ORANGE CITY COUNCIL

MANAGED AQUIFER RECHARGE FEASIBILITY STUDY

FINAL PROGRESS REPORT

7 JULY 2011

PROJECT DESCRIPTION

Orange City Council has conducted a project to assess the feasibility of harvesting urban stormwater within managed aquifer recharge schemes, funded by the Australian Government through the National Water Commission's Raising National Water Standards Program.

Background into Orange's need / impetus behind the project:

Orange City Council in the Central West of NSW has a population of about 40,000 people and is an important retail, government and service centre for the region. The city is located near the top of a major watershed, away from rivers and landforms suitable for large water storages. As the City grows and climate change impacts accrue, the ability of the city to provide a secure supply of water is limited by available water supply and available water storage.

The existing water storage capacity is about 22,000 megalitres (ML). A small volume of licenced bore water is also available however the potential to increase this volume is limited. Recent severe drought has focused the community's attention on water resources. A stormwater harvesting scheme from urban runoff within the City commenced in 2009 and is continuing to grow, however the capacity of this scheme is limited by storage capacity.

Future water supply options include a pipeline from the Macquarie River in the immediate future and in the mid-term (10-15 years from now) the possibility of a regional water supply scheme based on an enlarged Lake Rowlands, about 45 km south of the City. The eventuality of this scheme is unconfirmed and several issues require detailed investigation including long-term regional demand and inter-valley transfers. Expansion of water storage options is limited. Council is presently investigating improvements to the operation of Suma Park Dam that will potentially increase storage that will in turn increase secure yield.

Orange City Council is aware of the importance of secure water supply for the town and endeavour to maintain plans for water supplies 10 years ahead of present day operations. Orange City Council in conjunction with NSW Public Works and Geolyse, a consultancy, is undertaking a study of the secure yield of water for the City into the future.

This work is ongoing however preliminary data shows that one option to ensure secure water supplies 10-15 years in the future is to increase storage by about 20 gigalitres (GL). The capacity of Managed Aquifer Recharge (MAR) is one potential option to increase water storage capacity for the City.

The sites investigated:

This project proposes the trial of an MAR project in the Orange Local Government Area. The proposed trial will use 7 bore holes, spread across the geological formations in the area. Orange is located near the boundary of two geological formations and this project proposes the establishment of bores close to the City to fully understand the capacity, economics and operational requirements of MAR in different rock types.

Two of the required seven bores exist, (on Council managed land at the Orange Showground and at the Clifton Grove Shearing Shed). Five additional bores will be located close to the southern boundary of the City, on basalt rock. All proposed bore holes are within the Lachlan Fold Belt fractured rock aquifer. The project involves the pumping of treated water from the Suma Park Reservoir to the bore holes and subsequent recovery of this water. The outcome is increased operational knowledge of MAR in the Orange area as effective water storage and to confirm the ability of the aquifer to store and retrieve 20 GL of water.

DIFFICULTIES ENCOUNTERED

There are a number of risks that have been identified with undertaking the trial MAR project. These risks are further detailed in the business case report and mitigation measures are explained. There are three risks assessed as high after the proposed mitigation practice

- Regulatory, a social risk,
- Funding, a commercial risk and
- Pressure, flow rates volumes and levels - Technical Risk

The mitigation factors are assessed as effective however the above risks will be a potential cause of project slippage and cost escalation if not managed effectively from the beginning of the project.

The risk of impacted stakeholders exerting influence on the project is a major risk that can only be managed through an extensive, professional and well planned communication plan, initiated at the very beginning of the project. The success of the project depends on the execution of this communications plan.

Timeframes for the delivery of the project were considered adequate however contractor management is a role of paramount importance. Consultants who have appropriate expertise in this area are limited.

PROMOTIONAL ACTIVITIES & OPPORTUNITIES

No

FINANCIAL STATEMENT

A separate financial acquittal statement is in the process of being prepared and will be submitted in accordance with the Funding Agreement.

OPERATION, MECHANISMS AND PROCESSES TO ACHIEVE OBJECTIVES

A formal process of obtaining quotations as per the NSW Local Government Act was undertaken and a Consultant selected based on pre-determined criteria (price, experience and capability of team) The consultant was managed by Council Staff in order to achieve the required deliverables.

CONDUCT, BENEFITS AND OUTCOMES OF THE PROJECT

The project has been beneficial as MAR has now been identified and considered as a possible option for a Council's long term Water Supply Strategy and therefore included in our Integrated Water Cycle Evaluation Study.

The expected Outcomes of the Project were:

- a business case outlining the feasibility for implementing managed aquifer recharge and recovery schemes within the Orange City Council boundary in New South Wales at up to two sites (to be identified as part of this Project); and
- an increase in national knowledge of the approaches to determine the feasibility of managed aquifer recharge schemes.

Other outcomes achieved as a result of the project include

- Increased operational knowledge of MAR in the Orange area as an effective water storage

  Known ability to store a retrievable volume of 20 GL.

- Increased knowledge of the use of aquifers in Australia for storage and extraction

  Recovery rates (ML out for ML in) for a specific fractured rock aquifer;

  Storage capacity, for a specific fractured rock aquifer,

  The impact MAR on a specific fractured rock aquifer in terms of water quality and aquifer management (water table height, compatibility of water and sustainable extraction rates),

- Increased options to maintain water security for Orange City Council beyond the mid-term (10-15 year) planning horizon.

Council's viewpoint is that these outcomes have all been achieved.

EVALUATION OF THE PROJECT

Objectives of the project included:

a. Identify potential sites for a managed aquifer recharge scheme
b. Undertake up to two feasibility studies to investigate the suitability of managed aquifer recharge schemes at up to two sites including:
   i. Identify issues that may impact on a managed aquifer recharge scheme;
   ii. Conduct a regulatory assessment;
   iii. Undertake a catchment yield assessment;
   iv. Identify source and receiving water quality;
   v. Undertake an environmental water requirement assessment;

vi. Conduct a hydro geological assessment;

vii. Conduct a risk assessment; and

viii. Conduct business case planning including a functional design and estimated costs.

These objectives have all been achieved

Project progression

Council would like to progress implementation of the proposed outputs as identified below. The progression of the trial project will be subject to external funding becoming available to Council.

The proposed outputs from further implementation of the project include:

- Engineering plans to develop five (5) bores within the Orange Basalt area of the Lachlan Fold Belt fractured rock aquifer and within the catchment of the Macquarie River.
- Engineering plans for a pipeline to connect the above five (5) bores and two (2) existing bores (at the Orange showground and the Clifton Grove shearing shed) by pipeline to the Icely Road Treatment Plant and an inflow structure at either the Spring Creek or the Suma Park Reservoir.
- An operating plan to harvest, treat and pump stormwater into seven (7) bores within Orange City Council Local Government Area; five (5) in the Orange tertiary basalt; one (1) in the Ordovician Oakdale formation one (1) in the Silurian Anson formation all within the Lachlan Fold Belt fractured rock aquifer.
- An environmental investigation in compliance with NSW legislation to develop the bores and use them for a continuous trial MAR for at least five (5) years.
- Policy approvals and necessary licence(s) from the relevant NSW government departments to operate the trial MAR and pipeline according to the above plan.
- Construction and installation of lined bore holes, pumps, pipes, access infrastructure, necessary meters and a return flow structure with a capacity to pump up to one (1) ML/day to each bore hole from the Icely Road Treatment Plant and to extract up to one (1) ML/day from each bore hole for discharge to the nominated reservoir.
- An annual report for a minimum of five years following the commencement of MAR operations describing the operation of MAR in the Orange LGA and for each bore, the volume, cost, water quality and aquifer condition. This report will include other data required under operating approvals and licences.

Business Case Managed Aquifer Recharge Orange City Council

Prepared for Orange City Council

15 June 2011

Australian Government
National Water Commission

ORANGE
Australia's Colour City

Acknowledgements
This project was funded by the Australian Government through the National Water Commission‟s Raising National Water Standards Program.

This Business Case was prepared with the grateful assistance of following people. Wayne Beatty and John Boyd from Orange City Council, who provided background and technical information on the City‟s water storages, water use and water delivery system and background information on the proposed pipeline from the Macquarie River . Martin Haege from Geolyse Pty Ltd provided information regarding the annual inflows to the City‟s water supply and further background information regarding the proposed Macquarie River pipeline. Chris Jewell from Chris Jewell and Associates Pty Ltd, who prepared the Stage 1 and Stage 2 feasibility reports into MAR for the Orange area, on which this document draws heavily , as well as detailed scientific input to this document. This Business Case was prepared using the ITO framework for business project management developed by John Smyrk of Sigma Management Science who also provided the base template for this document.

QUALITY STATEMENT

PROJECT MANAGER	PROJECT TECHNICAL LEAD
Tony Martin	

PREPARED BY		
Philip Deamer	………… ……................	…30…/…05…/…2011…
CHECKED BY		
Vaughan Pearce	………………..............	30 /…05…/…2011…
REVIEWED BY		
	……………………………................	……/……/……
APPROVED FOR ISSUE BY		
	…………………………….........	…16…/…06…/…2011…

SYDNEY
Level 2, 39-41 Chandos Street, St Leonards, NSW 2065
PO Box 458, St Leonards, NSW 1590
TEL +61 2 9493 9700, FAX +61 2 9493 9799

REVISION SCHEDULE

Rev No	Date	Description	Signature Required			
			Prepared By	Checked By	Reviewed By	Approved By
1	30/05/11	Issued Draft	PD	VP		TM
2	7/6/11	Revised Draft	PD			

CONTENTS

TABLES

FIGURES

APPENDIX

1 Executive Summary

Orange City Council in the Central West of NSW has a population of about 40,000 people and is an important retail, government and service centre for the region. The city is located near the top of a major watershed, away from rivers and landforms suitable for large water storages. As the City grows and climate change impacts accrue, the ability of the city to provide a secure supply of water is limited by available water supply and available water storage.

The existing water storage capacity is about 22,000 megalitres (ML). A small volume of licenced bore water is also available however the potential to increase this volume is limited. Recent severe drought has focused the community"s attention on water resources. A stormwater harvesting scheme from urban runoff within the City commenced in 2009 and is continuing to grow, however the capacity of this scheme is limited by storage capacity.

Future water supply options include a pipeline from the Macquarie River in the immediate future and in the mid-term (10-15 years from now) the possibility of a regional water supply scheme based on an enlarged Lake Rowlands, about 45 km south of the City. The eventuality of this scheme is unconfirmed and several issues require detailed investigation including long-term regional demand and inter-valley transfers. Expansion of water storage options is limited. Council is presently investigating improvements to the operation of Suma Park Dam that will potentially increase storage that will in turn increase secure yield.

Orange City Council is aware of the importance of secure water supply for the town and endeavour to maintain plans for water supplies 10 years ahead of present day operations. Orange City Council in conjunction with NSW Public Works and Geolyse, a consultancy, is undertaking a study of the secure yield of water for the City into the future.

This work is ongoing however preliminary data shows that one option to ensure secure water supplies 10-15 years in the future is to increase storage by about 20 gigalitres (GL). The capacity of Managed Aquifer Recharge (MAR) is one potential option to increase water storage capacity for the City.

