the identification (and possible relocation) of sites not identified in the current assessment.

State Water intends to lodge an application under Part 5.1 of the EP&A Act for approval to carry out the state significant project.

Given the potential environmental impacts identified in this preliminary environmental assessment it has been determined that the proposal is likely to significantly affect the environment and therefore Director General's Requirements for an Environmental Impact Statement are being sought from the Director General of the Department of Planning and Infrastructure.

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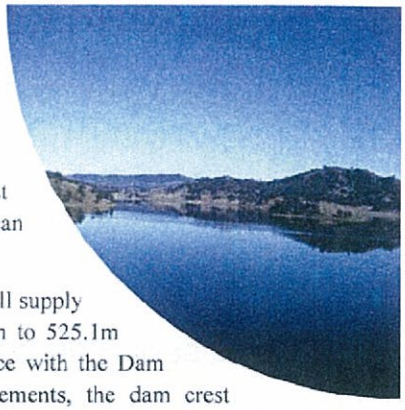


1 BACKGROUND

1.1 OVERVIEW

Chaffey Dam is located on the Peel River, approximately 43km by road to the southeast of Tamworth, via the village of Woolomin (Figure 1) in the Tamworth local government area (LGA).

The existing dam wall structure was constructed between 1976 and 1979, and comprises a 54m high earth and rockfill embankment with a crest length of approximately 430m. A Morning Glory Spillway, is in place which enables excess water to pass through the dam downstream to the Peel River. There is an auxiliary spillway on the left abutment which enables extreme flood flows to pass around the dam.

The dam has a storage volume of 62,000 ML, a reservoir surface area of 542 hectares and has a catchment area of 420 km^2. Each year it supplies approximately 9GL of potable town water to Tamworth and approximately 6.6GL of irrigation water to local landholders downstream.

Chaffey Dam is classified as a high hazard dam because of the potential consequences should the dam fail. To comply with the current Australian National Committee on Large Dams (ANCOLD) and NSW Dams Safety Committee safety standards for high hazard dams, Chaffey Dam needs to pass a probable maximum flood (PMF) if the reservoir were full at the commencement of flooding. At Chaffey the PMF has an estimated annual exceedence probability (AEP) of 1 in 1,000,000.

The morning glory spillway ensures that the dam provides some flood mitigation capacity, however the maximum flood that the dam could withstand was the 1 in 100,000 AEP event.

Recently a precast concrete wall was built along the dam crest and an auxiliary spillway put in place to ensure that it meets the requirements for a 1 in 470,000 flood. The auxiliary spillway has an earth and rockfill fuse plug embankment which is designed to fail in the event of an extreme flood. This directs the flood waters back to the Peel River, avoiding overtopping of the dam wall.

State Water is proposing to increase the dam's storage capacity to provide more water for town and irrigation supplies and the opportunity will be taken as part of those works to provide sufficient freeboard to the dam crest that the auxiliary spillway can safely pass a PMF.

It is proposed to raise the full supply level by 6.5m from 518.6m to 525.1m AHD. To ensure compliance with the Dam Safety Committee's requirements, the dam crest will need to be raised. Currently the dam crest is at 533.5m AHD and has a 1.8m parapet wall on top which gives an effective crest level of 535.3m AHD. The effective dam crest level will need to be raised by up to 8.4m to 543.7m AHD. In addition the spillways will also need to be modified.

1.2 PROJECT DEVELOPMENT HISTORY

State Water embarked on the Chaffey Dam Upgrade Program in 2003. The aim of the Program is to meet current safety standards for extreme flood and, potentially, to meet other desired outcomes such as improved water supply reliability.

The Chaffey Dam Upgrade Program includes identification of key flooding and augmentation issues, the development of potential options and preparation of environmental impact assessments.

Chaffey Dam provides major water supply storage for the Tamworth local government area. Concern has been expressed from the local community into the future reliability of supplies to Tamworth and Peel Valley irrigators as demands grow and as they have become more aware of the impacts of severe drought conditions.

Future demand and supply of water in Tamworth and the Peel Valley were assessed by GHD (2007) and Hunter Water Australia (2005). These studies considered water conservation measures, potential impacts from climate change, and future urban and rural water consumption needs.

The studies indicated that an augmentation of Chaffey Dam to 100 GL (from its current 62GL) would appropriately meet the future demand and supply needs of Tamworth and Peel Valley irrigators.

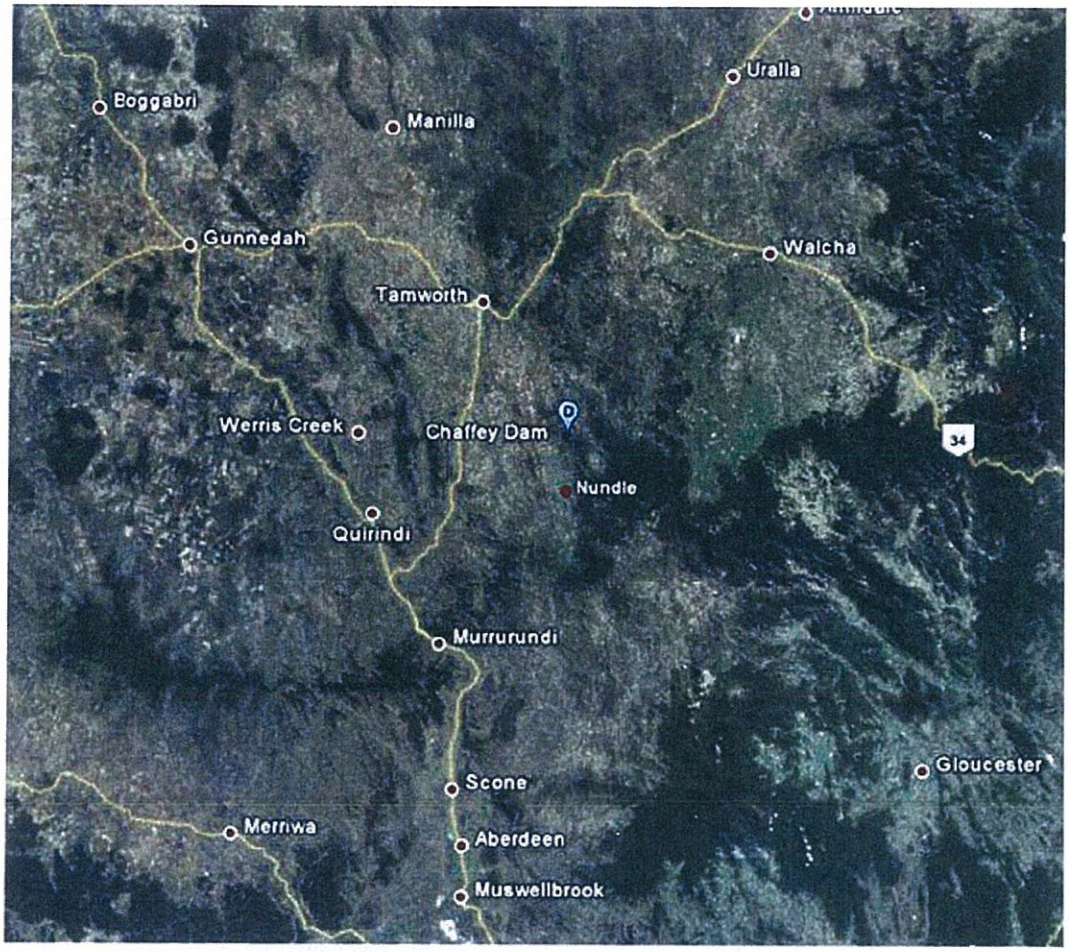


Figure 1: Location of Chaffey Dam (blue marker)

State Water completed interim works in July 2005 to increase the protection of the dam and downstream communities from very large floods, while long-term options to protect against extreme flooding were investigated. The interim works involved installation of a 467 metre long, 1.8 metre high parapet wall along the crest of the main embankment. This improved the safety of the dam, enabling floods with an AEP of 1 in 100,000 to be passed. However, this still fell significantly short of the ANCOLD and NSW Dams Safety Committee safety standards. An early warning system with alarm sirens at Woolomin was also installed as part of the interim safety measures for Chaffey Dam.

In 2007 the Federal and NSW Governments announced commitment to fund the Augmentation of Chaffey Dam. The Dam Safety Upgrade was to be fully funded by the NSW Government. The project was assessed to be subject to approval under Part 3A of the NSW

Environment Protection and Assessment Act 1979.

An assessment to identify the long term options for the Chaffey Dam upgrades (GHD 2007) and a preliminary environmental assessment (PEA) (GHD 2008) were undertaken for three upgrade options. These included:

Option 1 - Dam safety upgrade partial compliance (works – auxiliary spillway);

Option 2 - Dam safety upgrade full compliance (works – auxiliary spillway plus dam wall raising – no impact on full supply level); and

Option 3 - Dam safety upgrade full compliance plus augmentation (works –

auxiliary spillway, dam wall raising plus other works to increase supply storage capacity).

A risk based cost estimate for upgrade options was completed in 2008, defining the distribution of the possible ranges in the total project cost for the three preferred options that included augmentation of Chaffey Dam with full safety Upgrade. The base estimates were prepared from first principles on an indicative construction method. A workshop was held to quantify the inherent and contingent risks associated with the project and a Monte Carlo analysis was carried out to quantify the risk based cost probability distribution. Escalation cost during the life of the project was also estimated.

Following the development of a manageable set of options, the study on the need for augmentation and the results of the economic analysis (GHD, 2008), Option 3 was found to be the best performing full safety upgrade and augmentation option. Construction was dependent upon funds, and by 2009 the funds committed by the Federal and NSW Governments in 2007 for augmentation had not been made available to State Water Corporation, For this reason, Option 1 was constructed to immediately improve dam safety. This involved construction of a 35 m wide spillway with a 4.5 m high fuseplug. These works commenced in April 2010 and were completed in February 2011.

Since the completion of the PEA in 2008, a detailed flora and fauna impact assessment for the upgrade options has been completed (NWES, 2009) as well as a Review of Environmental Factors (REF) for the construction of the auxiliary spillway (Molino Stewart, 2009).

The NWES report identified and addressed information gaps in the original GHD report. This was done by reviewing the original PEA, undertaking detailed flora and fauna surveys, and preparing assessments for threatened species in accordance with the requirements of s5A of the Environmental Planning and Assessment Act 1979, Threatened Species Conservation Act 1995 and Environment Protection and Biodiversity Conservation Act 1999.

The REF was completed in 2009 and provided a comprehensive assessment of projected environmental impacts associated with construction and operation of the auxiliary spillway, as well as various management options to minimise impacts. These include offset strategies such as the development of a wildlife corridor and weed management plan. These activities have been underway since 2010 to mitigate the ecological impacts of construction.

The Federal and NSW Governments have now made funding available for the complete Chaffey Dam Safety Upgrade and Augmentation therefore completion of Option 3 is now proposed.

1.3 COMMUNITY CONSULTATION

The Chaffey Dam Upgrade Community Reference Panel was established to ensure that the people of the Peel Valley would be actively involved in the major upgrade project at Chaffey Dam. State Water relies on the panel to provide key advice on how best to approach the community to gather input and provide feedback into the project.

Formed in 2003, the Community Reference Panel meets regularly to understand the project and provide advice to assist with project management decisions. From the local viewpoint, the panel gives direction on the potential local and regional social, economic and environmental effects of the project.

The Community Reference Panel is made up of representatives from

local community groups;

individual members of the public;

special interest groups; and

local, state and federal government agencies.

(See Appendix B)

1.4 PROJECT JUSTIFICATION

There are three key reasons that the upgrade works are justified:

1. Dam safety to the PMF
2. Augment the irrigation supply
3. Augment town water supply

Based on current flood analysis, Chaffey Dam is sufficient to pass floods with an annual exceedence probability (AEP) of 1 in 470,000. To comply with the current Australian National Committee on Large Dams (ANCOLD) and NSW Dams Safety Committee safety standards for extreme floods, Chaffey Dam needs to pass floods with an AEP of

1 in 1,000,000 (the probable maximum flood) with the reservoir full.

Under the Dam Safety Committee's guidelines (DSC 11 'Acceptable Flood Capacity for Dams'), Chaffey Dam is classified as an extreme consequence category dam.

The small town of Woolomin has a population of approximately 100 people and is located directly downstream of Chaffey Dam on the Namoi River. If the dam wall were to fail it is reasonable to expect that there could be some loss of life due to the resultant floodwater.

Numerous towns and villages and rich agricultural country also surround the city of Tamworth. Agricultural produce includes beef, sheep, poultry, fish, summer and winter crops, cotton, dairying, eggs, fruit, vegetables and vineyards. These areas and industries would be severely threatened by the failure of the dam wall.

Population growth and expansion of city centres is putting increased pressures on town water supply. Irrigation demand is also growing and the local community have expressed concerns over potential future drought conditions from climatic cycles (such as during El Nino years) and also from potential longer term climate change which predicts less rainfall and increased temperatures for inland areas (CSIRO, 2007).

The augmentation of the dam will adequately secure both town water and irrigation supply for the local communities to ensure future economic growth and resident's livelihoods are not threatened.

1.5 PURPOSE AND STRUCTURE OF THIS DOCUMENT

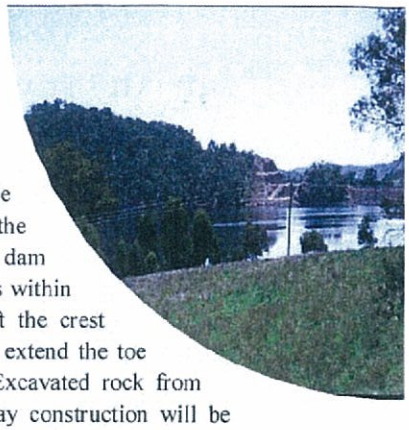
This preliminary environmental assessment (PEA) report has been prepared to support an application to the Director-General of the Department of Planning and Infrastructure (DPI) under the Environmental Planning and Assessment Act (EP&A Act) for Director General's requirements for an Environmental Impact Statement (EIS).

To this end, the PEA is a desk top analysis of available information about the study area, supported by discussions with appropriate State Water staff to verify desktop studies, the construction processes and to identify any other potential issues.

The report:

- Describes the project (Chapter 2) and the existing environment (Chapter 4)
- Discusses the legislative requirements and approvals needed (Chapter 3)
- Outlines the findings of a preliminary environmental assessment of construction and operation (Chapter 5 and 6)
- Outlines the environmental management measures proposed to be adopted (Chapter 7)
- Identifies the proposed scope of the subsequent environmental assessment for the project (Chapter 7)

While this PEA has relied on information from available reports and databases, more detailed and comprehensive environmental assessments will be undertaken as part of the investigations for the detailed design and EIS preparation which will reflect a clearer knowledge of the proposed works and the Director General's requirements for the EIS.



2 DESCRIPTION OF THE PROJECT

2.1 OVERVIEW

The proposed works include a dam safety upgrade to full compliance with DSC requirements plus augmentation of the dam's water supply storage. The works would augment the storage capacity from 62 GL to 100 GL and improve flood safety from 1 in 470,000 AEP event to 1 in 1,000,000 AEP event.

For the purpose of this report, the 'study area' includes

- the areas in the immediate vicinity of the dam wall which will be impacted by construction works
- upstream areas which will be frequently inundated up to the new reservoir full supply level
- upstream areas which will be occasionally inundated by flooding above the full supply level up to and including the PMF (*Figure 4*)
- downstream areas of the Peel River affected by dam releases and flood flows through the dam.

Small amounts of privately owned land would be affected by inundation and will require purchase by State Water (*Figure 5*).

2.2 PRINCIPAL COMPONENTS OF THE PROJECT

To complete the augmentation, three key tasks will need to be undertaken:

2.2.1 Raise the Dam Wall

To raise the full supply level by 6.5m the dam crest itself needs to be raised by up to 8.4m which will provide a total freeboard of 18.62m metres. Raising the dam wall to accommodate the increased storage of water will result in an increase in the permanent and flood inundation areas upstream of the dam.

Works include increasing the height of the dam wall by 10.2m with compacted earth and rockfill material on the top of the dam wall and on the downstream face of the dam wall. This will avoid works within the reservoir but will shift the crest centreline downstream and extend the toe of the dam downstream. Excavated rock from the recent auxiliary spillway construction will be utilised.

Key components of this task will include:

- Dismantling and removing the existing 1.8 metre high concrete parapet wall panels.
- Reconstructing the top part of the existing embankment to extend the central impervious clay core and the filter zones to the new embankment crest level. The clay is to be sourced from an area adjacent to the existing stockpile area (shown in Figure 2).
- Placing rockfill materials on top of the existing embankment to increase the crest level of the embankment by 10.2m
- Removing the existing unconsolidated fill materials along the downstream toe of the embankment to expose the buried part of the downstream toe and the original dam foundation.
- Treating and compacting the downstream toe and dam foundation.
- Placing new rockfill materials over the downstream face of the existing embankment. The rockfill material (excavated rock from the auxiliary spillway construction) is to be sourced from the existing stockpile areas shown in Figure 2.
- Disposing of unsuitable excavated materials in the existing stockpile area/spoil disposal area shown in Figure 2.

2.2.2 Modify the existing spillways

The Morning Glory spillway will have to be raised 6.5m to align with the new full supply level. The existing auxiliary spillway will also have to be modified to cope with the increased water levels, by either raising the top of the existing fuse plug and building a weir in the spillway floor or by partitioning the spillway and creating two fuse plugs of varying heights to control the amount of water being released downstream.

Key components of this task will include:

Raising the sill level of the existing morning glory spillway from 518.6m AHD to 525.1m AHD in order to augment the storage to 100 GL.

Raising the height of the intake tower by 8.42 metres to match the new crest level of the embankment dam.

Modifying the access bridge for the intake tower by raising it by 8.42 metres to 541.92m AHD to match the raised entrance level of the intake tower and the new embankment crest level.

Constructing an 18 metre long extension bridge to connect the existing bridge to the raised embankment crest.

Installing a flood gate across the concrete parapet wall to provide access to the raised bridge.

