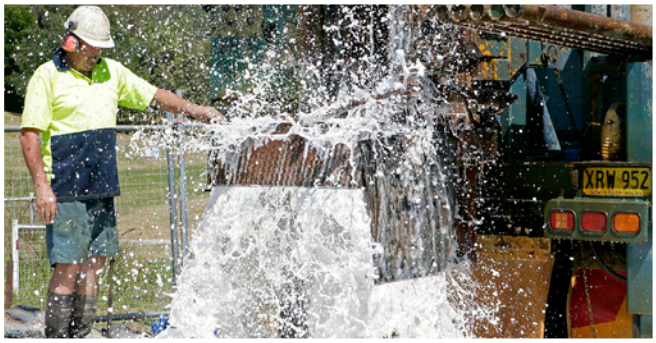
Upper Nepean (Kangaloon) borefield project



Preferred Project Report

Volume 1 – Main report

SYDNEY CATCHMENT AUTHORITY

This report is published in two parts:

Upper Nepean (Kangaloon) Borefield Project – Preferred Project Report – Volume 1 – Main Report

Upper Nepean (Kangaloon) Borefield Project – Preferred Project Report – Volume 2 – Appendices

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Printed January 2009
ISBN 978-1-876951-44-3 (Vol 1)

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Upper Nepean (Kangaloon) Borefield Project

Preferred Project Report

Volume 1 – Main Report

December 2008

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Contents

List of Tables

List of Figures

Appendices

Executive Summary

This preferred project report (PPR) has been prepared for the Upper Nepean (Kangaloon) Borefield development. The project involves the construction and operation of a borefield to supply water to the Greater Sydney and the Illawarra regions during severe drought periods. To provide the water, new water supply infrastructure would be built in the Upper Nepean Catchment at Kangaloon in the Southern Highlands.

The environmental assessment (EA) and this supporting PPR have been prepared in accordance with the provisions of Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) and the Australian Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The Sydney Catchment Authority (SCA) has reviewed all of the 147 submissions lodged as a result of the public exhibition of the Upper Nepean (Kangaloon) Borefield Project environmental assessment (EA) in April 2008. The SCA is now seeking planning approval for the borefield development. An approval period of 15 years is requested given the likely timeframe for commencement of a project of this nature, the substantial and confident understanding of the environment and the potential effects of the project, and the likely need to rapidly commence construction when the project is required.

The assessment is based on a rigorous and significant body of scientific, technical and cultural investigations that have taken place over more than three years. Key studies have been peer reviewed. These investigations and the borefield project have been supported and informed by an ongoing and comprehensive community consultation program.

This report presents the SCA's response to the submissions, further results from technical work completed on the geological structure; environmental linkages; capacity and sustainability aspects of the borefield; improved borefield designs; and property acquisitions.

Environmental assessment, exhibition, consultation and the submissions

The EA was on public exhibition from 2 April until 5 May 2008, and submissions were received up until 16 May 2008. The exhibition of the EA was widely publicised and involved three venues. All documents were available via the NSW Department of Planning's web site. There was extensive consultation with government agencies, local landowners and interest groups during the exhibition period. This consultation is ongoing.

The EA identified a number of key community and environmental concerns surrounding the project; outlined the borefield design, described the resource characteristics and environmental setting; and then discussed the impacts and the proposed management and mitigation measures. There has been substantial comment by stakeholders on these matters in their submissions.

Submissions raised concerns from the community about environmental impacts to water resources, water quality, ecosystems, local landscapes, the socio-economic effects to land and water use, project cost and consultation. Many submissions raised the need for further technical studies and more extensive monitoring. Broader issues relating to

planning approvals, the Metropolitan Water Plan and alternative water sources, and water resource management were raised.

In response to the submissions and further project development, improvements have been made to the project that further reduce environmental impacts in some sensitive vegetation areas along Tourist Road and Kirkland Road. Monitoring (and trigger and response) programs have also been enhanced to better assess and manage potential impacts. The monitoring targets the natural attributes and hydrological variability of the upper catchment, and assists in the prediction of water level and any environmental trends.

During construction, these issues will be managed through the careful selection of final bore locations, and pipeline and power routes within the corridors identified in the EA. Site works will be regulated through the implementation and auditing of sensitive construction and environmental management practices. Detailed construction environmental management plans (CEMPs) will be in place for all construction.

During operation, an adaptive management approach will detect and respond to changes in water level, water quality and environmental trends. Ongoing monitoring and periodic modelling updates will continue to inform improvements to the management and operation of the borefield. Monitoring of water levels will be particularly important for day-to-day borefield operation, and in contributing to the long-term assessment of operations.

New studies

Further results of pumping trials have been received since the EA was lodged and in all, more than 16 technical reports have been completed for this area over the last nine months. These studies include the final pumping trial results at Stockyard Swamp, final water quality studies, additional ecosystem studies, numerical modelling and the latest design refinements.

All the work has been internally or externally peer reviewed and all reports add to SCA's conclusion that the borefield development is viable, drought extractions are sustainable, and environmental impacts are manageable. The studies confirm there are no linkages between perched water bearing zones and the regional sandstone aquifer, and that stream connectivity is low. All studies confirm that the conclusions presented in the EA, and the proposed management and mitigation measures, are appropriate.

Design and construction changes

The borefield corridor, layout, and proposed designs are fundamentally the same as presented in the EA. The design has been further refined in the following ways:

- *detailed design of the water treatment facilities to fit into the local landscape – these designs cover water treatment (aeration) modules, tanks and collection ponds, and the two discharge locations on the Nepean River (downstream of the Tourist Road bridge crossing) and Maguires Creek (downstream of the culvert on Fire Trail No.3)*
- *future rationalisation of production bore locations – one proposed bore site (site 3O) will not be drilled in Area 3 and other production bore sites (mostly in Areas 1, 2, and 4) may change slightly due to the success of a recent trial of ground geophysical surveying techniques which will allow more precise location of bores*

- *improved in-situ water treatment - a preventative maintenance system has been included within each production bore compound*
- *minor pipeline route changes along Kirkland Road and Tourist Road (eastern area) to avoid natural vegetation and reduce impacts during construction*
- *minor power line route changes along Kirkland Road and Tourist Road (eastern area) to reduce visual impact during construction and operation.*

Operational changes

There are no proposed operational changes from those documented in the EA (except that production bores may operate at slightly lesser rates than their individual "safe yield" estimates).

The borefield operating range remains within 10 to 15 billion litres per year as previously advised in the EA. The installed capacity within the borefield will be around 18 billion litres per year so there will be some flexibility in borefield operations, pump scheduling and timing of extractions.

Latest numerical modelling suggests that borefield capacities will reduce over time because of the density of production bores and the local depletion of the sandstone aquifer in some areas. At the end of an extended pumping period, production rates of around 13 billion litres per year should still be achievable.

Environmental assessment

The design, construction and operational changes have been assessed and it is concluded that there will be reduced impacts (compared to the development proposal contained in the EA).

For the water treatment plant (WTP) areas, flood studies and architectural studies have been completed to ensure the developments are compatible with each of the chosen locations. The flood studies at the Tourist Road WTP show that the current flood levels vary by up to about 1.7 metres, but the incremental difference in flood levels pre and post construction of the collection ponds and the WTP structures is 30 millimetres to 70 millimetres. The collection ponds are likely to be overtopped during 1 in 20, 1 in 50, and 1 in 100 year floods. The inundation would be by only a few centimetres at the more frequent flood recurrence interval and is likely to slowly fill the ponds rather than scour the ponds. Inundation is only likely for a few hours and is unlikely to cause any water quality impact to the Nepean River.

The arrangement of the buildings that make up each of the WTPs is similar to farm buildings in the area. To fit better into the rural setting, the buildings are located in an informal arrangement defining a yard or hard stand. To minimise the scale and bulk of the facilities, and hence the visual impact, the water treatment modules and other plant is housed in a number of small buildings. The simple shed-like forms of the buildings with skillion roofs are intended to sit in the landscape in a low key manner.

The collection ponds and river discharge features fit within the landscape and have minimal visual impact.

Some traffic management planning will be required along Tourist Road during the construction of the Tourist Road WTP and its dedicated access road, as well as that section of Kirkland Road where the pipeline is to be constructed in the verge of the road.

The preferred project

With these refinements, the preferred project comprises:

- *75 production bores (cased and screened, and equipped with submersible pumps) ranging from 90 to 180 metres deep, positioned between 500 and 750 metres apart*
- *a buried water transfer system, with pipes ranging in diameter from 100 to 300 millimetres enabling the water to be transferred to the Nepean River system. An estimated 50 kilometres of buried piping will connect production bores with water treatment facilities*
- *two water quality treatment facilities to adjust temperature and oxygen levels, and to reduce iron concentrations*
- *two river discharge locations – one on the Nepean River and one on Maguires Creek – from where the water will flow to the Nepean Dam*
- *an 11 kilovolt (kV) power network (combination of overhead and buried power lines) supplying electricity to transformers that will power the submersible pumps and water treatment facilities*
- *an outdoor switchboard at each bore which will house the power and control switchgear to each bore pump*
- *fibre optic cabling from each bore to a central location for control and communications*
- *a preventative maintenance system at each bore location to prevent iron scaling and iron bacteria blooms*
- *a network of monitoring bores and gauging stations to monitor resource behaviour and manage borefield performance and impact.*

Environmental and resource monitoring

The proposed monitoring program outlines measures to reduce remaining uncertainties regarding borefield impacts. Increased and targeted environmental monitoring is proposed pre-construction, and then be more intensive during construction, operation and post operational phases. An adaptive management approach is proposed during all operational periods. Effective monitoring programs are essential to ensure that the environment and consumptive users are protected.

Three levels of resource and environmental monitoring planning are proposed:

- *detailed monitoring framework*
- *specific monitoring plans (to be developed later under Department of Water and Energy and Department of Environment and Climate Change licences)*
- *site management plans which will include monitoring (CEMPs and operational environmental monitoring plans when the borefield proceeds).*

The monitoring framework outlined in this PPR highlights the increased monitoring of ecosystems (including the use of control sites) during construction and operational periods.

Matters of national environmental significance

Several new studies confirm the disconnection between the upland swamp ecosystems and the regional aquifer in the Hawkesbury Sandstone. The project has been refined to further reduce impacts to threatened biodiversity. An additional threatened species assessment will be conducted in advance of finalising the production bore locations and the buried pipeline route, and additional monitoring is proposed in advance of and during the construction, operation and post operational phases.

Conclusion

In conclusion, the project is considered viable and is sustainable. Impacts are considered acceptable and the proposed management and mitigation measures comprehensive. It is recommended that, subject to adopting the proposed mitigation and management strategies, and the final draft Statement of Commitments presented in Section 7.3, the project should be granted planning approval.

1. Introduction

1.1 Purpose of this report

The Upper Nepean (Kangaloon) Borefield project is part of the NSW Government's Metropolitan Water Plan (MWP) to secure Sydney's water needs for the next 25 years. This project involves the construction and operation of a borefield to supply water during severe drought periods from the Upper Nepean Catchment near Kangaloon in the Southern Highlands.

An environmental assessment of the project was prepared and lodged by Sydney Catchment Authority (SCA) which responded to the requirements of the Director-General of the Department of Planning. The Department of Planning exhibited the environmental assessment between 2 April and 5 May 2008 and submissions were invited.

This preferred project report (PPR) analyses and responds to the issues raised in the submissions. The responses to the submissions are based on analysis of the issues raised, the findings of the environmental assessment and additional information gained since the environmental assessment was completed. This additional information addresses many of the issues raised in the submissions and helps to inform the proposed changes to the project.

1.2 Background

The NSW Government's strategy to achieve a sustainable and secure water supply for greater Sydney is outlined in the MWP. In addition to implementing demand management measures to reduce commercial, industrial and household water usage and other measures to increase recycling, this plan defines how the government will manage urban water sources in times of severe drought. Accessing groundwater is an important new drought response measure outlined in the 2006 plan. Construction of a 250 million litre per day (ML/d) desalination plant is under way and the use of this plant would be maximised during drought. In periods of extended and severe drought both the desalination plant and groundwater borefields would operate in order to supplement the available drinking water supply.

The NSW Government is advised by the Metropolitan Water Independent Review Panel, which provides expert advice and input into reviews of the MWP every four years. The implementation of the plan is monitored, evaluated and adapted as required. A review of the plan by this independent panel in 2006 strongly endorsed both the proposed use of groundwater as a supplementary water source during drought and the decision to proceed with the Upper Nepean (Kangaloon) Borefield and other borefields. The next MWP will be released in 2010.

Seven priority areas have been assessed under the MWP's groundwater investigation program since late 2004. The Upper Nepean (Kangaloon) area was the first area assessed to have potential for drought water supply. Two other areas have also been identified with resource potential but environmental studies have not been finalised and planning approvals and borefield design have not been initiated. There are likely to be other prospective areas across the Sydney Basin for raw potable and non-potable supplies that have not been investigated.

Substantial technical, scientific and environmental studies (more than 90) have defined the characteristics and attributes of the groundwater resource and the natural environment of the Upper Nepean (Kangaloon) borefield area. These investigations commenced in March 2005. Numerous peer reviews have shown the work to be scientifically rigorous and credible.

The project will provide a significant supplementary water source during severe drought. If dam levels drop to the MWP trigger of 40 percent capacity or below, groundwater from multiple sources can supply 30 to 45 billion litres of water each year during severe drought periods. A third of this water will come from the proposed Upper Nepean (Kangaloon) Borefield.

On 18 June 2008, the NSW Government decided to halt development of the Kangaloon Borefield once the environmental and planning assessment process is concluded and land acquisition, tender design and project documentation are completed. This deferral of the construction program was possible because of water savings efforts and the easing of drought conditions.

Although construction of the borefield will not proceed at this time, this level of readiness will enable the borefield to be built without delay in the event of a future drought emergency. The government's decision is consistent with the 2006 MWP strategy to build the borefield if the dam storage levels drop below the 40 percent trigger level in the future.

With the pending completion of the 250 million litres per day (ML/d) desalination plant it is unlikely that groundwater supply sources will be required for the foreseeable future. However groundwater is an important component of the diversification of water supply sources for the greater Sydney supply system, and hence a long-term planning approval is sought as a readiness strategy for the Kangaloon Borefield. This borefield would be the first of the multiple groundwater sources that would be developed if severe drought conditions returned for an extended period.

An approval period of 15 years is requested given the substantial commitment to investigations, property acquisitions, engineering designs and on-ground monitoring systems. An approval period of this length is sought on the basis of:

- detailed environmental understanding of the development and confidence in the predictions
- a requirement to rapidly commence construction (if severe drought returns)
- environmental conditions in the area, which are unlikely to significantly change over this period
- the local and minor nature of social impacts

- the period being consistent with expected timeframes to initiate the project.

1.3 Summary of the project

The borefield has been divided into four areas for possible staged development and commissioning. These areas and the borefield corridor are shown on **Figure 1.1**.

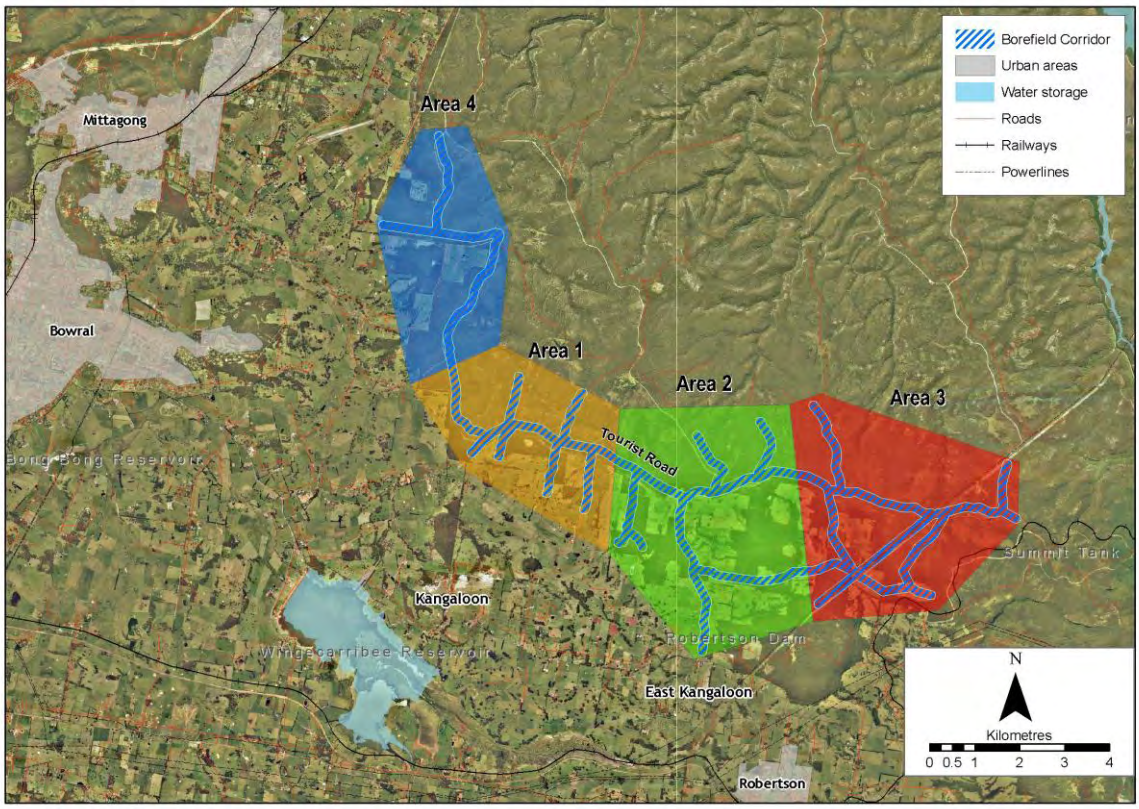

Figure 1.1 Kangaloon borefield showing corridor and Areas 1 to 4

The fundamentals of the project have not changed since the release of the environmental assessment (EA) in April 2008. The proposed borefield consists of five primary infrastructure components:

- the array of boreholes (both production bores and monitoring bores)
- the interconnecting pipework, water treatment facilities and discharge structures
- the electricity distribution network
- communication cabling and infrastructure
- upgraded fire trails to provide all weather access.

The borefield project comprises the following infrastructure:

- 75 production bores (cased and screened, and equipped with submersible pumps) ranging from 90 to 180 metres deep, positioned between 500 and 750 metres apart
- a buried water transfer system, with pipes ranging in diameter from 100 to 300 millimetres enabling the water to be transferred to the Nepean River system.

An estimated 50 kilometres of buried piping will connect production bores with water treatment facilities

- two water quality treatment facilities to adjust temperature and oxygen levels, and to reduce iron concentrations
- two river discharge locations – one on the Nepean River and one on Maguires Creek – from where the water will flow to the Nepean Dam
- an 11 kilovolt (kV) power network (combination of overhead and buried power lines) supplying electricity to transformers that will power the submersible pumps and water treatment facilities
- an outdoor switchboard at each bore which will house the power and control switchgear to each bore pump
- fibre optic cabling from each bore to a central location for control and communications
- a preventative maintenance system at each bore location to prevent iron scaling and iron bacteria blooms
- a network of monitoring bores and gauging stations to monitor resource behaviour and manage borefield performance and impact.

The proposal involves extracting 10 to 15 billion litres per year (GL/y) of water in drought periods. The period of operation will be dependent on the length of drought and number of significant rainfall recharge events. Operation will cease when dam storage levels increase above the operational trigger level of 40 percent under the current MWP.

1.4 The approval process

The Minister for Planning is assessing the project under Part 3A of the NSW *Environmental Planning & Assessment Act 1979* (EP&A Act) and has further declared the project 'critical infrastructure' as it is essential to the State for economic and social reasons. The Director-General of the Department of Planning issued his requirements for the environmental assessment of this project on 21 January 2007. A supplement to these requirements was issued on 6 August 2007. The Director-General's Requirements (DGRs) are provided in Appendix A.

The project was also declared to be a controlled action under the Australian *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) in July 2007. A bilateral agreement exists between the Australian Government and the NSW Government for projects assessed under Part 3A of the EP&A Act. Therefore the project is subject to a single environmental assessment, public exhibition and reporting process as prescribed in the bilateral agreement.

The environmental assessment was lodged with the Department of Planning for public exhibition in March 2008. The public exhibition was from 2 April to 5 May 2008. The submissions received during the exhibition period and up to the 16 May 2008 are addressed in the submissions report (Appendix B). The proposed modifications to the project and any environmental impacts of these modifications are contained in this preferred project report.

The Department of Planning will assess the project, including the environmental assessment, the preferred project report and all submissions received. The Department of

Planning prepares an assessment report for the Minister of Planning's determination of the project. The Australian Minister for the Environment, Heritage and the Arts will also make a decision on the project under the EPBC Act.

1.5 Consultation overview

Substantial consultation and briefings with government agencies, stakeholders and the local community occurred prior to and during the EA exhibition period. This included regular consultation through the Upper Nepean (Groundwater) Community Reference Group (CRG). The EA was on public exhibition from 2 April until 5 May 2008.

It was available for viewing at three locations and for viewing online at the Department of Planning web site at www.planning.nsw.gov.au.

A newsletter was distributed to all householders in the Southern Highlands at the commencement of the public exhibition period and the exhibition was advertised in metropolitan and local media.

1.6 Structure of this report

This preferred project report addresses the 147 submissions received on the proposed Kangaloon borefield project and provides a detailed consideration of the issues raised and outlines the proposed changes to the design, operation or management of the scheme.

The consultation process and overview of the submissions is provided in Chapter 2, the detailed consideration of the submissions is in Chapter 3, and the borefield design changes and monitoring framework are outlined in Chapter 4. Chapter 5 summaries the important technical studies completed since the lodgement and exhibition of the EA while Chapter 6 presents a summary of the changes relating to national environmental significance. The revised Statement of Commitments is provided in Chapter 7.

2. Consultation process and submissions

2.1 Consultation process

The Sydney Catchment Authority (SCA) began an extensive community consultation program in June 2006. This included the exhibition of the groundwater investigation reports and supporting technical reports (June to September 2006) and the subsequent compilation of a consultation and submissions report for the NSW Government. The consultation has also included widespread distribution of newsletters, media releases and web-based materials. Groundwater surveys were also completed for most properties within two kilometres of the borefield corridor in 2007 to identify all local water sources and land uses. Consultation has recently included the public exhibition of the environmental assessment (EA) and numerous briefings.

The consultation program targeted a range of stakeholders including local government authorities, Government agencies, environmental groups and associations, potentially affected landowners and business owners, other local residents, indigenous land councils and tribal groups.

The SCA undertook a range of communications to facilitate stakeholder contact with the project team, engage with stakeholders, disseminate information and identify and address issues as they emerged.