MAR is a relatively new concept in Australia, however it is used extensively overseas. Whilst the knowledge of groundwater management in NSW is good, establishing a large MAR scheme will require the collection of significant operational data. This project proposes the trial of an MAR project in the Orange Local Government Area. The proposed trial will use 7 bore holes, spread across the geological formations in the area. Orange is located near the boundary of two geological formations and this project proposes the establishment of bores close to the City to fully understand the capacity, economics and operational requirements of MAR in different rock types.

Two of the required seven bores exist, (on Council managed land at the Orange Showground and at the Clifton Grove Shearing Shed). Five additional bores will be located close to the southern boundary of the City, on basalt rock. All proposed bore holes are within the Lachlan Fold Belt fractured rock aquifer. The project involves the pumping of treated water from the Suma Park Reservoir to the bore holes and subsequent recovery of this water. The outcome is increased operational knowledge of MAR in the Orange area as effective water storage and to confirm the ability of the aquifer to store and retrieve 20 GL of water.

This Business Case has identified twelve main stakeholders groups including existing groundwater users adjoining landholders and government agencies responsible for the management of groundwater resources. A communication and consultation program with these stakeholders is part of the project. The project will be governed by a steering committee chaired by a senior council manager with project management the responsibility of staff from Orange City Council. The governance structure includes a stakeholder reference group.

A preliminary work plan for the project is presented in this Business Case. The estimated cost of the project is $2.1M for the first year, including $424K for Council staff, the establishment of a full time position for the life of the project and capital works of $1.3M. The ongoing annual cost for management, pumping, water treatment and maintenance is $358K.

A risk assessment for the project identified a total of fifteen risks. The highest risks identified are regulatory requirements to proceed with the project, the availability of funds to undertake the project and technical risk to operate the project as planned. Other important risks include the influence of impacted stakeholders, other unknown outcomes and the potential for contamination of water sources. An effective risk management strategy is proposed for all identified risks. A Quality Management Plan for the project includes a risk and issues register, established and monitored as part of the project governance.

This project to develop a trial MAR operation in Orange City Council is a high-yield, medium cost, medium risk project. A successful project will increase the knowledge of using managed aquifer recharge and recovery schemes within different rock types within a fractured rock aquifer and provide an option to increase the city"s raw water storage capacity.

2 Introduction

2.1 Purpose of Document

The purpose of the document is threefold:

- Develop a trial MAR operation within the Orange City Council Local Government Area to;
  - Increase the knowledge of using managed aquifer recharge and recovery schemes within different rock types within a fractured rock aquifer;
  - Provide an option to increase the city"s raw water storage capacity;
- establish the project"s key parameters
- brief key stakeholders.

2.2 Background

Orange City Council in the Central West NSW has limited water storage capacity. Located on the boundary of the Macquarie and Lachlan River watersheds, the landform and catchment size prevents the collection and storage of sufficient water for the future needs of the city.

In response the city has been a leader in water conservation measures and has reduced demand from 7,100 megalitres (ML) in 2002 to 3,735 ML in 2010, (Orange City Council, 2010) despite an increase in population. In 2007 Orange City Council completed an integrated water cycle management concept study (MWH Australia Pty Ltd, 2007) to assist it plan waster resource management for the city. A secure catchment yield completed in 2010 by NSW Public Works reported the secure yield for the city"s water supply is about 3,000 ML per annum. Under normal use conditions the City"s water use is presently 5,400 ML per annum. Ongoing studies suggest the city will require as much as 6,000 ML per annum in 2025.

Despite a good annual average rainfall of around 900 mm per annum (Australian Bureau of Meteorology, 2011), the city is unable to store sufficient water for its needs. A number of additional supply sources are available to the council including a small volume of bore water, a recently developed stormwater scheme and supply from the Macquarie River. Supply from the stormwater harvesting scheme is constrained by water storage capacity and the City is investigating enhancements to the Suma Park Reservoir to increase this capacity. Planning is currently underway to meet increased demand by a pipeline, connecting the City to the Macquarie River.

Looking further into the future an increase in secure yield is available if a suitable storage of about 20 GL can be located. One potential water storage option is Managed Aquifer Recharge (MAR).

2.3 Overview of the Project

The operation or MAR will be trialed in seven bores in the Orange area. Five bores will be established in fractured rocks of Orange tertiary basalt just south of Orange. Two established bores, one at the Orange City Showground and one at the Clifton Grove shearing shed will be used to show MAR operation in other parent rock types. The operation of this trial over 5 years will provide sufficient knowledge to determine the capabilities, and costs of using MAR in fractured rock aquifers in the Orange area to store and retrieve up to 20 GL of water.

2.4 Project Appraisal

This is a high-yield, medium cost, medium risk project.

3 Business Context

3.1 Background

The City of Orange, located on the Central Tablelands of New South Wales, about 260 km west of Sydney and 270 km north of Canberra has a population of just over 39,000 (Orange City Council, 2011). The City Council area of 290 square kilometers is surrounded by agricultural land. The local government area includes the city of Orange and the villages of Lucknow and Spring Hill. The city is a major commercial and public services centre with an economy based on retail, health care government services and education. Between 2001 and 2011 the city"s population has grown by 6.3%.

Orange is located near the catchment boundary between the Lachlan and Macquarie River systems, within the Murray-Darling Basin. A Map showing topography and catchment boundaries is presented as Appendix A. Mean annual rainfall recorded at Orange Airport, 12 kilometres south east of the city centre is 895.3 mm (Australian Bureau of Meteorology, 2011). Despite this good rainfall, the City"s location at the top of a major watershed means catchments are small and do not produce significant runoff. Also the landform within proximity of the city does not provide for large dam sites.

3.2 Existing Water Storage and Supply

The city relies principally upon surface catchments for its water supply, small creeks flowing to the Macquarie River. A small amount of groundwater is also pumped for municipal supplies, although the Orange Basalt aquifer, part of the Lachlan Fold Belt fractured rock aquifer, which underlies part of the city and the surrounding area, is extensively used by private abstractors for domestic, livestock, irrigation, mining and other purposes.

The City has 4 storage dams, progressively built since 1890 with a combined capacity of 22,895 megalitres (ML) ((Beatty, 2011). This data is summarised in Table 1.1 below.

Table 1 Water Storage Capacity Orange City Council

Reservoir Name	Storage capacity, ML	Year of Completion	Notes
Suma Park Dam	17290	1962	Supplies water to Icely Road treatment plant and receives stormwater harvested from Blackmans Creek.
Spring Creek Dam	4,500	1931	Above the catchment for Suma Park
Gosling Creek Dam	650	1890	Recreational use only
Lake Canobolas	455	1918	Recreational use only. In the Molong Creek Catchment.

In May 2011 all reservoirs are close to full however just over a year ago the water supply situation was dire – in December 2009 total storage was down to 22.9%, or just under 5,000 ML. A map showing the location of these storages is presented in Appendix B.

Water use is the subject of a significant communication effort by council and has resulted in a reduction in daily use per person from 460 litres (L) in 1992 to 235 L in 2010. Currently the city uses about 5,400 ML per annum under normal use conditions. The annual volume of water consumed per annum since 1992, and total population of Orange City Local Government Area, by year is presented in Appendix C.

A recent secure yield analysis undertaken by NSW Public Works in November 2009 indicated the annual secure yield of the Suma Creek catchment (this includes the two operational storages for Orange City Council) is about 3,400 megalitres (ML) per annum (Haege, 2011). Orange City Council has made application to extract bore water from groundwater resources in the area to supplement water supply for Orange. Investigations are currently in progress by Geolyse Pty Ltd, (a consultancy) Orange City Council and NSW Public Works to refine the estimates of secure yield. Preliminary results from this ongoing analysis show the supply of water to Orange City is close to the maximum secure yield and any rainfall deficit will require the City to operate under some level of water restriction.

In response to this situation, Orange City Council has implemented an aggressive program of wastage reduction and demand management and has developed two stormwater harvesting schemes, on Blackmans Swamp Creek and a recently-completed scheme on Ploughmans Creek. The Council is actively exploring a range of options to increase its water supply. These include;

- Investigation for a pipeline from the Macquarie River;
- Participation in a regional investigation to expand the storage of Lake Rowlands, 45 kilometres south of Orange, for regional supply.
- Investigation of local aquifers for water supply and storage of additional harvested stormwater.

The groundwater source of potable water for Orange is the Orange Basalt aquifer. Orange City Council has applied to the NSW Office of Water to extract from various bores in the area (Beatty, 2011). Investigations into the sustainable yield from this aquifer are being finalised for regulation under a water sharing plan. It is understood that existing users will hold all available entitlement under this plan when it is gazetted (C.M. Jewell & Associates Pty Ltd, 2011).

3.3 Water Balance

3.3.1 Demand

Annual demand for potable water supplies to Orange City Council is 5,400 ML per annum. Ongoing studies suggest this demand will increase to about 6,000 ML per annum beyond 2025.

3.3.2 Secure Yield

Current water planning for Orange City Council follows the NSW State Government guidelines known as the '5-10-20 rule':

1. Water Restrictions are not applied more than 5% of the time (Council continues to apply ongoing Water Conservation Measures in a bid to avoid imposing restrictions).
2. Water Restrictions are not imposed more often than once every 10 years on average.
3. Water Restrictions aim for no more than a 20% reduction in water demands.

A refinement of this rule is the „5-10-10 rule", that alters the reduction in point 3) so that water restriction aim for no more than a 10% reduction in water demand.

Preliminary secure yield planning by Orange City Council indicates that the secure yield from surface, ground and stormwater to Orange under the 5/10/10 rule is 5,000 ML per annum. This represents a 400 ML shortfall per annum. With increasing population this deficit between demand and supply will increase.

3.3.3 Climate Change.

The impacts of climate change include a 10 – 20 percent reduction of secure yield and a small increase in demand. Whilst the time frame for climate change impacts is beyond 2025, the impact of climate change will possibly increase the existing deficit between inflows and demand by at least 10 percent within the next 10 years, and potentially a greater amount beyond this.

3.4 Water Availability

Two potential sources of additional water for Orange available in the near term are stormwater harvesting, and water transferred from the Macquarie River downstream of Bathurst.

3.4.1 Stormwater Harvesting

Orange City Council completed the Blackmans Creek Swamp stormwater harvesting project in April 2009. A portion of the high flows are captured from storm events and transferred to a holding dam and settling ponds, referred to as batch ponds, before transfer to Suma Park Dam. The Review of Environmental Effects (REF) for the project set trigger flows, minimum base flows and stakeholder engagement processes (Orange City Council, 2009).

Currently, urban stormwater from Blackmans Swamp Creek is collected and stored in a 230 ML holding dam where it is held prior to transfer to two 17 ML batch ponds, treated with coagulant, then delivered to Suma Park Reservoir for storage and blending with catchment inflows.

The Ploughmans Creek stormwater harvesting scheme will be completed in mid 2011. The scheme will transfer a portion of the storm flows from the Ploughmans Creek catchment into Suma Park Dam. The stormwater will transfer via a series of constructed wetlands and holding ponds to improve water quality.