Extending the outlet tunnel of the intake tower by 9 metres

Constructing a new two bay fuse plug embankment with a sill level at 525.5m AHD at the current fuseplug location.

2.2.3 Modification of other infrastructure

Nundle Road (and its bridge) and Western Foreshore Road will be re-aligned and/or raised to ensure they are not blocked by storage water or flood water inundation. This may involve the purchase of private property should the routes need to be significantly altered. A number of smaller access roads to community facilities may also have to be re-aligned if they fall within the inundation area. Parts of the Tamworth Fishing Club facilities and the Bowling Alley Point Recreation Area will also need to be relocated. The roads and community facilities are shown in Figure 7.

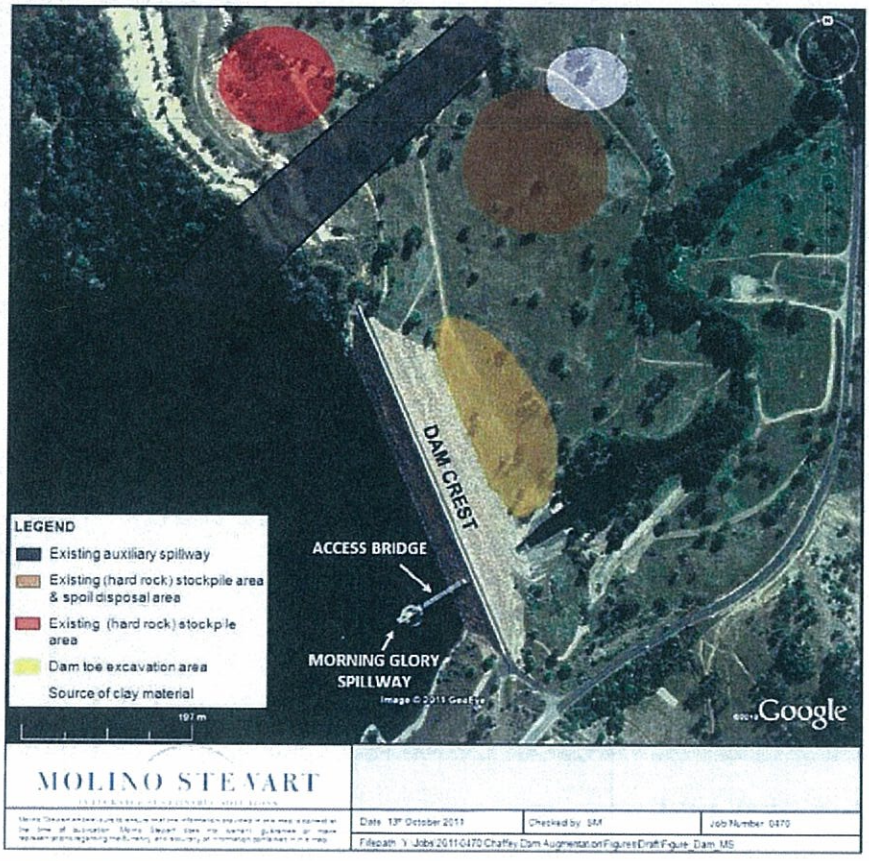


Figure 2: Proposed construction areas around dam wall

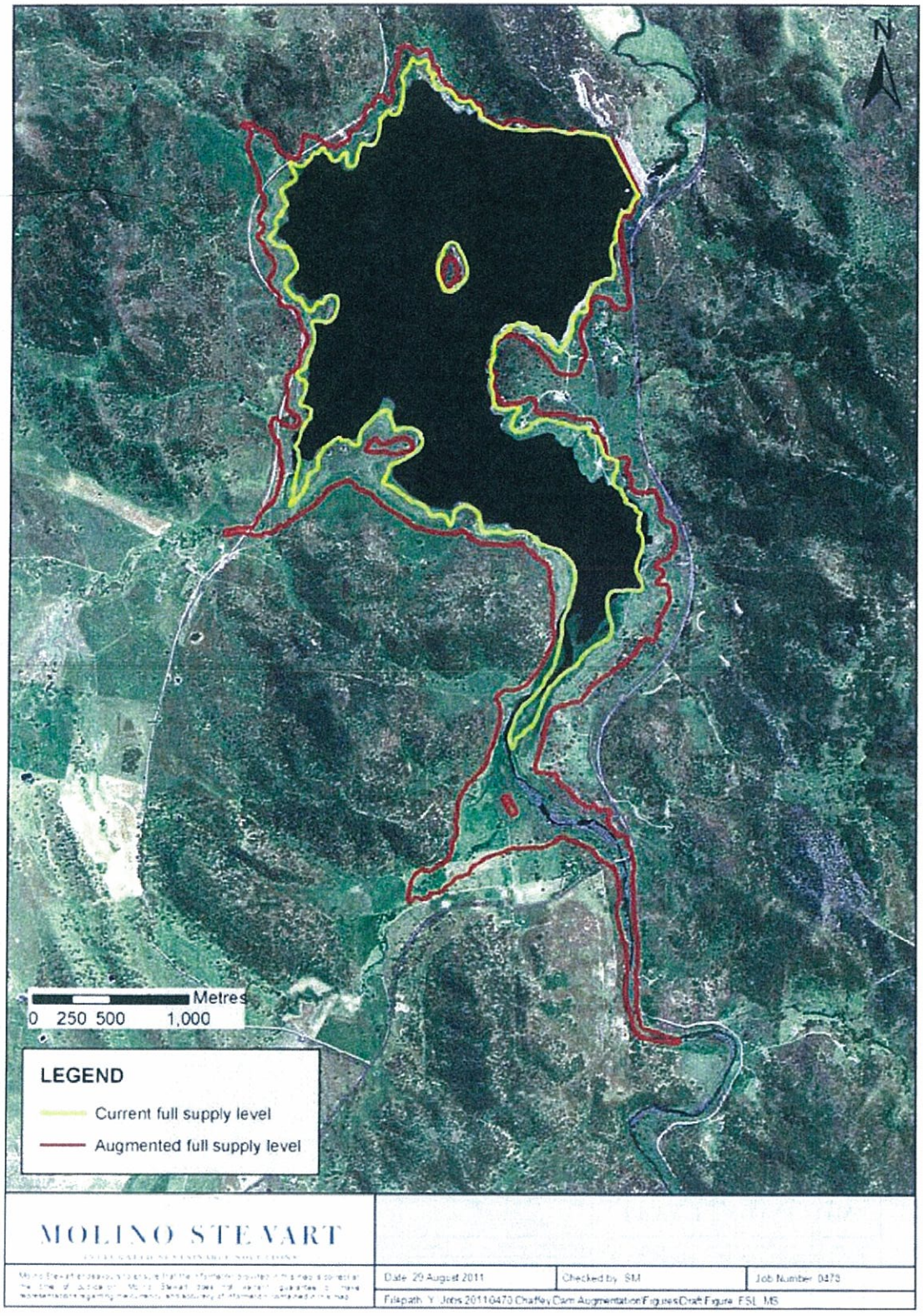


Figure 3: Current and new full supply level

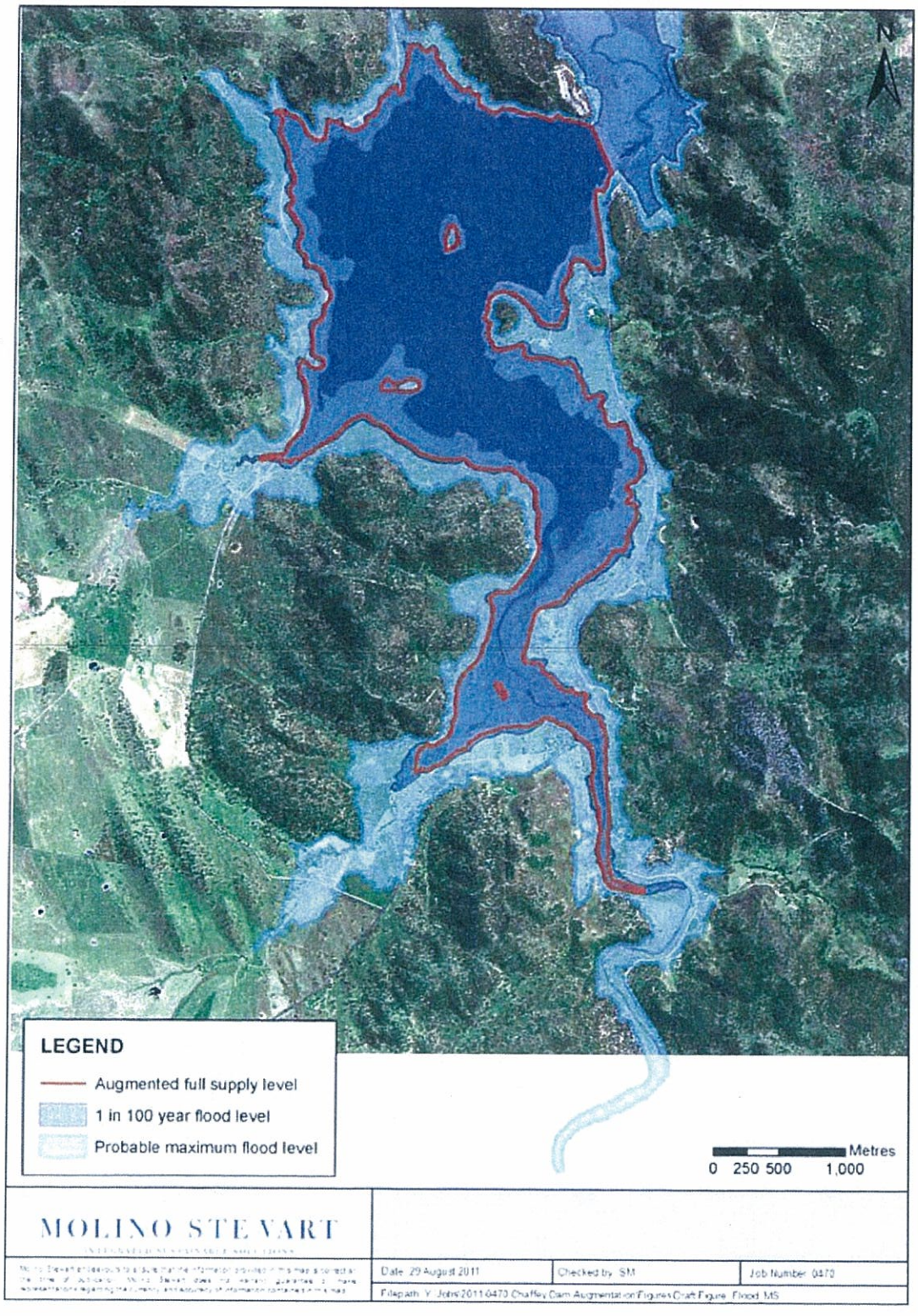


Figure 4: Possible flood levels (1% AEP and PMF)