Community reference group

In June 2006, the Minister for Environment appointed a 12-member Upper Nepean (Groundwater) Community Reference Group (CRG) to assist in communicating proposals for developing the Upper Nepean groundwater source. Interested people responded to a request for expressions of interest and were appointed on the basis of their ties to the local community and their interest in issues relating to the proposal. The CRG was independently chaired.

The CRG acted in an advisory role and was a key communication channel between the NSW Government and the Southern Highlands community about the potential to use groundwater from the Upper Nepean Catchment for water supply during drought. CRG meetings provided a forum for the SCA to discuss with the community matters regarding the potential extraction of groundwater and borefield development.

The group held its inaugural meeting on 3 July 2006, with a further 14 meetings held by the time of the exhibition of the EA, as well as a technical workshop and a guided site visit. CRG meeting minutes have been published on the SCA’s website. The CRG prepared a submission in response to the EA, which is addressed in this report and is provided in full in the submissions report in Appendix B.

2.2 Exhibition of the Environmental Assessment

The EA was placed on public exhibition from 2 April until 5 May 2008 at the following locations:

- Department of Planning, Information Centre, 23-33 Bridge Street, Sydney
- Nature Conservation Council of NSW, Level 2, 301 Kent Street, Sydney
- Wingecarribee Shire Council, Civic Centre, Elizabeth Street, Moss Vale
- Department of Planning web site at www.planning.nsw.gov.au.

Copies of the summary report were mailed to all landowners within two kilometres of the proposed borefield and all community members/groups who had made previous enquires about the project.

Submissions were invited from the public with the Department of Planning accepting submissions until the 16 May 2008.

All technical reports listed in the references and appendices were either publicly available or available on request. Public exhibition of technical documents formed the basis of community consultation. A summary report and newsletter were developed to highlight the key points of the EA.

In total, the SCA distributed 712 summary reports, 710 discs containing the full reports and 56 hard copies of the full EA. A further 39 hard copy appendices were distributed.

A 1300 community information phone line and project specific email address was also established.

The 1300 number and project email provided a communication channel for interested persons to request hard copies of technical documents, discuss the proposal or the technical outcomes with the project team, or request further information. The SCA received 141 enquiries through the 1300 line, a further 39 calls directly to the community relations team, and 31 email enquiries.

The SCA also prepared a project specific web page on its website. This included a link to the Department of Planning website which contained the EA.

Printed communication materials

A newsletter was distributed to 18,911 householders in the Southern Highlands at the commencement of the public exhibition (copy provided in Appendix B). The newsletter advised residents that the EA was on public exhibition, highlighted the key points in the EA, explained how to obtain a copy of the EA and invited submissions on the proposal.

Media and advertisements

The Department of Planning placed an advertisement in the government noticeboard section of the Sydney Morning Herald and Daily Telegraph as well as in local newspapers. There were multiple press articles in the local newspapers (Southern Highlands News, Your Times, and Illawarra Mercury) and coverage on radio (mainly ABC Illawarra).

Stakeholder briefings and communication

A series of targeted briefings were undertaken to fully inform and update key stakeholders on the progress of groundwater investigations. Briefings were given to the following stakeholders prior to (*) and during/post (#) the exhibition period:

- Upper Nepean Groundwater Community Reference Group (CRG) * #
- NSW Department of Environment & Climate Change (DECC) *
- NSW Department of Water & Energy (DWE) (four meetings) * #
- Australian Department of the Environment, Water, Heritage and the Arts (DEWHA) * #
- Wingecarribee Shire Council (WSC) (two meetings)* #
- Wingecarribee Environment & Sustainability Committee #
- Hawkesbury-Nepean Catchment Management Authority (HNCMA) #
- Nature Conservation Council (NCC) #
- Save Water Alliance (SWA) *
- Local Kangaloon residents #.

The SCA responded to stakeholder enquiries in a timely manner. Multiple points of contact were established to ensure that all stakeholders could contact the project team and were aware that their feedback on groundwater investigations was invited and welcomed. The SCA provided responsive briefings to issues as required or on request.

2.3 Overview of the submissions

The SCA received a total 147 submissions during the consultation period. Thirty one (31) submissions were from groups and 116 submissions were from individuals.

Five submissions were received from NSW Government agencies or local government (their submission number is in brackets):

- Department of Primary Industries (No.26)
- Department of Environment and Climate Change (No.79)
- Department of Water and Energy (No.124)
- Wingecarribee Shire Council (No.78 and No.81)
- Hawkesbury Nepean Catchment Management Authority (No.80)

Seventy six percent of respondents were from the Southern Highlands and 13 percent were from Sydney. Of the remaining respondents, six percent were from the Illawarra region, three percent from the Kiama area and two percent from other areas.

2.4 Issues raised in the submissions

Most of the submissions received objected to the Kangaloon borefield proposal. Table 2.1 represents the areas of concern that were raised most often in the submissions and the number of times that concern was raised. Some concerns were mentioned multiple times in some submissions hence the number of mentions exceeds the number of submissions.

Table 2.1 Key areas of concern raised in submissions

Classification name	Number of mentions
2.07.05 Recharge and discharge - areas and rates	338
2.04.02 Terrestrial flora and fauna	217
2.01.03 Groundwater	210
2.04.00 Ecosystems	206
2.07.12 Technical expertise and research adequacy	165
3.09.01 Metropolitan Water Plan	157
3.11.03 Cost of benefit versus environmental risk	148
2.02.00 Water quality	132
2.02.04 Iron and manganese	132
2.01.01 Rivers and creeks	130
3.11.02 Overall project cost	124
3.10.00 Other water sources	101
2.04.01 Aquatic flora and fauna	90
2.07.09 Ecosystem dependence	88
2.04.05 Threatened species/Endangered Ecological Communities	86
2.05.02 Clearing	84
2.04.03 Swamps	67
3.10.07 Demand management	65
2.07.15 Pumping trial	64
2.07.07 Drawdown rates and time lag	63
3.09.02 NSW planning approvals	63
2.07.02 Borefield yield and capacity	60
2.07.11 Surface water connectivity	58
3.06.01 Power	58
4.06.02 Bushfire	52
2.00.00 Environmental impacts and issues	51
3.10.01 Recycling	50
7.00.03 Other SCA catchment issues	48
2.07.16 Climate change	47
3.10.02 Desalination	45
3.09.04 Timing of the project	43
3.02.05 Visual impacts	41
3.06.04 Water treatment	40
2.01.02 Springs	39
3.06.02 Bores	39
3.01.03 Livestock use	37
6.01.01 Community consultation during planning	37
2.07.13 Modelling methodology/approach/predictions	36
4.05.01 Water sharing plans/embargo/licensing	35
2.07.10 Aquifer connectivity	30
3.01.02 Agricultural use	30
4.06.05 Water treatment	28
2.03.05 Water treatment plants/chemicals	27
2.07.03 Aquifer water age/dating/origin	27
4.04.00 Efficiency of transfer	27
2.08.00 Geology and geological structure	26
2.05.03 Mining Impacts	25
4.05.03 ESD principles/precautionary principle	25

3. Consideration of the submissions

This chapter outlines the responses to concerns raised in the submissions. It documents the responses, changes and refinements made to the project in response to the submissions, and references the most recent technical and environmental investigations. More detail on the project design and monitoring changes is provided in Chapter 4.

The reader is referred to the full submissions report (Appendix B) for a comprehensive analysis of all the issues raised in the 147 submissions that were received by the Department of Planning. For analysis, issues raised in the submissions have been grouped below into: environment; socio-economic; borefield design; management, monitoring and operations; and planning and governance. Only the most important issues and those with more than 25 respondents to each issue are discussed in detail below.

3.1 The natural environment

Environmental issues and potential impacts associated with the proposed borefield development were the primary objections to the borefield development. Under each of the main groupings (water resources, water quality, ecosystems and landscape) the main issues are discussed together with the Sydney Catchment Authority's (SCA) response.

3.1.1 Water resources

Groundwater resource impacts

Issues and impacts – Submissions related to links with ecosystems, resource conservation, and the sustainability of the project.

Response – Specific issues relating to attributes of the resource are covered below but as a general overview, investigations, pumping trials and monitoring have been in place now for more than three years. They indicate that deep groundwater pumping from the sandstone aquifers has negligible impact on surface ecosystems, and the extent of drawdown is all within the Upper Nepean catchment. If the borefield is constructed and becomes operational, comprehensive monitoring will be in place to monitor groundwater resource behaviour, monitor baseflows to permanent streams and monitor changes to key ecosystems.

Project change or refinement – There are no fundamental changes to the borefield proposal although monitoring programs will be expanded and additional monitoring locations are proposed during construction and operation to address concerns of environmental impact.

Geology and geological structure

Issues and impacts – Main concerns related to incorporating more information on sandstone-basalt connectivity and the complex geological structure (particularly fractures and faults) across the area into the conceptual model for the area.

Response – The conceptual model has been improved. The area around Mt Butler (immediately south of Tourist Road) where basalt is in contact with sandstone is recognised and has been included in the environmental assessment (EA), conceptual model and the latest numerical modelling (Coffey, 2008). The major faults across the area have been identified and are included in these models. Other fractured areas and zones are likely based on the latest geophysical surveys (GDCS, 2008) and should be identifiable based on the success of this method. A conservative approach (only identifying the known high permeability areas) is presented in the EA and the latest numerical modelling studies. Extra high permeability zones will be added to the conceptual and numerical model as new investigations are concluded when the project recommences.

The latest understanding and conceptual model is presented in Coffey (2008) and summarised in Appendix E. The updated conceptual model as described in the EA remains the best representation of the dynamics of this system. For the transient modelling, the model has been improved by dividing the Hawkesbury Sandstone into three layers and including the Mt Butler intrusion. The latest modelling results reinforce the earlier findings in the EA.

Project change or refinement – Surface geophysical profiling has been successful and will be used to select new investigation bore sites and to refine the location of proposed production bore sites when the borefield development proceeds. Fewer production bores may be drilled if high permeability targets produce higher bore yields. Also, a new monitoring location was established in the Mt Butler area and this confirms that basalt has intruded the sandstone in this area. This site is now part of the borefield monitoring network.

With the deferral of the borefield construction program, no additional infill drilling will be completed in Areas 2 and 3 to further improve the structural model or expand the groundwater monitoring network. This drilling would be one of the first activities undertaken when and if construction is activated in the future.

Aquifer connectivity

Issues and impacts – Concerns raised included perched water – sandstone aquifer links, basalt spring – sandstone aquifer links, surface water – sandstone aquifer links and ecosystem connectivity.

Response – The description of the catchment geology and hydrogeology provided in the EA has not changed and has been reinforced by more recent studies (SMEC, 2008; URS, 2008 and PB, 2008a and 2008b). The important relationships are:

(i) Perched water is rainfall derived - the maintenance of perched water tables is dependent on rainfall and evapo-transpiration, not the moisture conditions in the bedrock immediately below swamps and forested areas, or the regional water table in the sandstone strata.

(ii) Perched water is disconnected - perched water occurs in colluvial/alluvial and weathered rock areas and is usually separated from the regional sandstone aquifer by a low permeability zone. There is vertical leakage through weathered rock and fracture zones to the regional water table across the catchment. However on a local scale, if

substantial vertical leakage did occur in the vicinity of the swamps then perched water would never accumulate in the swamps. Where this process does occur, the leakage is controlled by the permeability of the clayey sediments and fractures, not any pumping stresses in the area.

(iii) Basalt spring water is mostly disconnected - springs are sourced by rainfall and do not support upland swamps. Basalt springs in the catchment (except in the Mt Butler area) cannot be sourced by water from the sandstone aquifer as the basalt rocks occur high in the catchment, are tens of metres above the top of the sandstone strata, and are separated by a low permeability shale/clay horizon.

(iv) Surface water and groundwater are poorly connected – recent research and development (R&D) studies, pumping trial and transient modelling studies suggest that stream connectivity is lower than previously assessed with baseflow losses in the range five to 20 percent of the pumped groundwater across the area (PB, 2008d and Coffey, 2008). This equates to an even lower percentage of actual streamflow.

(v) Ecosystem connectivity - Pumping trials have shown that upland swamps are disconnected and are not impacted by pumping. Work to date on terrestrial vegetation shows no linkages with deeper sandstone aquifers. Impacts on baseflows to streams are low and manageable while stygofauna surveys suggest that populations are widespread and able to migrate.

Ecosystem monitoring will be part of the monitoring program if the borefield is constructed and becomes operational.

Project change or refinement – In addition to the proposed (key site) monitoring commitments in the current non operational period, there will be additional monitoring of swamp and terrestrial vegetation pre construction, and during and after long operational cycles. Important sites within the immediate area of influence of the borefield are proposed together with remote reference sites (if suitable sites can be located).

Groundwater age and origin

Issues and impacts – Concerns were raised regarding the origin and migration of groundwater in the sandstone aquifers during and after pumping of the sandstone aquifer, and after the 2007 rainfall recharge events.

Response – The sandstone groundwater is a mixture of modern rainwater (locally recharged) and slightly older groundwater (again locally recharged but in residence in the sandstone aquifers for longer periods). What was observed after both pumping trials was that there was significant rainfall recharge reporting to the uppermost fractured aquifers but there was also water migrating laterally in the deeper aquifers. For the Tourist Road area, the signature of the water sampled at each of the pumping sites after the recovery period indicated that most groundwater had not changed in quality or age (PB, 2008a) however at the Stockyard Swamp sites there was a slight reduction in the age of the waters (PB, 2008b and PB, 2008c).

This indicates that the aquifer storage is large and that rainfall recharge (although substantial) is still a relatively small volume in comparison to the aquifer storage.

Therefore while water levels fully recover, and recharge is relatively quick, the age of the water does not change quickly because of the large aquifer storage volume.

Older groundwater at depth and along the flow path is consistent with the conceptual model and the nature of the drought water supply scheme to tap groundwater in the sandstone aquifers that will not discharge to nearby streams during severe drought periods.

Project change and refinement – No changes to the project are proposed. The proposed monitoring and an adaptive management approach will ensure that any effects are within the predicted range.

Surface water-groundwater interaction

Issues and impacts – The two primary issues of concern were surface water – groundwater interaction and the potential loss of surface water when the borefield is operational, and questions about why the SCA would extract water through the borefield that reappears as baseflow lower in the catchment.

Response – (i) R&D studies, pumping trial and transient modelling studies suggest that stream connectivity is low and losses are around five to 20 percent of the pumped groundwater across the area. Baseflow impacts include both captured discharge (water that would have discharged to permanent streams) and induced recharge (surface water lost to groundwater). The volumes lost from streams are very low in comparison to actual stream flow (PB, 2008d estimates five to seven percent of the flow reporting to the production bore is surface water based on the Doudles Folly Creek research). This is less than 150,000 litres per day from a creek that is flowing between three million litres per day (lowest baseflows) to in excess of 400 million litres per day (under transfers). Other recent studies (URS, 2008; SMEC, 2008; Coffey, 2008) confirm that impacts on ecosystems are not expected. However, baseflow and more ecosystem monitoring is proposed pre and post construction, and during operation to address residual concerns.

(ii) The important issue regarding baseflows lower in the catchment is the timescale at which water flows through the sandstone strata to discharge as baseflow in the lower catchment. This residence and flow time is of the order of thousands to tens of thousands of years. The sandstone groundwater in the borefield area is water that would not be available during any drought period hence the borefield strategy is to take part of the storage volume (close to the recharge area) during drought, and allow the depleted storage to recharge and recover at the conclusion of each drought period.

Project change and refinement – No changes to the borefield layout or operational procedures are proposed, although baseflow as measured at all stream gauge sites would be analysed during operations to assess any unexpected depletion trends.

Impacts on springs

Issues and impacts – Concerns related to the source of water that maintained springs and the connectivity with the sandstone aquifers (see also aquifer connectivity above).

Response – Basalt springs are sourced by rainfall and do not support any upland swamps which are also rainfall dependent. Basalt springs in the catchment (except in the Mt Butler

area) cannot be sourced by water from the sandstone aquifer as the basalt rocks occur high in the catchment, are tens of metres above the top of the sandstone strata and are separated by a low permeability shale/clay horizon. Sandstone groundwater does not flow uphill but rather flows to the north following the topography and the dip of the strata. SCA studies show no connectivity between the sandstone and the basalt aquifer systems (except in the Mt Butler area) and this disconnection is expected to be maintained even if a borefield was constructed and remained operational for long periods during severe drought.

Project change or refinement – Monitoring of more spring sites is proposed prior to borefield operation. At the present time two spring areas are being monitored in the vicinity of Mt Butler and the number across the area will increase during construction and borefield operational periods. SCA would seek expressions of interest from landowners for monitoring their springs in key areas.

Recharge/discharge areas

Issues and impacts – Issues related to better mapping of recharge and discharge areas, impacts on the Illawarra escarpment, variable recharge rates, recharge estimates and streamflow depletion.

Response – (i) Recharge to the sandstone aquifer system occurs everywhere the Hawkesbury Sandstone is exposed at surface. Some areas display fast recharge and large rises in water levels, other areas display time lags before maximum recharge occurs, while others only show small increases in water levels. Recharge rates and volumes are variable but it occurs everywhere in the landscape. Chemistry and water level studies support this process and have identified rainfall as the sole recharge source and the primary recharge areas as being upgradient of the main spine of the borefield along Tourist Road.

(ii) Pumping trials and transient modelling show no water level decline (or substantial loss of flow) at distance and certainly none as far away as the Illawarra escarpment during normal operational patterns. The model did suggest that drawdowns may just extend to the escarpment if there were back to back drought periods and the borefield operated for long periods. Drawdowns during the extended pumping trials were only within one-two kilometres and groundwater recharge after each of the pumping trials was localised and was not from areas "outside the borefield". Longer term predictions suggest the 10 metre drawdown contour occurs at two to 2.5 kilometres from operational bores and no noticeable drawdown is expected beyond five kilometres.

(iii) Recharge is variable across the area and different rates of recharge apply depending on the soil type, type of rainfall event and soil moisture conditions. URS studies predicted that for large recharge events in 2007 recharge rates could be in excess of nine percent of local rainfall. Recharge rates used in the transient model were more conservative at less than four percent. Recharge estimates provided by Evans (2008) of four billion litres per year in the primary recharge areas are in agreement with SCA's initial estimates of recharge, using the resource as a drought supply and being able to operate sustainably.

(iv) Captured groundwater discharge and induced recharge (from permanent streams) are the two processes that will impact baseflows during operational periods. Studies suggest that connectivity is low (URS, 2007, Coffey, 2008) and the impacts to streams are

relatively minor. Testing and research to date indicates that induced recharge is less than five to seven percent of the groundwater pumped at Doudles Folly Creek (PB, 2008d). Similarly the baseflow losses predicted by transient modelling studies are lower than previous estimates (Coffey, 2008). Monitoring of baseflows help quantify impacts during operational periods.

Project change and refinement – The extensive monitoring network will monitor water levels and confirm the extent of drawdowns both within and remote from the borefield. A number of observation bores exist within the borefield and downgradient, however additional monitoring locations will be established in upgradient locations prior to borefield construction. These are the main recharge and agricultural use areas.

Drawdown rates and time lag

Issues and impacts – Concerns raised included the lack of historical data, the importance of monitoring to provide early warning of impacts, and the lack of certainty (see also recharge / discharge areas above and monitoring below).

Response – There is now more than three years of groundwater level data for the area. This has been collected over the worse years of the recent drought and the wetter years of 2007 and 2008. The data provides an excellent data set to understand the natural variability of the regional sandstone aquifer. Monitoring of key sites will continue during the project deferral period to provide even greater understanding and certainty of water level trends.

The pumping trials provided an excellent understanding of the pattern of drawdowns to be expected if the borefield was operational. The trials suggest steep drawdowns in the vicinity of each production bore but limited drawdowns at distance. Preliminary modelling in 2006 suggested drawdowns would be less than 10 metres at distances greater than two kilometres. The latest transient modelling suggests similar drawdown patterns with the 10 metre drawdown contour located at distances of two to 2.5 kilometres at the end of extended pumping periods associated with severe drought. The impacts to most users are expected to be minimal as water level variations are likely to be within the normal range of fluctuations. Water level recovery after the pumping trials was relatively fast (being of the order of weeks and months to achieve full recovery) although the transient modelling suggests much longer time frames after extended pumping and extreme drought conditions.

The proposed use of the borefield during severe droughts recognises the importance of allowing the aquifer system to fully recover for many years after long operational periods.

Project change and refinement – The outline of the proposed monitoring plan, and associated network and frequency, is provided in the EA and is further expanded in this Preferred Project Report (PPR) in Section 4.4. The development of operational rules and likely on/off cycles will be developed in consultation with the Department of Water and Energy (DWE) as part of the final water licensing arrangements after planning approval.

Pumping trial

Issues and impacts – Issues raised included a lack of proof as to the sustainability of the borefield or the long-term impacts of sustained pumping, primarily because of the rainfall events that occurred before and after each trial.

Response – The two main issues are:

(i) Observed impacts - Water levels, water quality and the use of control sites was the approach used during the pumping trials to assess the baseflow impacts, swamp impacts and drawdown impacts at distance (or the lack of impact). For the respective areas around Butlers Swamp and Stockyard Swamp, the drawdowns and impacts will be the same as during the trials irrespective of whether there are seven or 75 bores pumping. The seven bores in the vicinity of Butlers Swamp (and the three at Stockyard Swamp) will be pumped at the same or lesser rates than was undertaken during the pumping trials - there is unlikely to be any additional pumping bores or stresses on the sandstone aquifers in these areas (just a longer period of operation which is why the transient modelling is useful). Transient modelling showed steep drawdowns around production bores and most drawdowns within 2.5 kilometres of the borefield.

(ii) Climatic conditions - Water levels were high at the start of both pumping trials (after rain) but drier conditions prevailed during each of the trials. Irrespective of the starting water levels, the performance of the pumping bores, interference drawdowns, impacts on shallow perched systems, and the extent of drawdowns were key data obtained from the trials. This information is equally valid from a wetter period as from a drought period, as it relates to the physical attributes of the sandstone and the fractured rock aquifer - primarily the permeability and connectivity attributes of the aquifer.

Project change and refinement – Each production bore will be tested for at least 24 hours prior to acceptance as part of any borefield that is constructed. No more pumping trials are warranted however there will be an extended commissioning period for the borefield and areas within the borefield. This will be the main method of confirming final pumping rates and the sustainability of different segments of the borefield.

Modelling

Issues and impacts – Concerns raised include flaws in the conceptual model in the environmental assessment and the failure to take into account the basalt aquifer (and potential connectivity). Also raised was the lack of a detailed transient model to demonstrate the impacts of this borefield being operational during severe drought conditions (see also geology and geological structure, and aquifer connectivity above).