Figure 1 Stormwater Harvesting Ploughmans Creek

Presently, storm events cannot be harvested when the holding dam and Suma Park Dams are full, limiting the capacity to harvest available water.

Modelling commissioned by Orange City Council of the stormwater harvesting system with the existing constraint of storage indicated that 8.4 megalitres per day (ML/d) of stormwater should be available for harvesting on approximately 40% of days, with smaller quantities available on a further 10% of days. This equates to around 1,300 ML per annum.

Adding additional storage to council‟s existing storage will potentially increase the annual harvest volume to around 1,700 ML/year. There is also the opportunity to implement a further stage on the Blackmans Swamp Creek stormwater catchment and this would increase the potential stormwater harvest to more than 2,000 ML per annum however there are no approvals to support this increase at present.

A temporary licence to operate the harvesting schemes under Section 22a of the NSW Water Management Act (2000) is held by Orange City Council. The licence does not specify a volume and has various conditions relating to monitoring, trigger storage levels and community consultation (Beatty, 2011).

3.4.1 Proposed Macquarie River Pipeline

In 2009, Orange City Council commissioned a feasibility study into the possibility of connecting the city via a pipeline to one of two water sources, Lake Rowlands or the Macquarie River. The feasibility study concluded that the most appropriate solution was to bring water from the Macquarie River. In October 2010, Orange City Council commissioned MWH to undertake a concept investigation study to determine the most suitable route for the pipeline. The concept study highlighted the most appropriate corridor for the pipeline.

Figure 2 Proposed Extraction Point on the Macquarie River

The study concluded that the water supply available from the Macquarie River at points downstream of the confluence with the Turon River (drawing on the sizeable catchment upstream of this point) would meet the expected water needs. A maximum of 1,800 ML per annum was assumed to be drawn from the Macquarie River for raw water supply to the City of Orange, in conjunction with the continued preferential use of the city‟s other water sources. On average this represented approximately 1.3% of the flow in the river below the confluence with the Turon. Subsequent and ongoing analysis linking extraction to river flows suggests the feasible volume available for extraction is less than this volume.

These studies are ongoing and unpublished. Current data suggests that water harvested from stormwater and Macquarie River water will be required to maintain secure yield to Orange City in the next 10 years.

3.4.2 Future Water Supply

In the mid-term planning horizon, 10 – 15 years from now, forecast demand will require additional water supply or additional water storage or both measures. Planning for all the above supply sources and enhancements will increase the security of the City"s water supply up to match its demand of up to 6,000 ML per annum in 2020. Beyond this demand a combination of additional water storage capacity and additional water supplies will be required to meet the City"s water needs.

In 2008 the organisation representing Central NSW Councils, Centroc, commissioned a detailed study of the region"s water supplies. (Centroc, 2011). The subsequent report recommended the augmentation of Lake Rowlands and connection with additional water users in the area including Orange City, (MWH, 2009). Development of this option would underwrite the security of water supply to Orange well beyond 2025. Although this option is the subject of rigorous investigation, further studies have not commenced and funding has not been secured.

There is a probability the annual water needs of Orange will exceed supply before Lake Rowlands is expanded. To accommodate this possibility Orange City Council commissioned a study to refine the projections for secure water yield under various scenarios. Studies for this report are underway and preliminary findings suggest an increase of 20 gigalitres (GL) to Orange City"s water storage capacity together with additional water supplies will increase the secure yield of water from known water resources by about 1,300 ML(Haege, 2011).

As mentioned previously, Orange is located at the top of a watershed and sites for large water storages are not available. One potential option to increase water storage is to intentionally pump water into groundwater storage, and retrieve it later.

3.5 Managed Aquifer Recharge (MAR)

Managed Aquifer Recharge (MAR) is the intentional recharge of water to aquifers to supplement natural recharge processes, in such a way that the water is available for subsequent recovery or environmental benefit.(C.M. Jewell & Associates Pty Ltd, 2011). Management is provided to ensure adequate protection of human health and the environment. It is not a new concept and has been in use, formally and informally, for decades.

A wide range of MAR technologies have been developed. These include:

- single-well systems, where water is injected and recovered from the same borehole;
- multi-well artificial recharge systems, where water is injected and recovered from different boreholes;
- recharge augmentation using dams, contour banks, basins, channels and galleries.

Another approach that has been widely used in Europe is known as bank filtration or induced recharge. Where a river or lake is connected (in hydraulic continuity) with an aquifer, it is possible to induce flow from the surface water body to the aquifer by controlled pumping from the aquifer. This can provide both over-season storage and, by using the natural attenuation capacity of the aquifer, a beneficial influence on water quality. The additional recharge to the aquifer that has occurred due to river leakage as a result of river regulation by, for example, Wyangala Dam and Burrendong Dam, may be regarded as a form of artificial recharge. However, these are inadvertent impacts of river regulation, and their location and magnitude are not controlled or managed in any way (C.M. Jewell & Associates Pty Ltd, 2011).

MAR projects are relatively new on the Australian landscape and their main purpose is Aquifer Storage and Recovery (ASR) (Natural Resource Management Ministerial Council, 2009). The CSIRO has completed some research, mainly in Western Australia and has some exposure to existing projects in South Australia, Queensland, Northern Territory and Victoria (CSIRO, 2010). MAR has also been discussed within the Menindee Lakes Project in NSW (SEWPaC, 2011). In NSW there has also been some investment in groundwater modelling[1] and the NSW Office of Water maintains a small but experienced groundwater modelling team. The Pratt Report (Pratt Water, 2004) identified ASR as a management option in the Murrumbidgee Valley, to among other things reduce the need for erosive high rivers during peak demand.

This project proposes a trial of MAR in the Orange area over a five year period. This will involve the low-pressure injection of treated water from Orange City Council storages into the Lachlan Fold Belt fractured rock aquifers. This is a confined aquifer and a maximal and residual risk assessment completed according to the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Managed Aquifer Recharge (AGMAR) (Natural Resource Management Ministerial Council, 2009) demonstrated acceptable management of all potential issues and hazards.

Many MAR techniques are only applicable in areas where there is an upper, unconfined aquifer to which water can infiltrate from surface watercourses or engineered structures. Where aquifers are confined by low-permeability layers, as is generally the case in the Lachlan Fold Belt aquifers, only well (borehole) recharge methods can be used. Well recharge methods are commonly divided into Aquifer Storage and recovery (ASR) where a single well is used for recharge and recovery, and Aquifer Storage, Transfer and Recovery (ASTR), where separate wells are used for recharge and recovery. In some cases, ASTR can involve the use of complex well-fields. Both systems are potentially viable in Orange (C.M. Jewell & Associates Pty Ltd, 2011).

3.5.1 ASTR

Artificial recharge of groundwater through wells, otherwise known as borehole injection, is not a new concept. Such systems have been in use in the USA (particularly in the Los Angeles basin in California, and in Florida), the Netherlands and Switzerland for many decades. Successful pilot trials were run in the UK in the 1970s, and a number of operational schemes were developed from those trials. There are many other examples, worldwide. Commonly, single-purpose, specially designed boreholes have been used for injection, and conventional drilled wells located at some distance from the injection wells have been used for subsequent extraction. In general, it would be fair to say that these systems have worked well only where:

- sufficient investigation has a good understanding of local hydrogeological conditions;
- the injection systems have been carefully designed to suit the hydrogeological conditions;
- the aquifers have been of relatively high permeability; and
- the injected water has been of very high quality.

The crucial water quality parameter for system operation is turbidity, which must be low. Clearly, if the injected water is to be extracted for potable use, it must also meet chemical and bacteriological drinking water quality standards. Even when good quality water is used, injection wells tend to plug, due to the exfiltration (deposition) of fine particulate matter on borehole walls and in the aquifer immediately surrounding the borehole. When injection rates fall because of plugging, boreholes need to be cleaned or redeveloped. The frequency of redevelopment required is highly dependent upon the quality of the injected water, and has a major impact upon the economics of borehole injection operations. Conversely, transfer through the aquifer, and the relatively long residence times involved in ASTR, can result in substantial improvement in water quality (C.M. Jewell & Associates Pty Ltd, 2011).

[1] For example see the Upper Macquarie Groundwater Model, June 2010 prepared by SKM under a grant from the National Water Commission. available at;
<http://www.water.nsw.gov.au/default.aspx?ArticleID=568&cx=013747903361892052062:ilsox0kpjyq&cof=FORID:10&ie=UTF-8&q=upper%20macquarie%20valley%20groundwater%20model&sa=Search#945>

3.5.2 ASR

ASR is the science and technology of the storage of water in an aquifer during times when water of good quality is available, and the recovery of water from the same borehole during times when it is needed. It is one of a wide range of managed aquifer recharge technologies, which include multi-well artificial recharge systems (where water is injected and recovered from different boreholes), and recharge augmentation using basins, channels and galleries. ASR has evolved rapidly during the past 25 years and is now being applied throughout the world, with some well-documented work in South Australia.(C.M. Jewell & Associates Pty Ltd, 2011).

The crucial distinguishing feature of ASR is that water is injected and recovered *from the same borehole*. As a consequence the borehole becomes, to a large extent, self-cleaning, much reducing the need for redevelopment. A second beneficial consequence is that ASR using potable-quality water can often be carried out in an aquifer where the native groundwater is of poor quality, for example, where salinity is high or the native groundwater has other undesirable chemical characteristics, such as high concentrations of heavy metals or other contaminants. ASR is achievable in such a situation because the injected water forms a „bubble" of high quality water around the well, and it is this water that is then recaptured by pumping. Of course there are constraints – aquifers are not homogeneous; mixing occurs at the margins; and recovery can never be 100% effective – nevertheless the systems have been found to work well in many circumstances, with reasonable recovery ratios. Often recoveries improve over a number of injection/pumping cycles (C.M. Jewell & Associates Pty Ltd, 2011).

However, it is important to recognise a limitation of ASR systems, in that the injected water can move downgradient with natural groundwater flow, and „escape" the capture zone or radius of influence of the pumping borehole, particularly if the storage period is long. Thus aquifer recharge and discharge cycles have to take account of natural flow systems.

In general, the key criteria to be addressed in making an initial assessment of the feasibility of ASR are;

a) Is the formation sufficiently permeable to permit injection and recovery at reasonable (and reasonably economic) rates?
b) Is sufficient storage capacity available?
c) Is the aquifer geometry such as to provide adequate containment, and thus recovery of injected

3.6 Geology and Hydrogeology of the Orange Area

An assessment of the potential for managed aquifer recharge in the Orange area must be based on an understanding of hydrogeology of the principal aquifer systems in the area. In turn this is based on an understanding of the geology of the rocks that host these aquifers.

3.6.1 Geology

The geology of the Orange area is dominated by the tertiary-age volcanic rocks that originated as lava flows of the extinct volcano that is now Mt. Canobolas and the much older Oakdale formation, formed during the Ordovician-Period. A heavily folded formation from the Silurian Period, the Anson formation occurs within the Oakdale formation, north of Orange.