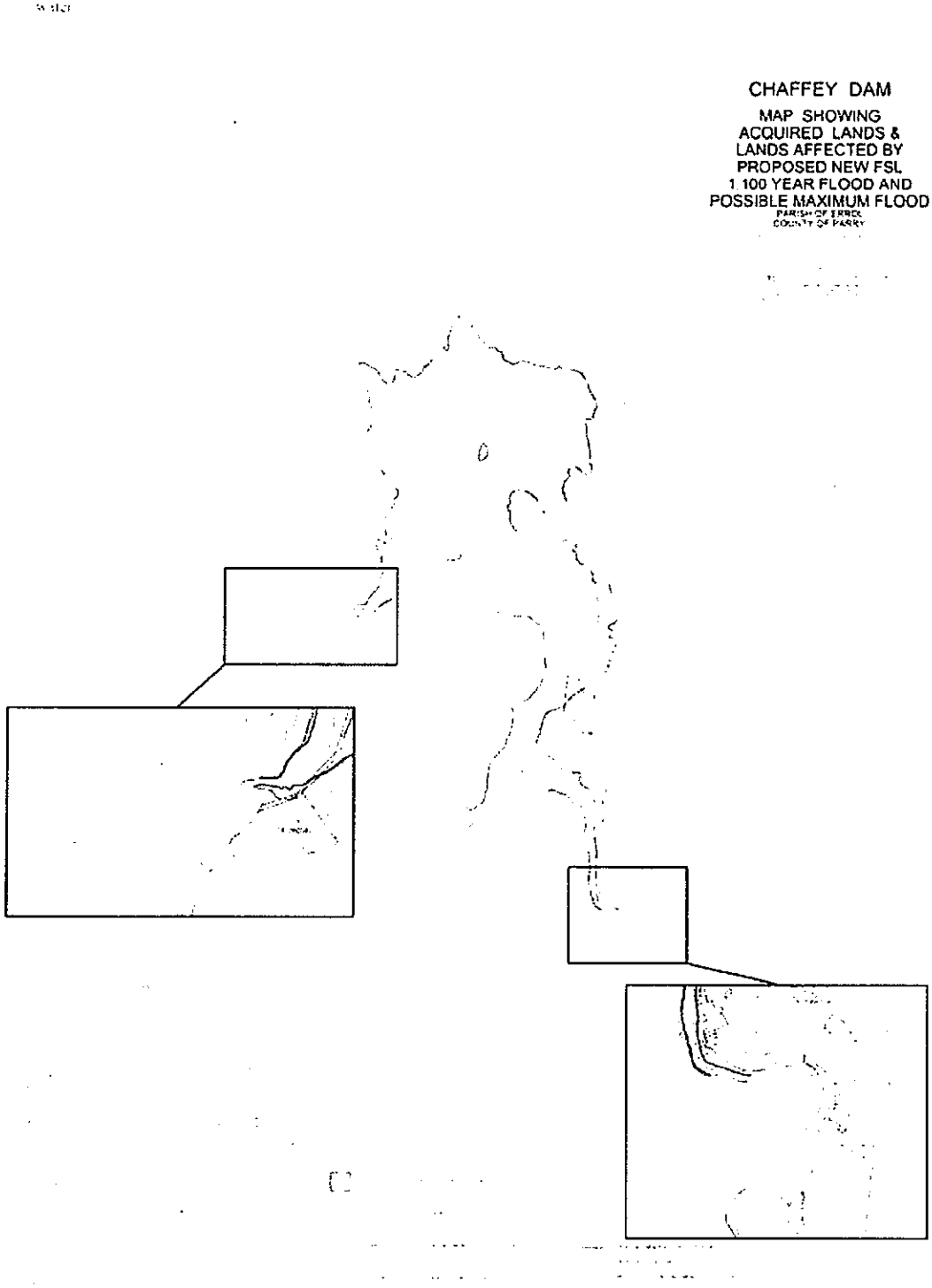


Figure 5: Private land affected by inundation

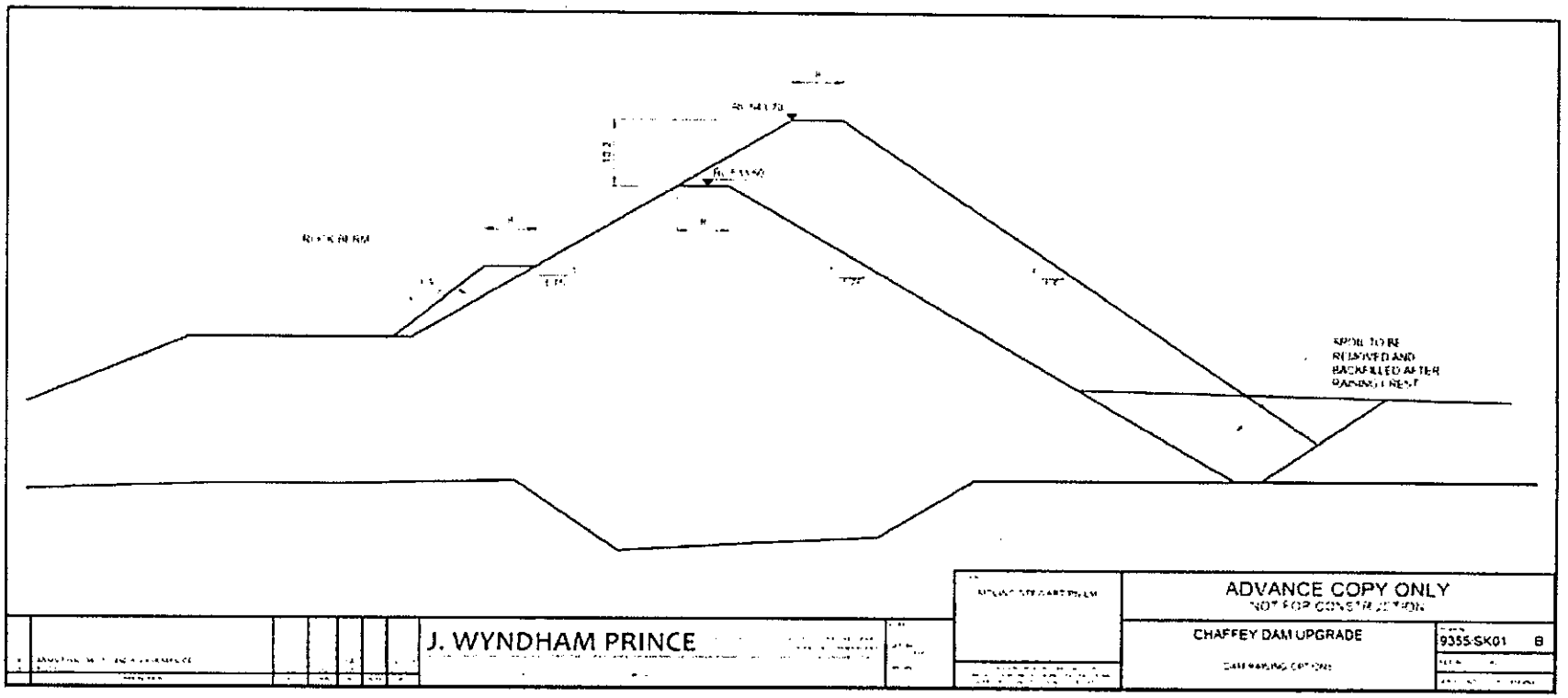


Figure 6: Dam Raising Drawing

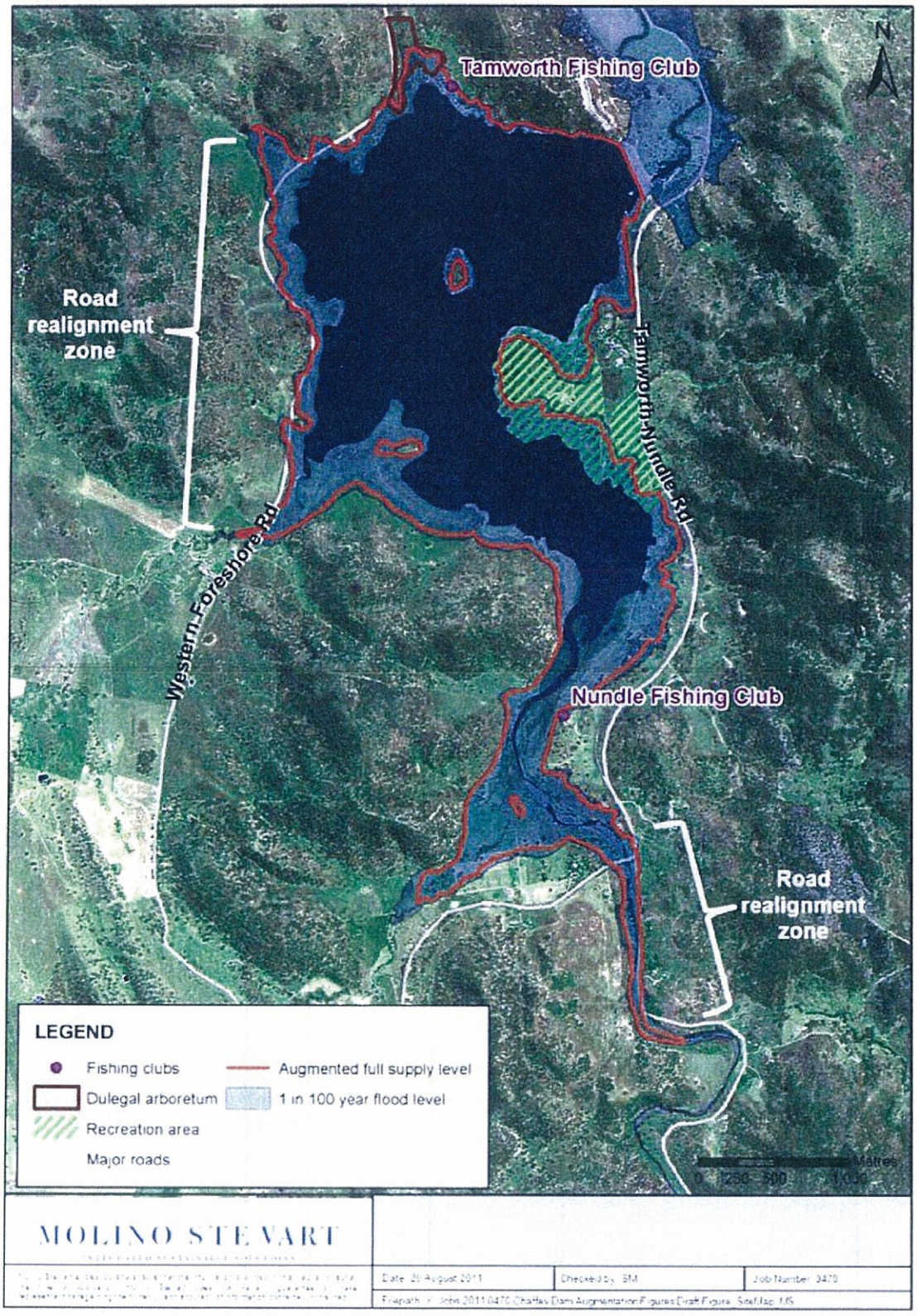


Figure 7: Location of roads and community facilities

2.3 COSTS AND TIMELINES

The project is expected to have a construction cost of approximately $42 million.

Construction is expected to take approximately two and a half years to complete.

A risk based cost estimate for upgrade options was completed in 2008, defining the distribution of the possible ranges in the total project cost for the three preferred options that included augmentation of Chaffey Dam with full safety Upgrade. The base estimates were prepared from first principles on an indicative construction method. A workshop was held to quantify the inherent and contingent risks associated with the project and a Monte Carlo analysis was carried out to quantify the risk based cost probability distribution. Escalation cost during the life of the project was also estimated.

2.4 FUTURE OPERATION OF THE DAM

The dam currently has a storage capacity of 62 GL. Approximately 15.6 GL is used per year, of this 9GL is used for water supply to Tamworth and irrigators use the remainder downstream on the Peel River.

Currently, irrigation and town water supplies are released from the dam via a multi-level offtake which discharges through an outlet structure at the base of the dam and into the Peel River. The augmented dam will operate in exactly the same way except the extension to the offtake tower will enable discharges from the additional higher levels of the storage. The multi-level offtake allows the operators to be selective about the temperature and quality of the water which is released.

The size of the outlet structure will not be increased so the maximum release flow rate will remain the same. However, the frequency of water supply releases will increase.

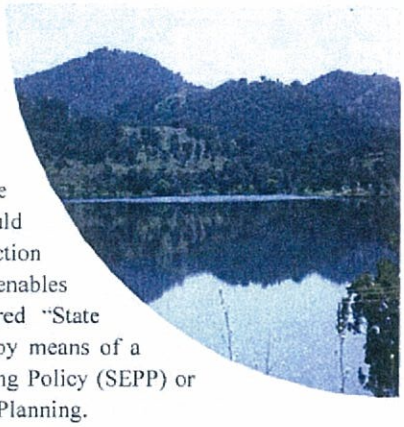
When the dam exceeds full supply level, water flows unimpeded through the morning glory spillway. Once the spillway is flowing at capacity, any additional increase in water level in the reservoir will not increase the outflows through the morning glory spillway. This outflow capping means that the morning glory spillway limits dam outflows to a maximum rate until the auxiliary spillway operates and in so doing provides significant flood mitigation benefits. The raised morning glory spillway will have the same maximum outflow capacity as the current dam. The increase in the volume of controlled water supply flows from the dam will be matched by a reduction in the size and frequency of uncontrolled flows through the morning glory spillway.

Currently for floods larger than the 1 in 10,000 AEP event the 4.5 metre high fuse plug embankment across the auxiliary spillway is overtopped and washed away by the floodwater, as is intended. By the water being discharged through the auxiliary spillway, a significant and rapid increase in the flood discharge capacity of the dam results in effectively limiting the rate of the rise of water in the storage. The fuse plug is so-called due to the sacrificial nature of the small embankment.

With the proposed works undertaken, during a flood, the reservoir would start to overflow via the raised morning glory spillway when the reservoir level rises above 525.1m AHD.

As the reservoir level continues to rise to above 534.7m AHD, water would overtop the fuse plug embankment. The fuse plug embankment would be completely eroded by the scouring action of water.

The reconfiguration of the fuse plug within the spillway will be designed so that the outflows from the auxiliary spillway will be as they are under the current auxiliary spillway for floods up to the 1 in 10,000 AEP event. This may have to be achieved by partitioning the spillway into two or more fuse plug bays with different trigger levels.



3 LEGISLATIVE CONSIDERATIONS

3.1 DAM SAFETY ACT

The NSW Dams Safety Committee (DSC) was constituted by the NSW Government under the *NSW Dams Safety Act 1978* to ensure the safety of dams in NSW

The role of the DSC is to:

> Protect the safety, welfare and interests of the community from dam failure by ensuring that risks from prescribed dams are tolerable;
>
> Ensure that DSC requirements are met, that risk are regularly reviewed, and further reduced if reasonably practicable; and
>
> Protect the security of dams and their stored waters from the effects of mining or other activities.

To undertake these roles the DSC is empowered with various enabling functions under the *NSW Dams Safety Act 1978*. This includes directing owners of dams to upgrade dams to meet current safety standards.

Chaffey Dam is ranked by the DSC as being in the "extreme" hazard category, which is based on the population at risk and the severity of damage and loss that would result from dam failure. In terms of the ANCOLD guidelines and DSC risk framework, the dam failure risks at Chaffey Dam are considered to be intolerable and therefore the DSC has directed State Water to improve the safety of the dam. The proposed augmentation will provide the opportunity to bring the dam up to an acceptable level of risk.

3.2 ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

The EP&A Act provides a framework for environmental planning and assessment in NSW. Recent amendments to the Act repealed the previous Part 3A of the Act and introduced Part 5.1 to provide an assessment and approval process for state significant infrastructure projects.

The Act defines infrastructure to include, amongst other things, "water supply systems" and "flood mitigation works". The proposed augmentation would fit both definitions. Section 115U of the Act enables infrastructure to be declared "State Significant Infrastructure" by means of a State Environmental Planning Policy (SEPP) or by order of the Minister for Planning.

State Significant Infrastructure can only proceed with the approval of the Minister who must require that an environmental impact statement (EIS) be prepared.

The Director General (Department of Planning and Infrastructure) issues Director General's requirements setting out the requirements for the EIS.

State Water intends to lodge an application under Part 5.1 of the EP&A Act for approval to carry out the project.

According to Section 115ZG of the EP&A Act, the following authorisations are not required for approved State Significant Infrastructure:

'(a) the concurrence under Part 3 of the Coastal Protection Act 1979 of the Minister administering that Part of the Act,

(b) a permit under section 201, 205 or 219 of the Fisheries Management Act 1994,

(c) an approval under Part 4, or an excavation permit under section 139, of the Heritage Act 1977,

(d) an Aboriginal heritage impact permit under section 90 of the National Parks and Wildlife Act 1974,

(e) an authorisation referred to in section 12 of the Native Vegetation Act 2003 (or under any Act to be repealed by that Act) to clear native vegetation or State protected land,

(g) a bush fire safety authority under section 100B of the Rural Fires Act 1997,

(h) a water use approval under section 89, a water management work approval under section 90 or an activity approval (other than an aquifer interference approval) under section 91 of the Water Management Act 2000.'

Also Division 8 of Part 6 of the Heritage Act, 1977 does not apply to prevent or interfere with the carrying out of approved State Significant Infrastructure.

Under Section 115ZH of the EP&A Act, the following authorisations cannot be refused if it is necessary for carrying out approved State Significant Infrastructure and is to be substantially consistent with the approval under this part:

> An environment protection licence under Chapter 3 of the *Protection of the Environment Operations Act 1997*; and
>
> A consent under s138 of the *Roads Act 1993*

amongst other things.

3.3 STATE ENVIRONMENTAL PLANNING POLICIES

State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP) was made on 1 October 2011. The SEPP declares certain types of development and infrastructure to be of State and regional significance.

This SEPP lists those infrastructure projects which are intended to be classified as State Significant infrastructure.

Schedule 3 of the SEPP includes

> (1)Development for the purpose of water storage and water treatment facilities (not including desalination plants) carried out by or on behalf of a public authority that has a capital investment value of more than $30 million.

The proposed augmentation works are to be carried out by a public authority (State Water) and will have a capital investment value or more than $30 million.

The SEPP also requires that the works be permissible without development consent under Part 4 of the Environmental Planning and Assessment Act.

State Environmental Planning Policy (Infrastructure) 2007 states that development for the purposes of water storage facilities is permissible without consent in several zones including RU1 Primary Production.

The proposed works would be undertaken on land zoned 1(a) (Rural 'A') in the Nundle Local Environmental Plan 2000 which is equivalent to the RU1 Zone. The works are permissible in this zone.

State Environmental Planning Policy No. 44 – Koala Habitat Protection (SEPP 44) aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas.

SEPP 44 applies to local government areas listed in Schedule 1. Nundle LGA is included in Schedule 1; therefore consideration of the potential application of SEPP 44 is required. Only two koala feed trees listed on Schedule 2 of SEPP 44 were identified – planted River Red Gum on the eastern foreshore of Chaffey Dam and White Box on the upper hills outside the study area. The SEPP 44 screening assessment concluded that koala tree species, as listed in Schedule 2 of SEPP 44, did not represent at least 15% of the total number of trees in the upper or lower strata of the tree component. As a result, the habitat is not considered to be core koala habitat, and no further consideration was given to SEPP 44.

3.4 OTHER RELEVANT NSW LEGISLATION

3.4.1 Threatened Species Conservation Act

The *Threatened Species Conservation Act 1995* (TSC Act) provides for the protection of threatened species, populations, endangered ecological communities and critical habitats and the identification and assessment of key threatening processes. In relation to development assessment, the provisions of the TSC Act have been integrated into the EP&A Act.

Section 5A of the EP&A Act requires that the assessment of all developments include consideration of whether the proposal is likely to impact on threatened species, populations or ecological communities. It establishes seven factors on which this assessment must be based (the 'Seven Part Test'). Where a significant impact is considered likely, a Species Impact Statement (SIS) must be prepared.

The potential impact of the proposal on threatened species and communities has been assessed and concludes that the proposal may have a significant impact on the endangered Booroolong Frog. Further field assessments and consultation with specialists are required before a conclusive

assessment of whether the proposal is likely to result in a significant impact on a species listed on the TSC Act can be made.

Under Section 91 of the TSC Act, the Director-General may grant a licence authorising a person to take action likely to result in harm to any animal that is of, or is part of, a threatened species, population or ecological community.

As the proposal may result in harm to the listed threatened species, a Section 91 licence may be required.

3.4.2 Fisheries Management Act

The *Fisheries Management Act 1994* (FM Act) applies to all waters within the limits of the State, except where Commonwealth legislation applies.

Under Section 218 of the Act, State Water is required to consult DPI Fisheries if it alters or modifies a dam. The proposal therefore is required to be referred to DPI Fisheries.

Section 218 of the Fisheries Management Act 1994 (Fishways to be provided in construction of dams and weirs) states that "a public authority that proposes to construct, alter or modify a dam, weir or reservoir on a waterway must, if the Minister so requests, include as a part of the works for the dam, weir or reservoir, or for its alteration or modification, a suitable fishway or fish by-pass".

The intent of Section 218 of the *FMA 1994* is to allow for the installation of a fishway to mitigate the impact of the weir or dam on fish migration where possible.

State Water previously consulted with the Department of Primary Industries regarding the requirement to install a fishway at Chaffey Dam during the earlier safety upgrade works and received formal notification that stated:

"NSW DPI does not recommend the capacity for a fishway be investigated and incorporated into the Chaffey Dam Safety Upgrade Project".

The letter from DPI is contained in Appendix A.

3.4.3 Protection of the Environment Operations Act

The *Protection of the Environment Operations Act, 1997* (POEO Act) is the primary piece of legislation regulating pollution control and waste disposal in NSW and is administered by the Office of Environment and Heritage (OEH).

The proposed works will be carried out with appropriate mitigation measures in place so that air, water and noise pollution will be minimal.

Scheduled activities (as defined in Schedule 1 of the Act) require an Environment Protection Licence (EPL), as does development which is proposed to be carried out which would enable scheduled activities to occur.

The Schedule refers to "extractive industries" (this is the only activity in the Schedule with the potential to apply to this project) as follows:

Extractive activities

(1) This clause applies to the following activities:

"land-based extractive activity", meaning the extraction, processing or storage of extractive materials, either for sale or re-use, by means of excavation, blasting, tunnelling, quarrying or other such land-based methods.

(2) In this clause, "extractive materials" means clay, sand, soil, stone, gravel, rock, sandstone or similar substances that are not minerals within the meaning of the Mining Act 1992 .

(3) Each activity referred to in Column 1 of the Table to this clause is declared to be a scheduled activity if it meets the criteria set out in Column 2 of that Table.

Table 1: Schedule 1 Extractive Activities definitions

Activity	**Criteria**
Land-based extractive activity	Involves the extraction, processing or storage of more than 30,000 tonnes per year of extractive materials

The proposed works, will involve the placement of approximately 400,000 cubic meters of rock fill. This will be sourced from rock excavated during construction of the auxiliary spillway and stockpiled on site. As stated in Table 1, works which involve the extraction of more than 30,000 cubic metres of extractive material for sale or for re-use for other purposes require an EPL. The

proposed works constitute a scheduled activity and therefore an environmental protection licence is required.

3.4.4 Water Management Act

The *Water Management Act 2000* (*WM Act*) is administered by the Office of Water in the Department of Primary Industries. The operation of Chaffey Dam is licensed under the *WM Act*.

Under the Act there are three kinds of water management works approvals including water supply work approvals which authorise the holder to construct and use a water supply work.

It is an offence to construct or use these things without approval and an application for approval would normally need to be made to the Minister.

However, Section 115ZG of the amended EP&A Act specifies that these authorisations are not required for approved State Significant Infrastructure.

3.4.5 Heritage Act

The *Heritage Act 1977* provides for the protection of non-Indigenous heritage. Chaffey Dam is listed on State Water's heritage register, as provided for by Section 170 of the Act. The proposed works will lead to added protection of heritage items downstream and the heritage value of the dam wall because they enhance the safety of the wall against catastrophic failure.

Under Section 57 of the *Heritage Act 1977*, a permit must be obtained for works, which have the potential to interfere with a heritage item or place, which is either listed on the State Heritage Register or the subject of an interim heritage order. There are no heritage items listed on the State Heritage Register or subject to an interim heritage order in the vicinity of Chaffey Dam (refer to Section 5.2). Therefore there are no requirements for a Section 60 application under the *Heritage Act 1977*.

However, there are a number of historic sites that have archaeological potential and therefore a Section 140 application for an excavation permit or a Section 57(2) exemption is normally required if works are proposed in those areas. But if the proposal is approved under Part 5.1 of the *Environmental Planning and Assessment Act 1979*, no excavation permits or exemption is required.

3.4.6 Roads Act 1993

Under Section 115ZH of the EP&A Act, a consent under s138 of the *Roads Act 1993* cannot be refused if it is necessary for the carrying out approved State Significant Infrastructure.

3.4.7 Native Vegetation Act

The *Native Vegetation Act 2003* applies to the clearing of native vegetation outside certain specified areas, and requires development consent from the Minister for Planning.