Response – The issues raised relate to the conceptual model and the older numerical model that was presented in the EA. The conceptual model as presented in the EA is correct but components have been slightly refined as part of the transient modelling study. The transient modelling is now complete (Coffey, 2008) and results provide more certainty about drawdowns and borefield impacts. The major improvements to the conceptual and transient numerical model are:

(i) The conceptual model has been improved and reviewed by independent peer reviewers and DWE, and is supported by these experts. The contact between basalt and

sandstone aquifers in the Mt Butler area has now been included in the model, and the known geological structure in the area (major fault features) has also been revised. If more high permeability areas are identified in areas of extensive fracturing, these will be included in future model reviews. The effect of more fracture zones and high permeability areas will be reduced drawdowns at some sites as higher volumes will be able to be taken from fewer bores, and the overall extent of drawdowns is expected to be less.

(ii) The original steady state model constructed in 2006 has been updated substantially with horizontal and vertical permeability, rainfall recharge, geology and geological structure, and river bed conductance reviewed and improved. High permeability areas have been refined, and the basaltic intrusion at Mt Butler included. The Hawkesbury Sandstone is now subdivided into three layers, and the revised model has been calibrated against the last three years of water level data (particularly the two pumping trials and the R&D pumping test at Doudles Folly Creek), and streamflow data along the Nepean River. More details and results are provided in Chapter 5.

Project change and refinement – The latest conceptualisation and transient model predictions of drawdown are in agreement with the details in the EA. Baseflow impacts are also less than originally proposed so no project changes are proposed.

Climate change

Issues and impacts – Issues related to concerns that climate change means less rainfall and the period of testing was not long enough to assess natural fluctuations and impacts. Therefore the work completed is not representative of the trends and climatic variability expected in the future.

Response –The investigation period covered the worst drought period on record and during 2007, there were some substantial rainfall events that are typical of drought breaking rainfall patterns in this area. The three years of data that is available is considered to be an excellent data set on which to base predictions about the borefield performance and sustainability. Recent numerical modelling also improves our understanding of resource behaviour.

New climate change modelling for south eastern Australia and the SCA's catchments is currently under way and will be progressively reported over the next 12 months by CSIRO. Earlier studies suggesting much lower rainfall patterns have been updated for coastal south eastern Australia. Similar rainfall, with increases in the extremes of rainfall patterns with perhaps less runoff due to drier profiles and higher temperatures, is currently one of most likely outcomes. If this outcome is correct, then a new groundwater resource and drought borefield would not be at risk from climate change. In fact groundwater could be a most useful water source as it would be protected from evaporation, and be recharged by extreme rainfall events.

Project change and refinement – The project currently addresses predicted changes. As these are refined for the area of the borefield, the predictions in this EA can be reviewed and refined. Any change to access to the water in the aquifer will be subject to water licensing.

3.1.2 Water quality

Iron treatment and removal

Issues and impacts – Issues mostly related to pollution caused by the aeration and removal of the dissolved iron during the treatment of the pumped groundwater, the generation of sludge requiring offsite disposal, and the potential impact on ecosystems.

Response – Sludge will only be generated at the water treatment plants and be fully contained in the collection ponds. Iron oxide is inert (it occurs naturally in soils and rocks) and there is no potential to impact swamps and wetlands or terrestrial vegetation. Negligible impact on the aquatic ecosystem of the Nepean River is expected (as all dissolved iron would be removed prior to run-of-river discharge to Nepean Dam) and there will be no impact on other streams.

This aeration treatment and sludge collection and removal process is commonly used for many borefield developments across NSW.

Project change and refinement – The water quality treatment process is fully self-contained and there is minimal risk of pollution. No changes to the water quality treatment process are proposed. Disposal and possible reuse options for the iron sludge will be revisited at the time of borefield construction.

3.1.3 Ecosystems

Upland swamps

Issues and impacts – Concerns related to operational impacts rather than construction impacts. There were continuing concerns that swamps were connected to the regional sandstone aquifer or that some other swamps had the potential to be connected and these had not been assessed. Based on a concern that swamps were connected and influenced by pumping, there was a view that ecosystem surveys should continue and be increased to confirm the content, diversity, and health of these ecosystems everywhere.

Response – The pumping trials for Butlers Swamp and Stockyard Swamp strongly concluded that the swamps are not connected to the regional sandstone aquifer. This conclusion has been supported by other studies and peer reviewers (SMEC, 2008, PB, 2008a and 2008b, Woolley, 2008). These swamps (and those in similar settings) are definitely supported by rainfall and shallow perched water.

Project change and refinement - Monitoring of perched water levels at key sites will continue and will be undertaken at new sites before, during and post construction, and during and after operational cycles. Those accessible swamps within the area of influence of the borefield (plus one control location) will be included in the monitoring program. In addition to confirming the conclusions of the EA under full operation of the borefield, the results will improve our understanding of the hydrology of these important ecosystems.

Terrestrial flora/fauna

Issues and impacts – The removal of trees and orchids were the main focus of the submission comments. There were comments that related to both construction and

operational impacts. It was advocated that a cautious approach was needed because if there was deep rooted vegetation, it may be sandstone groundwater dependent.

Response – (i) Construction – A minimal number of trees will be removed as part of this borefield proposal (as bore sites can be moved slightly to suit and the pipeline is flexible and able to be trenched/buried between trees), and the trenching is relatively shallow at about one metre depth. Threatened species and sensitive habitat area (eg. for koalas) will be avoided where possible.

(ii) Operation – The potential for terrestrial vegetation to be dependent on the regional sandstone aquifer is considered low based on the high rainfall environment and low accessibility for deep rooted vegetation to tap the regional groundwater table in the sandstone bedrock. Riparian vegetation is one area of slightly higher risk and this would be a focus of future monitoring programs.

Project change and refinement - Additional perched water table monitoring wells and baseline condition surveys will begin in advance of construction and operational periods. If there is any possibility of a linkage between regional groundwater and terrestrial vegetation then additional monitoring and associated triggers for responses will be included in the operational environmental management plan (OEMP).

Aquatic flora/fauna

Issues and impacts – Concerns related to the impacts of potential flooding caused by the treated water discharges to the Nepean River, changed stream conditions, and water quality and pollution potential (see also water quality above).

Response – (i) Flows and levels will be within the natural range of stream flows (except that flows will be more elevated during the extreme dry periods when this borefield would be operational). The increase in river height will be less than 250 millimetres and within the range of river levels experienced by fauna within the Nepean River. Based on the model results, there are expected to be negligible baseflow effects on other streams. Flows and heights within the Nepean River will depend on the number of operational bores, actual flows being processed by the water treatment plant facilities, and natural rainfall patterns.

(ii) Continuous monitoring of the treated water quality as it is discharged to the river will be part of the monitoring during operational cycles. Dissolved iron will be removed and temperature and oxygen levels will be adjusted to reflect ambient conditions. There is no potential for pollution.

Project change and refinement - No project changes are proposed.

Threatened species

Issues and impacts – Concerns related to the necessary protection of threatened species during both construction and operation, and were very similar to the terrestrial vegetation comments (see above).

Response – (i) Construction impacts will be minimised wherever possible. Listed threatened species and hollow trees will be avoided. The locations of identified threatened

species have been mapped in many instances and will be mapped again in advance of construction and protected from any disturbance. Construction will be rigorously managed to further limit potential impacts.

(ii) No special arrangements are proposed for operational periods – the increased monitoring proposed for swamps, terrestrial vegetation, and aquatic ecosystems will apply.

Project change and refinement - No project changes are proposed.

Ecosystem dependence

Issues and impacts – Most comments related to further studies of swamps and terrestrial vegetation (particularly the endangered ecological communities) so as to establish links with the regional aquifer system in the sandstone bedrock.

Response – Concerns are based on a view that ecosystems are dependent on the regional sandstone aquifer, and a view that the linkages are weak or not proven at this stage with additional studies required. This does not recognise the importance of shallow perched groundwater and its ecosystem function as distinct from the deeper regional groundwater in the sandstone bedrock which this project would access.

The pumping trials, water level monitoring and other studies have shown that upland swamps are disconnected and there is low connectivity with baseflow in streams. Work to date on terrestrial vegetation shows no linkages with deeper sandstone aquifers.

The depth to the regional water table in the sandstone and the blocky and massive nature of sandstone in some areas near surface is further evidence that swamps and terrestrial vegetation are unlikely to be dependent on this regional sandstone aquifer.

Project change and refinement – Additional perched water table wells and baseline condition surveys will begin in advance of any construction and operational periods. If this monitoring reveals any possibility of a linkage between regional groundwater and terrestrial vegetation then additional monitoring will be included in the operational environmental management plan (OEMP).

3.1.4 Landscape

Clearing

Issues and impacts – Concerns were raised regarding additional clearing of natural bushland required for borefield development (both power and pipeline routes).

Response - Minimal vegetation clearance is proposed as the routes chosen are along existing cleared or slashed corridors, and the bulk of the infrastructure will be underground, or screened from public roads and private lands.

Project change and refinement – Two route changes are proposed as part of the preferred project (see Chapter 4) and these routes will further minimise clearing for power and pipelines.

Visual impacts

Issues and impacts – Comments related to the protection of vegetation along Tourist Road, the screening of the WTP facilities, and power network issues such as pole type and underground power (see also power below and Chapter 4).

Response - Minimal vegetation clearance is proposed, and the bulk of the infrastructure will be underground, or screened from public roads and private lands. The water treatment facilities along Tourist Road and Fire Trail 3 will be located, designed and landscaped to minimise visual impact. Disturbed areas associated with construction activities will be rehabilitated quickly with local native species, and for this reason there will be minimal visual impact and changes to the landscape.

The current power design is to use timber poles across agricultural land (to blend into the rural landscape), and steel or concrete poles (from bushfire protection) in all other areas. Underground power is not normally approved for rural distribution networks. SCA has been able to secure some underground concessions from Integral Energy but additional underground sections are unlikely. These design elements will be reviewed again as part of the power design review and approvals process when the borefield development proceeds.

Project change and refinement – There are two route changes for power and pipelines that will improve visual amenity along Tourist Road and Kirkland Road (see Chapter 4).

Bushfire

Issues and impacts – Comments related to an increase in the risk of bushfires in the area because of the introduction of powerlines into bushland within the SCA Special Areas.

Response – The types of power lines adopted for the design are in accordance with the surrounding landscape (eg. steel/concrete poles within the Special Areas with aerial bundled cabling (ABC)). Appropriate fire breaks will be implemented in accordance with Integral Energy's guidelines and as per SCA’s asset protection zones for the protection of assets within SCA lands. Also, the majority of the proposed infrastructure is within slashed areas maintained by SCA adjacent to Tourist Road and internal fire trails to ensure there is regular maintenance and fire protection.

Project change and refinement - No project changes are proposed.

3.2 Socio-economic issues

The socio-economic issues and impacts raised in the submissions have been grouped under land and water use; project cost; and consultation. They are discussed together with the SCA’s response.

3.2.1 Land and water use

Agricultural and livestock use

Issues and impacts – Concerns raised mainly related to compensation associated with water supply impacts and loss of property value.

Response – When the borefield is operational, there will be an increased network of monitoring bores and spring monitoring locations between the borefield and existing private bores and springs on agricultural lands. The latest numerical modelling suggests that water levels variations beyond the normal range of fluctuations are only expected to occur within two to 2.5 kilometres of operational production bores. If groundwater supply impacts are evident and are attributable to borefield pumping then SCA will have a range of remedial measures in place to re-establish, augment or replace existing water supplies. Therefore the project and its limited operation do not affect the security of water supplies in a way that would influence property values across the area.

Project change and refinement - No project changes are proposed.

Mining impacts

Issues and impacts – Landowner concerns related to the structural integrity of the sandstone if there was groundwater depletion or mining activities overlapping with the borefield area, while mining company concerns related to the potential sterilisation of coal reserves.

Response – (i) There are no impacts to the integrity of the sandstone from pumping groundwater - the sandstone rock mass is too competent to compact or deform, and will not be affected by occasional pumping.

(ii) No studies have been undertaken on the impact of longwall mining on the area as there are no proposals to mine under the borefield at this time. The mining company would be required to address groundwater resources in obtaining mining approval.

(iii) The borefield and coal mining activities could co-exist given the vertical separation of the sandstone aquifer and the economic coal seams (around 120 to 150 metres) and provided monitoring confirms there is no impact on the regional aquifer in the Hawkesbury Sandstone. Sterilisation of the deep coal reserves is most unlikely.

Project change and refinement - No project changes are proposed.

3.2.2 Project cost

Project cost

Issues and impacts – Issues raised mostly related to what was perceived to be a large construction costs for a maximum 50 million litres per day and the expectation that there would be a full cost benefit analysis documented in the EA.

Response - The ACIL Tasman economic appraisal that reviewed the 2004 Metropolitan Water Plan in April 2006, critically evaluated groundwater in the context of other potable

water supplies for drought supply and supported the development of groundwater sources. It concluded that "knowing that the groundwater is available and can be brought into supply in time allows safe use of more dam water."

Project change and refinement – Construction of the project has been deferred for the foreseeable future so any decision to proceed in the future will be take into account the economic conditions prevailing at that time.

3.2.3 Consultation

Community consultation

Issues and impacts – Most respondents commented on consultation during the planning phase (mostly the lack of contact with potential stakeholders in the Illawarra), and a fewer number commented on expected consultation requirements during construction and operation.

Response – (i) The proposal has been widely publicised and communicated. Communities that are directly affected were central to the SCA's consultation. Wider publicity about the project ensured that the broader community was alerted to the project.

(ii) More information will be publicly released on both the construction works program and the operational program if the NSW Government decides to reactivate the borefield proposal.

(iii) The SCA has made a commitment to continue to consult extensively with the community if the project is reactivated (see Statement of Commitments). The consultation plan includes a focus on consultation with directly affected residents.

Project change and refinement - No project changes are proposed.

3.3 Borefield design

There was comment on several borefield design issues (particularly the power and water treatment plant facilities) and potential issues and impacts associated with the proposed borefield development. Issues raised have been grouped under borefield yield and capacity; production bores; power; and water treatment. They are discussed together with the SCA's response. Further explanation of the improvements made to the borefield design is outlined in Chapter 4.

3.3.1 Borefield yield and capacity

Borefield yield and capacity

Issues and impacts – Comments covered issues or concerns relating to storage size and depletion, recharge rates, production rates, drawdowns, estimates of safe yield and sustainable yield, together with extraction in the context of the current groundwater embargoes and proposed water sharing plan (WSP) initiatives (see also recharge and

drawdown rates sections above, and resource sustainability and water management sections below).

Response – (i) SCA storage estimates are based on bulk porosity of the saturated Hawkesbury Sandstone across its full thickness - values of one percent, three percent and five percent have been used in the EA for comparison. Values used are comparable with estimates of effective porosity provided in 2004 (three percent) (DIPNR, 2004) and estimates of specific yield (1.5 percent) that have been derived from the recent numerical modelling (Coffey, 2008). The facts show that storage values are large and the maximum pumped volumes will be less than 10 percent of the groundwater storage in the area of influence of the borefield during any one pumping cycle.

(ii) The SCA proposal is to take a maximum of 15 billion litres per year in years of severe drought and this is unlikely to occur more than two or three years a decade. The trigger for construction and operation is related to supply storage levels. Average annual recharge rates across the whole borefield and upper catchment area are around four to nine billion litres per year hence the expected volumes of recharge exceed the likely usage when compared over a longer term drought pumping/recovery cycle. The substantial volumes in storage provide the required buffer in drought seasons.

(iii) Long term sustainability is based on recharge (not storage) and hence actual recovery/recharge rates and cycles are the most important aquifer attributes. Storage is important in the context that it must be large to provide the necessary buffer during droughts. The Kangaloon aquifer satisfies all these requirements.

(iv) The amount of testing on this fractured rock aquifer system has been substantial and involves 25 pumping tests as well as two extended pumping trials. The volume of field testing and specialist studies completed is beyond what would normally be completed for a large groundwater development but given the complexity of this fractured rock aquifer, additional studies have been completed (and are ongoing) for this area.

The pumping trials were initiated (after discussions with peer reviewers) to provide additional certainty about bore capacity, extent of drawdowns, and impacts on local ecosystems.

Project change and refinement – Borefield corridor and layout remains the same as in the EA. Latest numerical modelling suggests that borefield capacity may be towards the lower to mid range of the expected 10 to 15 billion litres per year. Surface geophysical profiling has been successful and will be used to refine the location of proposed production bore sites if the borefield development proceeds. Fewer production bores may be drilled if high permeability targets produce higher bore yields.

Resource sustainability

Issues and impacts – The issues and impacts associated with sustainability have been separated from the borefield capacity section above to provide additional clarity. The submissions received indicate the need for further clarification about sustainable yield, individual bore yields and borefield capacity.

Response – (i) Sustainable yield (or the long-term average annual extraction limit) does not describe borefield capacity. It is a term used by the regulator, DWE, and relates to the

capacity of large aquifers over very large areas taking into account socio-economic and environmental requirements (and in this instance, the sandstone aquifer source is known as the Nepean Sandstones).

The Hawkesbury Sandstone in this catchment is a subset of the Nepean Sandstones source. SCA is proposing a drought water supply borefield with an assessed capacity in the range 10 to 15 billion litres per year which is small in comparison with the current sustainable yield estimates of around 100 billion litres per year.

(ii) Each production bore will have a safe yield that is based on a pumping test and its expected long-term performance. Borefield capacity is the collective ("safe yield") capacity of all production bores and is a more accurate term to use for this development as this recognises interference effects between bores. In reality, it is expected that the borefield will be pumped at less than its safe yield because the installed capacity of all bores will be more than the proposed maximum extraction of 15 billion litres per year and a proportion of bores will not be pumped because of cycling between areas.

(iii) The prospect of a SCA borefield in the Upper Nepean was factored into DWE's decision to embargo the parishes surrounding Kangaloon in late 2005, and does not compromise the sustainable yield of the sandstone resource. One of the purposes of the new water sharing plan (WSP) is to ensure that over-allocation does not occur.

The latest numerical modelling study describes the sustainability of the proposed borefield development and provides water balances for the historical drought events and proposed extraction scenarios. While drawdowns are steep in the vicinity of production bores, there is limited drawdown at distance. The sandstone aquifer may be depleted for short periods near some production bores but this should not impact other users or the environment. The intention is not to pump more than approximately 10 percent of the available water in storage during any one drought cycle.

Project change and refinement - No project changes are proposed.

3.3.2 Production bores

Bore layout and design

Issues and impacts – Comments relate to bore locations, bores creating pathways for the degradation of the aquifer and the catchment, and possible increases in pollution because of the high iron groundwater.

Response – (i) The proposed production bore locations have been identified for each area. Precise locations may change slightly depending on the results of geophysical surveys, infill test drilling results, site access, and required connections to the borefield infrastructure.

(ii) All bores would be cased and cemented near surface to exclude storm water inflows and to protect perched water tables. The two water treatment plants (WTPs) with substantial collection ponds will be in place to treat and remove dissolved iron prior to river discharge.

Project change and refinement - No project changes are proposed.

3.3.3 Power

Power

Issues and impacts – Most comments related to visual amenity and noise (visual amenity issues are mostly described above).

Response – Visual amenity has been minimised by upgrading existing power lines wherever possible. Where new power is required along Tourist Road these sections will be underground. Noise impacts are not expected with electrical power and submersible pumps however appropriate noise testing would take place for pad and pole-mounted transformers and pumps at both production bores and at the WTP facilities. If necessary, noise reduction measures would be built into the compound designs.

Project change and refinement – There are several route changes for power and pipelines that will improve visual amenity along Tourist Road and Kirkland Road (see Chapter 4). Noise monitoring will be carried out during construction and commissioning phases to ensure impacts are minimised. No additional project changes are proposed.

3.3.4 Water treatment

Water treatment

Issues and impacts – Issues raised related to visual impact (see above) and insufficient information regarding the dissolved iron treatment, sludge removal and disposal options, and the use of alum as a flocculent.

Response – Substantial engineering design and architectural layout has been completed on the WTPs since the exhibition of the EA. Architectural drawings are in Appendix D. In relation to specific issues:

(i) The water treatment facilities along Tourist Road and Fire Trail No.3 have been located, designed and include landscaping to minimise visual impact. Facilities will be screened and disturbed areas will be rehabilitated quickly with native local plant species.

(ii) The collection ponds at each WTP will be used to decant and recycle water from the backwashing and then to dry the iron oxide sludge so it is spadeable and can be removed using trucks. The current disposal option is landfill. Truck movements are likely to be monthly or quarterly and will not cause any traffic congestion.

(iii) The amount of alum to be added to the collection ponds to accelerate flocculation is minimal. Also all ponds are bunded and lined so there is no potential for chemicals to leak or over flow to the Nepean River during normal operations. If the scheme was operational and a large flood overtopped the bunds, then there would be some risk of iron oxide and alum overflowing to the Nepean River. As the flood flows would be very large, there would be substantial dilution and the environmental risk is considered very low.

The acids to be used to clean scale and iron oxides from production bores during start up are biodegradable organic acids that are non-toxic.

Project change and refinement – Locations and treatment processes remain the same, however substantial design layouts have been prepared to obtain project approval. Disposal and possible reuse options (apart from landfill) for the iron sludge will be revisited again at the time of borefield construction should the project proceed.

3.4 Management, monitoring and operations

The quantity and breadth of the technical studies was an issue for many respondents. There was substantial comment on improvements that could be made to proposed management and monitoring programs if the borefield development was approved. Issues are discussed under the respective headings below.

3.4.1 Technical studies

Technical studies and research adequacy

Issues and impacts – Comments on the technical studies were wide-ranging. The studies were considered too detailed or, on the other hand, were too preliminary. Views were expressed that the studies were thorough and excellent science while others viewed the investigations as inadequate. Most referenced the EA compilation, and critique reports commissioned by others, particularly Evans (2008) and HydroTasmania (2008).

Response – (i) The SCA has commissioned and completed substantial technical, scientific and environmental investigations (now numbering more than 90 studies) on the groundwater source at Kangaloon and the local environment of the proposed borefield area. The investigation programs began in the Upper Nepean at Kangaloon in March 2005 and monitoring programs have been under way for more than three years.

The scientific method and logic used for these investigations is rigorous and is considered best practice. Investigations have been staged, conclusions reviewed, and the important recommendations acted upon. The project was reviewed at critical milestones to ensure that investigations answered important resource and environment sustainability issues and informed the final engineering designs. The approach is endorsed by all peer reviewers. No flaws have been identified.

(ii) The technical studies were undertaken by recognised experts in their respective areas and issues were addressed comprehensively. SCA also audited and inspected field work programs when in progress and believes that all the information provided in the range of reports is accurate and reliable.