The sub-crop areas of the Orange Basalts (coloured orange,) Oakdale Formation (coloured green), and Anson Formation (coloured mauve), and also the location and orientation of regional faulting and folding, as derived from (Meakin, 1997), are shown in Figure 1.[2]

[2] Further detail on the geology of the area is available in Section 6.1 (page 22) of the Feasibility Study Managed Aquifer Recharge, Orange, February 2011. C.M.Jewell&Associates Pty Ltd.

The tertiary-age flood basalts appear in a broad are on the southern edge of Orange and extend well south of the Mount Canobolas area. The fractured rock aquifer within this rock type is well suited for water storage. (Jewell, 2011).

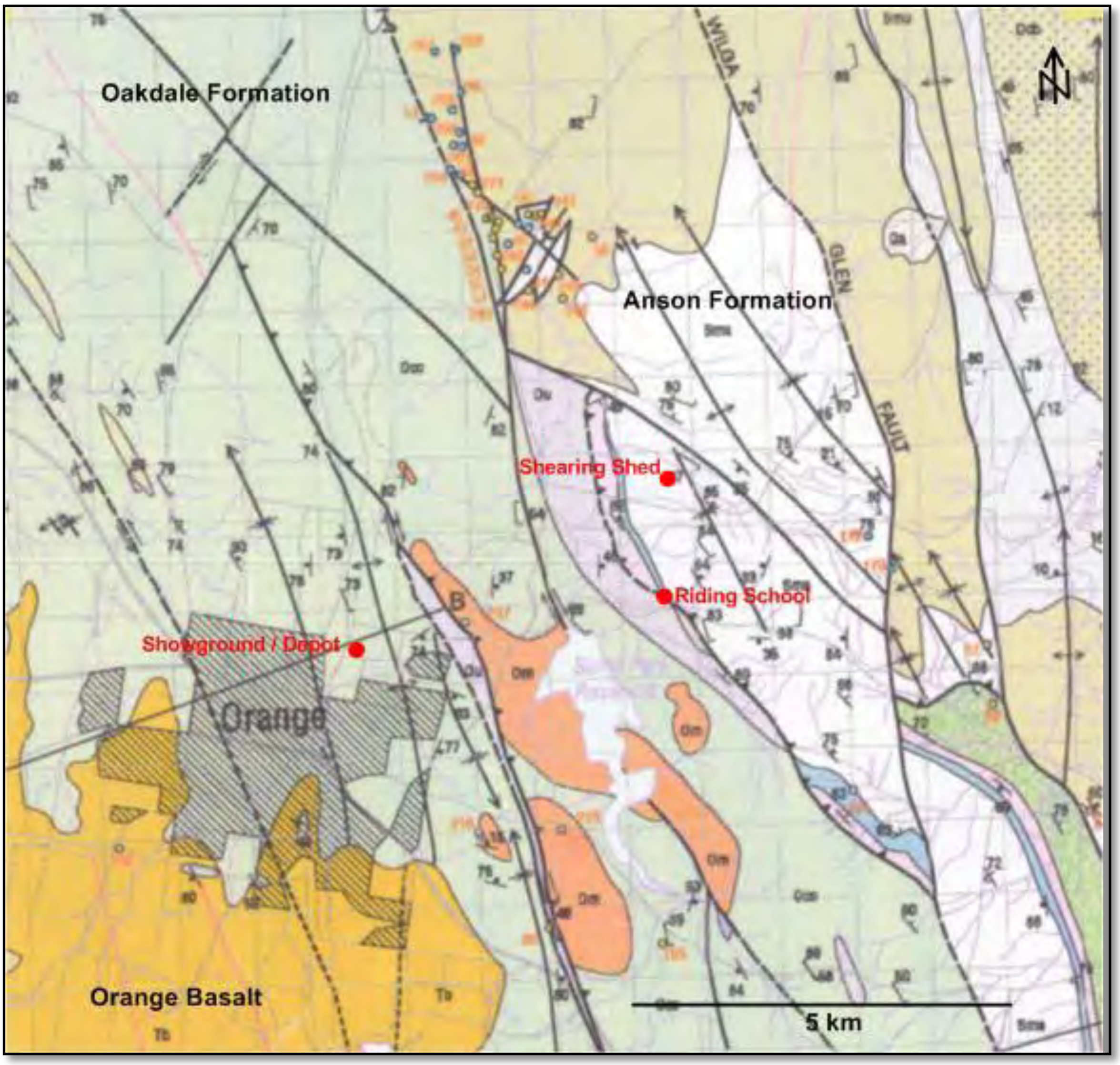


Figure 3 Geology of the Orange Area and Existing Bores.

Beneath the Tertiary-age flood basalts to the south and west of Orange are Ordovician units, including the Oakdale Formation, which in turn is a member of the Cabonne Group. The Oakdale Formation outcrops in a broad north-west–south-east trending band beneath the northern parts of Orange, Suma Park Reservoir and the western part of the Summer Hill Creek catchment below the Suma Park Dam. The rocks of the Oakdale Formation include mafic volcanic sandstone, basalt, siltstone, black shale, chert, breccia and conglomerate.(C.M. Jewell & Associates Pty Ltd, 2011)

East of the Suma Park fault, Silurian-age rocks of the Anson Formation are thrust on top of the Ordovician rocks. The Anson Formation includes carbonaceous pyritic siltstone, felsic volcanic rocks, volcanic sandstone and limestone. A steeply-dipping limestone band traverses the suburb of Clifton Grove. (C.M. Jewell & Associates Pty Ltd, 2011)

The Ordovician and Silurian rocks have undergone multiple deformation events including tight folding, faulting and thrusting. Around Orange, the regional folding has a predominant north-east to north-north-east trend; numerous faults and fold axes with these orientations traverse the North Orange, Suma Park and Clifton Grove areas. (C.M. Jewell & Associates Pty Ltd, 2011)

3.6.2 Hydrogeology

The Oakdale Formation has an outcrop area of about 450 km^2 north and east of Orange. The Anson Formation around Clifton Grove has an outcrop area of 30 km^2. Within these fractured rock aquifers, the water table is not as precisely defined as for granular aquifer materials, and is generally defined as the depth to which interconnecting joints, voids and fractures are water-filled; hence features such as the connectivity of a series of fractures both within and between rock units affect groundwater flow. The primary source of groundwater recharge in the area is the infiltration of soil-water

3.7 Trial MAR

The operational use of MAR to store up to 20 GL of water in aquifers near Orange will require the collection of additional information. Information required includes;

- The volumetric capacity of aquifers in the area to accept and hold water
- The impact of MAR on existing users
- Potential changes to water quality brought by MAR
- The economics of MAR
- What data should be collected to adequately monitor identified impacts.
- The community acceptance and expectations of MAR
- Environmental and ecological impacts of MAR in the specific area.

An operational trial of MAR in the Orange area, to include the main geological formations in the area will provide the necessary data required to guide government and council staff as well as the community in general to fully understand all the known and potential impacts of MAR.

3.8 Source and Receiving Water Quality

3.8.1 Source water

Sources of water for a trial MAR project include stormwater, harvested form Blackmans Swamp Creek and Ploughmans Creek and river water pumped from the Macquarie River. An intensive and ongoing program of water quality monitoring is in place for the Blackmans Swamp Creek stormwater scheme. This data is presented in both the Stage 1 and Stage 2 feasibility reports (C.M. Jewell & Associates Pty Ltd, 2011). In summary, the raw stormwater is not suitable for MAR without treatment, due to high turbidity, bacteria counts and heavy metal concentrations and contaminations by organic compounds. Water quality parameters for stormwater transferred to the Suma Park Reservoir following retention and primary treatment in a holding dam showed turbidity and chemical concentrations generally suitable for recharge however bacteria levels remained above levels suitable for recharge. The Stage 2 feasibility report stated further chlorination or UV treatment of the water is necessary to reduce bacteria counts to acceptable levels. Although not tested, it is assumed the raw stormwater from Ploughmans Creek will have similar quality and will require holding and treatment to reach standards suitable for MAR.

Macquarie River water is of higher quality than the raw stormwater on parameters tested however no bacteria data is presented in the feasibility reports.

3.8.1 Receiving Water

The quality of the water to receive the recharge water was sampled from bores at the Orange showground, Council‟s Margret Street depot and the Clifton Grove shearing shed. All bores are above the geological Oakdale formation and within or in close proximity to the proposed recharge bores.

The quality of bore water from the test bores is high with low turbidity, about half of Macquarie River water but conductivity was about twice that recorded for Macquarie Rive water (300 and 800 us/cm). At this level the water is suitable for human consumption.

Figure 4 Stormwater Batch Pond

Modelling of chemical and physical reaction through mixing the source and receiving water was completed as part of the feasibility study and reported in the Stage 2 report.(C.M. Jewell & Associates Pty Ltd, 2011). The results indicated general compatibility between the two water samples. No precipitation capable of causing aquifer blockage was predicted.

Test results for water from a bore on the Orange basalt geology will be required to confirm this aquifers ability to accept stormwater.

3.9 Conceptual Aquifer Model

In the area around Orange, the following conceptual aquifer model has been developed, based on the information provided in the feasibility studies.

Fractured-rock aquifers exist in the Tertiary Orange Basalt, the Silurian Anson Formation and the Ordovician Oakdale Formation. These formations are distributed as shown in Figure 1.

Aquifer permeability in different directions is likely to vary, with the principal axis parallel to the regional structure.

Bore yields range from less than 1 Litres per second (L/s) to nearly 40 L/s. Measured values of hydraulic conductivity are in the range 1 to 3 metres per day, averaged across aquifer zones 16 to 24 metres thick. Higher yields are likely close to major regional structures.

The aquifers are naturally recharged by excess precipitation. The aquifers contain low salinity groundwater that is generally of potable quality but there may be some local impact by aquifer minerals.

A recharge rate of 0.7 ML per day (8 L/sec) is possible.

3.10 MAR Operations

MAR will feasibly use the same pipeline network to both recharge and extract water. Two existing bores at the Orange Showground and the Clifton Grove Shearing Shed will be used initially to confirm the operational capacity of the project.

Following planning, up to five (5) additional bores will be located in aquifers within the Orange basalt geology. This formation extends to the southern edge of Orange and suitable bore locations on council or managed land or other public lands are available within Orange City Council.

Figure 5 Bore Head and Pipe

Once established all bores will connect to the Suma Park reservoir via a buried pipeline. The exact route will use council managed land such as road reserves to minimise the impact on private property. Nonetheless an exhaustive environmental and heritage investigation will be required to finally describe the route. Water for recharge will be provided by treated water from the Icely Road treatment plant. Water extracted from bores will be piped using the same pipe network to the Spring Creek catchment, probably just above Suma Park Reservoir. A discharge structure, including a holding dam to facilitate testing will be designed and built as part of the project.

A single bore hole has an inflow and outflow rate of 0.7 ML/day. Pipes will either recharge or extract however licenced extracted volume will be 20% less than recharge volume.