Section 12 of the *Native Vegetation Act 2003*, states that native vegetation must not be cleared except in accordance with a development consent granted in accordance with the Act. Section 25 of the Act goes on to state legislative exclusions. Some exclusions include clearing that is carried out in accordance with a certain license or permit issued under other Acts (i.e. specific permits under the *Fisheries Management Act 1994*, *Rivers and Foreshores Improvement Act 1948*, *Water Act 1912*, *Water Management Act 2000*).

Under the provisions of Part 5.1 of the *Environmental Planning and Assessment Act 1979*, an authorisation referred to in Section 12 of the *Native Vegetation Act 2003* would not be required.

3.4.8 National Parks and Wildlife Act

The *National Parks and Wildlife Act 1974* (NPW Act) is administered by the Office of Environment and Heritage and provides the basis for legal protection and management of Aboriginal sites and objects in NSW.

Previous cultural heritage studies have identified 11 items of Aboriginal heritage that may be potentially affected by the upgrade works. These items included artefact scatters, isolated finds and potential archaeological deposits.

Section 87 of the NPW Act states that a permit may be issued to disturb or excavate archaeological sites or objects and under Section 90 of the NPW Act, it is an offence to knowingly destroy, deface or damage an object, except in accordance with an approval granted under that section.

As the upgrade works would potentially affect 11 items of Aboriginal heritage, a Section 87 permit or Section 90 consent would normally be required.

However, as the proposal is to be assessed under the provisions of Part 5.1 of the *Environmental Planning and Assessment Act 1979*, no Section 87 permits or Section 90 consents are required.

The proposed works will lead to added protection of Aboriginal heritage items downstream because they enhance the safety of the dam wall against catastrophic failure.

3.5 COMMONWEALTH LEGISLATION

The *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* is administered by the Commonwealth Department of Sustainability, Environment, Water, Populations and Communities and its primary objective is to "provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance."

Environmental approvals under the EPBC Act may be required for an "action" that has, will have or that is likely to have a significant impact on:

(a) matters of national environmental significance (known as 'NES matters'), or

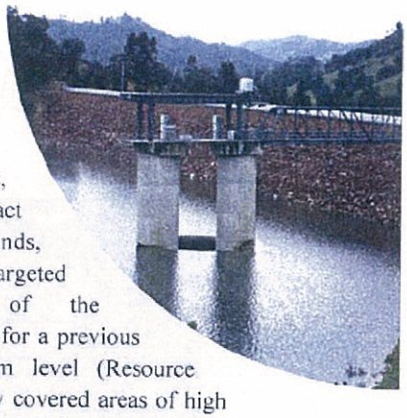
(b) the environment on Commonwealth land (whether or not the action is occurring on Commonwealth land).

Approval for such an action may be required from the Commonwealth Minister for Sustainability, Environment, Water, Populations and Communities.

An "action" is considered to include a project, development, undertaking, activity or series of activities. NES matters include:

- World heritage areas;
- National heritage places;
- Ramsar wetlands of international importance;
- Nationally listed threatened species and ecological communities;
- Listed migratory species;
- Nuclear actions; and
- Commonwealth marine areas.

As outlined in Section 6, the proposal may have a significant impact on an NES matter, including a number of threatened and endangered species, particularly the endangered Booroolong Frog habitat (nationally listed endangered species). It is therefore considered that the proposal may constitute a controlled action under the EPBC Act and a referral should be made to the Department.



4 EXISTING ENVIRONMENT

4.1 LAND USE

Figure 5 shows property ownership around the dam. Most of the land is in public ownership.

Existing land uses around the dam include:

Recreational and open space areas, including:

Bowling Alley Point Recreation Area managed by the Bowling Alley Point Recreation Reserve Trust;

Boating facilities;

Tamworth Fishing Club

Nundle Fishing Club

Land used for grazing (under private ownership and leasehold); and

State Water administration and maintenance facilities.

The location of the recreational facilities are shown in Figure 7.

4.2 HERITAGE

All of the listed and found heritage sites are shown in

Figure 8.

4.2.1 Indigenous heritage

The Chaffey Dam study area is located within the area of the Nungaroo Local Aboriginal Land Council (NLALC).

A total of 21 aboriginal sites have been found in the Chaffey Dam study area. These include;

Five Aboriginal sites recorded within the Chaffey Dam study area prior to the GHD report in 2008; however only one site is listed on the Aboriginal Heritage Information Management System (AHIMS) register. The listed site is an isolated find, *Nundle/Woolomin 1*, which was recorded in 1996 in the course of a survey of a proposed optic fibre cable route from Nundle to Woolomin (GHD, 2008).

Four unlisted sites, comprising two artefact scatters and two isolated finds, were identified during targeted archaeological survey of the foreshores of Chaffey Dam for a previous proposal to raise the dam level (Resource Planning: 1990). The survey covered areas of high predicted archaeological sensitivity. No grid references were provided for the sites (GHD, 2008).

Field surveys identified another twelve Aboriginal sites, including five artefact scatters and seven isolated finds. In addition, four areas of Aboriginal potential archaeological deposits (PAD) were identified during a field survey (GHD, 2008).

4.2.2 Non-indigenous heritage

A total of 24 non-indigenous heritage sites have been identified in the Chaffey dam study area. Of these, ten are previously recorded non-indigenous heritage sites, including eight historic sites and two monuments, are located within the Chaffey Dam study area. The Bowling Alley Point Geological site is listed on the Register of the National Estate. Chaffey Dam is listed on State Water's draft s170 heritage register due to its high local significance on the following factors:

The local economy

Local agriculture

Natural and cultural landscape

Social and recreational uses

An additional fourteen European sites were identified in the Chaffey Dam study area during a field survey by GHD (2008). These comprise a windmill and well, a stone wall associated with a mining area, a mining race and tailing mounds, remains and associated structures of four homesteads, (Rocklight, Hillview, Lynhurst and Lodhaver), commemorative plaques on the Bowling Alley Point Bridge, the entranceway to the Bowling Alley Point Cemetery and a house.

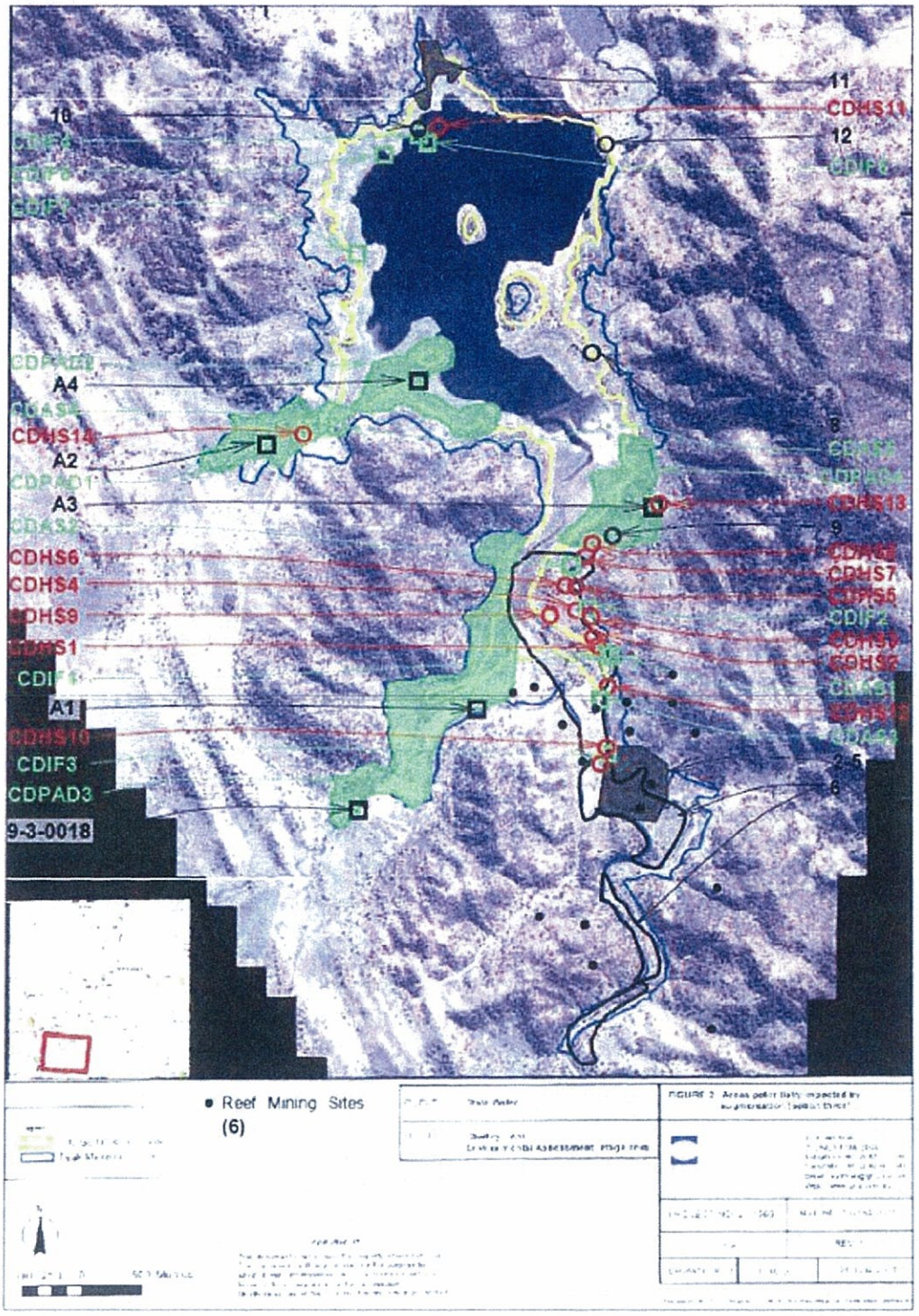


Figure 8: Location of all recorded heritage sites (indicative only)

4.3 ECOLOGY

4.3.1 Terrestrial Ecology

Seven distinct vegetation communities are present in the study area and these include:

Box-Gum Woodland;

Stringybark/Angophora Woodland;

Stringybark Woodland with associates of either Apple Box (*Eucalyptus malacoxylon)*, Roughbarked Apple (*Eucalyptus florida)*, Yellow Box (*Eucalyptus melliodora)* or Tumbledown Red Gum (*Eucalyptus dealbata)*;

Freshwater Wetlands;

Casuarina Riparian Vegetation;

Grassland; and

Plantings.

i) Threatened Flora Species

Based on literature review 29 threatened flora species have previously been recorded within 50km of the study area, or could potentially occur in the study area. Of these, three are considered likely to occur within the study area, based on habitat assessment, including the Small Snake Orchid (*Diuris pedunculata*), Narrow Goodenia (*Goodenia macbarronii*) and the New England Bush-pea (*Pultenaea setulosa* syn. *P.campbellii*).

ii) Threatened Fauna Species

The Booroolong Frog (*Litoria booroolongensis*) is listed as an Endangered Species both at a national level under the EPBC Act and a State level under the TSC Act.

Recent surveys (NWES, 2009) have found the frog occurring in the headwater streams of the Namoi Catchment between 400 to 700 metres above sea level. Sightings have also been recorded 2km downstream of the dam. Within the Namoi Catchment there is evidence of the frog in the mid to low elevation streams in the Cockburn and Peel River sub-catchments above Chaffey Dam. The population is conservatively estimated to be between 600 and 800 frogs (Namoi CMA). Thus the Namoi Catchment is an important area for the survival of this species and the upstream reaches above Chaffey Dam provides significant Booroolong Frog habitat that is not replicated anywhere else.

One threatened bird under the TSC Act, the eastern subspecies of the Brown Treecreeper (*Climacteris picumnus victoriae)*, was recorded in the study area during a field survey in 2008. Several migratory birds listed under the EPBC Act were sighted in the study area during the field survey, including the Whitebellied Sea-eagle (*Haliaeetus leucogaster)* and Great Egret (*Ardea alba*). Field surveys have also sighted Speckled Warblers, listed as vulnerable under the TSC Act, in the area around the auxiliary spillway.

Potential habitat for a range of threatened bird, reptile, mammal and bat species was identified within the study area, in particular within Box-Gum Woodland, rocky ridge on the northwest of Chaffey Dam, and the dam wall itself. The NPWS Atlas of NSW Wildlife revealed records for the Border Thick-tailed Gecko (*Underwoodisaurus sphyrurus*) in the vicinity of Chaffey Dam, and based on the results of the site inspection, potential habitat for this species is present within the inundation area. The Gecko is listed as vulnerable under both the TSC Act and the EPBC Act.

Literature, including the NSW Wildlife Atlas, was reviewed in November 2011 and no further threatened species have been recorded within ten kilometres of Chaffey Dam since 2009 (NSW NPWS, 2011).

iii) Endangered Ecological Communities

Parts of the study area that are mapped as Box-Gum Woodland are characteristic of White Box-Yellow Box-Blakely's Red Gum Woodland, listed under the TSC Act (GHD, 2008).

One area of Box-Gum Woodland that occurs above the 100 GL full supply level and below the PMF Level is characteristic of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, listed under the EPBC Act. This area differs from the TSC Act definition of Box-Gum Woodland as it has a predominantly native groundcover.

Literature has been recently reviewed and no further Endangered Ecological Communities have been recorded within the Chaffey Dam study site since 2009 (NSW NPWS, 2011).

4.3.2 Aquatic Ecology

The aquatic ecological community in the natural drainage system of the Darling River (Darling River) is listed as an endangered ecological community (EEC) under the FM Act and the TSC Act. The Darling River EEC includes the Peel River downstream of Chaffey Dam. The Darling River includes all fish and aquatic invertebrates but it does not include mammals (such as platypuses), reptiles, birds and amphibians (such as frogs).

There is also potential for the Silver Perch (*Bidyanus bidyanus*), listed as vulnerable under the FM Act and TSC Act, to occur in the study area. There is potential for the Murray Cod (*Maccullochella peelii peelii*), listed as vulnerable under the EPBC Act, to occur in the study area. The River Snail (*Notopala sublineata*) is listed as 'endangered' on the FM Act and based on the habitat available within the study area, it is considered likely that the species may occur within the Peel River upstream and downstream of the reservoir.

4.4 CATCHMENT MANAGEMENT AND WATER QUALITY

4.4.1 Upstream

The Peel River is located in the Namoi Catchment. Water quality in the Namoi River catchment is variable. Water quality in the catchment is affected by nutrients, particularly phosphorus and nitrogen.

The following have been identified as likely sources of nutrients within the catchment:

- Silt erosion;
- Natural phosphate deposits in the catchment;
- Recreational activities;
- Stormwater runoff; and
- Agriculture discharge (livestock waste and fertiliser).

The combination of heavy summer rainfall events and the steep, sparsely vegetated catchment create high rates of sediment erosion in the region. These sources of nutrients and erosion products are routed into waterways and are deposited in the reservoir during high flow events.

Few catchment management strategies have been properly implemented, so high sediment and nutrient loads continue to enter Chaffey Reservoir. Phosphorous is generally accepted as the most significant nutrient that is inputted into Chaffey Reservoir, and is predominantly comprised of filterable reactive phosphorus (FRP), which is generally comprised primarily of orthophosphate (PO_4).

4.4.2 The Reservoir

High nutrient loading into Chaffey Reservoir from the upstream catchment promotes eutrophication. The dissolved phosphorous in the water column is predominantly PO_4, which is the most bio-available form to algae. Hence, algal blooms are often comprised of toxic cyanobacteria such as *Anabaena* and *Microcystis*, which can occur throughout the year.

Chaffey reservoir also has high rates of nutrient and metal release from the sediments that contribute to the water quality issues in the reservoir. This internal nutrient source occurs primarily during the summer with the development of anoxic conditions at the sediment-water interface. As a result, high fluxes of dissolved nutrients (FRP and nitrogen (NHx)) and reduced dissolved forms of metals (particularly iron and manganese) are injected into the overlying water column. These anoxic conditions also promote sulfate reducing bacteria that release phosphorous into the water column previously bound in the sediments.

The occurrence of algal blooms and the development of anoxic conditions are in large part driven by thermal stratification, which occurs throughout most of the year except during winter in Chaffey Reservoir. During summer, the water column stratifies, mixing below the surface waters is inhibited and a large temperature gradient develops.

4.4.3 Downstream

The primary water quality issues are generally of concern for the downstream aquatic ecosystem in terms of oxygen content, temperature, nutrient levels and metals concentrations.

Chaffey Dam has a multi-level intake (i.e. outlet) tower that can be configured to extract water from a range of reservoir depths so there is opportunity to

control the temperature of the released waters during the period of thermal stratification from November to April through extraction of cooler deep (hypolimnetic) waters, warmer surface (epilimnetic) waters or a blend.

Chaffey Dam therefore has minor cold water pollution potential to downstream environments because of predominately extraction from shallow depths (and hence warm temperatures) and small discharge volumes compared to flows downstream of the confluence with other rivers.

Management of downstream water quality requires consideration of large scale reservoir activities to manage nutrients and algal blooms, as well as storage management to control oxygen levels and water temperatures.

Water temperatures are substantially warmer at Tamworth (downstream) than Bowling Point Alley (upstream) by several degrees. Seasonal variations in electrical conductivity occur downstream and upstream, but Chaffey Dam causes a consistent 'buffering' type effect that yields constant electrical conductivity over the year.

The effect of Chaffey Dam is to moderate turbidity fluctuations immediately downstream, however substantive variations in response to river discharge and catchment inputs occur upstream and further downstream. In effect, Chaffey Dam acts as a sedimentation basin.

Measurements in pH clearly indicate the system is alkaline in nature. In terms of nutrients, there are elevated levels of total nitrogen (TN) and total phosphorous (TP) immediately below Chaffey Dam, which indicate that Chaffey Dam acts as a nutrient source for downstream reaches of the Peel River. However, nitrogen and phosphorus biogeochemical processes over the reach of Peel River from Chaffey Dam to Tamworth do lower these nutrient levels considerably.