(iii) The investigation program has continually responded to new issues or identified gaps as they arose. Most of the important studies recommended in the early technical reports and by our peer reviewer have been followed up in subsequent technical studies in 2007 and 2008. In fact some of the issues raised by Evans (2008) and HydroTasmania (2008) were already in progress and are addressed in recent reports. These more recent studies are discussed in Chapter 5 of the PPR.

Project change and refinement - No project changes are proposed.

3.4.2 Monitoring

Groundwater/surface water monitoring

Issues and impacts – There was significant comment on control sites and the extent of monitoring (for groundwater and ecosystems), and the nature and timing of monitoring that would be most useful for assessing ecosystem impacts. Many of the comments raised were based on the premise that the sandstone aquifer and ecosystems were connected and that substantial groundwater monitoring was required to assess the severity of impacts once borefield pumping commenced. There was limited mention of surface water monitoring.

Response – Studies have shown that upland swamps are disconnected from the regional sandstone aquifer and there is low connectivity with baseflow to streams in this area. Work to date on terrestrial vegetation shows no linkages with deeper sandstone aquifers. Studies have shown there is no strong connectivity between surface ecosystems and the regional aquifer in the sandstone bedrock in this area. Groundwater monitoring (particularly of perched water systems) to inform environmental impacts on upland swamps and riparian vegetation will be included in the proposed monitoring program when the borefield is constructed and becomes operational.

(i) Groundwater monitoring to the south of the main borefield spine requires further assessment to identify suitable sites for springs and bores on private property (some areas have been proposed but negotiations have not been completed at this time). To the north, there are sufficient bores located on SCA land to monitor downgradient conditions.

(ii) The permanent streams in the area are Doudles Folly Creek, Nepean River, Burke River, Little River and Dudewaugh Creek. Levels and flow will be measured at upstream and downstream locations along the Nepean River. The other streams will be gauged where access and natural stream conditions provide a suitable gauging location. Gauges will be located to monitor heights and flows prior to the operation of the borefield.

Project change and refinement - More monitoring bores to monitor regional groundwater levels south of the borefield, more spring locations, and more shallow wells to monitor perched water levels around swamps and trees will be established as part of the larger monitoring network proposed when the borefield proposal is reactivated.

Ecosystem monitoring

Issues and impacts - There was comment on control sites and the extent of monitoring (for groundwater and ecosystems), and the nature and timing of monitoring that would be most useful for assessing ecosystem impacts. Other comments, based on an assumption that the sandstone aquifer and ecosystems were connected, related to the monitoring of ecosystems (particularly swamps and terrestrial vegetation) to assess impacts when borefield pumping commences.

Response - Studies have shown that upland swamps are disconnected from the regional sandstone aquifer and there is low connectivity with baseflow to streams in this area. Work to date on terrestrial vegetation shows no linkages with deeper sandstone aquifers, although there may be some risk to riparian vegetation. The SCA does not believe there is a strong connectivity between surface ecosystems and the regional sandstone aquifer in

this area. However to address concerns, ecosystem monitoring will be part of the proposed monitoring program if the borefield is constructed and becomes operational. This will be used in combination with the data from the groundwater monitoring bore and surface water gauging networks.

(i) There is a large variability in the condition of ecosystems from season to season. The design of the program and the selection of suitable control sites for the upland swamps and terrestrial vegetation will need to be carefully evaluated in terms of the benefits they will offer to ongoing practical assessment of the project. Studies to date show that perched water systems are disconnected from the regional sandstone aquifers so monitoring would target this aspect. In addition, the SCA will work with Department of Environment and Climate Change (DECC) and the Department of Environment, Water, Heritage and the Arts (DEWHA) to identify suitable control sites away from the influence of the main borefield to evaluate any pumping impacts.

(ii) The baseline data sets SCA has completed to date have been six monthly across two seasons (Autumn and Spring in 2006 and 2007) and there has been little correlation between each season. Clearly targeted and well designed monitoring over a timescale appropriate to the environment and the potential impacts is a more practical response. The proposed ecosystem monitoring once the project is reactivated involves detailed six monthly monitoring (Spring and Autumn) with more detailed assessment if impacts are apparent or strongly suspected. In the non-operational periods (except for the immediate post operational period), five yearly (Spring) assessments are planned.

Project change and refinement - Ecosystem monitoring requirements will be expanded for swamp and terrestrial ecosystems. Further details are proposed in Section 4.4 of this report and will be included in the construction environmental monitoring plans (CEMPs) and operation environmental monitoring plans (OEMPs), and the respective monitoring and management plans.

3.4.3 Operations

Issues and impacts - Some other general comments on operational issues were raised. These were mostly related to the precautionary principle and adaptive management approaches being adopted when the borefield proceeds (also see comments on ESD below).

Response – There are many strategies available to pump within the borefield when operational (eg. cycling between each of the four areas; individual bores on/off or reduced in capacity; extended recovery periods after rain etc). Modelling has confirmed that the maximum of 15 billion litres per year may not be available every year depending on aquifer permeability, resource behaviour, and water level or ecosystem trends. The installed capacity within the borefield will be around 18 billion litres per year so there will be some flexibility in the method and timing of extractions.

Project change and refinement – No project changes are proposed.

3.5 Planning and governance

3.5.1 Planning

Metropolitan Water Plan

Issues and impacts – A broad range of issues were raised related to other elements of the Metropolitan Water Plan (MWP) (see alternative water sources below). The main borefield issue related to the relatively small volume of water available during drought periods.

Response – (i) The MWP provides a comprehensive and detailed strategy for water supply and management.

(ii) While the Kangaloon borefield may only produce three percent of the greater Sydney supply during severe drought, the total volume of all groundwater sources (if developed) could be around eight to 10 percent which is significant during these water shortage periods. The borefield is strategically placed for securing supplies to the Illawarra and could provide around 60 percent of their requirements during severe drought.

Project change and refinement - No project changes are proposed.

Planning approvals

Issues and impacts – Issues were raised regarding the major uncertainties in respect of the local environment, resource behaviour, and the complexity of the information provided. Views were expressed that the approvals process is flawed.

Response – (i) The EA provides a comprehensive description and assessment of the attributes of the groundwater resource and the local environment, and thoroughly examined and reported on potential impacts of the project. By necessity the information is comprehensive and thorough, reflecting the complexity of hydrogeology. The EA and supporting studies present a very high standard of information and understanding about the project.

(ii) The proposal has been widely publicised and communicated. Communities that are directly affected were central to the SCA's comprehensive consultation strategy. Wider publicity about the project ensured that the broader community was alerted to the project.

(ii) The proposal is being dealt with in accordance with the requirements of the NSW EP&A Act and the Australian EPBC Act.

Project change and refinement - No project changes are proposed.

Project timing

Issues and impacts – Concerns were raised about proceeding with the borefield at this time given that dam storage levels are increasing and the desalination plant is under construction.

Response - The NSW Government decided not to proceed to construction of the Kangaloon Borefield in June 2008 (after the closure of submissions) as a result of

Sydney's water saving efforts, the easing of the drought conditions with recent rainfall, and improved dam storage levels over the previous 12 months.

Project change and refinement – With the deferral of the construction of the borefield, no new activities beyond planning approvals, property acquisitions, tender designs and ongoing monitoring and bore maintenance are proposed. No project changes are proposed, but the timing changes mean that a 15 year approval period is being sought to cover any medium-term requirement for the project.

Ecologically sustainable development/Precautionary principle

Issues and impacts – Issues were raised about the basis of uncertainty of borefield performance and impact on water resources and the environment. It was proposed that a precautionary approach should be taken as the environmental risks are too high to proceed.

Response – (i) There is substantial certainty about the impacts of the development after the completion of the two pumping trials in 2007 and 2008, and other technical studies (particularly the transient modelling study). These studies show that surface water - groundwater connectivity is low in this part of the catchment. Deep sandstone aquifers are poorly connected to permanent streams and terrestrial vegetation, and are not connected to upland swamps - the project is not expected to impact on the local streams or ecosystems but this will be the subject of ongoing monitoring.

(ii) The ecological sustainability of the project is described in the EA. Substantial information has been gathered about the project allowing a well-informed decision to be made about the project. The key areas of uncertainty about this type of project have been comprehensively addressed and a rigorous monitoring and adaptive management regime will ensure consistency with the predicted outcomes.

Project change and refinement - No project changes are proposed.

3.5.2 Alternative water sources

Other water sources

Issues and impacts – These were general issues raised in submissions relating to broad water supply management options and the use of groundwater as a last resort.

Response – The MWP contains a comprehensive review of alternative water sources and describes their contribution to the water supply strategy for the greater Sydney region. Groundwater is only being proposed as a water supply source for use during severe drought periods. The MWP is currently under review and the next plan will be released in 2010.

Project change and refinement - No project changes are proposed.

Recycling

Issues and impacts – Comments were made about water wastage in Sydney and more widespread usage of water tanks before other options are seriously considered.

Response – The MWP contains a comprehensive review of the use of recycled water and describes its contribution to the water supply strategy for the greater Sydney region.

Project change and refinement - No project changes are proposed.

Desalination

Issues and impacts – Now that the desalination plant is under construction, the maximum use of this facility is likely to continue into the future (even if it had to be expanded from its current design capacity of 250 million litres per day).

Response – The MWP contains a comprehensive review of the use of desalination and describes its contribution to the water supply strategy for the greater Sydney region.

It is noted however that the business case for borefield development assumes an operating desalination plant of 250 million litres per day.

Project change and refinement - No project changes are proposed.

Demand management

Issues and impacts – Various suggestions were supplied including comments on water rates, pricing, availability of water, water efficient appliances, etc.

Response – The MWP contains a comprehensive review of the role of demand management and its contribution to the water supply strategy for the greater Sydney region.

Project change and refinement - No project changes are proposed.

3.5.3 Water management

Water sharing plan/embargoes/licensing

Issues and impacts – Issues raised included imposition of embargoes, SCA gaining a borefield allocation in the face of these embargoes, and adherence to the National Water Initiative (NWI).

Response - (i) The prospect of a large SCA borefield in the Upper Nepean catchment was factored into DWE's decision to embargo the parishes surrounding Kangaloon in late 2005, and does not compromise the sustainability of the sandstone resource.

(ii) This borefield project and the groundwater allocation for drought water supply, and DWE’s water sharing plan (WSP) have not been developed in isolation. The Nepean Sandstones groundwater source will not be over allocated as a result of this development. The SCA proposal is to take a maximum of 15 billion litres in years of severe drought, and this is unlikely to occur more than two or three years a decade. The SCA allocation is

factored into the sustainable yield calculations for the Nepean Sandstones groundwater source (which is currently estimated at around 100 billion litres per year). The purpose of the new WSP is to better regulate all consumptive users and to ensure that over-allocation never occurs.

(iii) The proposed development complies with the National Water Initiative (NWI) and there is no over-allocation of the regional sandstone groundwater resource when considering the longer-term planning, allocation and expected usage timeframe.

Project change and refinement - No project changes are proposed.

3.6 Agency issues

Key NSW government agencies and Wingecarribee Shire Council provided substantial comment on the borefield proposal. Most advocated a precautionary approach and adoption of additional monitoring systems. The major issues for each agency are provided in the issues and responses table in Appendix C, and are categorised as follows.

Department of Primary Industries

- Coal seam gas
- Water users
- Ecosystem impact (fisheries)

Department of Environment and Climate Change

- Ecosystem impact (surface water)
- Ecosystem impact (threatened species)
- Ecosystem impact (groundwater dependent ecosystems)
- Aboriginal heritage
- Protection of the Environment and Operations (PoEO) licence (water treatment discharge and conveyance)

Department of Water and Energy

- Hydrogeological assessment and resource impacts
- Infrastructure works
- Ecosystem and environmental impact

Wingecarribee Shire Council

- Government policy
- Sustainability
- Hydrogeological assessment and resource impacts
- Technical studies
- Operational triggers and monitoring
- Iron waste
- Water transfers
- Approvals

- Design
- Traffic control

Hawkesbury Nepean Catchment Management Authority

- Ecosystem protection

4. Preferred project updates

This chapter outlines the responses to design concerns raised in the submissions and proposed as part of finalising the engineering design for the proposed borefield. It describes the proposed design, construction and operational changes. Architectural design extracts from the preferred design report (Commerce, 2008) are provided in Appendix D. In addition, the proposed monitoring framework for the borefield is outlined in this chapter.

4.1 Design and construction changes

4.1.1 Production bores

There are currently 12 production bores within the Upper Nepean (Kangaloon) Borefield corridor that have been constructed for investigation and trial purposes. There are seven production bores in the central area borefield near Tourist Road where the road crosses over the Nepean River, three to the east on Fire Trail No. 1 near Stockyard Swamp, and two to the west (one on each of Fire Trails No. 2A and 3).

There will be a maximum of 75 production bores in the final scheme (no change to the number proposed in the environmental assessment (EA)). The only change to the assigned locations in the environmental assessment is that site 3O (just off Tourist Road in the Little River sub-catchment in Area 3) will be retained as an observation bore rather than being converted to a production bore. This bore has been deleted because of the changed alignment of the pipeline and power in this eastern area. Another site to replace this bore has not been selected at this time.

All corridors identified in the EA are to be retained for potential production bore locations. A ground geophysical method (resistivity imaging in combination with vertical electrical soundings (VES)) will be used to better define the geological structure, resource prospectivity and optimum bore sites. It would confirm the final locations of each of the proposed investigation / production bore sites in Areas 1, 2 and 4.

4.1.2 Pipeline

For water transfer, the interconnecting pipework will mostly consist of the following pipe sizes: 100 millimetres, 150 millimetres, 200 millimetres, 250 millimetres and 300 millimetres. Pipe sizes have reduced from the original design based on slightly lower production rates and different pipeline routes. The largest pipeline diameter is now expected to be 300 millimetres (previously 375 millimetres).

The pipework for the production bores will be mostly on SCA lands and follow the existing road reserves along Tourist Road, other public roads, and the adjoining SCA fire trails. There are a few minor changes to the pipeline design provided in the EA. The revised alignments are shown on **Figure 4.1**. The pipeline route has changed in two areas:

- Area 3 - it avoids the heavily vegetated section of Tourist Road from Moresby Hill Road to Fire Trail No.1A as the pipeline now follows the Transgrid easement to the north east and then returns westwards along Fire Trail No.1A
- Area 2 - it runs beside Kirkland Road (instead of across private land) for the total length of road between the ex-forestry depot (SCA land) near Kangaloon Road and Tourist Road.

4.1.3 Power

Provision of power supply to the borefield will require network extensions and augmentation of the existing 11kV Integral Energy (IE) distribution system located in the area between Mittagong and Robertson. IE has proposed that Robertson and Mittagong Zone sub-stations will supply the power for this project and existing distribution feeders will have to be augmented. Information sourced from a power line survey of the borefield indicates that the extent of augmentation work covers a total route length of approximately 18.3 kilometres. This is in addition to the 45 kilometres within the borefield area. The augmentation work follows existing power alignments and involves replacement of some poles, addition of new poles, and re-stringing of power lines.

Detailed design has recently been completed. There is some minor alignment and changes to types of cabling within the borefield area (to that previously proposed in the EA) based on the field surveys and changed pipeline routes. The revised alignments are shown on **Figure 4.2** and include:

- Area 3 – no power lines north along Tourist Road from the intersection with Moresby Hill Road
- Area 2 – changed alignment along Kirkland Road (Kangaloon Road to Moresby Hill Road section) to minimise crossings or upgrades across private land
- Area 2 – minor changed alignments in the vicinity of the intersection of Tourist Road and Kirkland Road to minimise crossings or upgrades across private land.

4.1.4 Water treatment facilities

The location of the two water treatment plants (WTPs) has not changed from the EA but there is now additional detail regarding the footprint and the specific location of buildings and collection ponds within each of the facilities.

The preferred option for the Area 4 WTP is at a location adjacent to Maguires Creek and Fire Trail 2B. The chosen location is shown in **Figure 4.3**. The maximum anticipated flow through the treatment plant would be 10 million litres per day (ML/d).

Groundwater from Areas 1, 2, and 3 would be treated at a site adjacent to the Nepean River near Tourist Road. The location is shown in **Figure 4.4**. The maximum anticipated flow through the WTP at this location will be 40 ML/d.

The treated water discharge points will be located immediately downgradient of the two WTP locations as shown in **Figure 4.3** and **Figure 4.4.**