Assuming plant and equipment will operate at 90% uptime, then;
0.7 ML/day*365 days per year*90% uptime = 230 ML per annum pipe and bore capacity per borehole.

Allocating 55% of this capacity to recharge, and the remainder to extraction converts to 125 ML/annum recharge and 105 ML/annum extraction per borehole.

7 boreholes will provide about 1,600 ML per annum of bore and pipe capacity, capable of recharging 880 ML per annum and extracting 720 ML per annum using a single pipe network.

3.11 Aquifer Management

A draft Water Sharing Plan for the Lachlan Fold Belt fractured rock aquifers was released by the New South Wales Office of Water (NoW) in December 2010. Once gazetted, this plan will include both the Orange Basalt and Oakdale Formation aquifers.

The Orange Basalt, Oakdale and Anson Formation aquifers are included in the Lachlan Fold Belt MDB Groundwater Source, which extends over 180,000 km^2. The draft Water Sharing Plan does not provide any guidance concerning Managed Aquifer Recharge. However, s59(2) of the Draft Water Sharing Plan states:

(2) This Plan may be amended to provide for managed aquifer recharge. Note. Managed Aquifer Recharge schemes involve taking water such as recycled water or urban stormwater, treating it and then storing it in underground aquifers under controlled conditions. This water can then be extracted at a later time. (C.M. Jewell & Associates Pty Ltd, 2011)

3.11.1 Monitoring

The impact of the proposed trial MAR on the aquifers will require the establishment of monitoring bores, sometimes known as piezometers. “Monitoring bores are important because they provide the data for regional groundwater management plans, catchment initiatives and site remediation action plans. These bores are the basis on which important decisions are made about aquifer characteristics, trends, likely human and ecological impacts and strategies for protection or clean up. (Land and Water Biodiversity Committee, 2003). These bores are smaller than the MAR bores and generally established in either a grid, or transect to provide the necessary data. This project will include for an average of four monitoring bores for each extraction bore, subject to discussions with the NSW Office of Water and other stakeholders.

3.12 Location

A bore field over the Orange Basalt, Oakdale and Anson formations in the Lachlan Fold Belt fractured rock aquifer has been selected because;

- All three geologies are close to the treatment plant and the Suma Park Reservoir
- A network of road reserves under the control of Orange City Council is available
- Any potential water storage is required in these rock types
- The site is within and adjacent to existing test bores
- The sites proximity to power and 3G coverage for remote SCADA.

The land is generally zoned rural residential. Bores and the pipes servicing them will be located within road reserves. There is the potential to develop the MAR such that some bores will be exclusively for either injection or extraction.

3.13 Regulatory Assessment

3.13.1 Groundwater Recharge

Preliminary discussions with NoW, has indicated that NoW does not have a firm policy on MAR proposals. Rather, any proposal will be treated on its merits, subject to compliance with the provisions of any water sharing plan that is in force for the area concerned, and with state-wide groundwater management policies. However, NoW will regard protection of the quality groundwater resources and the rights of existing groundwater users as a priority (C.M. Jewell & Associates Pty Ltd, 2011).

As indicated in Section 3.11, the draft Water Sharing Plan for the Lachlan Fold Belt Groundwater Source does not provide any guidance concerning MAR.

The key state-wide policies that must be considered are:

- The NSW State Groundwater Policy Framework Document (1997)
- The NSW State Groundwater Quality Protection Policy (1998)
- The NSW State Groundwater Dependent Ecosystems Policy (2002).

The volume of groundwater recovered following injection is entwined in the regulatory process. Without an entitlement to the resource, any volume extracted will need to be injected. The volume of water recovered by an aquifer is unknown. The Stage 2 feasibility report (C.M. Jewell & Associates Pty Ltd, 2011) suggested that 80% of injected water can be recovered. For planning purposes a recovery of 80 percent is used. This factor will be the subject of monitoring and calibration of models should the project proceed.

3.14 Rationale

During the last decade Orange City Council has endured water shortages along with several other towns and cities in Australia. Its topographical location prevents development of a suitable dam in the practical vicinity of Orange. A growing city with a strong service economy, establishing a reliable source of water capable of servicing the city now and into the future is a primary task for the city council, responding to community needs and its legal responsibilities.

Investigations into a regional water supply based on an enlarged Lake Rowlands , 45 kilometers south of the city have been under way for several years and further funding is required to finalise the design of the project, estimated to cost $300M. Although such a storage could (and potentially will) increase the security of water for Orange, it is realistically an unknown number of years away. The pipeline to supply the city from Lake Rowlands is also a difficult route, crossing freehold land for the entire distance and moving water from the Lachlan to the Macquarie Valley. The Lake Rowlands project is also dependent on other jurisdictions and overall regional demand, both factors somewhat out of the control of Orange City Council. Orange City Council is determined that planning maintains a ten year lead over demand and MAR provides the City with an opportunity entirely under its control to increase secure water supply.

3.15 Strategic Fit

Orange City Council is required to supply the City of Orange and the villages of Lucknow and Spring Hill with potable water, under the Local Government Act. The level of service and security of supply is the subject of this legal requirement and other standards and guidelines. The Orange water supply storage system is six times more likely to fail than the accepted industry standard for water authorities.(Orange City Council, 2011). This project will provide data to allow planners to substantially reduce or eliminate this potential for failure and provide the water uses of Orange City with a reliable water supply enjoyed by the vast majority of Australians.

3.16 Project Dependencies

This project is independent of other projects. Sufficient water is available from the stormwater harvesting scheme to operate this trial of managed aquifer recharge. Part of this project is to obtain a licence from the NSW government for operation of the scheme for five years.

The outcome of this project is to provide accurate operational data regarding the use of MAR in the Orange area so that the potential for aquifer storage in the Orange area is understood, including all operational, technical, environmental and economic details.

Other schemes to increase the storage and supply of water to Orange will proceed but may be altered with the increase storage and supply capacity proposed by this project. One project is the Lake Rowlands project. Another related project is the ongoing investigation into the integrated water cycle management for the central west region and the secure yield study for Orange City Council.

4 Statement of Scope

4.1 Project Objective

The objective of this project is to provide Orange City Council with accurate and complete information to explore the option of using managed aquifer recharge to increase its water storage capacity by up to 20 GL, and maintain security of water supply to its customers under the “5-10-10 rule” beyond the mid-term (10-15 year) planning horizon.

4.2 Target Outcomes

1. Increased operational knowledge of MAR in the Orange area as an effective water storage
   - Known ability to store a retrievable volume of 20 GL.
2. Increased knowledge of the use of aquifers in Australia for storage and extraction
   - Recovery rates (ML out for ML in) for a specific fractured rock aquifer;
   - Storage capacity, for a specific fractured rock aquifer,
   - The impact MAR on a specific fractured rock aquifer in terms of water quality and aquifer management (water table height, compatibility of water and sustainable extraction rates),
3. Increased options to maintain water security for Orange City Council beyond the mid-term (10-15 year) planning horizon.

4.3 Undesirable Outcomes

1. Increased reporting requirements on Orange City Council
2. Increased risk exposure
3. Increased risk management works

4.4 Proposed Outputs

1. Engineering plans to develop five (5) bores within the Orange Basalt area of the Lachlan Fold Belt fractured rock aquifer and within the catchment of the Macquarie River.

2. Engineering plans for a pipeline to connect the above five (5) bores and two (2) existing bores (at the Orange showground and the Clifton Grove shearing shed) by pipeline to the Icely Road Treatment Plant and an inflow structure at either the Spring Creek or the Suma Park Reservoir.

3. An operating plan to harvest, treat and pump stormwater into seven (7) bores within Orange City Council Local Government Area; five (5) in the Orange tertiary basalt; one (1) in the Ordovician Oakdale formation one (1) in the Silurian Anson formation all within the Lachlan Fold Belt fractured rock aquifer.

4. An environmental investigation in compliance with NSW legislation to develop the bores and use them for a continuous trial MAR for at least five (5) years.

5. Policy approvals and necessary licence(s) from the relevant NSW government departments to operate the trial MAR and pipeline according to the above plan.

6. Construction and installation of lined bore holes, pumps, pipes, access infrastructure, necessary meters and a return flow structure with a capacity to pump up to one (1) ML/day to each bore hole from the Icely Road Treatment Plant and to extract up to one (1) ML/day from each bore hole for discharge to the nominated reservoir.

7. An annual report for a minimum of five years following the commencement of MAR operations describing the operation of MAR in the Orange LGA and for each bore, the volume, cost, water quality and aquifer condition. This report will include other data required under operating approvals and licences.

4.5 Utilisation Map

Table 2 below matches the Outcome to Outputs via a customer. This in turn guides stakeholder management.

Table 2 Utilisation Map. Links Outcome to Output via the Customer

OUTCOMES / OUTPUTS	Increased operational knowledge of MAR	Increased knowledge of the use of aquifers in Australia	Increased options to maintain water security to Orange
Engineering Plans for New Bores		• Orange City Council • NWC	
Engineering plans for connecting pipelines		• Orange City Council • NWC	
Operating Plan for 7 bores.	• Orange City Council NWC		
Environmental approvals	• Orange City Council • NWC		
Policy approvals and license(s)	• Orange City Council • NoW • NWC		
Construction/installation of bores, pipes, pumps meters and civil works.	• Orange City Council • NWC		
Operation and Annual Reports	• Orange City Council	• NoW • NWC	• Orange City Council

4.6 Excluded outputs

Nil

5 Stakeholders

Table 3 below defines stakeholders in the project and defines their stakeholding

Table 3 Stakeholders and their Stakeholding

No.	Name of Stakeholder entity	Stakeholding	Generic Stakeholding Membership	Issues Raised with this stakeholder	How we will engage this stakeholder
	Orange City Council (OCC)	• Project will not proceed without commitment by OCC • The project will improve a key performance factor for OCC (water security)	Customer Funder Beneficiary	Expenditure of council funds and value of money Alternative solutions	Presentation of a common compelling story.
	CENTROC	• Will influence support for the project in government • The project will impact on the long-term water planning sponsored by CENTROC	Impactee Influencer	Consistency with other lobby efforts Impact on long-term planning options	Presentation of a common compelling story.
	NSW Office of Water (NoW)	• A key scope of the project is a licence granted by the NSW Office of Water. • The project will increase inquiry (both positive and negative) to NoW	Customer Impactee Influencer	Licencing MAR and stormwater harvesting	Presentation of a common compelling story.
	State Member	• Source of key local support for the project. • The project will increase inquiry (both positive and negative) to the State member	Impactee Influencer	Consistent with other government policy	Presentation of a common compelling story.
	National Water Commission	• Potential funders and key supporters of the project • Key outcomes from the project will be used by the NWC.	Customer Beneficiary Funder	Is the project possible, innovative technically sound and fit for purpose	Presentation of a common compelling story.