The composition of total nitrogen downstream of Chaffey Dam shows relatively low levels of organic nitrogen and ammoniacal nitrogen (NHx), which indicates Nitrogen Oxide (NOx) is likely the dominant form of nitrogen in this river reach. However, the lack of available NOx data does not allow for a clearer assessment of the composition of TN (GHD, 2008).

Total iron levels are generally greater immediately downstream of Chaffey Dam though maximal levels have been recorded upstream of the reservoir.

It is clear that Chaffey Dam has a large effect on EC, turbidity, nutrients and iron in the downstream reach of the Peel River.

Currently, environmental flows are not implemented on the Peel River. However, the Peel River Water Sharing Plan requires that an environmental contingency allowance (ECA) is to be set aside in Chaffey Dam water storage and managed once the dam storage capacity has been enlarged to 100,000 ML.

4.5 VISUAL AMENITY

The visual character of the local landscape has been significantly altered by the existing dam, which has become the dominant visual feature within the study area. The dam wall and left bank quarry are visible from sections of the Tamworth-Nundle Road for up to 2 kilometres downstream. The wall and surrounding ridge on the western side of the dam can be viewed for up to 2 to 3 kilometres upstream to the south and west. Chaffey Dam itself has a limited viewing catchment as it is surrounded by undulating hills. There is a public viewing area on the north-eastern bank of the dam, which faces northwest to the dam wall and left bank as well as affording views of the water body.

The number of sensitive receptors in the vicinity of Chaffey Dam is limited. There are no residential properties that have a direct view of the dam wall. One residence was identified in the vicinity of Chaffey Dam and this is located approximately 4 kilometres south west of the dam wall, and approximately 1 kilometre from the existing full supply level. The view of the area surrounding the dam wall from this residence is obscured. The main visual receptors in the study area are:

- Recreational users of Chaffey Dam (e.g. fishermen, boating or water sport enthusiasts);
- Visitors or tourists to the Dam, especially those using the public viewing area;
- Drivers along the Tamworth-Nundle Road along the eastern edge of the dam and immediately downstream; and
- Drivers along the back Woolomin Road along the western edge of the dam.

4.6 ROAD INFRASTRUCTURE

The Tamworth - Nundle Road is a sealed road which runs along the eastern boundary of the dam and into the upstream reaches. Western Foreshore Road is un-sealed and runs the length of the western foreshore of the dam. There is short section of sealed road connecting the two which crosses the Peel River via a bridge a little upstream of the current full supply level. Smaller un-sealed roads provide access to the various community clubs and the recreation areas.

4.7 DOWNSTREAM ENVIRONMENT

Downstream of Chaffey Dam the Peel River is included as part of the Darling River drainage system (Fisheries Scientific Committee 2003). The Darling River is listed as an endangered ecological community under the Fisheries Management Act and thus so is the Peel River downstream of Chaffey Dam.

The Peel River downstream of Chaffey Dam can be described as a low to moderate sinuosity gravel-bed river. Channel bed morphology is characterised by a pool-riffle sequence set within a channel of relatively consistent dimensions of between 30 – 40 metres wide and 3 – 6 metres deep. The channel gradient downstream of Chaffey Dam ranges from 0.0033 m/m to 0.0016 m/m and exhibits a downstream decreasing trend (Gorrick, 2004).

The channel banks of the Peel River are relatively cohesive, composed dominantly of silt material, and are generally stable. Gorrick (2004) identified only one location where pronounced bank erosion is occurring. This is located approximately 2 kilometres downstream of the dam wall and is associated with a narrowing of the valley. Gorrick (2004) attributes this erosion to a potential increase in flow competence as a result of the valley constriction and warns that this area could be particularly vulnerable to changes in flow regimes that increase flow competence.

The channel is set within relatively broad floodplains of fine-grained alluvium with minimal relief and support crops and improved pasture for grazing. As a result the floodplains have been largely cleared and the vegetated riparian zone along the river generally does not extend much further than 5 metres from the top of the channel banks.

Three major tributaries enter the Peel River between Chaffey Dam and Tamworth. These are:

- Duncans Creek which enters the Peel River approximately 5 kilometres downstream of the dam and has a catchment area of 93 km2;
- Dungowan Creek which enters the Peel River at Woolomin, approximately 15 kilometres downstream of the dam, and has a catchment area of 344 km2; and
- Cockburn River which enters the Peel River just upstream of Tamworth and has a catchment area of approximately 1,130 km2.

As a result there is a general trend of increasing valley width downstream with increasing catchment area. Immediately below the dam valley widths are generally less than 500 metres.

This increases to be between 800 and 1,200 metres between Woolomin and Piallamore and up to 2,500 metres at Tamworth. Beyond the confluence with Dungowan Creek, the floodplains often display anabranches (secondary channels) that convey water during moderate high flow events.

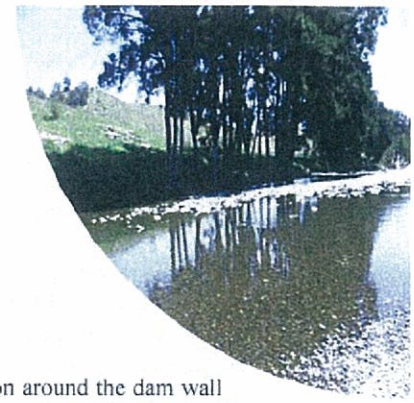
Riparian vegetation along the Peel River is dominated by river oak (*Casuarina cunninghamiana*).

Through an analysis of historical aerial photography, Gorrick (2004) determined that overall tree cover along the Peel River has increased since the construction of Chaffey Dam. This has predominantly involved the growth of river oaks along the lower banks associated with channel encroachment through the development of bar and bench features. Gorrick (2004) attributes this to the attenuation of scouring flows as a result of flow regime changes imparted by the existing dam. However, increased vegetation colonisation may also be a result of the increased availability of water as a result of downstream flow transfers from Chaffey Dam as well as policy and attitude changes to riparian management that have occurred over the last two to three decades.

The presence of Chaffey Dam and the demands for water from Tamworth and irrigators has a significant influence on the hydrological regime of the Peel River. Since the construction of the dam, there has been a decrease in the frequency and size of large flow events and an increase in base flow volumes and frequency.

In a study on the downstream geomorphic impacts of the existing dam, Gorrick (2004) found that floods of low to moderate frequency have undergone reductions of around 90% for all events up to the 1 in 50 AEP decreasing to 24% for the 1 in 200 AEP. However, Gorrick (2004) found that the geomorphic response to the altered flow regime has been largely limited to the development of in-channel benches and pool infilling downstream of the two major tributaries (Duncans and Dungowan Creeks) (GHD, 2008).

This has been attributed to intrinsic factors such as armoured gravel surfaces, well-vegetated cohesive banks, limited sediment inputs and the dissipation of flood waters across relatively wide floodplains in comparison to channel width.



5 PRELIMINARY ENVIRONMENTAL ASSESSMENT – CONSTRUCTION

Construction impacts will generally be limited to the immediate vicinity of the dam wall and the sections of road which need to be realigned.

5.1 SEDIMENT AND EROSION

Excavation activities around the toe of the dam wall will have the potential for soil erosion by clearing vegetation and exposing soil surfaces.

Sediment controls will be required to ensure sediments are not allowed to run-off into the downstream environment.

Similarly, there is expected to be potential erosion and sedimentation from the road construction and bridge raising works which will need to be controlled.

5.2 WATER QUALITY

The main construction impacts on water quality could principally be due to any increase in silt loads as explained in Section 5.1 and the subsequent turbidity and deposition.

This could result in turbidity and smothering of river substrate and reduction in water quality, downstream of the dam wall due to wall raising activities, in the reservoir due to re-alignment of the road and in the upstream reaches due to road re-alignment and bridge reconfiguration.

The raising of the Morning Glory spillway within the reservoir could also potentially impact on water quality via possible fuel, oil or chemical spills from the construction machinery and barge. This will reduce water quality and have flow on impacts to aquatic flora and fauna both within the reservoir and in the downstream environment.

5.3 ECOLOGY

5.3.1 Terrestrial

Construction and excavation around the dam wall will result in the loss of very little terrestrial fauna habitat because those areas which will be disturbed have only moderate habitat value and will be rehabilitated following construction. .

The areas around the dam wall are important habitat for Speckled Warblers. Other species potentially occurring in the area include the Carpet Python and the Spotted-tailed Quoll (considered a priority species of conservation concern by OEH).

The Border Thick-tailed Gecko is known to live in the rock armouring on the face of the dam wall. Although this will be replaced as part of the construction, it will be disturbed during construction.

Initial ecological assessments (GHD, 2008) identified the potential for a number of threatened microbat and wetland and woodland bird species to occur around the dam wall. Subsequent investigations in 2009 found that the subject site does not provide suitable habitat for the vulnerable bats, and the habitat present is not considered preferred habitat for the wetland and woodland birds, however the subject site may be used by the Squirrel Glider, Yellow-bellied Sheathtail Bat and Spotted-tailed Quoll as part of their foraging range and as a temporary refuge area.

A flora survey around the dam wall location found none of the threatened plants recorded elsewhere in the region, and none are considered likely to occur due to the sites history of disturbance associated with the original dam construction, and clearing and grazing prior to that.

Areas of vegetation will also need to be cleared for the re-alignment of the roads although most of these areas are sparsely treed. Construction also has the potential to spread weeds or create ground easily colonised by weed species.

5.3.2 Aquatic

Downstream, ecological impacts may arise from decreased water quality from increases in silt loads and turbidity and the smothering of river substrate.

This may result in reduced food supply and loss of large-particle substrates and deep-water habitats for fish, as well as effects of suspended solids on native fish species.

Sediment released during construction could result in the filling of interstitial spaces in the rough substrates (gravel, cobbles, boulders) in which macro-invertebrate food species are found. Turbidity can also affect the light availability to macrophytes resulting in reduced productivity and supply of organic material to the stream food web.

5.4 HERITAGE

Chaffey Dam as it is listed on the State Water s170 heritage register would be potentially impacted due to construction work on the dam wall.

Despite this, the heritage impacts would be minimal as the upgrade is preserving the dam structure and reducing the likelihood of future failure. This is seen as a positive heritage impact.

There are also a number of heritage sites which may be affected by the road re-alignment works on both the Tamworth-Nundle Road and the Western Foreshore Road. These impacts can be further determined once the full extent of the road re-alignment is decided on.

5.5 NOISE

There is likely to be temporary noise impacts associated with construction machinery on the dam wall. This is not likely to be significant due to a lack of sensitive receptors in the general area. The biggest noise impacts are likely to be on recreational users of the Chaffey Dam area and on properties that fall close to the road construction works near the upper reaches of the storage.

5.6 AIR QUALITY

Construction of the proposal may result in minor air quality impacts e.g. particulate matter disturbance. It is likely that dust will be generated during the civil construction works associated with the dam wall raising, the re-alignment of the roads and other associated construction activities. Additionally, there could be fumes from machinery.

The impact on local air quality would depend on materials used, equipment and local weather conditions.

None of these impacts are likely to affect local amenity in residential or commercial areas due to the distance of the construction area from nearby sensitive receivers.

These impacts would be managed by standard construction air quality management measures.

5.7 VISUAL AMENITY

The construction works would create minor short-term and localised visual impacts such as construction machinery and traffic, however these changes are likely to have a relatively small overall impact as there are very few sensitive receptors in the area. The changes would affect recreational users and visitors to Chaffey Dam as well as drivers along the Tamworth-Nundle Road.

However since the proposed works will alter the views in the vicinity over the long-term, the visual impacts of the proposal are dealt with more thoroughly under "Operational Impacts" later in this document.

5.8 RECREATIONAL FACILITIES

Construction works will not limit access to recreational facilities although road works may create some delays in access.

5.9 TRAFFIC

There is likely to be an increase in traffic along the Tamworth-Nundle Road for construction vehicles and machinery throughout the duration of the project. These increases will also apply to the various access roads and Western Foreshore Road as they are re-aligned.

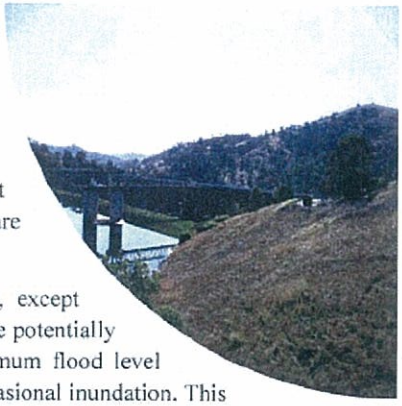
As the roads are re-aligned, there may be temporary disruptions to traffic with reduced speed limits and limited lane operation.

5.10 WASTE MANAGEMENT

The proposal would generate certain construction wastes and would generally be limited to material wastes (such as spoil, scrap metal, waste concrete), putrescible wastes, drinking cartons and food scraps from construction crew and green wastes.

Operational waste would be generally limited to putrescible waste, drinking cartons and food scraps from State Water employees and visitors to the site. Operational waste would not alter significantly from existing operations.

Waste would be managed to the principles embodied in the *Waste Avoidance and Resource Recovery Act 2001* and include avoidance and reuse with disposal as a last resort.



6 PRELIMINARY ENVIRONMENTAL ASSESSMENT - OPERATIONAL

6.1 UPSTREAM IMPACTS

Upstream operational impacts will mainly be restricted to those areas which will be below the new full supply level and which will be frequently inundated. Although flooding will impact on areas above full supply level, these impacts will be occasional and of short duration.

6.1.1 Heritage

a) Indigenous

The increase in the full supply level is expected to potentially affect a number of Indigenous sites, including three artefact scatters, four isolated finds and four areas of potential archaeological deposit.

These sites would be affected by permanent or semi-permanent inundation. Inundation would destroy, move or wash away any surface artefacts. This would reduce the significance and integrity of the sites. Potential archaeological deposits would also be affected disturbing the deposits, washing away sediments and causing lag deposits. Again this would reduce the significance and integrity of the sites.

b) European

It is estimated that approximately five European heritage sites could be affected by permanent or semi-permanent inundation, including a commemorative plaque, a footbridge, Chaffey Dam, the Dulegal Arboretum and the possible remains of 'Lodhaver' homestead.

The significance of the footbridge, plaque and arboretum would be significantly reduced and damage would be caused to these sites if inundated. However the footbridge and plaque can be removed and relocated out of the inundation area. Damage would also be done to 'Lodhaver' reducing its integrity and possibly its significance. The Dulegal Arboretum is highly disturbed and many of the species planted have not thrived so impacts are expected to be minimal.

All of the remaining sites, except the geological site, would be potentially affected by the peak maximum flood level and would be subject to occasional inundation. This inundation would affect the integrity of the sites and disturb subsurface archaeological deposits. European sites may be permanently and irrevocably damaged reducing their significance.

6.1.2 Ecology

a) Terrestrial Ecology

The species listed as being affected during the construction stage also have the potential to be affected during operation if increased water levels inundate and degrade their habitat areas.

The loss of riffle habitats by inundation will occur in the upstream reaches of the Peel River. Shallow riffles and run zones are regions of high productivity, which are flooded when a river is impounded. These riffle zones are key frog habitat. Approximately 2.5km of river is expected to be affected by the changes in full supply level. Habitat loss and degradation which includes the modification of stream channels and loss of riffle zones is a major threat to the endangered Booroolong Frog species.

Some areas of riparian vegetation will also be affected as they become inundated. High water levels can impact on riparian vegetation by depriving trees of water, eroding root systems and in some instances killing plants by immersing their roots for extended periods. As well as consolidating banks, riparian vegetation also supplies organic input to the stream food web and cover for animals foraging and entering or leaving their burrows. The proposed works will result in the movement of the current bands of affectation such as the river bed shallows, pools, riffles, banks and stream reaches further upslope and upstream.

Areas of native vegetation, plantings and introduced grassland would be inundated by increasing the full supply level of the dam, including parts of the Box-Gum Woodland Endangered Ecological Community.

Potential impacts associated with habitat changes from increased areas of inundation include:

- Loss of terrestrial fauna habitat;
- Reduction in habitat for woodland birds, such as Brown Treecreeper;
- A beneficial increase in habitat for water birds
- Changes in ecological processes and ecosystem functions within areas of increased inundation; and
- Flow-on effects to upstream and downstream areas due to modified ecosystem functioning.

b) Aquatic Ecology

The establishment of blue-green algal blooms can result in the toxic poisoning of aquatic biota such as waterbirds and fish, and adverse impacts on aquatic vegetation and macro-invertebrates.

However the increase in surface area of the reservoir and upstream reaches will also produce a positive impact on aquatic ecology by increasing the amount of fish habitat.

6.1.3 Catchment Management and Water Quality

Simulations that have been run on the reservoir water quality suggest that in general, there is less oxygen in the deep waters and greater internal nutrient loading from the sediments, which is reflected by higher nutrient levels in the hypolimnion. The lower oxygen levels in the bottom waters also result in elevated iron levels because of sediment release of reduced dissolved forms. The simulations highlight that an effective measure to improve the reservoir water quality is to maintain oxygen levels in the bottom waters to inhibit the release of dissolved nutrients and metals from the sediments.

The works have the potential to produce impacts within the reservoir, associated with cold water pollution and blue-green algal blooms.

6.1.4 Visual Amenity

The works are unlikely to significantly change the existing visual characteristics of the area as the overall shape and scale of the dam wall structure will be similar to the existing structure.

The perceived change in the views from the raising of the embankment height and increased footprint area as observed by an individual will vary with distance from the embankment.

The perceived changes will be largest near the dam wall, specifically, the visitor's car park and the Tamworth-Nundle Road) and the amount of perceived change will reduce as the observed distance is increased.

The visual impact of the additional works proposed is likely to be low as there are few sensitive receptors in the area. As previously discussed, there are no residents in the region who have a view of the dam wall. The changes in the height of the dam wall will be most obvious to people who regularly drive along the Tamworth-Nundle Road, which passes next to the existing dam wall.

Regular recreational users of the dam and its surrounds will also perceive a noticeable change in the size of the dam wall.

6.1.5 Recreational and Private Land

The proposal will result in the permanent inundation of some small parcels of privately owned property (see Figure 5). State Water will be required to purchase this land from the property owners.