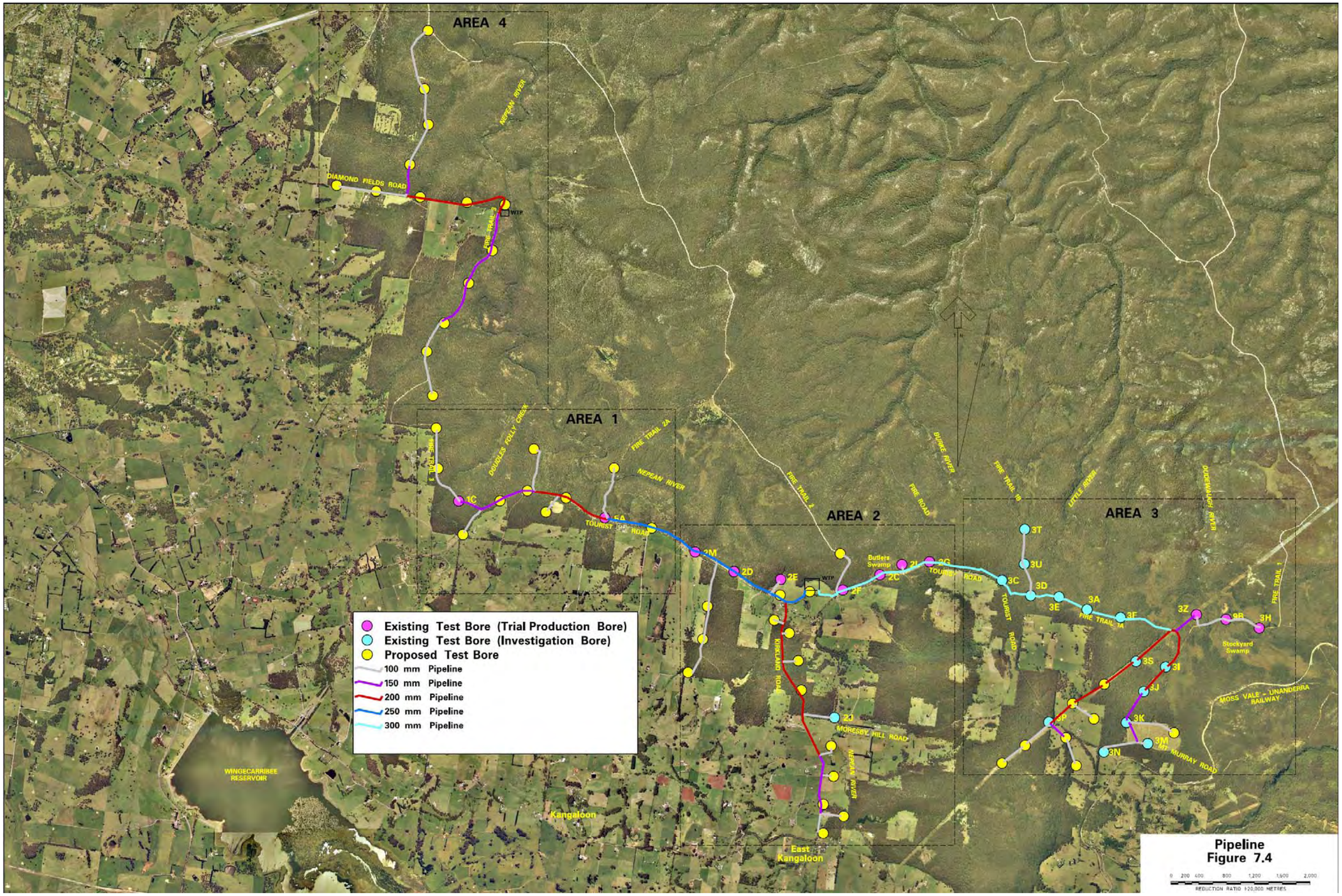

Figure 4.1 Kangaloon Borefield – Proposed pipeline layout and design

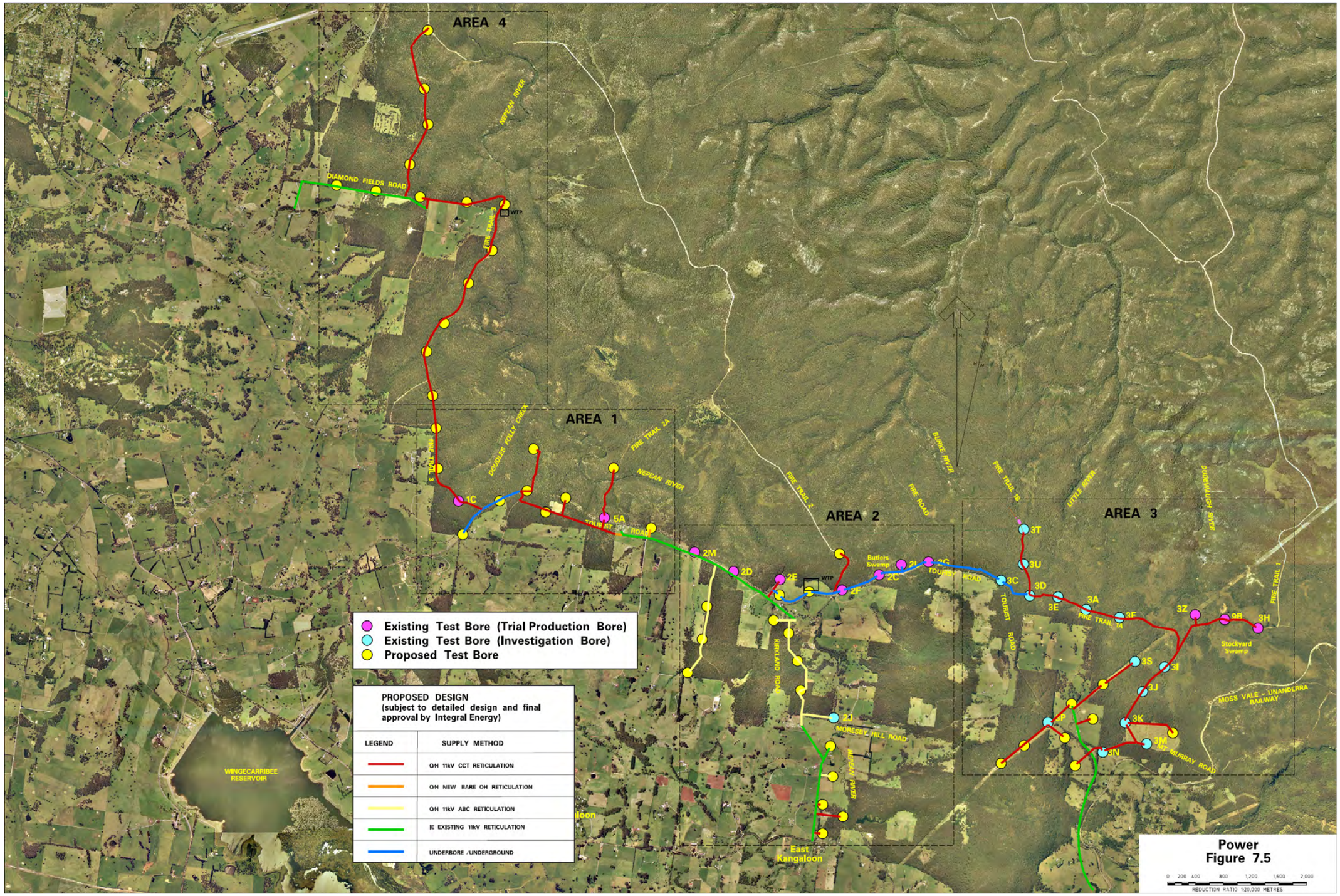

Figure 4.2 – Kangaloon Borefield – Proposed power layout and design

Figure 4.3: Layout of water treatment plant at Northern discharge

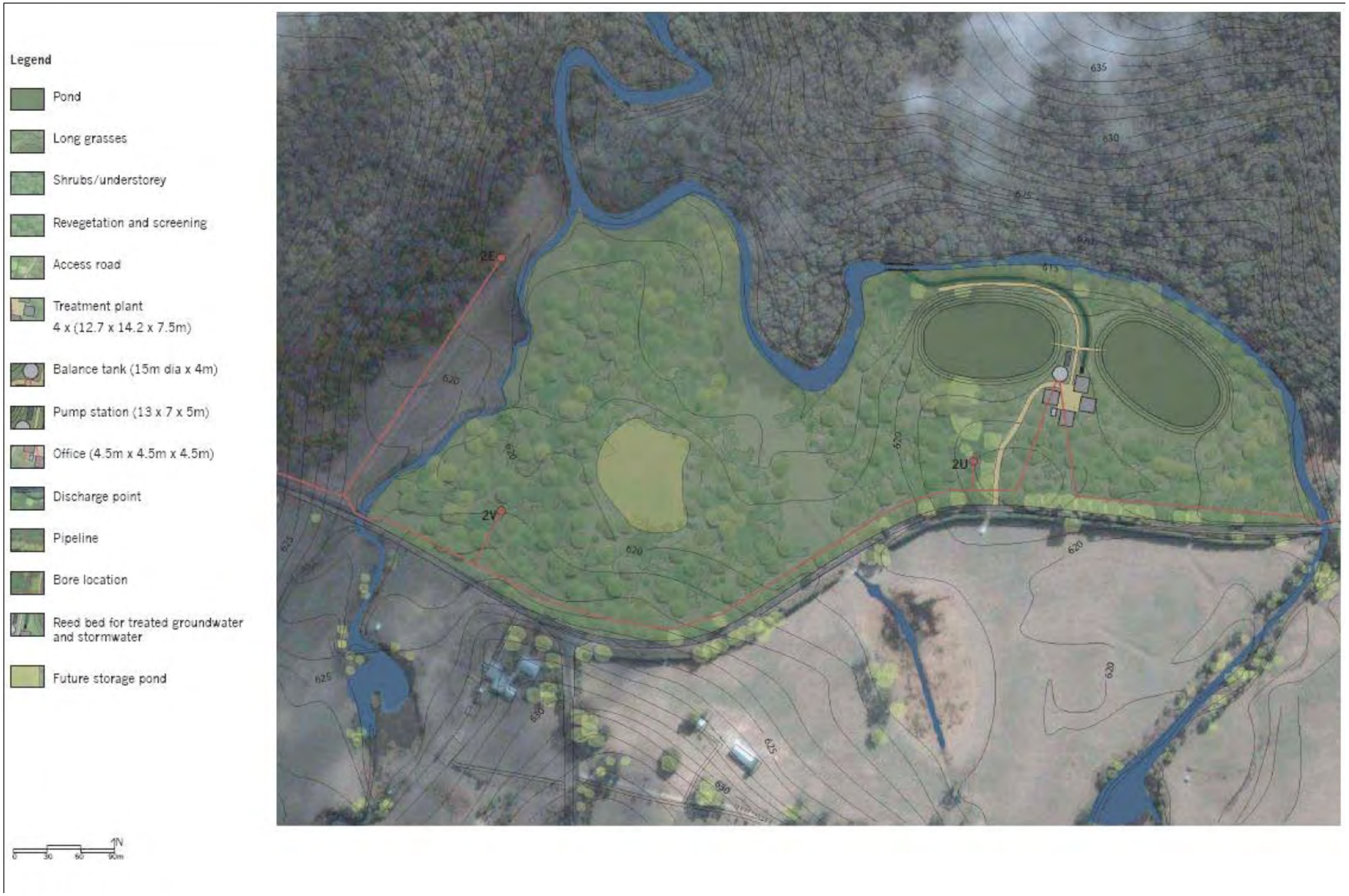

Figure 4.4: Layout of water treatment plant at Tourist Road discharge

Plant layout

The water treatment plants (WTPs) would be designed as modular units of 10 ML/d each. Modules would be added as required to meet the installed capacity of the borefield as different stages are built.

The estimated plant footprint for a 10 ML/d ejector aeration system with media filtration is about 13 metres x 12 metres with a height of about six metres (a spray aeration system would be slightly larger in area and height). These dimensions do not allow for clearances around and above the plant.

The water treatment facility for Area 1, 2 and 3 would initially be designed to cater for a flow of 30 ML/d, upgradeable to 40 ML/d (i.e. three modules upgradeable to four modules).

At the inlet to the Tourist Road plant a balance tank would be required to account for the variable inflows from production bores. This balance tank would be 0.5 ML in volume and in the order of 12-15 metres in diameter and three to four metres in height.

In addition to the above there would be a pumping station to pump water from the balance tank to the aerators. The power requirement would be about 100 kilowatts (kW) for each 10 ML/d module. The footprint of the pumping station, for the ultimate 40 ML/d WTP capacity, would be approximately 13 metres by seven metres and approximately four metres high.

The plant layout and architectural designs for the Tourist Road WTP are shown in Appendix D.

The water treatment facility for Area 4 would be designed to cater for a flow of 10 ML/d (i.e. one module).

At the inlet to the Northern plant, a balance tank would be required to account for the variable inflows from production bores. This balance tank would be 0.2 ML in volume and in the order of eight to nine metres in diameter and three to four metres in height.

In addition to the above there would be a pumping station to pump water from the balance tank to the aerators. The power requirement would be about 100 kW for a 10 ML/d module. This pumping station would be approximately six metres by seven metres and approximately four metres high.

A schematic showing the plant layout for the Northern WTP is shown in Appendix D.

Collection ponds

Two collection ponds would be constructed at each WTP site, into which the process residual from the media cleaning would be discharged for drying prior to disposal or reuse. The collection ponds will fit in with the local land contours and soil types. It is expected that some of the spoil excavated during the pipeline trenching and installation will be used for earthworks required at each of the WTP sites.

The basis of design and sizing for the collection ponds is the same at both the WTPs. The collection ponds for the Tourist Road site will be approximately 135 metres by 50 metres (0.7 hectares) each, while the collection ponds at the Maguires Creek site would be about 70 metres by 30 metres (0.2 hectares) in area. All ponds would have a depth of two metres, which includes 0.5 metres for water and 0.5 metres freeboard.

Flooding

As the site for the Tourist Road WTP is adjacent to the Nepean River and is in a known flood zone, flood studies were undertaken for the site (Commerce, 2008b). The flood study investigated the 1 in 20, 1 in 50 and 1 in 100 year flood levels for the site for both pre and post WTP construction conditions.

The flood studies at the Tourist Road WTP show that the various flood levels vary by up to about 1.7 metres, but the incremental difference in flood levels pre and post construction of the collection ponds and the WTP structures is only 30 millimetres to 70 millimetres. The collection ponds are likely to be overtopped during 1 in 20, 1 in 50 and 1 in 100 year floods. The inundation would be by only a few centimetres at the more frequent flood recurrence interval and is likely to slowly fill the ponds rather than scour the ponds. Inundation is only likely for a few hours.

The WTP would be located above the 1 in 20 year flood level with electrical equipment located off the ground within the site buildings.

Architectural design

The water treatment plant for areas 1, 2 and 3 is in a highly visible location off Tourist Road. Architectural input was sought in the design of the Tourist Road WTP and its associated structures to minimise its visual impact. These same concepts were later applied to the Northern WTP site.

The requirements for each of the sites include the location of a WTP, which includes buildings for each water treatment module and associated water collection ponds, a pumping station, a balance tank and a treated water discharge feature.

A set of full architectural drawings can be found in Appendix D.

The informal arrangement of the buildings that make up the WTP is indicative of farm buildings in the area. To fit better into the rural setting, the buildings are located in an informal arrangement defining a yard or hard stand. Because the scale and bulk of the buildings is a potential issue (especially at the Tourist Road WTP site), the buildings have been reduced in scale by housing the plant in a number of smaller buildings. The simple shed-like forms of the buildings with skillion roofs are intended to sit in the landscape in a low key manner. The smaller buildings and simple architectural forms are designed to mitigate the visual impact of this building grouping.

Guidelines and building dimensions have been developed so the development remains in keeping with the rural residential character of the area (Tourist Road WTP) and the bushland setting (Northern WTP). The collection ponds and river discharge feature have no visual impact.

4.1.5 Water discharge facilities

Treated water from the Tourist Road WTP would be discharged to Nepean River via a 200-250 metre long earthen open channel. The channel would run from the WTP to the river between the two lagoons as shown in **Figure 4.4**. The channel would be of trapezoidal shape with a three metre wide bed and 1(V):3(H) side slopes and would have a longitudinal gradient between 100–200 percent.

The upstream end of the channel would consist of a typical culvert headwall structure to receive treated water from the WTP. The channel would join the river at a 45 degree angle in the direction of flow at a level approximately 1.5 metres higher than riverbed level. At the connection point to the river, the open channel would be lined with a 300 millimetres thick Reno mattress (for at least 10 metres of the channel). Gabion boxes would be placed on the riverbank at two to three metres height above the sandstone riverbed and are expected to extend approximately 20 metres in length. The opposite bank of the river at this location would also be armoured with rock boulders.

At the Northern WTP discharge location, the creek bed downstream of the causeway has a flat rock surface on the southern side and is suitable for discharging treated groundwater. It is proposed to discharge water to the creek via a partially buried concrete pit consisting of a weir as shown in the EA. Water from the treatment plant would flow into the discharge pit by gravity. The design is unchanged from the concepts provided in the EA.

The weir is expected to be no more than 1.5 metres wide for a flow of 10 ML/d. The outlet area of the weir is mainly solid rock of cascade type and therefore overflowing water from the weir would flow through the rock surface into the creek without causing any erosion. As such, no other erosion protection works are required as the creek bed at this location forms a rocky apron, ensuring dispersed water flow. The discharge pipeline from the WTP would be laid along the side of the fire trail between trees.

Water discharge locations will be monitored for erosion. If erosion occurs, rectification works will be undertaken.

4.2 Operational changes

4.2.1 Production bores

Based on the results of pilot testing and subsequent investigations, the likely extraction rate (or “safe” yield) for a production bore is estimated to be between five and 15 litres per second (L/s) with occasional supplies to 30 L/s per bore. The installed capacity of the borefield is expected to be greater than 18 billion litres per year based on the cumulative “safe yields” for all production bores. However this over estimates the expected pumped volumes as it is unlikely that all bores would be operational together, and even if they were, they would not operate continuously for 12 months.

The maximum borefield extractions will not exceed 15 billion litres per year in any 12 month period of operation. Currently the criteria for operation during severe drought periods would be:

- bores would operate continuously[1] at a rate that is approximately 90 percent of their safe yield
- bores in Areas 1 and 4 will not operate if there are transfers from the Shoalhaven Scheme via Wingecarribee Reservoir exceeding 400 million litres per day
- no bores anywhere will operate if the transfers from the Shoalhaven Scheme via Wingecarribee Reservoir exceed 600 million litres per day
- all bores would be turned off for 60 days if there is 100 millimetres of rainfall in any month
- all bores would be turned off for 180 days if there is 250 millimetres of rainfall in any month.

These criteria are the basis of the modelling runs provided in Coffey, 2008. The actual pumping areas and the on/off schedule will depend on:

- the “safe yields” for the production bores (and their performance over time)
- actual rainfall patterns
- Shoalhaven scheme transfers
- Department of Water and Energy water sharing plan and licensing conditions
- monitoring and management triggers.

It is now proposed that bore pumps would remain in the bores during both the drought and non-drought cycles. Bores will be pumped annually for at least six hours to ensure that all equipment remains operational. To prevent iron scaling and bacteria, which may potentially clog bores (slots and screens) and damage pumps, dosing facilities will be provided at each production bore. Each bore will be dosed annually while not in use; at the commencement of a new cycle; and daily while in use (see Section 4.3.1 for a description of the dosing process).

The proposed treatment of production bores when commencing a new pumping cycle is different to the other dosing events. Before recommencing, each bore will be dosed with a biodegradable organic acid to remove any build up of iron bacteria and scale in the pump and on the casing and screens. First flush water generated when the bores are brought on line after these long recovery periods will be pumped to the collection ponds at the WTP.

Preventative maintenance at other times will involve dosing using a chlorinated solution. The chlorination is required to keep iron bacteria and slimes under control during pumping and non pumping cycles. It will be generated on site from a saline solution that is converted to a weak acid. The chlorinated water for treatment will be stored in each compound (eg. in a small 2500 litre tank) and during operational cycles will be backwashed into the bore on a daily basis. During operational periods, this water will be pumped through the WTP rather than bypassed to the collection ponds. During non pumping periods, the water will be pumped to the WTP collection ponds.

Compounds for safety and security purposes are planned around each of the production bores and associated site infrastructure in areas of higher risk.

[1] *Continuous meaning that bores will generally be pumping for around 23 hours per day with one hour per day allowed for backwashing*

4.2.2 Pipeline

Even though there are a few minor route changes there are no operational changes associated with the pipeline infrastructure.

4.2.3 Power

Even though there are a few minor route changes there are no operational changes associated with the power infrastructure.

4.2.4 Water treatment facilities

The WTPs and production bores will be centrally controlled at the Tourist Road facility and will also operate automatically from a remote location. Plant operators will also be able to manually initiate plant operation from either location. Operator attendance may be required on site intermittently in order to perform maintenance work and to check monitoring equipment.

Two collection ponds would be provided at each site, with one in the filling cycle and the other in the drying cycle. When the collection ponds have filled, the concentrated residual stream will begin a drying cycle. Alum would be dosed into the collection ponds to concentrate the residual from the expected 0.1 percent (w/v) to about 2 percent (w/v). Alum will slightly reduce the pH and hence it is expected that only iron and no manganese will be removed from the backwash water.

The two collection ponds at each site will be sized for a six month cycle instead of a 12 month cycle, and space allocated to construct a third pond (at the Tourist Road site) if an extra pond is required during the operation of the scheme. This would minimise the impact on the environment and the surrounding landscape.

The dried iron waste product that would accumulate in the collection ponds will be removed and either disposed of in landfill or recycled where possible. Waste removal has been designed to occur once every six months.

Rainwater from roofs of the treatment plant buildings is not to be collected or channelled, but rather gutterless roofs are to be used to reduce risk of debris collection and fire risk. Splash zones around buildings are to be provided and surface drainage engineered to not enter critical parts of the WTPs.

4.2.5 Water discharge facilities

Maintenance on the discharge channel from the Tourist Road WTP to the river will be required before the plant is put into operation after each recovery cycle. The discharge point may also require maintenance before the WTP becomes operational. This is to ensure no silt or debris has built up in the channel or discharge point. Rainwater and runoff collected from the treatment facility buildings and hard stand areas will be directed to the outlet channel to help alleviate the maintenance required within the channel.

Treated groundwater from Areas 1, 2, and 3 will be released to the Nepean River from the Tourist Road WTP downstream of the Tourist Road bridge. The discharge location is

shown in **Figure 4.4**. The maximum anticipated flow discharge at this location will be 40 ML/d. The discharge location has sandy, loamy river banks with the river bed being sandstone bedrock. There are no sandy alluvial bedload deposits in the bed of the river that could be scoured by the groundwater discharges during low flow drought periods when the scheme is likely to be producing at its maximum.

The proposed discharge point for Area 4 (from the Northern WTP) is located on the downstream side of the Maguires Creek crossing of Fire Trail 3, just north of the intersection with Fire Trail 2B. The chosen location is shown in **Figure 4.3** (and is unchanged from the detail provided in the EA). Maguires Creek is an ephemeral (temporary) stream with sandstone bedrock. The Maguires Creek crossing on Fire Trail 3 is a causeway that does not have low flow culverts and is therefore overtopped whenever there is a flow in the creek. Maguires Creek joins the Nepean River about 80 metres downstream of this point and this section of the creek is very rocky with large sandstone outcrops.

No maintenance on the discharge arrangements from the Northern WTP to Maguires Creek will be required before the plant is put into operation. Runoff from this site will just follow the site contours into the surrounding bushland and creek line.

4.3 Environmental assessment of changes

4.3.1 Production bores

There is only one bore location change and the operational yield of individual bores is expected to be lower than previous estimates provided in the EA. The full environmental assessment of the current borefield configuration and likely pumping rates is provided in Chapter 3 of the EA.

The transient modelling of the current borefield layout and the expected pumping rates for 75 production bores (Coffey, 2008) predicts the water balances and drawdown impacts at distance. The extent of drawdowns is similar to the earlier predictive results in Chapter 9 of the EA. Water balances change with the rainfall patterns but for the most likely severe drought case, 80 percent of groundwater pumped is sourced from aquifer storage. Overall the groundwater resource impacts are manageable.

One operational change is that each production bore will be dosed on a periodic basis to minimise iron scale and iron fouling at each site. Dosing with an organic acid after long rest periods will involve backwashing 500-1000 litres of product into each bore and the adjacent aquifer. Product will be delivered in sealed containers to site and injected into the water column at each production bore. After the recommended contact time, the waste water will be pumped direct to the collection ponds at the WTP. These acids are non-toxic and biodegradable, and recommended for use in maintaining bore performance.

Dosing during operational periods will involve a small storage tank located at each bore site to retain a small volume of the pumped groundwater each day. Water will be electrolysed (or a small amount of sea salt added with the water then electrolysed) to generate a chlorinated solution that is suitable for backwashing through the pump and into each production bore. This water (when pumping recommences) will be pumped to the

WTPs and through the treatment process. The dosing will also occur annually during non-operational periods.

There is no additional impact caused by the minor design and operational changes to that already described in the EA.

4.3.2 Pipeline

The pipeline has mostly reduced in diameter and there are two route changes (see Section 4.1.2). Impacts from construction mostly remain as described in the EA report. There are no flora, fauna, or archaeological issues associated with these routes changes, and there will be less impact to native flora as a result of the changes. There are no operational impacts.

A greater construction impact will occur to traffic and general access as a result of the pipeline route change along Kirkland Road. The revised proposal is to construct and bury the pipeline in the eastern road verge of the existing road reserve. As this public road is narrow, it is expected that there will be partial road closures during the construction of this southern arm of the borefield. Closures would be restricted to closing just one lane of traffic while the shallow trench is dug and the trunk pipeline is being laid. Traffic management planning will be required along Kirkland Road during the construction phase. Traffic impacts will be less as a result of deleting the pipeline route along Tourist Road between Moresby Hill Road and Fire Trail 1A.

No additional mitigation measures are required during either the construction or operational phases.

4.3.3 Power

Slightly lesser disturbance of lands is proposed within the main borefield area (see Section 4.1.3), however additional power line augmentation (replacement of existing poles, new poles, and restringing of lines) is expected to be required in providing power from each of the Mittagong and Robertson substations.

Less impact will occur to native flora as a result of the power line route changes within the borefield.

There is no additional impact caused by these minor design changes to that already described in the EA.

4.3.4 Water treatment facilities

Detailed design of the WTPs indicates that it may be necessary to import clay / fill to line the collection ponds and construct the berms, and to remove shallow rock during excavation of the collection ponds. Site requirements are dependent on a geotechnical investigation of each site which has not begun for either site. Additional construction vehicle movements would also include materials delivery for construction of the WTP buildings and associated infrastructure and for construction personnel. The mitigation and management measures specified in the EA are sufficient to address potential traffic impacts associated with construction of the WTPs.

Impacts from operation remain as described in the EA. However, there is a minor alteration to the road design entry / exit onto Tourist Road at the proposed new access road entry to the Tourist Road WTP. The new Tourist Road WTP entry / exit (see **Figure 4.4**) provides the best east-west visibility but the final design would be determined in consultation with Wingecarribee Shire Council to ensure consistency with council's road design principles and criteria.

The public would have interrupted views of the WTP site as they travel along Tourist Road due to screening by roadside vegetation and trees on the paddock where the WTP would be built. Revegetation to screen the area will be established before the construction program commences. Additionally, the WTP and associated components are sufficiently distant from Tourist Road that they would represent only a small part of the visual landscape. Similarly, nearby residences are sufficiently distant from the WTP that site buildings would represent only a small part of their visual landscape. Therefore, no significant visual impacts would occur from construction activities at the WTP sites and there are no ongoing operational issues once the vegetation screening is in place.

Access to the Northern WTP would be along existing roads and fire trails without any significant changes to traffic and access arrangements.

Some traffic management planning will be required along Tourist Road during the construction of the Tourist Road WTP and its dedicated access road.

No additional mitigation measures are required during either the construction or operational phases.

4.3.5 Water discharge facilities

In order to minimise potential erosion and sedimentation impacts during construction at the Tourist Road WTP discharge site, a small coffer dam may be built upstream of the discharge site and water piped from the coffer dam to a location downstream of the river bank construction area. Following completion of the works, the coffer dam would be disassembled, and restoration and revegetation works would ensure that all disturbed river bank surfaces are rehabilitated to avoid any longer-term impacts. The bed of the Nepean River is on rock so no disturbance to the bed is expected.

During operational periods, the grass in the discharge channel from the WTP would be kept short to minimise water loss. During both the operational and non-operational periods, stormwater from the built environment part of the site would be redirected to the start of the discharge channel. The discharge channel would be well maintained at all times.

No additional mitigation measures are required during either the construction or operational phases.

4.4 Monitoring plan update

An adaptive management approach will be applied if the borefield is approved, constructed and operated. Effective monitoring programs are essential to ensure the

environment and consumptive users are protected. The conceptual understanding of the project's interactions with the environment and the objectives of the program are set out in the EA.