No.	Name of Stakeholder entity	Stakeholding	Generic Stakeholding Membership	Issues Raised with this stakeholder	How we will engage this stakeholder
	Commonwealth Department of Sustainability, Environment, Water, Population and Communities	• SEWPaC are a key supporter of the project and will be the source of opinion to federal government ministers about the use of MAR. • Potential funder. • They will use data from the project for further investigation into MAR	Funder Impactee Influencer	Does the project fit within the SDL, MDB Plan Is it consistent with other policies fit for purpose	Presentation of a common compelling story.
	Central Tablelands Water	• Will influence support for the project in government • The project will impact on CTW"s long-term infrastructure plans.	Impactee Influencer	Consistency with other lobby efforts Impact on long-term planning options	Presentation of a common compelling story. Contact by OCC councillors
	Landholders adjacent to bore holes	• The project may adversely impact them or they may perceive the project will adversely impact them during construction and operation. • The project may benefit them by increasing security of their water supply • May actively campaign against the project	Customer Impactee Influencer	Groundwater condition Construction noise/dust Long-term health Sustainability Historical user rights	Engagement plan based on common compelling story. On ground facilitators using standard “sales aid” data and presentations
	Community downstream of Suma Park Reservoir	• May perceive the project will impact the flow of water through their land. • May actively campaign against the project	Impactee Influencer	Impact on flows Sustainability Consistent with catchment management	Engagement plan based on common compelling story. On ground facilitators using standard “sales aid” data and presentations

No.	Name of Stakeholder entity	Stakeholding	Generic Stakeholding Membership	Issues Raised with this stakeholder	How we will engage this stakeholder
	Orange water users	• Some will claim the project will impact the community s under the precautionary principle. • May claim an adverse impact on water quality • Will benefit from the project by increased security of water supply.	Beneficiary Customer Influencer	Health Sustainability	Engagement plan based on common compelling story. On ground facilitators using standard "sales aid" data and presentations
	NSW Department of Health	• The project may require an operating licence or some authority from the NSW Department of Health. • The project will increase inquiry (both positive and negative) to this department.	Impactee Influencer	Health impacts Provision of a licence	Presentation of a common compelling story.
	Commonwealth Department of Health	• The project may require an operating licence or some authority from the Commonwealth Department of Health. • The project will increase inquiry (both positive and negative) to this department.	Impactee Influencer	Health impacts	Presentation of a common compelling story.
	Drilling Contractors	• The project will provide them work • They will often be a point of entry to the project by the public	Supplier		Presentation of a common compelling story. Early engagement and ongoing provision of standard information
	Council workers	• Will undertake work on the project • Will be the point of entry for public opinion of the project	Team members		Presentation of a common compelling story.
	Consultants	• The project will provide economic work • They will be a source of information to other stakeholders	Suppliers		Presentation of a common compelling story.

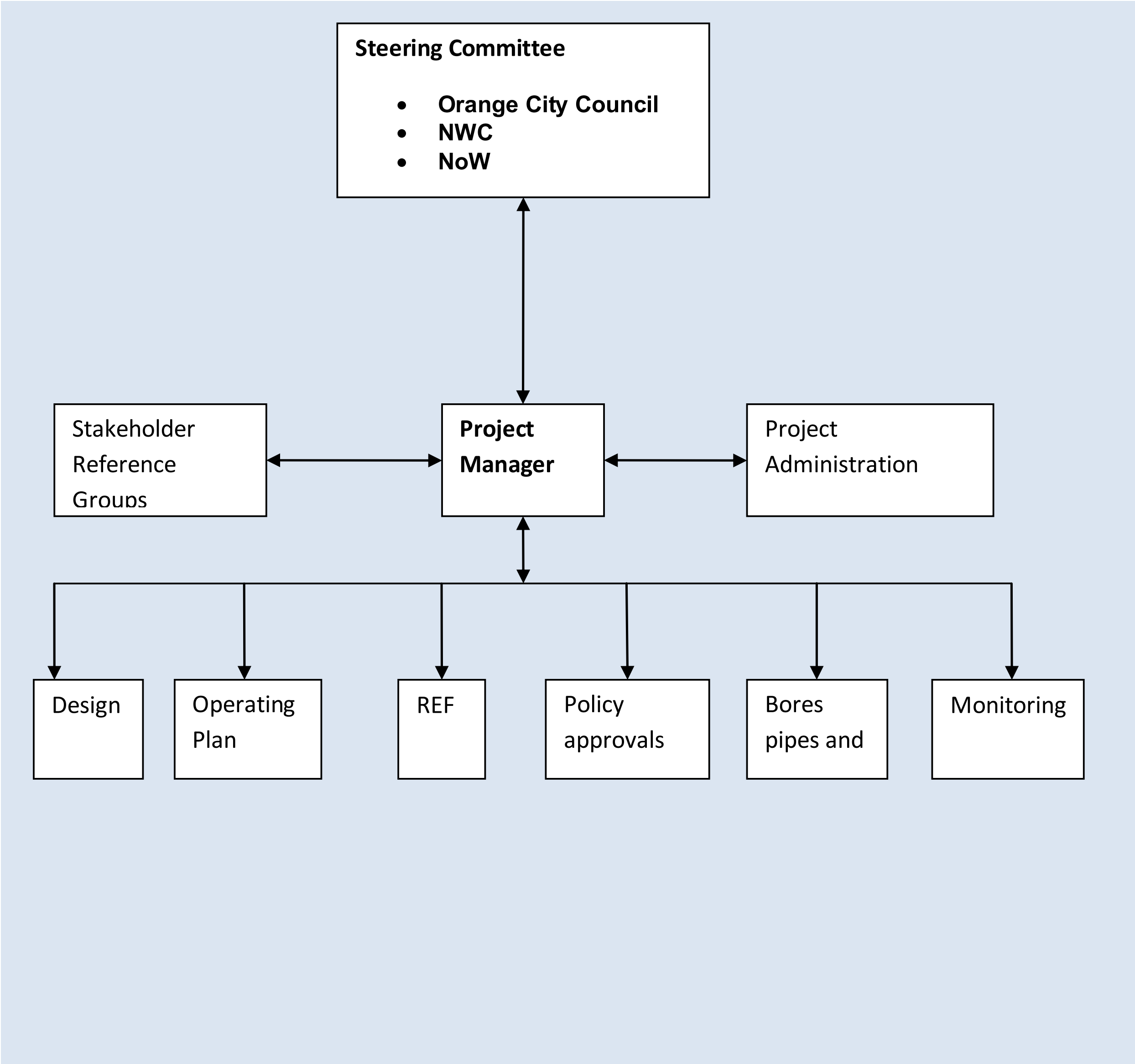
6 Project Governance

A project governance model is presented in Figure 6 below. Membership of the various elements of the governance models (committees and groups) is presented in Table 4 below. The Steering Committee is accountable to the funder (to be determined) to deliver the project outcomes. The Project Manager is accountable to the Steering Committee to deliver the scope. Various Reference Groups are engaged according to the Stakeholder Engagement Plan. They are established by and report to the Project Manager.

Table 4 Proposed Governance Responsibilities

Element	Members	Role
Steering Committee	Chris Devitt (OCC) National Water Commission NSW Office of Water	Accountable to the Project funder for the delivery of outcomes
Project Manager	Wayne Beatty (OCC)	Accountable to the Steering Committee for the Project Outputs Secretariat to the Steering Committee
Project Administration	Risk and Issues Manager Stakeholder Manager Project Administrator	Management of the risk and issues register Preparation and presentation of reports Implementation and maintenance of the Stakeholder Engagement Plan
Project Team	Orange city Council staff	Managers of the sub-projects
Reference Groups	Groups defined by the Project Manager, in accordance with the Stakeholder Engagement Plan	Provide expert and community input to the development and implementation of the sub-projects

Figure 6 Proposed Governance Model



7 High-level Plan

7.1 Assumptions

This Business Case assumes;

- The technical viability confirmed by the feasibility reports (C.M. Jewell & Associates Pty Ltd, 2011) is maintained for the life of the project, including the ability of aquifers in the Orange basalt area to accept stormwater recharge.
- Sufficient stormwater river water is available to operate the recharge of the trial bores, up to 125 ML/bore.
- That the recovery, infiltration and extraction rates for MAR does not vary substantially than the numbers used throughout this report.
- The water treatment plant owned by Orange City Council at Icely Road can treat an additional 7 ML per day for supply to the recharge bores.
- Access to land for the necessary pipelines and bores holes to operate the trial.
- Preliminary estimates suggesting increased storage of 20 GL will increase the secure yield by up to 1,300GL are correct.

7.2 Project Budget

A High level budget for the project, based on delivery of the target outputs is presented as Table 5.

Table 5 High Level Budget

RESOURCES			(dollar amount expressed in 1000s)		
OUTPUT	**Council Engineer/Staff**	**Consultants**	**Contractor**	**Civil Works**	**TOTAL**
Locate	$31.2	$6.0	-	-	$37.2
Design	$22.0	$56.0	-	-	$78.0
Plan	$11.2	$68.0	-	-	$79.2
REF	$48.0	$40.0	-	-	$88.0
Licence	$48.0	$0.0	-	-	$48.0
Build	$120.0	$116.0	$650.0	$700.0	$1,586.0
Reporting Year 1	$144.0	$52.2	-	-	
Annual Operating Costs					**$358**
	$424.4	**$338.2**	**$650.0**	**$700.0**	
TOTAL YEAR 1					**$2,112.6**

Ongoing operating costs are $196K in 2011 dollars for five years. This includes the funding of a full time position for five years, to manage the operation and reporting requirements.

7.3 Project Plan

A high level project plan is presented as Figure 7 below. This plan is based on the preliminary work plan information provided in Section 7.4. It shows the establishment phase of the project. Ongoing monitoring will continue for the five years of the trial. This project plan includes a full time position to manage and monitor the project.