Other recreational areas such as parts of the Tamworth Fishing Club and the Recreation Area will be inundated under the new full supply level. However, they will be moved to an area out of the permanent inundation zone so there will be no loss to recreational facilities.

The amenity of the Chaffey Dam reservoir is likely to be increased with an increase in water area providing more opportunities and a larger area for water based recreation activities.

6.2 DOWNSTREAM IMPACTS

6.2.1 Flow and Flood Regime

Downstream operational impacts will mainly arise from changes in the frequency of downstream flows and potentially any change in quality. Under most conditions the extent of inundation from dam outflows will not change because the outlet works

and the morning glory spillway will maintain their existing capacities.

This will mean that the maximum discharge from both the outlet works and the morning glory spillway will remain unchanged. What will change is that outflows will be controlled more frequently as more water is released for water supply and uncontrolled overflows through the morning glory spillway will become less frequent.

Data analysis (GHD 2008) suggests that annual average flows in the Peel River immediately below the dam would decrease by about 2%. The impact on average flows would diminish further downstream of the dam as other tributaries make a greater contribution to total flow.

With regard to the distribution of flows, immediately downstream of the dam, there would be an increase in the magnitude of the low flows (those which represent the 5th percentile). Those which occur up to 85th percentile would decrease slightly and there would be an 8% reduction in the 90th percentile flows. There would be no change in the proportion of time subject to high flows. These impacts would generally diminish further downstream of the dam.

The new fuse plug arrangement will be designed to ensure that the peak outflows from the auxiliary spillway will be no greater than those which would result from the existing spillway arrangement.

With the dam being made PMF safe, downstream flooding will be less than would occur under current conditions.

6.2.2 Heritage

Because the extent of downstream flooding will not change there is not likely to be any significant impacts on indigenous or non-indigenous heritage.

6.2.3 Catchment Management and Water Quality

Potential downstream impacts associated with water released from the reservoir include changes in physio-chemical factors affecting the aquatic environment such as sediment, water temperature, dissolved oxygen, nutrients and toxic chemicals, as well as toxic algae.

Cold water pollution does occur as a result of the operation of Chaffey Dam. However, Chaffey Dam has a multi-level intake (i.e. outlet) tower that can be configured to extract water from a range of reservoir depths to reduce the impacts.

In terms of environmental flows, the Peel River Water Sharing Plan requires that an environmental contingency allowance (ECA) is to be set aside in Chaffey Dam water storage and managed once the dam storage capacity has been enlarged to 100,000 ML. Water in the ECA account will be released to return some of the natural flow variability to the upper reaches of the Peel River which have been adversely affected by river regulation. As per the water sharing plan a minimum daily release will be made from Chaffey Dam that is equal to 3 ML except when a release of greater than 3 ML/day is required to meet basic landholder rights and access licence extractions or when a release is being made under other subclauses of the plan.

This will have a beneficial impact on the river environment downstream.

6.2.4 Sediment and Erosion

Bank erosion can result from varied flow releases from the dam which can cause a loss of riparian vegetation and associated fauna habitats. Other impacts include increased turbidity and smothering of benthic (streambed) habitats which in turn impacts on aquatic biota such as macroinvertebrates and platypus.

The original dam construction resulted in about a 90% reduction in flows immediately downstream of the dam for all flows up to about the 1 in 50 AEP event. Gorrick (2004) found that this has limited impact on the downstream geomorphology because of the intrinsic characteristics of the channel. The much small changes to flow caused by the augmentation are therefore unlikely to significantly change the downstream geomorphology.

6.2.5 Ecology

a) Terrestrial Ecology

Reduced flows or high flows can impact on riparian vegetation by depriving trees of water, eroding root systems and in some instances killing plants by immersing their roots for extended periods. As well as consolidating banks, riparian vegetation also

supplies organic input to the stream food web and cover for animals foraging and entering or leaving their burrows.

Platypuses normally dig their resting and nesting burrows in banks consolidated by the roots of riparian vegetation, hence a loss of riparian vegetation has the potential to adversely affect the downstream platypus population.

While the change in flow regime is expected to only be small, particularly compared to pre-dam flows, it may have an impact on the terrestrial ecology if these changes in flow affect riparian vegetation.

b) Aquatic Ecology

A range of impacts from the modification to the flow regime of the river could result in changes to the downstream river environment by contributing to a decrease in native fish species, creating conditions suitable for the proliferation of carp, providing ideal conditions for blue-green algal blooms and degrading and eroding channels, riverbanks, floodplains and wetlands downstream of the dam.

Data analysis previously undertaken for the works indicates that the modeled change to water flow is likely to only be around two per cent, which is considered unlikely to have a significant impact on Murray Cod occurring downstream of the dam and is not expected to significantly impact upon the ecological function of the river.

Loss of flow over downstream riffle zones may also result, creating movement barriers for aquatic fauna, particularly fish. Loss of riffle habitats can be of major ecological significance as shallow riffles and run zones may be lost. Many types of macroinvertebrates and microscopic organisms are confined to riffles, and these are highly productive areas providing a food supply for other components of the aquatic system.

Release of cold water pollution from the reservoir has the potential to impact on the downstream aquatic ecology by restricting breeding habits and depressing growth rates, however the use of the multi-level offtake system can be used to reduce the level of impact.

There is currently no fishway in place for Chaffey Dam and previous consultation with DPI Fisheries has indicated that it is not required as a part of this upgrade. Therefore there will be no change to fish movement as a result of the works.

6.2.6 Public recreation and safety

The downstream environment may be subjected to more frequent flows, however the measures currently in place for warning downstream residents about releases will remain in place.

7 CONCLUSION

7.1 CONCLUSIONS

Given the potential environmental impacts identified in this preliminary environmental assessment it is recommended that a precautionary approach be taken, involving forming the view that the proposal is likely to significantly affect the environment.

There are potential significant impacts on threatened and endangered species and items of Indigenous and Non-indigenous heritage

The most significant ecological impact would be the loss or degradation of upstream environments that form a significant part of the endangered Booroolong Frog habitat.

Preliminary assessments of the significance of these impacts on matters of National Environmental Significance (NES) were performed and concluded that the proposal may also result in a significant impact on the Border Thick-tailed Gecko.

Further field assessments and consultation with specialist ecologists is recommended as a guide to further assess whether the proposal is likely to result in a significant impact on other endangered and threatened species.

Supplementary surveys are recommended as a further guide to the consideration of impacts, including:

- Active searches for the presence of Booroolong Frogs upstream and downstream of Chaffey Dam
- Active searches for Border thick-tailed Gecko;
- Anabat surveys, spotlighting and harp trapping for threatened microbats;
- Field surveys for areas of Box-gum Woodland which might extend below the 100 GL full supply level and be subject to regular inundation or other direct impacts; and
- Targeted surveys for cryptic or seasonally-flowering threatened plants.

The modest changes in downstream flows compared to those which currently exist and in particular compared to pre-dam flows means that the ecological impacts due to the dam augmentation are likely to be minor.

It should be noted that in order to offset potential ecological impacts of the dam safety upgrade works, a wildlife corridor plan and weed management plan were produced for the auxiliary spillway construction. The offset activities outlined in these detailed plans have been underway since the construction of the auxiliary spillway in 2010, ameliorating ecological impacts.

There are potentially significant heritage impacts arising from the disturbance of indigenous and non

Indigenous cultural heritage sites with inundation. Detailed heritage surveys of the proposed inundation area would be required to further describe impacts and allow the identification (and possible relocation) of sites not identified in the current assessment.

7.2 PROPOSED SCOPE OF ENVIRONMENTAL IMPACT ASSESSMENT

Environmental Impact Assessment prepared in accordance with the Director-Generals requirements and determining the extent of impact on all aspects of the environment

Stakeholder and community consultation process

Terrestrial ecological assessment, including field surveys, 7-Part tests and assessments of impacts on matters of NES.

Aquatic ecological assessment, including field surveys, 7-Part tests and assessments of impacts on matters of NES.

Indigenous heritage study, including field surveys of potential archaeological sites and options for relocation

Non-indigenous heritage assessment including field surveys of present and potential heritage sites and their options for relocation

7.3 SUMMARY OF DRAFT MANAGEMENT AND MITIGATION OPTIONS

Mitigation/management measures	**Timing**
General management plans	
Implementation of a construction environmental management plan which addresses controls for sediment and erosion, water quality, noise, air pollution, weed control, flora and fauna protection, traffic control, waste management and public safety.	Pre-construction
Implementation of an operational environmental management plan	Post Construction
Indigenous heritage	
A comprehensive survey will be undertaken of the study area focusing on areas that have not previously been surveyed. The identification of Aboriginal sites will be included in this survey. Following this survey, additional areas of potential archaeological deposit may be identified that require subsurface investigation.	Pre-construction
Subsurface archaeological testing of potential Aboriginal archaeological deposits CDPAD1-CPAD4 will be undertaken within the area affected by the full supply water level. This will be undertaken before the environmental assessment of the project is completed as the results from these investigations will inform the assessment of the impact of the project on the Aboriginal heritage of the study area.	Pre-construction
Subsurface archaeological testing of potential archaeological deposits associated with recorded sites CDAS1, CDAS2, CDAS4 and CDAS5 will be undertaken before the environmental assessment of the project is completed as the results from these investigations will inform the assessment of the impact of the project on the Aboriginal heritage of the study area.	Pre-construction
Further discussions will be held with Aboriginal stakeholders regarding the relocation or collection of artefacts from sites Nundle/Woolomin 1, A1-A4, CDAS3 and CDIF1-7.	Pre-construction
Non indigenous heritage	
If impact to site 8 (iron footbridge) is to occur then the footbridge will be moved out of the impact area.	Pre-construction
If impact to site CDHS12 is to occur then further assessment will be undertaken including a heritage significance assessment	Pre-construction
The Australian Agricultural Company commemorative plaque will be moved away from the new full supply level of the dam.	Pre-construction
If impact to site 11 (Dulegal Arboretum) is to occur the extent of this impact will be further investigated.	Pre-construction
Site CDHS11 (possible remains of 'Lodhaver' homestead) would be	Pre-construction

affected by the full supply dam level and its historical significance will be evaluated.	
Ecology	
A construction and operational flora and fauna management plan as part of the CEMP	pre-construction
Collection of seed and propagation for subsequent planting above the inundation level.	pre-construction
A foreshore and riparian zone management plan will be developed.	pre-construction
Development of a survey and subsequent monitoring program of terrestrial and aquatic flora and fauna and riparian vegetation. This should confirm the species that are located within the areas of construction and inundation. The monitoring program should include collection of preconstruction data to enable an assessment of the impacts 'before' and 'after' to be undertaken. Mitigation strategies involving future monitoring, relocation or providing offsets to be considered.	pre-construction and post construction
The flora and fauna monitoring program be used to evaluate the efficacy of the mitigation measures and inform other operational measures as required.	Post construction
Water Quality	
Operation of dam in accordance with the *Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and fractured Rock Water Sources 2010.*	Post construction
Other	
State Water conduct ongoing consultation with the community regarding the status of the proposal and likely impacts on the community.	During environmental impact assessment phase

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Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources 2010

APPENDIX A- NSW DPI Letter

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Now incorporating NSW Fisheries
ABN 51 734 124 150-002

Our ref DamSafteyProgram160107
Your ref

29th January 2007

Mrs Jocelyn Karsten
Environmental Project Officer
State Water Corporation
PO Box 2213
DANGAR NSW 2309

Dear Jocelyn

Dam Safety Upgrade Program

Thank you for your letter dated the 4th December 2006 concerning State Water Corporations Dam Safety Upgrade Program. I am writing to outline NSW DPI's initial assessment of the application of section 218 of the *Fisheries Management Act 1994* to 5 relevant major dam safety upgrades that will be undertaken in the next 5 to 10 years. The Departments initial assessment is based on the outline of the proposed upgrade works provided in your letter.

As you are aware, section 218 of the *Fisheries Management Act 1994* (Fishways to be provided in construction of dams and weirs) states that "a public authority that proposes to construct, alter or modify a dam, weir or reservoir on a waterway must, if the Minister so requests, include as a part of the works for the dam, weir or reservoir, or for its alteration or modification, a suitable fishway or fish by-pass". The intent of Section 218 of the *FMA 1994* is to allow for the installation of a fishway to mitigate the impact of weir or dam on fish migration where possible.

There are several aspects which are considered when applying this provision. The relevant aspects include:

1. Presence of native fish that require to migrate as part of their lifecycle
2. Potential extent and value of habitat to be reinstated to fish migration
3. Presence of other barriers to fish migration and future actions and developments
4. Cost benefit of a fishway

Burrendong Dam

Burrendong Dam is a significant barrier to fish migration on the Macquarie River and impacts upon the lifecycles of several threatened species, populations and the endangered ecological community in the natural drainage system of the

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Tel 02 6042 4200
Fax 02 6041 0113

lowland catchment of the Darling River. There are potentially 21 native fish species which are unable to migrate past this structure.

The backed up waters of Burrendong Dam influence the junction of the Cudgegong and Macquarie Rivers. The nature and extent of fish habitat both upstream in these rivers and downstream in the Macquarie River is significant.

Recently, NSWDPI has worked closely with SWC to construct four fishways at Duck Creek Regulator, Crooked Creek Regulator, Gunningbar Weir and Warren Weir in the Macquarie Valley. Furthermore, NSWDPI has managed the development of a new fishway at Dubbo Weir on Macquarie River. These recent activities represent a major contribution to the cumulative rehabilitation of fish passage obstructions in the Macquarie Catchment.

I understand that the proposed works involve installing a 3.1 metre high parapet wall on the main and saddle dams as well as raising of spillway walls. The cost of a fishway solution at Burrendong Dam is likely to be significant. however project development and feasibility investigations will allow for the cost benefit of a fishway to be analysed in due course over the life of this upgrade project.

Chaffey Dam

Chaffey Dam is a barrier to fish migration on the Peel River. The endangered ecological community is located downstream of Chaffey Dam. There are potentially 21 native fish species which are unable to migrate past this structure.

The extent and quality of fish habitat upstream of Chaffey Dam is limited.

Recently, NSWDPI has worked closely with SWC to progress fishway development as a part of the Keepit Dam Saftey Upgrade project. This represents a major contribution to the cumulative rehabilitation of fish passage obstructions in the Namoi Catchment.

I understand that the proposed works involve installing a fuse plug auxiliary spillway and may also involve the raising of the weir crest and augmentation of the dams storage. There is potential for the project to result in the raising of the dam wall by up to 8 metres. The cost of a fishway solution at Chaffey Dam is likely to be significant.

Copeton Dam

Copeton Dam is a significant barrier to fish migration on the Gwydir River and impacts upon the lifecycles of several threatened species, populations and the endangered ecological community in the natural drainage system of the lowland catchment of the Darling River. There are potentially 21 native fish species which are unable to migrate past this structure.

The nature and extent of fish habitat upstream and downstream of Copeton Dam is significant. The waters upstream of Copeton Dam represent one of the most extensive areas in the Murray Darling Basin that is not populated by the alien species European Carp.

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Fax 02 6041 0113

I understand that the proposed works involve installing a fuse plug auxiliary spillway and possibly raising the dam wall. The cost of a fishway solution at Copeton Dam is likely to be significant, however project development and feasibility investigations will allow for the cost benefit of a fishway to be analysed in due course over the life of this upgrade project.

Split Rock Dam

Split Rock Dam is a significant barrier to fish migration on the Manilla River and impacts upon the lifecycles of several threatened species, populations and the endangered ecological community in the natural drainage system of the lowland catchment of the Darling River. There are potentially 21 native fish species which are unable to migrate past this structure.

The nature and extent of fish habitat upstream and downstream of Split Rock Dam is significant.

I understand that the proposed works involve installing a 2 metre high parapet wall on the main and saddle dams and possibly a fuse-plug auxiliary spillway. The cost of a fishway solution at Split Rock Dam is likely to be significant, however project development and feasibility investigations will allow for the cost benefit of a fishway to be analysed in due course over the life of this upgrade project.

Wyangala Dam

Wyangala Dam is a significant barrier to fish migration on the Lachlan River and impacts upon the lifecycles of several threatened species, populations and the endangered ecological community in the natural drainage system of the lowland catchment of the Lachlan River. There are potentially 17 native fish species which are unable to migrate past this structure.

The backed up waters of Wyangala Dam influence the junction of the Lachlan and Abercrombie Rivers. The nature and extent of fish habitat both upstream in these rivers and downstream in the Lachlan River is significant.

Recently, NSWDPI has worked closely with SWC to construct two fishways at Bumbuggan Creek Weir and Island Creek Weir in the Lachlan Valley. Furthermore, SWC is also progressing the design of a new fishway at Lake Cargellico Weir on Lachlan River. These recent activities represent a major contribution to the cumulative rehabilitation of fish passage obstructions in the Lachlan Catchment.

I understand that the proposed works involve installing a 1.6 metre high parapet wall and an auxiliary spillway. The cost of a fishway solution at Wyangala Dam is likely to be significant, however project development and feasibility investigations will allow for the cost benefit of a fishway to be analysed in due course over the life of this upgrade project.

In view of the above information, NSWDPI recommends that the capacity for a fishway be investigated and incorporated into the Burrendong, Copeton, Split Rock and Wyangala Dam Safety Upgrade Projects.

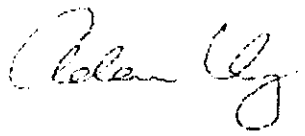
Department of Primary Industries
3 556 Macauley Street
ALBURY NSW 2640

www.dpi.nsw.gov.au
Tel 02 6042 4200
Fax 02 6041 0113

NSWDPI does not recommend the capacity for a fishway be investigated and incorporated into the Chaffey Dam Safety Upgrade Project.

If you have any questions please do not hesitate to contact me on (02) 6042 4200.