Three levels of resource and environmental monitoring planning are proposed:

- detailed monitoring framework (see Section 4.4.1)
- specific monitoring plans (to be developed later under Department of Water and Energy and Department of Environment and Climate Change licences)
- site management plans (CEMPs, OEMPs etc when the borefield proceeds).

4.4.1 Detailed monitoring framework

The following information is presented in addition to the preliminary information in Chapter 12 in the EA. Monitoring programs have been reviewed and the use of control sites and more intensive monitoring during construction and operational periods has now been included. A summary of the revised monitoring framework is presented in Table 4.1 and the current groundwater monitoring locations are shown in **Figure 4.5.**

Table 4.1 Summary of Kangaloon Borefield monitoring framework

Borefield Stage	Sandstone within Borefield	Sandstone Remote from Borefield (north)	Sandstone Remote from Borefield (south)	Shallow Perched Water within Borefield	Shallow Perched Water Remote from Borefield	Springs on Private Property	Nepean River	Doudles Folly Creek, Little River and Dudewaugh Creek	Other Permanent streams and tributaries	Butlers and Stockyard Swamps	Control swamp	Other Upland Swamps within Borefield	Terrestrial Vegetation	Control vegetation community	Aquatic Ecosystems - Discharge Locations	Aquatic Ecosystems - Permanent stream locations	Aquifer Ecosystems
Non Operational Periods																	
Groundwater	X	X	L	X		L											
Surface water							X	X									
Ecosystems										*			$				
Immediately Pre - Construction																	
Groundwater	X #	X	X E	X E #	E	E			E								
Surface water							X	X									
Ecosystems										**	E **	E **	**	E **	E **	E **	E **
Construction																	
Groundwater	XX #	X	X	XX #	X	X											
Surface water							XX	XX	XX						E #	E #	
Ecosystems										***	***		***	***	***		
Operational																	
Groundwater	XX ##	XX	XX	XX #	XX	X									###		
Surface water							XX	XX	XX						###		
Ecosystems										***	***	***	***	***	***	***	**
Immediately Post - Operational																	
Groundwater	XX	X	XX	XX	X	X											
Surface water							X	X									
Ecosystems										***	***		***	***	***		

Key

X	Water levels - Key sites - 6 monthly download	*	Ecosystem monitoring - 5 years
XX	Water levels - All sites - quarterly download	**	Ecosystem monitoring - baseline
		***	Ecosystem monitoring - 6 monthly
#	Water quality - Key sites - baseline		
##	Water quality - Key sites - 6 monthly	L	Limited
###	Water quality - continuous and/or more frequent	E	Establish new sites

The expanded monitoring framework presented in Tables 4.2 (non operational), 4.3 (construction) and 4.4 (operational) for surface water, groundwater and ecosystems provides the basis for monitoring the project's performance in relation to construction and operational impacts. The framework emphasises the monitoring of groundwater and surface water to provide a direct and practical measure of environmental change. There is additional ecosystem monitoring (including control sites) proposed in the lead up to construction and then through the operational periods.

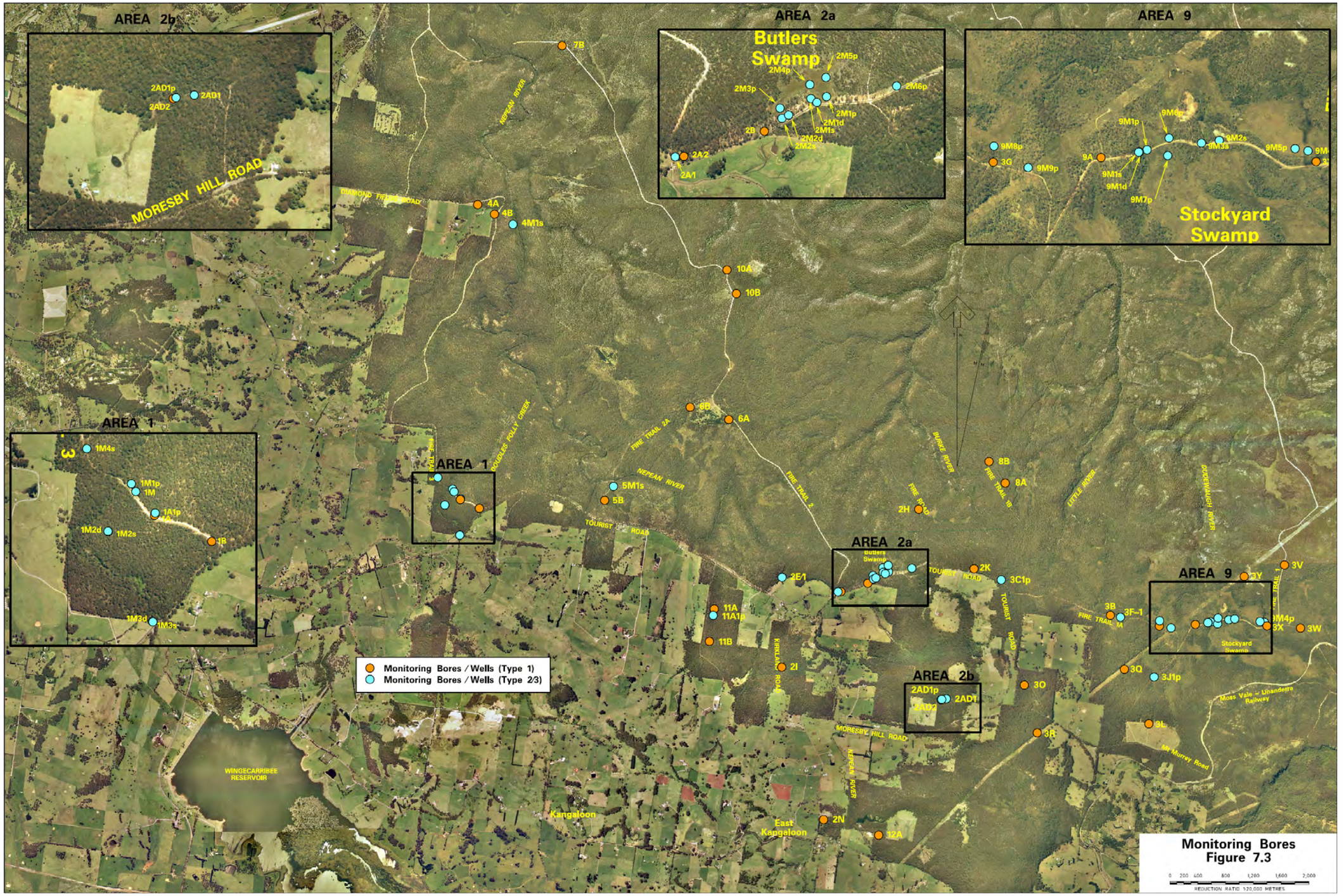

Figure 4.5 – Kangaloon Borefield – Current groundwater monitoring locations

Aquifer changes could include both water levels and water quality impacts, but for this development the primary focus is water levels (in the case of bores and shallow wells) and flows (in the case of springs and watercourses). Water sources and ecosystems that are linked with the sandstone landscape in the Upper Nepean catchment will be afforded a higher priority than more remote areas in the basalt and shale landscape, as investigations indicate the basalt and shale landscapes are mostly disconnected from the regional sandstone resource. Remote areas outside the Upper Nepean catchment are not included as pumping trials and numerical modelling have indicated that groundwater impacts will be negligible at distance.

In recognition of the importance of the upland swamp vegetation communities and selected vegetation communities, ongoing monitoring of these communities will be undertaken (and control sites will be established) even though there is no known connectivity and groundwater dependence (with the regional sandstone aquifers) is unlikely.

Changes in ecosystem composition and health can have a number of potential causes and subtle changes may occur over a very long period. Some of these changes may be due to natural (climatic) variations, and some may be due to human activity, including but not limited to borefield operation. It is proposed to monitor key ecosystems, and the main physical factors associated with borefield extractions. Ecosystem monitoring could then be intensified if trend data suggests a link and a possible impact.

There are several phases of development and operation. The monitoring activities are either increased or decreased depending on the phase and the risk of impacts to water resources and to the environment. These phases and activities are:

Before construction (see also Table 4.2)

- Baseline data collection at key sites will involve:
    - continuous water level data – six monthly downloads (key surface water and groundwater sites) to improve hydrological and hydrogeological understanding of the catchment, and improve numerical modelling
    - five yearly surveys (in Spring) of important swamp and terrestrial vegetation locations for biodiversity and condition for the purpose of tracking the natural variability of ecosystem biodiversity in those ecosystems.

The borefield construction program has been deferred by the NSW Government. The SCA is using this framework to plan data collection requirements from 2009/10.

Construction (see also Table 4.3)

- 12 months in advance of construction, prepare water level and flow, water quality and ecological monitoring programs that cover both construction and operational activities
- Six months in advance of construction, establish remaining regional monitoring sites (nested observation bore sites), local sensitive sites (shallow wells in swamps, and nearby terrestrial vegetation and riparian vegetation), control sites (shallow wells in remote swamp and vegetation communities) and extra gauging locations on permanent streams, plus a baseline survey of important ecosystem sites. This will specifically involve:

  - setting up new key water level monitoring locations (both surface water and groundwater) in addition to the key sites network to establish the more extensive baseline conditions
  - surveying all important ecosystem sites (swamp, terrestrial vegetation, aquatic and aquifer)
- Immediately pre-construction (in advance of any activity with particular focus on the borefield corridor and the main construction sites) work will involve:
  - continuous collection of water level data – three monthly downloads (existing and new sites) to analyse the more extensive baseline
  - sampling water quality samples at key sites (both surface water and groundwater)
- During construction (for the whole period of construction and commissioning) work will involve:
  - continuous collection of water level data – three monthly downloads (key sites) to analyse trends;
  - sampling water quality samples every six months at key sites (both surface water and groundwater)
  - six monthly surveying (Autumn and Spring) of important aquatic, swamp and terrestrial vegetation locations for biodiversity and condition
- Immediately post-construction/commissioning, undertake one monitoring and reporting event at least three months after the cessation of activities with particular focus on the main construction sites. Work will involve:
  - continuous collection of water level data – three monthly download (key sites) to analyse any trends/return to baseline.

  Note that no water quality samples or ecosystem surveys are proposed in this post-construction phase unless impacts were identified during construction.

Operation (see also Table 4.4)

- During operation, work will involve:
  - continuous collection of water level data – three monthly downloads (all sites) to establish any trends
  - sampling water quality every six months at key sites (both surface water and groundwater)
  - six monthly surveying (Autumn and Spring) of important aquatic, swamp and terrestrial vegetation locations for biodiversity and condition
  - annual monitoring at aquifer ecosystem locations
- Immediately post-operation (monitoring recovery/recharge is important so more intensive data collection and analysis is proposed for the 12 months after a long operational cycle) work will involve:
  - continuous collection of water level data – three monthly downloads (key sites) to establish any trends/return to baseline
  - six monthly surveying (Autumn and Spring) of important aquatic, swamp and terrestrial vegetation locations for biodiversity and condition.

Should the operational monitoring indicate that the project is changing the physical environment through, for example, a substantial change in creek flows, accelerated perched water loss, or a change in water chemistry, then additional and more intensive ecosystem monitoring will be undertaken to establish the link between the physical change and ecosystem health, and to implement appropriate mitigation measures.

Note that no ecosystem surveys are proposed beyond the full recovery of regional groundwater levels or 12 months (whichever is the lesser) unless there is evidence to suggest that ecosystems are at risk as a result of the borefield operation.

Non operational periods (see also Table 4.2)

- Data collection at key sites will involve:
    - continuous collection of water level data – six monthly downloads (key surface water and groundwater sites) to improve hydrological and hydrogeological understanding of the catchment, confirming recharge and discharge processes, and improved numerical modelling
    - surveying every five years (in Spring) of important swamp and terrestrial vegetation locations for biodiversity and condition.

4.5 Management responses

The following management responses (triggers and responses) will be adopted if monitoring indicates an unacceptable environmental or resource impact. These are based on the targets in Tables 4.3 and 4.4 and are expanded from those proposed in the EA.

- Management responses that involve water quantity measures could include:
    - if there are substantial water level declines (beyond two kilometres and beyond what is predicted in the model), adjustment of the extraction regime by altering the proportion of water extracted from different bores or borefield areas
    - if there are excessive natural or transmission losses from permanent streams attributable to pumping, adjustment of the extraction regime of bores located close to these streams where these losses have been proven.
- Management responses that involve water quality measures could include:
    - deactivation of the bores (and investigation) if salinity increases beyond the expected natural range for groundwater within sandstone aquifers
    - adjustment of treatment processes if iron levels in treated groundwater are inconsistent with those in the Nepean River receiving the discharged groundwater.
- Management responses that involve ecosystem measures could include:
    - development of responses with the regulators, if monitoring results indicate unacceptable environmental impacts due to borefield operation (eg. accelerated drying of swamps and terrestrial vegetation)
    - temporary reduction in extraction rates while further investigations are undertaken into potentially unacceptable impacts

    - permanent changes to extraction rates or locations where determined appropriate by SCA and DWE.
- Management responses that involve new infrastructure works within the borefield could include:
    - replacement of submersible pumps in some production bores to pump less water and reduce drawdowns
    - decommissioning of some production bores where water level declines are considered excessive and are shown to be severely impacting users or ecosystems
    - installation of additional production bores in areas where acceptable user or environmental impacts are expected and there is spare capacity in the aquifer system
    - refurbishment of some bores to exclude shallow water zones and possibly lower pumps in these production bores to access deeper groundwater
    - upgrading of the WTP treatment processes.
- Management responses that involve new works for private users within the influence of the borefield could include:
    - lowering of pumps in bores to access deeper groundwater where water levels have declined but there is still sufficient groundwater available for existing uses
    - replacement of pumps where it is necessary to upsize the pumping equipment to maintain water supplies for existing uses
    - deepening of bores where water levels have dropped to unacceptable low levels and supplies for existing uses cannot be maintained from existing bores
    - provision of new water supply options (eg. bores or tanks or pipeline connections) where spring and creek flows have been impacted by borefield operation.

In addition, the monitoring network responses may trigger additional investigations to better understand and devise the most appropriate management response. These investigations could include:

- independent (third party) reviews to evaluate observed impacts and to assess investigation and management responses
- additional Type 1, Type 2 or Type 3 monitoring bores and wells
- additional data logger locations
- addition stream gauge locations
- additional water quality sampling programs
- additional (or local scale) numerical modelling
- investigations into managed aquifer recharge.

Table 4.2 Detailed monitoring framework – Non operational periods and In advance of construction

Environmental aspect	Purpose	Parameter	Target value	Monitoring approach	Management contingencies
Surface water	***5 sites***		***6 monthly download***		
Stream flow (Nepean River – two sites)	To assess stream heights and flows.	Stream flow Water levels	None	Stream gauges to confirm flows and heights at representative locations.	Not applicable
Stream flow (Little River, Dudewaugh Creek and Doudles Folly Creek)	To assess stream heights.	Water Levels	None	Stream monitoring to confirm heights at representative locations.	Not applicable
Groundwater	***~100 sites***		***6 monthly download***		
Groundwater levels within the whole borefield area – Type 3 Perched water Type 2 Shallow sandstone Type 1 Whole sandstone	To determine the natural variability, and recovery/recharge after pumping cycles.	Water level (m) and height (m AHD)	None	Dataloggers and manual gauging events. Monitoring locations as shown in Figure 4.5 (existing installations). Bores will be inspected and monitoring will occur at all production bores and monitoring bores and wells at least once per year. There are currently three locations on or adjacent to private property (two springs and one bore).	Not applicable
Ecosystems	***5 sites***		***Spring every 5 years***		
Swamp vegetation	To assess biodiversity, condition and health	Indicator species	None.	Quadrat sampling. Butlers and Stockyard Swamps only.	Not applicable
Terrestrial vegetation #	To assess biodiversity, condition and health	Indicator species (to be determined)	None	Typical woodland and riparian communities. Three areas to be selected	Not applicable

Note: # vegetation communities near wells 1A1p, 1M1p, 11A1p, 2AD1p (Moist Shale Messmate Forest), and 3C1p, 3J1p, (Highland Shale tall open forest).

Table 4.3 Detailed monitoring framework – Borefield construction

Environmental aspect	Purpose	Parameter	Target value	Monitoring approach	Management contingencies
Surface water	***7 (WL) + 2 (WQ) + 2 construction sites***		***3 monthly download***		
Surface water quality (Nepean River and Maguires Creek discharge sites plus permanent streams downstream of selected construction sites)	To assess natural stream water quality and any construction impacts.	pH Temperature Iron (total) Manganese Salinity Dissolved Oxygen Oxidation potential (Eh)	6.5-8 pH unit 5-25ºC <5.0 mg/L <1.5 mg/L <400 µS/cm 85-110% sat Na	Grab samples from flowing portion of stream. Downstream of major construction activities at permanent stream locations (two to be selected)	Any noticeable change in water quality downstream of construction locations will be used to immediately improve CEMPs and change site practices.
Stream flow (Nepean River – two sites) *	To assess stream heights and flows.	Stream flow Water levels	None	Stream gauges to confirm flows and heights at representative locations.	Not applicable
Stream flow (Little River, Dudewaugh Creek and Doudles Folly Creek) *	To assess stream heights.	Water Levels	None	Stream monitoring to confirm heights at representative locations.	Not applicable
Stream flow (Upper Nepean Site, Burke River Site)	To assess stream heights.	Water Levels	None	Stream monitoring to confirm heights at representative locations.	Not applicable
Groundwater	***~120 (WL) + 4 (WQ) sites***		***3 monthly download***		
Groundwater quality at key sites within the borefield (say four – one for each area)	To confirm natural groundwater quality.	pH Temperature Iron (total) Manganese Salinity Dissolved oxygen Oxidation potential (Eh)	4.5-8 pH unit 10-18ºC <40 mg/L <2 mg/L <500 µS/cm 0-110% sat Na	Grab samples at four key bore locations.	Not applicable

Environmental aspect	Purpose	Parameter	Target value	Monitoring approach	Management contingencies
Groundwater levels within the whole borefield area (existing sites) Type 3 Perched water Type 2 Shallow sandstone Type 1 Whole sandstone	To determine the natural variability.	Water level (m) and height (m AHD)	None	Dataloggers and manual gauging events. Monitoring locations as shown in Figure 4.5 (existing installations). Bores will be inspected and monitoring will occur at all production bores and monitoring bores and wells at least once per year. There are three locations on or adjacent to private property (two springs and one bore)	Not applicable
Groundwater levels within the whole borefield area (new sites) Type 3 Perched water Type 2 Shallow sandstone Type 1 Whole sandstone	To determine the natural variability.	Water level (m) and height (m AHD)	None	Dataloggers and manual gauging events. Monitoring locations to be determined (mostly swamp and upgradient locations).	Upgradient locations to be determined by Expression of Interest (EoI) process (fall back is to construct within road reserve if difficult to gain access to private lands). Establish sites within remainder of upland swamps in borefield area and at remote control sites for swamps and vegetation.
Spring sites on private properties	To monitor the natural variability of springs	Basalt Aquifer - flows from springs and water levels where possible	None.	Dataloggers (key sites).	Locations to be determined by EoI process.
Ecosystems	***10 sites***		***Autumn and Spring during whole period***		
Swamp vegetation	To assess biodiversity, condition and health	Indicator species	None.	Quadrat sampling. Butlers and Stockyard Swamps and control swamp only.	Minimising access and exclusion are the primary mitigation measures however any noticeable change in upland swamps downstream of construction locations will also be used to improve CEMPs and site practices.

Environmental aspect	Purpose	Parameter	Target value	Monitoring approach	Management contingencies
Terrestrial vegetation #	To assess biodiversity, condition and health	Indicator species (to be determined)	None	Typical woodland and riparian communities with borefield and control site	Minimising activities in forested areas is the primary mitigation measure however any noticeable change in forested areas downstream of construction locations will also be used to immediately improve CEMPs and site practices.
Aquatic biota	To assess biodiversity, condition and health	Indicator species (to be determined)	None	Upstream and downstream of the two WTP discharge locations.	Total exclusion is the primary mitigation measures however any noticeable change in aquatic plants and animals downstream of construction locations will also be used to immediately improve CEMPs and site practices.

Note: * existing sites; # vegetation communities near wells 1A1p, 1M1p, 11A1p, 2AD1p (Moist Shale Messmate Forest), and 3C1p, 3J1p, (Highland Shale tall open forest).

Table 4.4 Detailed monitoring framework – Borefield operation

Environmental aspect	Purpose	Parameter	Target value	Monitoring approach	Management contingencies
Surface water	***10 (WL) + 10 (WQ) + 4 (discharge) sites***		***3 monthly download***		
Surface water quality (all 10 gauge sites plus Nepean River and Maguires Creek discharge sites)	To assess stream water quality due to the treated groundwater discharge, and natural trends at other sites.	pH Temperature Iron (total) Manganese Salinity Dissolved Oxygen Oxidation potential (Eh)	6.5-8 pH unit 5-25ºC <5.0 mg/L <1.5 mg/L <400 µS/cm 85-110% sat Na	Grab samples from flowing portion of stream. Upstream and downstream of scheme discharge points (two locations and four sample locations).	Improve the treatment and discharge of groundwater prior to discharge.
Stream flow (Nepean River – two sites)	To assess stream flows and levels, and to quantify stream losses/gains due to the groundwater discharge.	Stream flow Water levels	<800% increase in baseflows <300 mm rise in river stage	Stream gauges to confirm that flows are within natural range. Upstream and downstream of proposed discharge points (two locations).	Vary flows to mimic natural range to some extent (although natural runoff is still expected to dominate the surface hydrology). Refine groundwater discharge patterns accordingly.
Stream flow (Little River, Dudewaugh Creek and Doudles Folly Creek)	To assess stream heights.	Water levels	None	Stream monitoring to confirm heights at representative locations.	If levels or stream flow diminishes, confirm cause and take remedial action if borefield related
Stream flow (Upper Nepean Site, Burke River Site)	To assess stream heights and flow at the upper Nepean River location and Burke River.	Water levels	None	Stream monitoring to confirm heights at representative locations.	If levels or stream flow diminishes, confirm cause and take remedial action if borefield related
Tributary flow (three ephemeral creek locations between lower Nepean river gauges)	To confirm water balances and any stream losses.	Stream flow Water levels	None None	Stream gauges to confirm that flows are within natural range.	Data will assist in determining whether there are any significant changes/losses associated with pumping and WTP discharges.