Figure 7 High Level Project Plan

TASK	Aug-11	Nov-11	Feb-12	May-12	Aug-12	Nov-12	Feb-13	Jun-15	Jun-17
Engineering plans for new bores	$37K								
Engineering plans for pipelines		$78K							
Operating plan for 7 bores		$79K							
Environmental approvals			$88K						
Policy approvals and license(s)				$48K					
Construction of civil works					$1,586K				
Operation and annual reporting						$236K Year 1		$358Kp.a. Years 2 to 5	

7.4 Preliminary Workplan

Table 6 Preliminary Workplan

Outputs	Activities	Start Date	End Date	Estimated Cost $K
Engineering plans to develop five (5) bores within the Orange Basalt area of the Lachlan Fold Belt fractured rock aquifer and within the catchment of the Macquarie River.	• Identify extent of bore field • Define land tenure and compile list of potential sites • Confirm geology and liaise with NoW to confirm bore site is feasible • Identify specific stakeholders for each bore • Prepare engineering plan of each bore site. • Prepare written specification of each bore site • Identify piezometers sites to monitor aquifer in the vicinity of bores.	August 2011	August 2011	Identify and plan nominated bore sites. Identify specific stakeholders $37.2
Engineering plans for a pipeline to connect the above five (5) bores and two (2) existing bores (at the Orange showground and the Clifton Grove shearing shed) by pipeline to the Icely Road Treatment Plant and an inflow structure at either the Spring Creek or the Suma Park Reservoir.	• Define pipeline route to all bores • Determine maximum flow and pressure for each pipe. • Specify meters • Design meter location, bore head and distribution network, including diameter reductions and pressure management. • Design SCADA • Specify data management and systems integration with OCC • Specify location and size of recharge pumps • Specify extraction pumps • Specify and design power supply for all pumps • Locate the site for and design a return structure	August 2011	October 2011	Design and specify pipes, pumps, meters, bore heads, outlet structure and power supply $78.0

Outputs	Activities	Start Date	End Date	Estimated Cost $K
An operating plan to harvest, treat and pump stormwater into seven (7) bores within Orange City Council Local Government Area; five (5) in the Orange tertiary basalt; one (1) in the Ordovician Oakdale formation one(1) in the Silurian Anson formation all within the Lachlan Fold Belt fractured rock aquifer.	• Review guidelines and feasibility reports and prepare draft operating conditions. • Identify specific stakeholders for each bore hole • Identify project stakeholders • Review risk assessment • Define recharge and extraction depth for each bore • Research trigger indicators for pumping/extraction • Identify piezometers sites • Prepare operating plan • Develop maintenance plan	October 2011	October 2011	Review existing data and prepare operating plan. $79.2
An environmental investigation in compliance with NSW legislation to develop the bores and use them for a trial MAR over at least five (5) years.	• Research and describe appropriate planning process and regulation • Identify and collect data • Consult and communicate with stakeholders • Complete necessary environmental investigations • Determine Planning approval	October 2011	February 2012	EIS and associated communication $88.0
Policy approvals and necessary licence(s) from the relevant NSW government departments to operate the trial MAR and pipeline according to the above plan.	• Ongoing Discussions with NSW Office of Water • Identify relevant legislation • Consult and communicate with stakeholders • Request and obtain necessary approvals to operate MAR	October 2011	June 2012	Communications and briefing, including in-kind costs and project management $48.0

Outputs	Activities	Start Date	End Date	Estimated Cost $K
Construction and installation of lined bore holes, pumps, pipes, access infrastructure, necessary meters and a return flow structure with a capacity to pump up to one (1) ML/day to each bore hole from the Icely Road Treatment Plant and to extract up to one (1) ML/day from each bore hole for discharge to the nominated reservoir. Network of monitoring bores (piezometers)	• Drill and line bore holes • Drill piezometers holes • Construct inflow structure • Install pipelines, electrical connections • Install SCADA • Testing of bores and SCADA • Commission bores • Commission system • Ongoing communications with stakeholders	June 2012	July 2012	Drill bore holes, piezometers holes and construct pipeline and civil works. $1,586.0
An annual report for a minimum of five years following the commencement of MAR operations describing the operation of MAR in the Orange LGA and for each bore, the volume, cost, water quality and aquifer condition. This report will include other data required under operating approvals and licences.	• Confirm data collection requirement in consultation with stakeholders • Confirm systems integration with OCC to provide data security and backup • Confirm licence conditions and reporting protocols • Collect and analyse data • Prepare annual reports	July 2012	July 2017	Collect, store and analyse data. Prepare and submit reports. $236 year 1 including Operating cost $358 per annum years 2-5
TOTALS		August 2011	July 2017	

7.5 Resource Plan and Budget

7.5.1 Bore Field Plan

Output: Engineering plans to develop five (5) bores within the Orange Basalt area of the Lachlan Fold Belt fractured rock aquifer and within the catchment of the Macquarie River.

Table 7 Resources for Bore Field Plan

Activity	Resources	Time	Estimated Cost $K	Estimated Cost Range $K (-20% - +30%)	
Identify extent of bore field	Council Engineer	8 people hours plus disbursements	$1.6	$1.3	$2.1
Define land tenure and compile list of potential sites	Council Engineer	8 people hours plus disbursements	$1.6	$1.3	$2.1
Confirm geology and liaise with NoW to confirm bore site is feasible	Council Engineer	40 people hours plus disbursements	$8.0	$6.4	$10.4
Identify specific stakeholders for each bore	Council Engineer	40people hours plus disbursements	$8.0	$6.4	$10.4
Prepare engineering plan of each bore site.	Consultant	30people hours plus disbursements	$6.0	$4.8	$7.8
	Council Engineer	10 people hours plus disbursements	$2.0	$1.6	$2.6
Prepare specification of each bore site	Council Engineer	40people hours plus disbursements	$8.0	$1.6	$10.4
Identify piezometers sites to monitor aquifer in the vicinity of bores.	Council Engineer	10 people hours plus disbursements	$2.0	$6.4	$2.6
TOTAL			**$37.2**	**$29.8**	**$48.4**

7.5.2 Engineering Plan

Output: Engineering plans for a pipeline to connect the above five (5) bores and two (2) existing bores (at the Orange showground and the Clifton Grove shearing shed) by pipeline to the Icely Road Treatment Plant and an inflow structure at either the Spring Creek or the Suma Park Reservoir

Table 8 Resources for Engineering Plan

Activity	Resources	Time	Estimated Cost $K	Estimated Cost Range $K(-20% – +30%)	
Define pipeline route to all bores	Council Engineer	20 people hours plus disbursements	$4.0	$3.2	$5.2
Determine maximum flow and pressure for each pipe.	Consultant	20 people hours plus disbursements	$5.0	$4.0	$6.5
Specify meters	Consultant	8 people hours plus disbursements	$2.0	$1.6	$2.6
Design meter location, bore head and distribution network, including pipe size, quality and pressure management.	Consultant Council Engineer	40 people hours plus disbursements 20 people hours plus disbursements	$10.0 $4.0	$8.0 $3.2	$13.0 $5.2
Design SCADA	Consultants Council Engineer	40people hours plus disbursements 20 people hours plus disbursements	$10.0 $4.0	$8.0 $3.2	$13.0 $5.2
Specify data management and systems integration with OCC	Consultant Council Engineer	40people hours plus disbursements 20 people hours plus disbursements	$10.0 $4.0	$8.0 $3.2	$13.0 $5.2
Specify location and size of recharge pumps	Consultant	8 people hours plus disbursements	$2.0	$1.6	$2.6
Specify extraction pumps	Consultant	8 people hours plus disbursements	$2.0	$1.6	$2.6
Specify and design power supply for all pumps	Consultant	20 people hours plus disbursements	$5.0	$4.0	$6.5
Locate the site for and design a return structure	Consultant Council Engineer	40 people hours plus disbursements 30 people hours plus disbursements	$10.0 $6.0	$8.0 $4.8	$13.0 $7.8
TOTAL			**$78.0**	**$62.4**	**$101.4**

7.5.3 Operating Plan

Output: An operating plan to harvest, treat and pump stormwater into seven (7) bores within Orange City Council Local Government Area; five (5) in the Orange tertiary basalt; one (1) in the Ordovician Oakdale formation; one(1) in the Silurian Anson formation; all within the Lachlan Fold Belt fractured rock aquifer.

Table 9 Resources for Operating Plan

Activity	Resources	Time	Estimated Cost $K	Estimated Cost Range $K (-20% — +30%)	
Review guidelines and feasibility reports and prepare draft operating conditions.	Consultant	40 people hours plus disbursements	$11.6	$9.3	$15.1
Identify specific stakeholders for each bore hole	Council Engineer	8 people hours plus disbursements	$1.6	$1.3	$2.1
Identify project stakeholders	Council Engineer	8 people hours plus disbursements	$1.6	$1.3	$2.1
Review risk assessment	Consultant Council Engineer	40 people hours plus disbursements 20 people hours plus disbursements	$11.6 $4.0	$9.3 $3.2	$15.1 $5.2
Define recharge and extraction depth for each bore	Consultants Council Engineer	20people hours plus disbursements 10 people hours plus disbursements	$5.0 $2.0	$4.0 $1.6	$6.5 $2.6
Research trigger indicators for pumping/extraction	Consultant	40people hours plus disbursements	$11.6	$9.3	$15.1
Identify piezometers sites	Consultant	20people hours plus disbursements	$5.0	$4.0	$6.5
Prepare Operating Plan	Consultant	60 people hours plus disbursements	$17.4	$13.9	$22.6
Develop maintenance plan	Consultants Council Engineer	20people hours plus disbursements 10 people hours plus disbursements	$5.8 $2.0	$4.6 $1.6	$7.5 $2.6
TOTAL			**$79.2**	**$63.4**	**$103.0**

7.5.4 Environmental Investigations

Output: An environmental investigation in compliance with NSW legislation to develop the bores and use them for a trial MAR over at least five (5) years.

Table 10 Resources for Environmental Investigation

Activity	Resources	Time	Estimated Cost $K	Estimated Cost Range $K (-20% — +30%)	
Research and describe appropriate planning process and regulation	Council Engineer/Staff	20 people hours plus disbursements	$4.0	$3.2	$5.2
Identify and collect data	Council Engineer/Staff	60 people hours plus disbursements	$12.0	$9.6	$15.6
Consult and communicate with stakeholders	Council Engineer/Staff	40 people hours plus disbursements	$8.0	$6.4	$10.4
Complete necessary environmental investigations	Consultant Council Engineer	160 people hours plus disbursements 80 people hours plus disbursements	$40.0 $16.0	$32.0 $12.8	$52.0 $20.8
Determine Planning approval	Council Engineer/Staff	40 people hours plus disbursements	$8.0	$6.4	$10.4
TOTALS			**$88.0**	**$70.4**	**$114.4**

7.5.5 Policy Approvals and Licencing

Output: Policy approvals and necessary licence(s) from the relevant NSW government departments to operate the trial MAR and pipeline according to the above plan.

Table 11 Resources for Policy Approvals and Licencing

Activity	Resources	Time	Estimated Cost $K	Estimated Cost Range $K (-20% — +30%)	
Ongoing Discussions with NSW Office of Water	Council Engineer/Staff	60 people hours plus disbursements	$12.0	$9.6	$15.6
Identify relevant legislation	Council Engineer/Staff	60 people hours plus disbursements	$12.0	$9.6	$15.6
Consult and communicate with stakeholders	Council Engineer/Staff	60 people hours plus disbursements	$12.0	$9.6	$15.6
Request and obtain necessary approvals to operate MAR	Council Engineer/Staff	60 people hours plus disbursements	$12.0	$9.6	$15.6
TOTAL			**$48.0**	**$32.4**	**$62.4**

7.5.6 Construction

Output: Construction and installation of lined bore holes, pumps, pipes, access infrastructure, necessary meters and a return flow structure with a capacity to pump up to one (1) ML/day to each bore hole from the Icely Road Treatment Plant and to extract up to one (1) ML/day from each bore hole for discharge to the nominated reservoir. Network of monitoring bores (piezometers)

Table 12 Resources for Construction

Activity	Resources	Time	Estimated Cost $K	Estimated Cost Range $K (-20% — +30%)	
Drill and line bore holes	Contractor	5 Bores plus lining/caps	$300.0	$240.0	$390.0
	Council Engineer	60 people hours plus disbursements	$12.0	$9.6	$15.6
Drill piezometers holes	Contractor	4 piezometer holes per MAR bore plus lining/caps	$280.0	$224.0	$364.0
	Council Engineer	120 people hours plus disbursements	$24.0	$19.2	$31.2
Construct inflow structure	Contractor	Civil works	$200.0	$160.0	$260.0
	Council Engineer	60 people hours plus disbursements	$12.0	$9.6	$15.6
Install pipelines, electrical connections	Contractor	20,000 metres pipe	$300.0	$240.0	$390.0
	Council Engineer	60 people hours plus disbursements	$12.0	$9.6	$15.6
Install SCADA	Contractor	Civil works	$200.0	$160.0	$260.0
	Council Engineer	60 people hours plus disbursements	$12.0	$9.6	$15.6
Testing of bores and SCADA	Contractor	Civil works	$50.0	$40.0	$65.0
	Council Engineer	60 people hours plus disbursements	$12.0	$9.6	$15.6
Commission bores	Contractor	Civil works	$12.0	$9.6	$15.6
	Council Engineer	60 people hours plus disbursements	$12.0	$9.6	$15.6
Commission system	Contractor	Civil works	$10.0	$8.0	$13.0
	Council Engineer	60 people hours plus disbursements	$12.0	$9.6	$15.6
Ongoing communications with stakeholders	Consultant	400 people hours plus disbursements	$116.0	$92.8	$150.8
	Council Engineer	60 people hours plus disbursements	$12.0	$9.6	$15.6
TOTAL:			**$1,586**	**$1,270**	**$2,060**

7.5.7 Reporting

Output: An annual report for a minimum of five years following the commencement of MAR operations describing the operation of MAR in the Orange LGA and for each bore, the volume, cost, water quality and aquifer condition. This report will include other data required under operating approvals and licences.