Yours faithfully



Adam Vey
Senior Conservation Manager
Aquatic Habitat Rehabilitation (State Water Liaisons)

Department of Primary Industries
3 556 Macauley Street
ALBURY NSW 2640

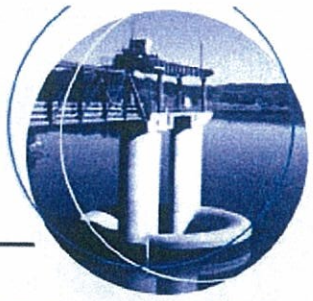
www.dpi.nsw.gov.au
Tel 02 6042 4200
Fax 02 6041 0113

APPENDIX B – Chaffey Community Reference Panel Information Sheet

Chaffey Dam Upgrade

Information Sheet

August 2003



Community Reference Panel

The Chaffey Dam Upgrade Community Reference Panel was established to ensure that the people of the Peel Valley would be effectively involved in the major upgrade project at Chaffey Dam. State Water relies on the panel to provide key advice on how best to approach the community to gather input and feedback into the project.

Formed in 2003, the Community Reference Panel meets regularly to understand the project and provide advice to assist with project management decisions. From the local viewpoint, the panel gives direction on the potential local and regional social, economical and environmental effects of the project.

The Community Reference Panel is made up of representatives from

- local community groups;
- individual members of the public;
- special interest groups; and
- local, state and federal government agencies.

A key outcome for the Community Reference Panel (CRP) is to make a recommendation on the preferred solution for consideration. An Environmental Impact Statement will then be completed on the preferred solution.

Who is on the CRP?

Councillor Phil Betts Mayor of Parry Shire Council, chairs the CRP and the other panel members include:

PANEL MEMBERS

Mayor, Tamworth City Council **James Treloar**	Tamworth City Council **Wilton Boyd**
Nundle Shire Council **Jan Hahn**	Nundle Shire Council **Peter Schofield**
Councillor, Parry Shire Council **Alan Sinclair**	Bowling Alley Point Recreation Reserve Trust **Derek Hill**
Namoi Peel Customer Service Committee and Namoi Valley Water Users Association Inc **Jerry Killen**	Peel Valley Water Users Association **Rex Tout**
Peel Valley Water Users Association **Tom Woolaston**	Nature Conservation Council **Vicki Urquhart**
NSW Environment Protection Authority **Greg Roberts**	NSW Fisheries **David Ward**
Aboriginal & Torres Strait Islander Commission **Bob Faulkner**	NSW State Emergency Service **Bob Allen**
Department of Infrastructure, Planning and Natural Resources - Regional Director **Randall Hart**	Department of Infrastructure, Planning and Natural Resources **Neal Foster**
NSW Dams Safety Committee **Norman Himsley**	Ministry Of Energy & Utilities - Town Water & Services **Ian Burton**
State Water - General Manager **Abel Immaraj**	State Water - Customer Service Manager **Jubrahil Khan**

For further information:

State Water Project Manager, David Watson. Phone: (02) 9895 7374

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Chaffey Dam Safety Upgrade

RISK BASED ESTIMATE REPORT

10 June 2008

Document Status	
Project:	Chaffey Dam Safety Upgrade
Assignment:	Risk based cost estimate
E&P Assignment No:	22558
Client Job No:	Contract SWC 3851
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Evans & Peck Pty Ltd

Phone: + 61 2 9495 0500

Fax: +61 2 9495 0520

Email: Sydney@evanspeck.com

Website: www.evanspeck.com.au

Level 6, Tower 2

475 Victoria Avenue

Chatswood NSW 2067

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1 EXECUTIVE SUMMARY

Background

Evans & Peck (E&P) has been requested by State Water Corporation (SW) to provide a risk based cost estimate for the Chaffey Dam Safety Upgrade. The project comprises a series of upgrade works to improve the operations and safety of the spillway for the dam.

E&P has prepared an estimate from first principles based on an indicative construction method. E&P has also prepared an indicative construction schedule as a basis for preparing an estimate of contractor's indirect costs and escalation. SW have provided estimates of the project management, design and other client costs to be included in the budget. A risk and opportunity workshop was held with key project team members on 20 February 2008. A selected group were present to review the base estimate and evaluate and quantify the inherent and contingent risks outside of the assumptions made by E&P in the base estimate.

Results

Following the workshop, E&P prepared a risk model to predict the distribution of the possible ranges in the total project cost. The results of the risk model are as shown in the Table 1.1.

Table 1.1 also includes E&P's preliminary assessment of escalation costs. Assuming an average annual nominal rate of escalation of 6% compound, a construction start date in mid 2009 and a 2 year construction period, E&P estimates that the total additional cost due to escalation would be approximately 13% for both the full upgrade and dam safety option, and 10% for the auxiliary spillway option.

Table 1.1 Summary of Results

Description	Dam safety and augmentation Option A21HB-FP	Dam Safety Upgrade Option 10FP	Auxiliary Spillway only
Base Estimate (in 2008 dollars)	$40.2M	$20.5M	$8.8M
P50 Total Project Cost (in 2008 dollars)	$42.9M	$21.6M	$8.9M
P90 Total Project Cost (in 2008 dollars)	$46.3M	$23.7M	$10.3M
Base estimate of escalation	$6.0M	$3.1M	$1.0M

Key Assumptions, Risks and Recommendations

The **key assumptions**, which have not been accounted for in the risk-based estimate, are:

That the works will be carried out as a construct-only form of contract, with the contractor being responsible only for temporary works design;

The risk of contractor default is excluded from the estimate;

The estimate is provided in February 2008 dollars, with no allowance for escalation;

SW will negotiate and agree an efficient timeframe for the works which does not require a contractor to accelerate the works;

For the full upgrade option, the Morning Glory (MG) spillway works can commence immediately once the auxiliary spillway is excavated, prior to the embankment raising being complete;

For the full upgrade option, the risk model includes nominal delay risks due to flooding risks. No allowances have been made for premiums paid to transfer flooding risks to a contractor , nor has there been any allowance for the provision of temporary diversion works to prevent a flooding event from impacting on the construction works;

For the full upgrade option, it is assumed that a flooding event occurring during the construction of the new MG spillway would only have an impact on temporary works. No allowance has been made for possible damage to the existing dam infrastructure due to flooding occurring through partially constructed works.

The **major risks**, which have been included in the risk-based estimate include:

Uncertainty in the cost of raising the MG spillway, due to inherent risk in the complicated nature of the works;

The quantity of material required to be excavated for the new auxiliary spillway, and the uncertainty in the extent of drilling and blasting that is required;

Contractor's indirect costs due to uncertainty in the level of supervision required and the duration of the project;

- Contractor's margin;
- SW design and project management costs; and

Upstream costs.

In order to validate and mitigate the above risks, E&P **recommends** that SW focus its project planning on activities that will confirm:

1. The full scope and staging of the project;
2. The preferred procurement strategy and master program. The procurement strategy should include for adequate means to undertake consultation or negotiation with contractor(s) to develop an appropriate and cost effective sharing of risk;
3. The risk management strategy and plan that identifies, assess and develops treatment plans for the key risks in the project;
4. State Water's key requirements for effective maintenance and operation of the infrastructure and the constraints on construction activities;
5. Geotechnical conditions in the vicinity of the new auxiliary spillway and embankment raising;

For the full dam safety and augmentation option, it is also recommended that the following be verified:

6. The staging of and temporary works required so that the level of risk to the infrastructure is not increased;
7. The feasibility of alternative designs that will permit alternative construction methods that have the potential to cater for some flood events and/or to reduce the construction time for the spillway; and
8. State Water's ability to manage storage levels in the dam to reduce and mitigate the risk of flooding to the partially constructed works.

Confirmation of the above will permit E&P's risk-based estimate and assumptions to be further validated and allow a more accurate assessment of project cost and risk allowances.

2 INTRODUCTION

Evans & Peck (E&P) has been requested by State Water Corporation (SW) to provide a risk based cost estimate for the Chaffey Dam Upgrade. The full scope of the project comprises:

- Raising the existing embankment dam wall;

  Construction of a new auxiliary spillway; and

  Increasing the height of the existing Morning Glory (MG) spillway to increase storage capacity.

SW has asked E&P to provide estimates of the following options:

1. An option which includes for the full scope of dam safety upgrade as well as augmentation of the storage (Option A21HB-FP);
2. An option which includes for the full scope of dam safety upgrade i.e. constructing the new auxiliary spillway and raising the dam wall (Option 10FP);
3. An option to construct the auxiliary spillway only as per the details in the previous two options (auxiliary spillway only option).

3 METHOD

The Base Estimate has been calculated from first principles with input from SW and based upon concept design information provided by SW and GHD. The base estimate and assumptions are described in more detail in Section 4 – Base Estimate, and includes discussion on:

- Background information;

  Direct Cost Estimate;

  Preliminary Construction Schedule;

- Indirect Cost Estimate; and

  Client Costs.

A risk & opportunity workshop was carried out with SW and GHD representatives on 20 February 2008 in order to test the assumptions, made by E&P, in the base estimate and to quantify the inherent and contingent risks associated with the project. This process is described in more detail in Section 5 - Risk & Opportunity Analysis.

An @Risk simulation (Monte Carlo analysis) was also carried out by E&P to quantify the risk based cost probability distribution. The Input Data and the @Risk Model Outputs are included in the Appendices for reference. A list of the critical risks has also been included in Section 5 – Risk & Opportunity Analysis.

4 BASE ESTIMATE

4.1 BACKGROUND INFORMATION

E&P has prepared a risk-based cost estimate for the Chaffey Dam Safety Upgrade. The budget estimates are based on the following documents, provided by SW:

- Chaffey Dam Enlargement, Concept Design Report, Public Works Department of NSW for the Department of Water Resources, September 1990; and
- Chaffey Dam Upgrade – Further Assessment of Long Term Options, Report by GHD for State Water Corporation, April 2007; and
- Chaffey Dam: Brief Site Inspection of 12 November 2007, Geotechnical Report by NSW Department of Commerce, December 2007.

E&P has obtained market prices from suppliers and subcontractors for selected items of work. The suppliers and subcontractors are listed in Table 4.1. Copies of written quotations, where available, are provided in Appendix 1.

Table 4.1 – Suppliers and Subcontractors Quotations

Supplier / Subcontractor	Equipment / Works
Hunter Wharf and Barge	Barges
Hanson Construction Materials Pty Ltd	Concrete and quarry materials
Daracon Engineering Pty Ltd	Construction Plant
G.B.P. Cranes	Mobile Cranes
Peri Australia	Formwork systems (informal quote only)

4.2 DIRECT COST ESTIMATE

The estimate is broken down into contractor's direct costs and indirect costs. The direct costs have been further subdivided into the works items listed in Table 4.2. A copy of the Direct Cost Estimate, in Expert Estimation format, is included in Appendix 2.

The agreed baseline assumptions are detailed in Table 4.2 below.

Table 4.2 – Direct Cost Assumptions

Component	Assumptions
Embankment raising	On the downstream side, the land required for the site camp, belongs to State Water and is does not have to be acquired/leased. The creek crossing can be used as an access way for heavy plant and site set-up. A 300 square metre footing was allowed for at the foot of the parapet wall. Sections of the old guardrail can be re-used. A bulking factor of 1.25 was allowed for. Allowance made to resurface car park in parapet storage area. Allowance made for water cart operation for all works involving Zone 1 (clay) materials. The creek crossing can be used as an access way for plant for the entire period of the embankment works. No piling is required to support bridging works at dissipator outlet extension.
Auxiliary spillway	The material from the excavation of the auxiliary spillway is 75% hard rock and 25 % soft rock. Rock anchoring and shotcrete to 2% of the auxiliary spillway walls was allowed for. A concrete lined spillway channel, to provide cover for the temporary outlet channel at completion of MG spillway, is allowed for; No allowance made for grout curtain beneath the fuseplugs.
Access bridge to morning Glory spillway	Bridge to be lifted off using a barge crane, placed on pontoons and temporarily stored. Allowance made for temporary pontoon access bridge It is assumed that the existing outlet will be able to be temporarily operated without changing the configuration of the baulks and trash racks.
Morning Glory spillway	Steel coffer dam or similar temporary works allowed for Morning Glory spillway works. Construction of temporary outlet through auxiliary spillway will not be required to enable construction of Morning Glory spillway. The adopted designs detailed in September 1990 report for PWD are still valid. Allowances have been made for new supply costs for the 5t capacity hoist crane and the M&E works for the new lift. Internal surfaces formed based on Peri system. Quantity of concrete based on GHD estimate of 1,930 cu.m External surfaces to be formed using precast concrete panels (similar to original construction of spillway)

4.3 PRELIMINARY CONSTRUCTION SCHEDULE

E&P has produced a preliminary construction schedule to assist the estimating process and specifically for calculation of time related site indirect costs associated with the project. A copy of the construction schedule is included as Appendix 3.

The preliminary construction schedule indicates construction duration of approximately 91 weeks for either the full upgrade or full dam safety options. The preliminary construction schedule indicates the auxiliary spillway option could be completed in a shorter timeframe of approximately 35 weeks. All time-based indirect costs estimated are based on these durations.

4.4 INDIRECT COST ESTIMATE

The indirect costs have been further subdivided into the works items listed in Table 4.3. A copy of the Indirect Cost Estimate, in Expert Estimation format, is included in Appendix 2.

The base estimate assumptions were reviewed as part of the risk analysis during the risk workshop. The agreed baseline assumptions are detailed in Table 4.3 below.

Table 4.3 – Indirect Cost Assumptions

Component	Assumptions
Contractor Indirects	SW will make available area for contractor's compound near the works Temporary fencing required around the works Allowances for bank guarantees, long service leave levy, contract works insurance SW will provide full design with the contractor being responsible only for temporary works design
Contractor's Margin	Allowance of 15% for off-site overheads and profit, applied to total direct and indirect costs, including inherent risk.
Directs and indirect costs	Based on 91 week construction period (see Appendix 3). Construction of the new MG spillway can commence once the auxiliary spillway has been constructed but before the reinforced earth wall is complete.

4.5 CLIENT COSTS

SW have provided estimates of the likely client costs required to deliver the project. The estimate has been subdivided into the following components:

- Design and Project Management (15% of construction cost);
- Upstream Costs; and

Other SW costs (2.5% of project costs).

E&P has reviewed the margins applied for design and project management and other SW costs and considers that they are within the expected range for infrastructure projects of this nature.

5 RISK / OPPORTUNITY ANALYSIS

A risk & opportunity workshop was carried out on 20 February 2008. A selected group of SW and GHD staff were present to review the base estimate and evaluate and quantify the inherent and contingent risks outside of the assumptions made by E&P in the base estimate. Refer Appendix 4 for a more detailed description of the Risk Based Cost Estimating Process.

5.1 PROJECT OBJECTIVES

The first stage of the risk and opportunity workshop was to agree the project objectives. E&P had produced a preliminary list, which was discussed and a final list of project objectives was developed and agreed by the group. The identification, evaluation and quantification of risks & opportunities were then carried out with the agreed Project Objectives in mind.

The Project Objectives agreed at the workshop are to:

- To upgrade the existing Chaffey Dam to 2008 Dam Safety standards;
- To minimise adverse environmental impacts;
- To minimise planned operational disruption and avoid unplanned disruption;
- To ensure protection of construction workers and SW personnel during the works;
- Augment the capacity of the dam storage to 100 GL; and
- To complete construction of Stage 1 by 2012.

5.2 INHERENT RISK ASSESSMENT

An assessment of inherent risk, that is, risk due to uncertainty in scope, metrics, and pricing, has been made by E&P based on the assumptions applied during the estimation process and the likely accuracy of the information provided by SW, GHD, suppliers and subcontractors.

E&P has analysed the base estimate in order to develop a risk based cost estimate for the project. The analysis required some judgement to be made as to the likely range of costs for each of the individual components of the estimate. An item that is well described and where quotes have been received from suppliers may be expected to have a smaller range of possible costs of, say +/- 5%. However an item, which has not been fully specified and where no quotations or market prices exist may be expected to have a much larger range of possible costs of, say –25% +40%.

Each of the components of the estimate has been analysed and a range of possible outcomes has been applied to each component. An assessment of the likely probability distribution is also applied to each component i.e. triangular, uniform, normal or pert.

This information was recorded on an Excel spreadsheet for later inclusion in the @Risk model. Refer to Appendix 4 for a copy of the Inherent Risk Model used as the inputs to the @Risk model.

5.3 CONTINGENT RISK ASSESSMENT

An assessment of contingent risk, that is, risk associated with events that may or may not occur and have not been included as an item in the base estimate, was also made during the workshop of 20 February 2008.

The analysis of risks and opportunities was broken down into the following areas for ease of assessment:

- Feasibility & Funding;
- Political & Community;
- Planning & Environment;
- Design & Delivery, and
- Contractual & Commercial.

A list of contingent risks & opportunities was developed during the workshop. The risks & opportunities were evaluated individually in order to estimate the likelihood of occurrence and also the consequence. The process being similar to the assessment of inherent risk described above with the additional evaluation of likelihood to allow that the risks may or may not occur at all.

This information was also recorded on an Excel spreadsheet for later inclusion in the @Risk model. Refer to Appendix 4 for a copy of the Contingent Risk Model, used as the inputs to the @Risk model.

5.4 RISK MODELLING

Subsequent to the workshop, E&P analysed the information recorded during the workshop and carried out an @Risk probabilistic analysis (Monte Carlo simulation) of the data to produce the combined graph of Risk Based Cost Probability Distributions detailed in Section 2 - Summary of Results.

The range of possible outcomes can be represented as a histogram or, as provided in this report, as a cumulative distribution of probability of exceedance vs. cost. The probability of exceedance can be described as the likelihood of completing the project for less than the budget amount specified. The cumulative distribution allows the probability of exceedance, for any given cost, to be interpreted directly from the graphs. Conversely for any chosen probability of exceedance, the appropriate cost value can also be interpreted directly from the curves. The @Risk model outputs are included in Appendix 5.

5.5 MAJOR RISKS AND OPPORTUNITIES

The major risks, which have been included in the estimate of Total Project Cost include:

- Uncertainty in the cost of raising the MG spillway, due to inherent risk in the complicated nature of the works;

  The quantity of material required to be excavated for the new auxiliary spillway, and the uncertainty in the extent of drilling and blasting that is required;

  Contractor's indirect costs due to uncertainty in the level of supervision required and the duration of the project;

- Contractor's margin;

  Client design and project management costs; and

  Client upstream costs.