Environmental aspect	Purpose	Parameter	Target value	Monitoring approach	Management contingencies
Groundwater	***~120 + 6 (WQ) sites***		***3 monthly download***		
Groundwater quality within the borefield (key sites – 1 in Area 1, 2 in Area 2, 2 in Area 3, and 1 in Area 4)	To confirm the consistency of quality of extracted groundwater.	pH Temperature Iron (total) Manganese Salinity Dissolved oxygen Oxidation potential (Eh)	4.5-8 pH unit 10-18ºC 40 mg/L <2 mg/L <500 µS/cm 0-110% sat Na	Grab samples at individual key bore locations (to assess variability). Selected production bores and monitoring bores to be determined in the Operational Environmental Monitoring Plan.	If unforeseen changes are occurring within the aquifer, undertake repeat and additional sampling in the first instance. If real changes, track raw water quality at the WTPs and expand sampling in local area
Groundwater quality at the points of discharge to the Nepean River and Maguires Creek	To confirm the consistency of quality of discharged groundwater.	pH Temperature Iron (total) Manganese Salinity Dissolved oxygen Oxidation potential (Eh)	6-8 pH unit Within 2ºC of river WQ <5 mg/L <1.5 mg/L <500 µS/cm 85-110%sat Na	Grab samples or in line sampling at the discharge locations from each of the WTPs.	Improve the treatment and discharge of groundwater so that the discharged groundwater is compatible with receiving surface water environment (focus on iron levels, oxygen and temperature).
Groundwater levels within the whole borefield area (key observation bore/well sites) Type 3 Perched water Type 2 Shallow sandstone Type 1 Whole sandstone	To determine the extent of drawdown during active phases of extraction, the influence of recharge events and rate of recovery during recovery/recharge phases.	Water level (m) and height (m AHD)	(1) Perched water zone – water levels rise and recede at same rate as 2006-2009. (2) Sandstone Aquifer – within 20% of modelled predictions.	Dataloggers and gauging events. Monitoring locations as shown in Figure 4.5 (existing installations), plus others to be determined in the Operational Environmental Monitoring Plan.	Trends at observation bores will be the most meaningful for assessing any ecosystem impacts – if borefield impact on ecosystem is proven reduce yields, or switch off closest production bores so as to manage water level recovery.
Groundwater levels within the whole borefield area (production bore sites)	Data will be used to inform the operation of the borefield, specifically the	Water level (m) and height (m AHD)	Water level to be kept at or above the	Dataloggers in all production bores.	If water levels are falling quicker than expected at production sites – (i) reduce bore yield and if this cannot be

Environmental aspect	Purpose	Parameter	Target value	Monitoring approach	Management contingencies
	rate of pumping at individual bore sites, and acceptable duration of pumping phases and overall project operation and recovery phases.		recommended pump intake setting		maintained (ii) shut off pump for minimum 30 day period.
Groundwater levels on private properties	To monitor water level responses on private property as a result of the borefield operations and to early warning of effects on: (1) basalt springs (2) sandstone aquifers.	(1) Basalt Aquifer flows from springs and water levels where possible (2) Sandstone Aquifer water levels	(1) Basalt Aquifer – within 20% of flows assessed under the February 2007 groundwater surveys. (2) Sandstone Aquifer – within 20% of modelled predictions.	Dataloggers. Selected springs and bores on private properties, and dedicated monitoring bores on private property (several types).	Increase monitoring and investigate causes Will need to look at a range of compensatory measures provided the decline in level and supply is borefield related.
Ecosystems	***~40 sites***		***Autumn and Spring during whole period***		
Swamp vegetation	To assess if there are any unexpected or unusual trends in ecosystem health due to changes in the perched water profile.	Indicator species	Consistent with control area results.	Quadrat sampling. 18 swamps in the vicinity of the borefield including Butlers and Stockyard Swamps and remote control swamp.	Reassess relationship between groundwater and swamp ecology if borefield related.
Terrestrial vegetation	To determine any change in terrestrial vegetation biodiversity, condition and health. Long-term assessment and possible indicator of groundwater dependency.	Indicator species (to be determined)	Consistent with control area results.	Typical woodland and riparian communities – locations to be determined in the Operational Environmental Monitoring Plan. Only triggered if Type 2 or Type 3 monitoring bores suggest unacceptable water level declines.	Any noticeable change of terrestrial vegetation will be evaluated. Importantly, monitoring will be long-term in nature and any change in terrestrial vegetation will be evaluated in the context of other possible causes, including climatic change.
Aquatic biota	Evaluation of impact of discharges of groundwater on aquatic plants and animals. Sensitivity to changes in flow rate and	Indicator species (to be determined)	Consistent with upgradient sampling location.	Upstream and downstream of the discharge locations. To be determined in Operational Environmental Monitoring Plan. Only triggered if low baseflows	Any noticeable change in aquatic plants and animals upstream and downstream of discharge points will be used to determine acceptability of new flow rates and groundwater

Environmental aspect	Purpose	Parameter	Target value	Monitoring approach	Management contingencies
	water chemistry.			decrease by more than 50% and/or water quality is not compatible with receiving water.	discharge. Importantly, monitoring will be long-term in nature and any change in aquatic plants and animals will be evaluated in the context of other possible causes, including climatic change.
Aquifer ecosystem	To assess if there are any unexpected or unusual trends in ecosystem diversity due to lowering regional water table	Indicator species (to be determined)	None	Bailer and net sampling at key shallow monitoring bore/well sites within the borefield area. Annual program only	Monitoring will be long-term in nature and any change in aquifer biodiversity will be evaluated in the context of other possible causes, including climatic change.

4.5.1 Specific monitoring plans

Detailed monitoring plans will be developed in consultation with the Department of Planning (DoP), the Department of Water and Energy (DWE) regarding groundwater resource monitoring, and the Department of Environment and Climate Change (DECC) regarding receiving water discharges.

These plans will be referenced within any licences that SCA holds for borefield activities. They will also be the basis of compliance reporting requirements.

4.5.2 Site management plans

There will be at least one construction environmental management plan (CEMP) for the construction activities and an operational environmental management plan (OEMP) for the operational tasks. Within each of the plans there will be a specific monitoring and management plan that describes the network locations, and main physical attributes of the groundwater resource (water levels and water quality), surface water (water levels and flow), and ecosystems (monitoring transects).

The CEMPs will be prepared by site contractors for site works during the periods of further investigations, and during construction and commissioning. They will be submitted to the Department of Planning or other agency (as appropriate) for approval prior to the commencement of works. These plans will include important sub-plans such as soil and water management plans and traffic management plans.

The OEMP will include the specific monitoring plans approved under licence.

5. Supplementary technical studies

Numerous technical reports have been completed since the environmental assessment (EA) was lodged in March 2008 and since the public exhibition of the EA in April-May 2008. These studies mostly relate to the final pumping trial results, additional ecosystem studies, numerical modelling and the latest engineering revisions. Important recent studies include:

- *Stygofauna Baseline Assessment for Kangaloon Borefield Investigations – Southern Highlands NSW,* October 2008
- *Transient Groundwater Modelling Study Upper Nepean (Kangaloon) Borefield,* November 2008
- *Upper Nepean (Kangaloon) Borefield – Supplementary Environmental Impact Assessment*, September 2008
- *Upper Nepean (Kangaloon) Borefield Water Treatment Processes – Bores, Pipelines, and Water Treatment Plants Preferred Design Report*, September 2008
- *Resistivity Imaging and Sounding Survey for Kangaloon Borefield Investigations.* November 2008
- *Water Quality Monitoring during Pumping Trial – Upper Nepean Trial Borefield – Final Report*, February 2008
- *Stockyard Swamp Pumping Trial – Water Quality Monitoring Report*, August 2008
- *Additional Tritium Results for Stockyard Swamp Pumping Trial*, Letter dated 8 September 2008
- *Latest Results – Upper Nepean Research Project at Doudles Folly Creek*, Letter dated 9 October 2008
- *Baseline Groundwater Dependent Ecosystem Evaluation Study – Upper Nepean Groundwater Pilot Studies: Spring 2007 Baseline Ecosystem,* March 2008
- *Groundwater Discharge Zones, Upper Nepean River September 2008.* Science Section. SCA Science Report September 2008
- *Stockyard Swamp Borefield Trial – End of Trial Water Level and Drawdown Assessment*, March 2008
- *Upper Nepean (Kangaloon) Borefield - Area 3 Investigations - Drilling and Testing of Production and Monitoring Bores. Completion Report,* February 2008
- *Stockyard Swamp Borefield – Three Month Pumping Trial Recovery Report*, June 2008
- *Upper Nepean Groundwater Studies – Groundwater Level Monitoring Program - July 2008 Annual Report.* August 2008
- *Peer Review of Technical Reports: Stockyard Swamp Borefield Trial. End of Trial Water Level and Drawdown Assessment.* April 2008

All the work has been peer reviewed and all reports add to the conclusion that the borefield development is viable, drought extractions are sustainable and environmental impacts are limited and can be managed and mitigated.

Summaries of the conclusions of the four most important studies that support the sustainability of the borefield development are below:

Numerical transient modelling report (Coffey, 2008)

A new transient model has been built and is calibrated against the latest available water level, stream flow and hydrogeological data. It is a useful tool to assess borefield performance under drought conditions. The objectives of this transient modelling study were to:

- improve the predictive capacity of the existing groundwater model by upgrading the model aquifer structure, and aquifer parameter distribution, and undertake transient calibration using the data collected in the borefield area since the Stage 1 studies (Coffey, 2006)
- conduct new predictive simulations using the recalibrated model to more reliably assess borefield performance. Borefield capacities of 10,000 to 15,000 million litres per year (ML/yr) (from a network of 75 production bores) for periods of several years were assessed.

Two borefield capacities were modelled against two low rainfall scenarios – the recent drought period (a severe drought) and back-to-back severe droughts never experienced before in the historical record (an extreme drought). The simulated groundwater pumping from the 75 production bores across the borefield is also the maximum stress ever likely to be continuously applied.

Modelling indicates that around 80 percent or more of groundwater is sourced from aquifer storage during a single pumping event, and around 70 percent if there were back-to-back pumping events during an extreme drought. Based on this result, the borefield provides a useful contribution to water supply in times of severe drought. When the borefield ceases pumping, the river baseflow losses continue for about eight years with the loss partially replenishing aquifer storage. Baseflow losses are small in comparison to actual river and creek flows, and during operation, the treated groundwater discharges from the water treatment plants to the Nepean River more than make up for the minor baseflow losses along the Nepean River.

The modelling confirms that the borefield provides groundwater which, although it is ultimately supplied by rainfall and streamflow, is water that can be made available during a critical time. It is not otherwise available to the supply system. Following the critical drought periods, the expected wetter periods (when excess water supply is likely to be available) will allow the depleted aquifer storage to replenish.

Borefield capacities in excess of 35 to 40 million litres per day (ML/d) can be sustained for the first 12 months of borefield operation, however rates decline as the more dense extraction areas dewater. The total borefield pumping rate in Year 3 of an extended pumping event is predicted to be around 20 to 25ML/d (based on no bores restarting after local depletion and recovery of levels).

Water level drawdowns are similar to those predicted in the earlier steady state modelling with the 10 metre drawdown contour extending to a maximum of around two kilometres from the centres of pumping at the end of a severe drought (a single pumping event) and

to a maximum of 2.5 kilometres at the end of an extreme drought event (back to back pumping events). No drawdowns are propagated into other catchments.

If production bores were strategically placed on high permeability features and recovery of water levels in dewatered areas allowed the recommencement of pumping, the attainable borefield pumping rate could be up to 35ML/d (around 13,000 ML/yr) at the end of an extended pumping event.

A summarised version of the Executive Summary from the modelling report is provided in Appendix E.

Upper Nepean surface water – groundwater interaction research project at Doudles Folly Creek (PB, 2008d)

The objective of this research study was to identify and quantify the nature of surface water - groundwater interaction in the fractured Hawkesbury Sandstone under both natural and pumping conditions. The initial results from the study have confirmed that the induced recharge component of baseflow depletion is low.

The sandstone aquifer in the vicinity of Doudles Folly Creek consists of three distinct flow systems (shallow, intermediate and deep). The separation of the fractured aquifer into these three zones is based upon the following results of the long pumping and tracer tests:

- variation in water levels between shallow, deep and composite bores indicate some hydraulic separation
- packer tests show relative chemical and isotopic differences between zones
- geophysical surveys and down-hole cameras identify a distinct fracture zone – referred to as the intermediate zone
- tracer test and packer test results showed a quicker breakthrough and higher concentration in the intermediate zone, slower/lower breakthrough in the shallow zone, and negligible breakthrough in the deep zone
- recovery period chemical and isotopic concentrations returned to baseline conditions – indicating each zone is not recharging the other and thus changing mixing ratios.

The distinction between shallow and deep portions of the Hawkesbury Sandstone aquifer is likely to be applicable on a regional basis. The presence of an intermediate zone(s) is more likely to be localised.

Extensive chemical, isotope and hydraulic testing in 2007 improved the understanding and conceptualisation of the surface water – groundwater interaction under pumping condition. Conclusions to date are:

- pumping will reduce groundwater gradients to the creek and reversal of hydraulic gradients can occur
- under pumping, the stream becomes disconnected, but there is an ongoing streamflow contribution to the regional sandstone aquifer and any production bores. What actually happens is by drawing water levels below the base of the creek a vertical hydraulic gradient of one is created – both maximising connection but at the same time limiting any further seepage from the creek. Because the

primary pathway for flow is through fractures in connection with the creek and these are not dewatered as a result of pumping, this connection is still maintained despite a measured head differential which would indicate a disconnection in the classical sense

- given the above conceptualisation, the measured five to seven percent streamflow contribution to the pumped groundwater is the maximum contribution expected from this reach of creek even under longer term and more intensive pumping operations because:
    - further drawdown cannot induce a greater hydraulic gradient
    - further drawdown could create dewatering of important fractures and thus reduce connection
    - the pumping trial occurred during periods of significant rain and water transfers – therefore greater access to surface flow is not likely, especially considering borefield use is designed for extended drought periods.

To put the five to seven percent of surface flow reporting to the production bore into perspective, this is less than 150,000 litres per day from a creek that is flowing between 3 million litres per day (lowest baseflows) to in excess of 400 million litres per day (under transfers). As a percentage of the actual creek flow, this is less than 0.05 percent to a maximum of 5 percent.

Water Quality Monitoring during Pumping Trial – Upper Nepean Trial Borefield – Final Report (PB, 2008a)

Parsons Brinckerhoff was commissioned to undertake monthly groundwater and surface water quality and environmental isotope sampling to characterise potential changes in water quality or groundwater age with time during a long term pumping test at the Upper Nepean Trial Borefield at the Tourist Road site, and to identify potential impacts on surface water systems due to the discharge of groundwater from the pumping bores. A sampling event was also undertaken during the groundwater recovery period after pumping to assess any water quality changes following pumping.

Trend analysis of data collected during the four month pumping test showed no significant change in salinity (electrical conductivity), pH, dissolved oxygen, and major ion chemistry of groundwater and surface water during pumping. Temperature decreased in both groundwater and surface water during the pumping trial as a result of a decrease in the ambient air temperatures from Autumn to Winter.

A minor increase in dissolved iron and manganese concentration was noted in one production bore.

Stable isotope (oxygen-18 and deuterium) data indicates that both groundwater and surface water originates from rainfall.

Uncorrected radiocarbon ages for groundwater samples taken during pumping ranged from modern (<50 years old) to 7,431 years old. The maximum corrected groundwater age was ~5,100 years old. These results are consistent with previous investigations.

Groundwater chemistry during the recovery period was generally comparable to groundwater chemistry during the pumping test; however, there were slight differences in

groundwater age, with recovery groundwater ages being marginally older for Bore 2C than at the start of pumping, and younger in Bores 2G and 2E. The radiocarbon and tritium data indicates that the contribution of “new” recharge water to water level recovery was minor, and that the recovery of water level was primarily due to the inflow of water from the aquifer unaffected by pumping into those zones depleted due to pumping.

The results of additional chemical and isotopic sampling from perched monitoring wells in the colluvial deposits of Butlers Swamp support the findings of hydrogeological studies, which indicate that perched groundwater in Butlers Swamp is recent rainfall and is independent of the Hawkesbury Sandstone aquifer.

The chemical and isotopic study undertaken during the pumping trial confirms that the borefield (once operational) will most likely source most groundwater from aquifer storage.

Stockyard Swamp Pumping Trial – Water Quality Monitoring Report (PB, 2008b)

Parsons Brinckerhoff (PB) was commissioned to undertake baseline water quality and isotope sampling from perched wells in Stockyard Swamp (prior to pumping trial) and monthly groundwater and surface water sampling from selected sites for chemical and isotopic analysis during a three month pumping trial of deep sandstone aquifers at Stockyard Swamp.

The objective of the pumping trial and the chemical and isotope sampling program was to establish if there is any relationship between the shallow perched water bearing zone at Stockyard Swamp with the deeper regional aquifer system in the Hawkesbury Sandstone aquifers.

Groundwater conditions in the Hawkesbury Sandstone during the pumping trial were characterised by low salinity, slightly acidic to neutral pH conditions, oxidising redox conditions and low dissolved oxygen concentrations. There were small variations in field parameters during the 90-day pumping trial but no significant trends or changes were noted.

Concentrations of total iron, dissolved iron and manganese were elevated in groundwater from the Hawkesbury Sandstone during the pumping trial and remained relatively stable.

Stable isotope (oxygen-18 and deuterium) values did not change significantly during pumping and indicate that the regional groundwater originates from rainfall.

The uncorrected radiocarbon ages of groundwater during pumping ranged from 5,142 to 7,252 years old and the maximum corrected ‘model’ age was ~ 4,850 years old. During the pumping trial, there was no significant change in groundwater age at Bore 3H, however, there was an increase in groundwater age at Bore 9B. These results indicate that at Bore 9B, older water is being drawn in from fractures and/or the sandstone matrix or the ratio of modern to older waters decreases as pumping progresses. The results are consistent with the upper fracture zones being dewatered at this site.

Uncorrected and corrected radiocarbon ages for groundwater sampled from production bores during the recovery period were marginally younger than at the end of the pumping trial but were comparable to those measured at the start of the pumping trial. The radiocarbon data indicates that the contribution of “new” recharge water to water level

recovery was minor, and that the recovery of groundwater level at the production bore sites was primarily due to the inflow of deep groundwater. Rainfall recharge is evident during the recovery period however changes in chemistry appear to be masked by the contribution from the deeper aquifer zones.

The results of additional chemical and isotopic sampling from perched wells in colluvial deposits of Stockyard Swamp support the findings of the hydrogeological studies, which indicate that perched groundwater in Stockyard Swamp is rainfall-dependent and is independent of the Hawkesbury Sandstone aquifer.

6. Matters of national environmental significance

The purpose of this chapter is to provide supplementary information (that has arisen in recent months as a result of the public submissions or technical studies completed by SCA) on the impacts of the project on matters of National Environmental Significance (NES), as defined under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The primary objective of the Australian Government's EPBC Act is to 'provide for the protection of the environment, especially those aspects of the environment that are matters of NES'. The EPBC Act identifies seven matters of NES, two of which are applicable to the project area (threatened species and ecological communities, and migratory species). These matters are discussed in detail in Chapter 10 of the environmental assessment (EA).

There were no new issues or studies presented in any of the submissions received in relation to threatened species and ecological communities. There was however substantial comment on the perceived risk of the borefield development to these ecosystems, all of which was based on there being a strong connection between surficial ecosystems and the regional sandstone aquifer.

The Department of Environment and Climate Change (DECC) also recommended that a new targeted and seasonally relevant survey for threatened species be completed prior to finalising the configuration of the borefield, the location of individual bores and the route of associated pipelines. This requirement has been included in the proposed Statement of Commitments.

It is anticipated that there will be limited construction impact and no operational impact on the threatened species and ecological communities in the project area. There is additional information from the recently completed studies to support this conclusion.

Pumping trial water quality reports

The following Parsons Brinckerhoff (PB) studies provided conclusions about age and residence time of water in the perched and sandstone aquifers, and provide an insight into recharge processes after substantial rainfall events:

- *Water Quality Monitoring during Pumping Trial – Upper Nepean Trial Borefield – Final Report*, February 2008
- *Stockyard Swamp Pumping Trial – Water Quality Monitoring Report*, August 2008
- *Additional Tritium Results for Stockyard Swamp Pumping Trial*, Letter dated 8 September 2008

The Tourist Road pumping trial water quality report concluded that

> "*Isotopic and chemical data confirms that perched groundwater in Butlers Swamp and the adjacent area is rainfall-dependent and is independent of the Hawkesbury*

Sandstone aquifer system" and that "*the chemical and isotopic study undertaken during the pumping trial confirms that the borefield (once operational) will most likely source most groundwater from aquifer storage*".

The Stockyard Swamp pumping trial water quality reports concluded that

"*Isotopic and chemical data confirms that perched groundwater in Stockyard Swamp and the adjacent area is rainfall-dependent and is independent of the Hawkesbury Sandstone aquifer system; therefore borefield development is not expected to impact the perched water bearing zones associated with the Stockyard Swamp.*"

Stockyard Swamp pumping trial reports

Two reports were written at the conclusion of the second pumping trial (at Stockyard Swamp). The first report is the URS assessment report and the second is the Woolley peer review report:

- *Stockyard Swamp Borefield Trial – End of Trial Water Level and Drawdown Assessment*, March 2008
- *Peer Review of Technical Reports: Stockyard Swamp Borefield Trial. End of Trial Water Level and Drawdown Assessment.* April 2008

The URS report concluded that

- *groundwater in the surficial (colluvial) deposits within Stockyard Swamp is wholly dependent upon rainfall, and rainfall intensity and pattern*
- *groundwater in the surficial (colluvial) deposits within Stockyard Swamp is perched by between 1 and 8 eight metres above the potentiometric surface in the regional Hawkesbury Sandstone aquifer and, therefore, is separated from it by a substantial unsaturated zone, rendering the two systems independent from each other*
- *pumping of the regional sandstone aquifers is not impacting upon the shallow hydrology of Stockyard Swamp*
- *there is no apparent connection between Dudewaugh Creek and the sandstone aquifer during the pumping trial at the outlet of Stockyard Swamp and at the pond located approximately 100m downstream along the same creek line*

The Woolley peer review concluded "*I concur with the first four conclusions in Section 4 of the URS report. These relate to the connectivity between the deep sandstone aquifers being pumped and the perched water in Stockyard Swamp, which was the prime objective of the study*".

Ecosystem monitoring report

This following report is the Spring 2007 survey of important ecosystems within the borefield area:

- *Baseline Groundwater Dependent Ecosystem Evaluation Study – Upper Nepean Groundwater Pilot Studies: Spring 2007 Baseline Ecosystem,* March 2008.