5.6 MAJOR ASSUMPTIONS AND EXCLUSIONS

The major assumptions and exclusions from the estimate include:

The works will be carried out as a construct-only form of contract, with the contractor being responsible only for temporary works design;

No allowance for the risk of contractor default has been included;

The base estimate is provided in February 2008 dollars, with no allowance for escalation;

SW will negotiate and agree an efficient timeframe for the works which does not require the contractor to accelerate the works, either by provision of additional resources or extended shift work;

For the full upgrade option, the MG spillway works can commence once the auxiliary spillway is complete and prior to the embankment raising being complete;

For the full upgrade option, the risk model includes nominal risks due to flooding. No allowances have been made for premiums to transfer flooding risks to a contractor or for temporary diversions that would prevent a flooding event from impacting on the works. SW has instructed E&P that it will develop an appropriate and cost effective sharing of risk with its preferred contractor. On this basis, E&P has included in the risk model for some delay events due to flooding which have been quantified using E&P's estimate of the average weekly indirect cost together with SW's estimate of likelihood and extent of flooding that could be expected;

For the full upgrade option, it is assumed that a flooding event occurring during the construction of the new MG spillway would only have an impact on temporary works. No

allowance has been made for possible damage to the existing dam infrastructure due to flooding occurring when the MG spillway works are only partially constructed.

6 SUMMARY OF RESULTS

6.1 BASE ESTIMATE

The base estimate for Chaffey Dam Safety Upgrade, including contractor's direct and indirect costs and SW costs and excluding risks are detailed in Table 6.1.

Table 6.1 – Base Estimate Summary– Excluding Risk Allowances

Description	Full upgrade Option	Full dam safety option	Auxiliary spillway option
Direct Costs			
Embankment Raising	9,556,755	5,936,028	N/A
Auxiliary spillway	3,464,736	3,932,336	3,932,336
Access bridge to the MG spillway	903,546	N/A	N/A
MG Spillway construction	5,202,829	N/A	N/A
Indirect Costs			
Total Indirect Cost	6,936,363	4,477,003	1,770,044
Total Contractors Margin	3,909,634	2,151,805	855,357
Total Contract Cost (excluding risk)	**29,973,864**	**16,497,172**	**6,557,737**
Client Cost			
Design and Project Management	4,496,080	2,474,576	983,661
Upstream costs	4,730,000	1,080,000	1,080,000
Other SW costs	979,999	501,294	215,535
Total client cost (excluding risk)	**10,206,079**	**4,055,870**	**2,279,196**
Total Project Cost (excluding risk)	**40,179,943**	**20,553,042**	**8,836,933**

6.2 RISK BASED ESTIMATE

Risk based cost probability distributions for the Chaffey Dam Safety Upgrade have been calculated and the summary of the results are provided in Figures 6.1 to 6.3. The P50 and P90 values are listed in Table 6.2. The detailed risk model outputs are included in Appendix 6.

Figure 6.1: Probability Distribution – Full Upgrade Option

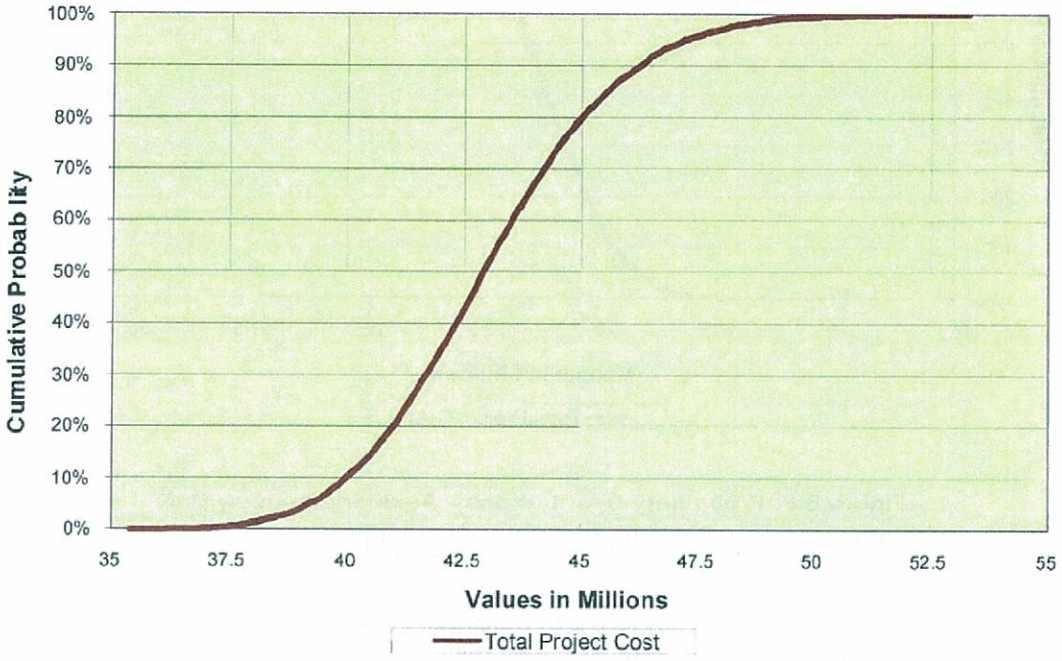

Figure 6.2: Probability Distributions – Full Dam Safety Option

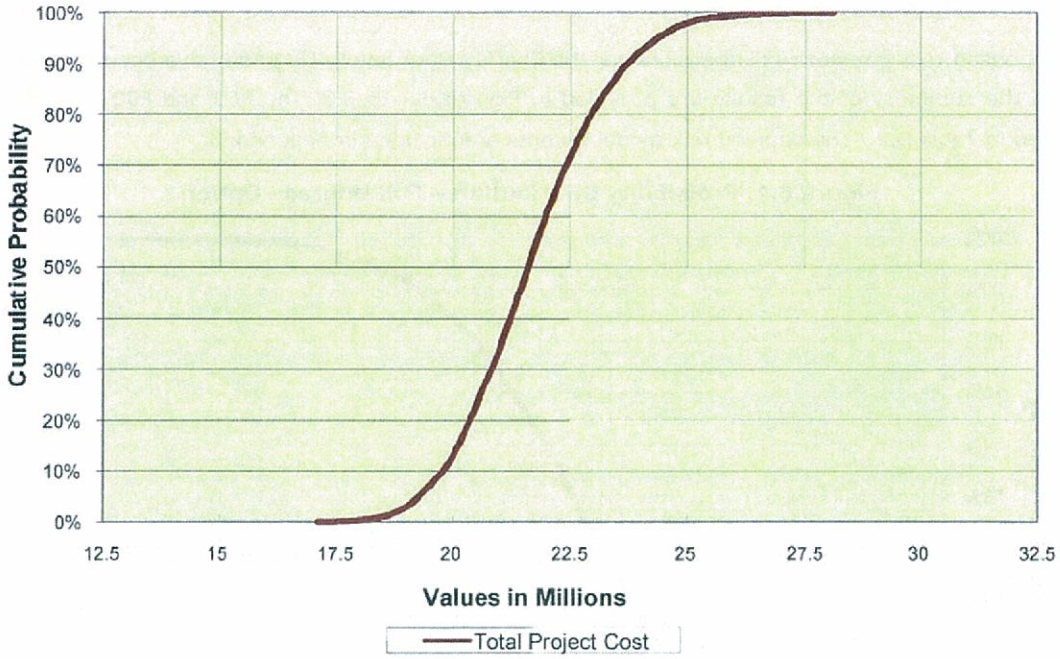

Figure 6.3: Probability Distributions – Auxiliary Spillway Only

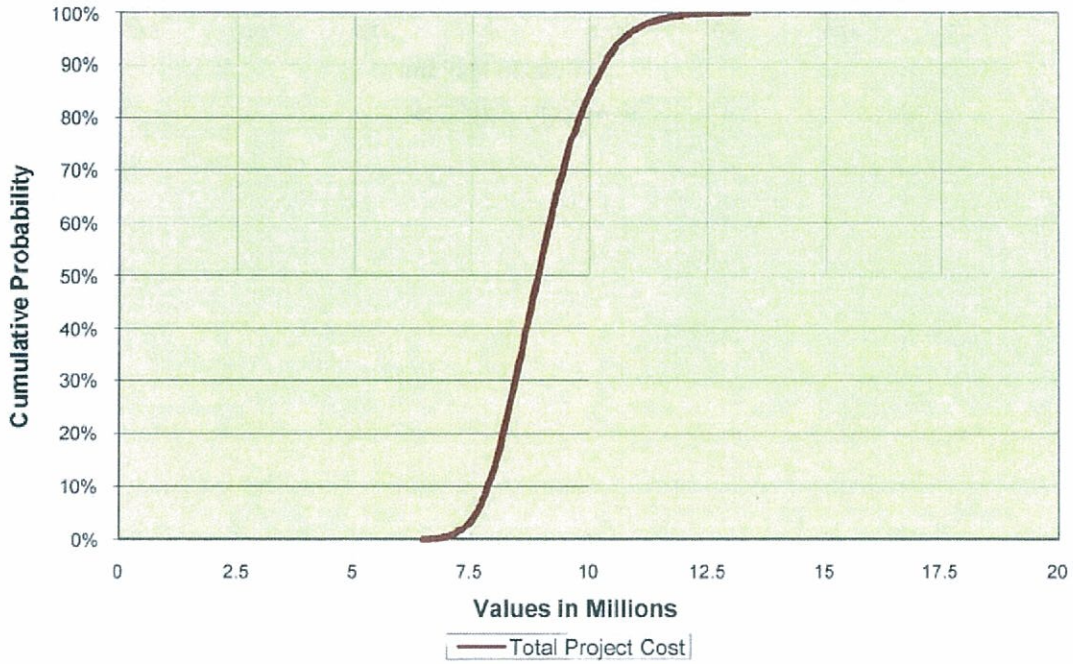

Table 6.2 Summary of Results

Description	Dam safety and augmentation Option A21HB-FP	Dam Safety Upgrade Option 10FP	Auxiliary Spillway only
P50 Total Project Cost (in 2008 dollars)	$42.9M	$21.6M	$8.9M
P90 Total Project Cost (in 2008 dollars)	$46.3M	$23.7M	$10.3M

The curves shown in Figure 6.1 to 6.3 indicate the likely Total Project Costs, including contract costs, client costs, inherent risk and contingent risk.

6.3 ESCALATION ESTIMATE

The estimates above are given in 2008 dollars and do not include any allowances for escalation. Assuming an average nominal annual rate of escalation of 6% compound, a construction start date in mid 2009 and a 2 year construction period, E&P estimates that the total additional cost due to escalation would be approximately 13% for both the full upgrade and dam safety option. The escalation for the auxiliary spillway option would be slightly reduced due to a shorter construction timeframe (approximately 10%). E&P's preliminary base estimate of escalation of each option is as shown in Table 6.3.

Table 6.3 Base Escalation Estimate

Description	Dam safety and augmentation Option A21HB-FP	Dam Safety Upgrade Option 10FP	Auxiliary Spillway only
P90 Total Project Cost (in 2008 dollars)	$46.3M	$23.7M	$10.3M
Base estimate of escalation	$6.0M	$3.1M	$1.0M

7 RECOMMENDATIONS

As the Chaffey Dam Upgrade project is further developed, E&P recommends that State Water focus project planning on activities that will confirm:

1. The full scope and staging of the project;
2. The preferred procurement strategy and master program. The procurement strategy should include for adequate means to undertake consultation or negotiation with contractor(s) to develop an appropriate and cost effective sharing of risk;
3. The risk management strategy and plan that identifies, assess and develops treatment plans for the key risks in the project;
4. State Water's key requirements for effective maintenance and operation of the infrastructure and the constraints on construction activities;
5. Geotechnical conditions in the vicinity of the new auxiliary spillway and embankment raising;

For the full dam safety and augmentation option, it is also recommended that the following items be confirmed:

6. The staging of and temporary works required so that the level of risk to the infrastructure is not increased;
7. The feasibility of alternative designs that will permit alternative construction methods such as constructing the spillway in segments, constructing the new spillway with temporary openings, or using precast concrete. These alternatives may permit some flood events to be catered for and/or reduce the construction time for the spillway; and
8. State Water's ability to manage storage levels in the dam to reduce and mitigate the risk of flooding to the partially constructed works.

The activities above will allow the risk-based estimate and assumptions to be validated and permit a more accurate assessment of project cost risk.

Land Details Chaffey Dam Augmentation

LOT/POR	DP/CROWN	TITLE REFERENCE
1	DP 589247	1/589247
5	DP 1139971	5/1139917
7	DP 1139917	7/1139917
6	DP 1139917	6/1139917
1	DP 631895	1/631895
2	DP 631895	2/631895
8	DP260040	8/260040
9	DP260040	9/260040
1	DP 598184	1/598184
2	DP 598184	2/589184
3	DP 598184	3/598184
2	DP 709662	
8	DP 261290	8/261290
149	1541-1764	149/755324
12	1676-1764	12/755324
13	1676-1764	13/755324
14	1676-1764	14/755324
15	1676-1764	15/755324
16	1676-1764	16/755324
17	1676-1764	17/755324
1	DP 719760	1/719760
2	DP 719760	2/719760
3	DP 719760	3/719760
4	DP 719760	4/719760
5	DP 719760	5/719760
6	DP 719760	6/719760
7	DP 719760	7/719760
54	159-1764	Pt A/C 9527-73
104	895-1764	Pt A/C 9527-73
105	896-1764	Pt A/C 9527-73
106	897-1764	Pt A/C 9527-73
103	909-1764	103/755324
93	851-1764	Pt. A/C 9527-72
94	852-1764	Pt. A/C 9527-72
7	DP 261290	7/261290

Roads

3	1676-1764	Pt. A/C 1046-63
4	1676-1764	Pt. A/C 1046-63
5	1676-1764	Pt. A/C 1046-63
6	1676-1764	Pt. A/C 1046-63
7	1676-1764	Pt. A/C 1046-63
10	DP 111770	Pt. A/C 10968-51
11	DP 111770	Pt. A/C 10968-51
4	DP 111770	4/111770
5	DP 111770	Pt. A/C 4227-136
7	DP 111770	Pt. A/C 4227-136
8	DP 111770	Pt. A/C 4227-136
6	DP 111770	6/111770
156	1597-1764	156/755324
91	3319-1764	Pt. A/C 6811-73
225	2740-1764	Pt. A/C 6811-73
240	2744-1764	240/755324
239	2744-1764	239/755324
238	2744-1764	238/755324
237	2744-1764	Pt. No 149 Bk 3271
241	2745-1764	Pt. No 149 Bk 3271
226	2740-1764	226/755324
227	2740-1764	227/755324

Land Details Chaffey Dam Augmentation

LOT/POR	DP/CROWN	TITLE REFERENCE
SEC 19		
249	2782-1764	No 898 Bk 3348
228	2741-1764	228/755324
229	2741-1764	229/755324
276	3018-1764	276/755324
1	DP 606961	1/606961
A1 S8	1-1748	Pt. A/C 37-138
A5 S13	1-1748	Pt. A/C 37-138
A2 S8	1-1748	Pt. A/C 2599-233
A3 S8	1-1748	Pt. A/C 2599-233
A4 S8	1-1748	Pt. A/C 2599-233
A5 S8	1-1748	Serial 319 Fol 232
A6 S8	1-1748	Serial 319 Fol 232
A7 S8	1-1748	7/8/758020
A8 S8	1-1748	Pt. A/C 2599-232
A9 S8	1-1748	Pt. A/C 2599-232
A10 S8	1-1748	Pt. A/C 2599-232
A1 S12	2-2688	Pt. A/C 3343-138
A2 S12	2-2688	Pt. A/C 3343-138
A10 S12	1-1748	
A7 S12	2-2688	Pt. A/C 3212-248
A8 S12	2-2688	Pt. A/C 3212-248
A3 S12	2-2688	Pt. A/C 3212-249
A4 S12	2-2688	Pt. A/C 3212-249
A5 S12	2-2688	Pt. A/C 3212-40
A6 S12	2-2688	Pt. A/C 3212-40
A6 S7	1-1748	Pt. Vol 27 Fol 74
A1 S7	1-1748	Pt. Vol 370 Fol 114
A10 S7	1-1748	Pt. Vol 370 Fol 114
A2 S7	1-1748	2/7/758020
A3 S7	1-1748	Pt. A/C 3059-95
A4 S7	1-1748	Pt. A/C 3059-95
A5 S7	1-1748	Pt. A/C 3059-95
A9 S7	1-1748	9/7/758020
A7 S7	1-1748	Pt. A/C 3059-96
A8 S7	1-1748	Pt. A/C 3059-96
A2 S13	1-1748	
A3 S13	1-1748	
A4 S13	1-1748	
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277	3019-1764	Pt. No 273 Bk 3332
231	2742-1764	231/755324
232	2742-1764	232/755324
284	3158-1764	284/755324
1	DP 252679	1/252679
2	DP 252679	2/252679
3	DP 252679	3/252679
4	DP 252679	4/252679
50	97-1764	50/755324
51	96-1764	51/755324
52	130-1764	52/755324
74	82-1764	74/755324
Reserve	2407-3100	
Reserve	2407-3100	
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Reserve	2408-3100	40/755324 PT
Reserve	2408-3100	
	2408-3100	
139	1347-1764	139/755324
87	1157868	87/1157868
160	1608-1764	160/755324
30	92-1764	30/755324
1	DP 955377	1/955377
2	DP 955377	2/955377
3	DP 955377	3/955377

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159	1607-1764	159/755324
2	DP 585684	2/585684
158	2823-1764	158/755324
33	99-1764	33/755324
19	1091-1764	Pt. A/C 4981-184
35	100-1764	Pt. A/C 4981-184
87	3369-1764	No 895 Bk 3323
34	101-1764	34/755324
3	DP 611964	3/611964
4	DP 611964	4/611964
1	DP1125418	1/1125418
257	2902-1764	257/755324
295	3379-1764	295/755324