The SMEC report concluded that:

> "*The upland swamps of the study area are considered to be facultatively dependent on perched groundwater that occurs in the colluvial sediments within the study area, when it is available. Recent studies have shown that it is unlikely that there is any connection between the regional sandstone aquifer and these perched systems. It is also considered more likely that changes to aquatic ecosystems are more likely to result from changes in river flow as a result of groundwater discharge than any potential groundwater-surface water interactions. In addition, the regional aquifer often occurs at depth beneath the woodland and forest ecosystems within the study area. Thus it is considered unlikely that terrestrial vegetation would be utilising this water source in these areas. However, extended long term groundwater pumping over the permanent borefield area has not been undertaken and thus any changes to the aquatic and terrestrial ecosystems present as a result of long term pumping have not been identified. The current study provides the baseline ecological conditions of these ecosystems to allow for future monitoring comparisons if the permanent borefield is constructed and utilised*".

There is no new information regarding migratory species for the project area and no impact is anticipated.

The minor engineering design changes outlined in Chapter 4 do not impact on threatened species and ecological communities, or migratory species.

Conclusion

Several new reports have been finalised that confirm the disconnection between the surficial ecosystems and the regional aquifer in the Hawkesbury Sandstone. The project has also been developed to minimise impacts to threatened biodiversity. An additional threatened species survey will be conducted in advance of finalising the production bore locations and the buried pipeline route. Locations will be advised to contractors as part of the tender and construction environmental management plan (CEMP) requirements.

The borefield layout will be optimised to maximise yields and to minimise ecological impacts. Pumping trial data from both Butlers Swamp and Stockyard Swamp indicates that the perched water systems are disconnected from the regional sandstone aquifers. Production bores (when operational) would cause water level declines in the regional aquifer in the near vicinity of these swamps, but will not impact the ecology of these swamps. If monitoring indicates that there is a connection at these or other swamps that is not recognised at the present time, then mitigation measures will include a lesser rate of pumping (for selected bores), changed periods of operation and possible closure of some production bores.

Ongoing monitoring of groundwater levels will provide an even greater certainty of the relationship between deep groundwater and perched water within upland swamps, and occasional ecosystem monitoring will monitor the seasonal variability.

Special access and management approaches (under the CEMPs) will be adopted during the construction program to minimise impacts to the fringes of upland swamps where pipeline crossings are required. Adaptive management will be implemented during operational periods if any impacts are detected to the swamp or vegetation communities.

7. Statement of Commitments

7.1 The preferred project

The Sydney Catchment Authority (SCA) is seeking project approval for the construction and operation of all components of the Upper Nepean (Kangaloon) Borefield project.

The project is described in Chapter 7 of the environmental assessment (EA), as amended by the refinements described in Chapter 3, and in Sections 4.1 and 4.2 of Chapter 4 of this preferred project report (PPR). The only project changes are:

- confirmed locations for the two water treatment facilities (modules, tanks and collection ponds) and the two discharge locations on the Nepean River and Maguires Creek
- a preventative maintenance system within the compound for backwashing each production bore
- minor pipeline route changes along Kirkland Road and Tourist Road (eastern area) that will reduce environmental impacts during construction
- minor power line route changes along Kirkland Road and Tourist Road (eastern area) that will reduce environmental impacts
- increased monitoring of ecosystems (including the use of control sites) during construction and operational periods.

In summary, the borefield project comprises the following elements and the overall concept is unchanged:

- 75 production bores (cased and screened, and equipped with submersible pumps) ranging from 90 to 180 metres deep, positioned between 500 and 750 metres apart
- a buried water transfer system, with pipes ranging in diameter from 100 to 300 millimetres enabling the water to be transferred to the Nepean River system. An estimated 50 kilometres of buried piping will connect production bores with water treatment facilities
- two water quality treatment facilities to adjust temperature and oxygen levels, and to reduce iron concentrations
- two river discharge locations – one on the Nepean River and one on Maguires Creek – from where the water will flow to the Nepean Dam
- an 11 kilovolt (kV) power network (combination of overhead and buried power lines) supplying electricity to transformers that will power the submersible pumps and water treatment facilities
- an outdoor switchboard at each bore which will house the power and control switchgear to each bore pump
- fibre optic cabling from each bore to a central location for control and communications
- a preventative maintenance system at each bore location to prevent iron scaling and iron bacteria blooms

- a network of monitoring bores and gauging stations to monitor resource behaviour and manage borefield performance and impact.

Although construction of the borefield will not proceed at this time, an approval to construct and operate the borefield is important because it adds to the diversified mix of water sources available for the greater Sydney area. This level of readiness will enable the borefield to be built without delay in the event of a future drought emergency. The Government's decision is consistent with the 2006 MWP strategy to build the borefield if the dam storage levels drop below the 40 percent trigger level in the future.

An approval period of 15 years is requested given the substantial commitment to investigations, property acquisitions, engineering designs and on-ground monitoring systems. An approval period of this length is sought on the basis of:

- detailed environmental understanding of the development and confidence in the predictions
- a requirement to rapidly commence construction (if severe drought returns)
- environmental conditions in the area are unlikely to significantly change over this period
- social impacts are local and minor
- the period is consistent with expected timeframes to initiate the project.

7.2 Overview of commitments

The SCA suggests that the following timeframe condition may be appropriate for any borefield development approval: "This project approval shall lapse on (date to be inserted), unless works the subject of this project approval or any other project approval granted with respect to the Upper Nepean (Kangaloon) Borefield concept approval are physically commenced on or before that date. The Director-General may extend this lapse date if the proponent demonstrates to the satisfaction of the Director-General that the borefield technology remains current, appropriate and reflective of best practice at the date the approval would otherwise lapse".

As a result of the submissions received, recent design changes and a commitment to expanded environmental monitoring, the SCA has made some amendments to the draft statement of commitments presented in the EA.

The revised statement of commitments outlines the management measures to avoid or reduce the environmental impacts of the project. The SCA will design, construct and operate the project in accordance with these commitments.

7.3 Revised Statement of Commitments

This section contains the SCA's revised statement of commitments. Any changes since the exhibition of the EA are highlighted in **bold**.

Table 7.1 Final draft Statement of Commitments

	ACTION
	Compliance
1	The Sydney Catchment Authority (SCA) will certify in writing to the Department of Planning (DoP) that it has complied with all relevant conditions of approval before the commencement of construction, the commencement of commissioning, and the commencement of operation. Where the project is commenced in stages, the SCA shall provide such certification for each stage of construction or operation.
2	The groundwater extraction will be in accordance with the sustainable yield of the Nepean Sandstone groundwater source, as set out in the Water Sharing Plan for the Greater Metropolitan Region - Groundwater Sources (*Water Management Act 2000*) and **at the borefield scale, as** defined in the SCA's water management licence as issued by the Department of Water and Energy (DWE).
3	Prior to the commissioning of the project the SCA will liaise with the DWE to effect amendments to SCA's water management licence (WML), to identify this new water source, pumping and discharge infrastructure locations, the allocated volume, pumping triggers and restrictions, and, consistent with this approval, relevant monitoring and reporting conditions.
new	**This borefield will only be used for abstractions during drought periods and a maximum of 15 billion litres will be pumped in any 12 month period.**
	Environmental management
4	Before construction of the project, the SCA will have prepared and will require contractors to implement a Construction environmental management plan (CEMP), which will detail the environmental management practices and procedures to be followed during the construction of the project. The CEMP/s will be prepared in accordance with the *Guideline for the Preparation of Environmental Management Plans* (DIPNR, 2004). The CEMP will be consistent with the statement of commitments and any conditions of approval, and will include the conditions of any licences issued by government authorities. The CEMP will include measures for surface water management, soil and erosion control, flora and fauna protection, noise management, dust control, traffic management, bushfire hazard and complaints handling.
5	Prior to the operation of the project, the SCA will prepare an Operational Environmental Management Plan (OEMP), which will detail the environmental management practices and procedures to be followed during the operation of the project. The OEMP will be consistent with the statement of commitments, including conditions of approval, and will include the conditions of any licences issued by government authorities. The OEMP will also include details of the environmental performance monitoring carried out during the operation of the project, and measures to manage impacts on the groundwater resources affected by the project, as well as impacts on swamps and streams.
	Monitoring and reporting
6	The SCA will develop detailed **water level and flow, water quality and ecological monitoring programs** in consultation with DWE **and DECC**, consistent with the monitoring framework set out in Chapter 12 of the environmental assessment (EA) **and Section 4.4 of the PPR**, to monitor the **construction and** operational impacts of the project. The monitoring programs will begin before the **construction and** operation of the project, **and continue for a minimum 12 months after a long operational cycle**. Results of the program will be reported as per WML conditions to the DWE, **PoEO conditions to the DECC** and to the DoP for information and approval.
7	Prior to the commissioning of normal operations of the water treatment facilities, the SCA will undertake testing to ensure that treated water to be discharged to the

	ACTION
	Nepean River is within the water quality range for iron, manganese, pH, dissolved oxygen and temperature specified in Chapter 12 **of the EA**.
new	**During operation of the borefield, treated groundwater will be monitored at each of the water treatment facilities – at a location after treatment and prior to discharge to the Nepean River and Maguires Creek, and at locations immediately upstream and downstream of each discharge location along the Nepean River.**
8	During operation of the borefield, operational procedures will be regularly reviewed and audits will be undertaken as part of the SCA's environmental audit program, to ensure that all mitigation measures and approval conditions are properly implemented. The audits will be documented and incorporated into compliance reports during the active phases of the project.
9	The SCA will prepare and submit an annual performance review report by 1 May each year to the DoP, addressing the project's compliance with the conditions of approval, stakeholder and community consultation about environmental performance and the outcomes of that consultation, and the proposed environmental monitoring and management for the next three years.
10	The SCA will undertake research and monitoring to enhance the predictive modelling of the effects of its groundwater extraction on the groundwater resources of the sandstone aquifer. This will include further clarification of the **geological structure, and the** relationship between groundwater level and rainfall under conditions of changing long-term rainfall, and groundwater level and perched water in swamps and baseflows in streams.
new	**The SCA will maintain and update its numerical groundwater model for the borefield on a minimum five year basis using the relevant groundwater level, streamflow and rainfall data collected in the preceding period.**
	Community information and consultation
11	Subject to confidentiality, the SCA will make all documents required under the approval available for public inspection on request.
12	The SCA will prepare and implement a Community and Stakeholder Engagement Plan (CSEP) before the start of construction. The CSEP will detail how the SCA will liaise with potentially affected residents and authorities, notify the public about the project, and provide opportunities for consultation meetings with community representatives. The SCA will take a number of actions to ensure that the community continues to be informed of the project during both construction and operation (these will be fully documented in the CSEP). During construction of the project, community consultation will include: • a community consultation strategy outlining who will be consulted, when they will be consulted, and tools for consultation • the widespread distribution of SCA **and contractor** contact details • establishing the SCA **communications and consultation** team as a key point of contact for all community concerns • implementing a dedicated 1300 phone line and a dedicated email address as key contact points for the community • publishing and distributing newsletters and advertisements periodically to the communities of Kangaloon, East Kangaloon, Glenquarry, Robertson and the wider areas of Mittagong and Bowral • a project specific **section on the SCA** website, which will be updated regularly

	ACTION
	• a complaints procedure that is consistent with SCA community relations procedures • stakeholder briefings held at key stages of construction During the operational phase of the project, the following will occur: • ongoing communications through newsletter, advertisements and website updates • preparation and distribution of **regular** monitoring reports regarding borefield performance, **environmental conditions** and trends • continuation of the dedicated 1300 phone line and dedicated email address as key contact points for the community.
13	SCA will continue to consult with the Department of Primary Industries (DPI) - Minerals Division, and with coal and petroleum lease holders, about the relationship of the project to mineral and gas resources, and proposed mining operations **that encroach on the borefield area**.
	Groundwater bores and wells
14	Bores and wells will be constructed in accordance with the *Minimum Construction Requirements for Water Bores in Australia*, and tested in accordance with AS2368 – 1990 *Test Pumping of Water Wells.*
new	**All production bores will be cased and cemented at surface to a minimum 10 metre depth to exclude any perched water or water in alluvial sediments from draining to the bore.**
15	Monitoring boreholes will be located to best assess borefield performance and water levels in the perched water bearing zones and sandstone aquifer systems. **Perched water table monitoring will be established at a control swamp location and accessible swamp locations with the borefield, and at terrestrial vegetation locations.** Monitoring boreholes located within swamps will be either hand augured or drilled using portable equipment carried by hand into the swamp.
	Hydrology and water quality
new	**Water quality will be monitored at key sites during the construction period to ensure that there is no sediment or other impact to any stream.**
16	Groundwater will not be discharged for transfer along the Nepean River when the cumulative daily volumes of water exceed the limits set in the SCA's water management licence for transfers from Wingecarribee Reservoir to Lake Nepean.
17	Stream flows and water quality will be monitored **during operational periods** in the Nepean River downstream of the proposed discharge locations, and at other permanent stream locations where there may be an impact on levels and flows.
	Ecology
18	The SCA will ensure that the project avoids direct impact on *Persoonia glaucescens*, hollow habitat trees and endangered ecological communities.
new	**The SCA will undertake a targeted and seasonally relevant survey for threatened species prior to confirmation of the final locations for production bores, pipelines and power lines.**
19	Where the pipeline traverses the edge of endangered ecological communities, the CEMP/s will document detailed measures to minimise impacts. These will include restricting the construction corridor in those locations to 10 metres wide, not trenching beyond the base of the swamps, and finishing trenches to ensure that the overall hydrology of the swamps is not impaired.

	ACTION
20	Temporary construction compounds, temporary stockpiles and storage areas will be located to minimise the clearing of native vegetation.
21	All natural streams (other than ephemeral watercourses and drainage lines) to be crossed by the pipeline, will be traversed by underboring construction or attaching infrastructure to existing crossings such as bridges or causeways. **Riparian zones will be protected and rehabilitated if damaged during construction.**
22	All revegetation works will be undertaken with locally native species and consistent with the principles of ecological restoration.
23	The final location of individual production and monitoring bore sites, the pipeline, the power line and other components of the project infrastructure will be determined in consultation with a qualified ecologist to avoid impacts on threatened species or endangered ecological communities.
24	The mitigation and management measures in Section 9.4.4 of the EA will be adopted in the CEMP/s and followed by contractors during the construction phase.
25	If the hydrogeological and hydrological monitoring program triggers ecological monitoring, the expanded monitoring program to assess impacts on any groundwater dependent ecosystems will be implemented as described in Chapter 12 of the EA **and Section 4.4 of the PPR**.
26	If monitoring indicates that there is a connection that is not recognised at the present time, then management initiatives will include a lesser rate of pumping (of selected bores), changed periods of operation and possible closure of some production bores.
27	Discharge structures will be designed, located, constructed and operated to prevent river bed scouring and bank erosion.
28	The project will avoid direct impact to threatened species and endangered ecological communities.
	Land issues and property
29	The SCA will consult with Wingecarribee Shire Council about the **location,** construction and operation of any bore sites, power lines or pipelines within the road reserve **in the 12 months prior to construction**.
new	**The SCA will consult with landowners affected by easements in the 12 months prior to construction in respect of access, infrastructure locations, valuations and compensation.**
30	Monitoring of water levels in selected existing springs and bores on private properties will be undertaken, in accordance with Chapter 12 of the EA **and Section 4.4 of the PPR**, to assess the extent of water level declines and impacts and the need to change infrastructure or operational strategies.
	Aboriginal heritage
31	The location of individual bores, the pipeline and other components of the project infrastructure will be determined in consultation with the Aboriginal community and a qualified heritage specialist. Locations will be designed to avoid impacts on Aboriginal artefacts or features of importance to the Aboriginal community **(such as scar tress)**, as identified in the work of Biosis (2006) and Navin Officer (2007), which is detailed in Section 4.11.3 of the EA.
32	In accordance with the recommendations in Navin Officer (2007), an archaeological subsurface investigation will be conducted in all areas of high and moderate archaeological sensitivity, including sites that are associated with potential archaeological deposits. **Areas of high archaeological sensitivity will be investigated prior to any construction activities commencing.**

ACTION	
33	Consultation will continue with Aboriginal stakeholder groups about the location of proposed works that will affect identified items of cultural importance and to determine appropriate management options.
Socio-economic	
34	Should private bore users experience a reduction in water supply that is clearly attributable to the operation of the project, modifications will be made to existing bores and/or pumps, or compensatory measures will be offered. Measures may include modification to existing bores (e.g. lowering of pumps or deepening/replacing bores) or the provision of alternative water supplies, not at the landowner's expense.
Traffic and transport	
35	A traffic management plan will be prepared, in consultation with Wingecarribee Shire Council, as part of the CEMP to manage and mitigate traffic impacts during construction.
36	A road, bridge and culvert dilapidation study will be completed before the start of the construction program and again at its completion. Any damage to **public** roads caused by construction will be restored in a timely manner.
37	Any opening of the road pavement of Tourist Road, **Diamond Fields Road, Rowlands Road, Kirkland Road, Moresby Hill Road, and Mt Murray Road** will be avoided or undertaken so that vehicular access is possible during any construction works.
Noise	
38	A noise management plan will be prepared as part of the CEMP/s to manage and mitigate noise impacts during construction. Construction that would generate an audible noise at any residential premises will only occur during the following hours: a) 7.00 am to 7.00 pm from Monday to Friday (daylight hours only) b) 8.00 am to 1.00 pm on Saturday These hours may be varied in certain circumstances, on a case-by-case basis and subject to evidence that the acoustic environment of sensitive receptors would not be disturbed.
39	The **production bores and** water treatment facilities will be designed, operated and maintained so that there is no audible noise at any existing residential premises.
Visual and landscape	
new	**Vegetation screens will be established on lands that SCA has recently purchased along Tourist Road in advance of the borefield construction program.**
40	All construction areas will be progressively rehabilitated.
41	Existing vegetation will be retained where possible and new plantings provided to screen the construction and completed works.
42	Proposed above ground structures will be designed, treated or landscaped to minimise any visual impacts.
43	Power supply infrastructure and pipelines within selected areas of the borefield corridor area along Tourist Road, as described Section 9.10.4 **of the EA and Section 4.1 of the PPR**, will be placed underground to minimise the visual impact of the project.
44	Permanent external lighting will only be provided at the water treatment facilities for

	ACTION
	security purposes. All external lighting will be mounted, screened, directed or operated such that it does not create a nuisance to surrounding land uses.
	Soil and water management
45	Soil and water management controls, as described in Section 9.1.3 of the EA, will be employed to minimise soil erosion and the discharge of sediment and other pollutants to land or water during the construction of the project. These controls will be maintained until all ground disturbed by the works has been stabilised and rehabilitated.
46	All stockpiled materials will be stabilised. Spoil stockpiles will be located away from watercourses.
	Waste management
47	Waste management practices will follow the resource management hierarchy principles embodied in the *Waste Avoidance and Resource Recovery Act 2001*, namely to: • avoid unnecessary resource consumption • recover resources (including reuse, reprocessing, recycling and energy recovery) • dispose to appropriate waste facilities (as a last resort).
48	All non-recyclable waste will be disposed of at an appropriately licensed waste disposal facility.
49	All vegetation cleared during construction will be stockpiled for later replacement on the ground as part of site restoration.
50	All soil/spoil excavated during construction will be either stockpiled for replacement following completion of the works, re-used elsewhere as part of site restoration **or for WTP construction, used for void rehabilitation within the Special Areas**, or removed for disposal to landfill or reuse outside the project area.
51	Any water treatment wastes generated during the operation of the borefield will be collected and transported for reuse or to an approved waste facility.
	European Heritage
52	The sites identified as possessing a high cultural heritage significance at a local level (as defined in Section 4.12 in the EA) will not be disturbed.
	Air Quality
53	During construction, equipment and vehicles will be maintained to meet DECC air quality requirements and will only be operated within the nominated hours.
	Power
54	A communication strategy advising possible temporary power arrangements will be implemented during the upgrade and refurbishment of the existing mains power supply.
	Greenhouse and energy
55	During construction, the use of bio diesel fuel will be used wherever feasible.
56	During operation, the development of permanent mains electricity supplies to the project will be undertaken as soon as is practicably possible. Measures will be taken to ensure that the infrastructure consumes minimal energy in stand-by mode.

8. Conclusion

The Sydney Catchment Authority (SCA) has reviewed all 147 submissions lodged as a result of the public exhibition of the Upper Nepean (Kangaloon) Borefield Project environmental assessment (EA) in April 2008. Up to October 2008 there has also been additional technical work completed on the geological structure; environmental linkages; capacity and sustainability aspects of the borefield; improved borefield designs; and property acquisitions.

The conclusions of these recent studies reinforce the earlier understanding of linkages between surface water, groundwater and natural ecosystems that were presented in the EA and supporting technical studies.

The EA and this preferred project report (PPR) have been prepared in accordance with the provisions of Part 3A of the NSW *Environmental Planning & Assessment Act 1979* (EP&A Act) and the Australian *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The SCA is now seeking approval for the borefield development. An approval period of 15 years is requested given the substantial commitment to investigations, property acquisitions, engineering designs and on-ground monitoring systems. Given the current project deferral and the uncertainty of drought water supply requirements in the medium-long term, this period is also consistent with potential timeframes for initiating the project.

Both the EA and the PPR provide an assessment of the environmental impacts of the project, consider the potential positive and negative impacts, recommend management and mitigation measures to protect the environment, and overall, ensure that the project does not have significant impact on the environment.

The assessment is based on a rigorous and significant body of scientific, technical and cultural investigations that have taken place over more than three years. These investigations have been supported and informed by an ongoing and comprehensive community consultation program.

The borefield project would provide:

- a new water source during severe drought (readiness strategy)
- a new bulk water supply source, with similar capacity to existing storage dams (diversification)
- potential for staged development, depending on demand and hydrogeological factors (flexibility)
- the first stage in the strategic and progressive development of groundwater sources (expansion)
- potential deferral of an increase in capacity of the desalination plant (lower cost option)
- increased supply security for the Illawarra (certainty)
- improved information for catchment and water supply management (surface water/groundwater interaction, research benefits)

- improved monitoring of the natural environment (groundwater, surface water and nearby ecosystems).

The EA identified a number of key community and environmental issues surrounding the project, and there has been substantial comment by all stakeholders on these matters in their submissions.

There are no new issues raised in these submissions but there have been some minor design changes to minimise environmental impacts in sensitive vegetation areas along Tourist Road and Kirkland Road. Monitoring programs have also been expanded to address concerns that the development will severely impact the local environment and deplete water resources.

During construction, these issues would be managed through the careful selection of final bore locations, and pipeline and power routes. Site works will be regulated through the implementation and auditing of sensitive construction and environmental management practices.

During operation, control sites will be established and an adaptive management approach will prevail to detect trends and confirm changes. Ongoing monitoring and periodic modelling updates will continue to inform improvements to the management and operation of the borefield, particularly triggers for borefield operation.

In conclusion, the project is considered viable and is sustainable. Impacts are considered acceptable and the proposed management and mitigation measures comprehensive. It is recommended that, subject to adopting the proposed mitigation and management strategies, and the final draft statement of commitments presented in Section 7.3, the project should be approved.

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