Table 13 Resources for Reporting Year 1.

Activity	Resources	Time	Estimated Cost $K	Estimated Cost Range $K (-20% — +30%)	
Confirm data collection requirement in consultation with stakeholders	Consultant Council Engineer/Staff	40 people hours plus disbursements 40 people hours plus disbursements	$17.4 $12.0	$13.9 $9.6	$22.6 $15.6
Confirm systems integration with OCC to provide data security and backup	Consultant Council Engineer/Staff	40 people hours plus disbursements 40 people hours plus disbursements	$17.4 $12.0	$13.9 $9.6	$22.6 $15.6
Confirm licence conditions and reporting protocols	Council Engineer/Staff	Full time Role 5 years	$120.0	$96.0	$156.0
Collect and analyse data	Council Engineer/Staff	Included in Full Time role	-		
Prepare annual reports	Consultant Council Engineer/Staff	160 people hours plus disbursements Included in Full Time role	$17.4 -	$13.9	$22.6
Year 1 Operating Cost	Treatment Pumping		$40	$32	$52
TOTALS			**$236.2**	**$189.0**	**$307.0**

Table 14 Annual Operating Costs

Activity	Unit	Rate	Estimated Cost $K p.a.	Estimated Cost Range $K (-20% — +30%)	
Treatment	880ML	$50/ML	$44	$35	$57
Pumping	1,600ML	$40/ML	$64	$51	$83
Maintenance			$130	$100	$170
Management	1FTE		$120	$96	$156
TOTALS			**$358**	**$282**	**$466**

8 Risk Management

A risk assessment and mitigation table is included below. Risks are represented graphically.
There are three risks assessed as high after the proposed mitigation practice;

- Regulatory, a social risk,
- Funding, a commercial risk
- Pressure, flow rates volumes and levels- Technical Risk

The mitigation factors are assessed as effective however the above risks will be a potential cause of project slippage and cost escalation if not managed effectively from the beginning of the project.
The risk of impacted stakeholders exerting influence on the project is a major risk that can only be managed through an extensive, professional and well planned communication plan, initiated at the very beginning of the project. The success of the project depends on the execution of this communications plan.

Table 15 Risk Assessment and Mitigation; Orange City Council Managed Aquifer Recharge

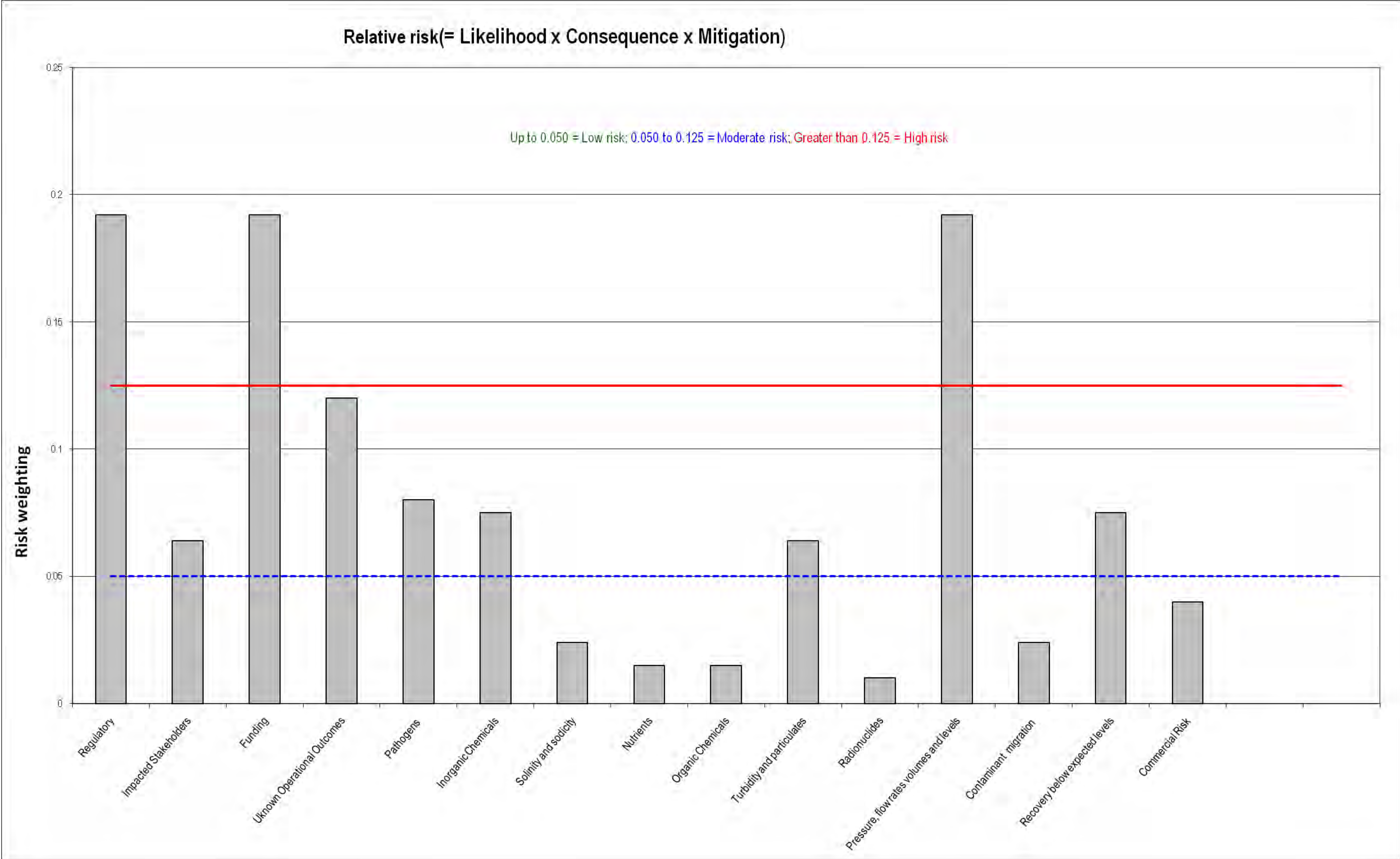
Risk Areas	Risk descriptions	Likelihood		Consequence			Mitigation			Risk
				Description	Rating		Description	Rating		
Regulatory – Social Risk	Difficulty obtaining regulatory approvals from government health department and office of water	Will probably happen	0.8	Project cannot become operational; investment to date becomes sunk cost	Significant effect	0.8	Establish relationship with all levels of NSW government at project commencement highlighting project and risk management	Effective	0.3	**0.192**
Impacted Stakeholders – Social Risk	Impactees will use all means of influence to impede project	Will probably happen	0.8	Project will become bogged in conflict, issue management and reactive messages	Significant effect	0.8	At project initiation engage a suitably experienced communication group to identify impactees, and consult with them. This will include local field workers and a high level communication plan.	Excellent	0.1	**0.064**
Funding	Funding is not available	Will probably happen	0.8	Project stalls; water security options for Orange remain limited, project cost potentially sunk	Significant effect	0.8	Identify likely funding sources and develop a common compelling story within the community to promote funding for the project	Effective	0.3	**0.192**

Risk Areas	Risk descriptions	Likelihood		Consequence			Mitigation			Risk
				Description	Rating		Description	Rating		
Unknown Operational Outcomes – Technical Risk	This is a new concept to the area and unknown impacts, such as reduced pressure for existing users, increases in spring flows, unintended water logging etc.	Could happen	0.5	Project stops, costs potentially sunk	Significant effect	0.8	Negotiate an initial test bore to commence as soon as possible; Consult with the community on indicators for operational problems; include feedback to communications plan.	Effective	0.3	**0.12**
Pathogens	Microbiological quality of source water below AGMAR standards	Will probably happen	0.8	Epidemic	Disastrous	1	Treatment to drinking water standard both pre and post injection.	Excellent	0.1	**0.08**
Inorganic Chemicals	Potential for precipitation of iron and manganese hydroxides when recharge water is mixed with existing groundwater	Could happen	0.5	exfiltration of bore holes, reducing recharge and reduction capacity	Moderate effect	0.5	Increased settling time and revised treatments prior to injection, as indicated by ongoing water quality tests	Effective	0.3	**0.075**
Salinity and sodicity	Existing groundwater may increase surface salinity	Unlikely to happen	0.3	Impact on plants growing in the recharge area	Significant effect	0.8	Installation of piezometers to monitor groundwater depth and quality, providing guidance on the injection rate to mitigate any effect	Excellent	0.1	**0.024**

Risk Areas	Risk descriptions	Likelihood		Consequence			Mitigation			Risk
				Description	Rating		Description	Rating		
Nutrients	Recharge water and existing groundwater may include high levels of nutrients such as nitrogen and phosphorus	Unlikely to happen	0.3	Impact on maintaining the quality of stored water, particularly in relation to algal blooms	Moderate effect	0.5	Installation of piezometers to monitor groundwater depth and quality, providing guidance on the period of holding and pretreatment required for injection, and the rate of mixing with the recovered water	Excellent	0.1	**0.015**
Organic Chemicals	Organic levels such as residual herbicide could contaminate other waters	Unlikely to happen	0.3	Potential for contamination of groundwater from recharge water	Moderate effect	0.5	Ongoing monitoring of stormwater inflows with the capacity to divert this water to streamflow	Excellent	0.1	**0.015**
Turbidity and particulates	Turbid water from stormwater and Macquarie River water	Will probably happen	0.8	Turbid water will clog bore holes and the voids within the fractured rock aquifer	Significant effect	0.8	Pretreatment including holding and batch treatment with coagulant	Excellent	0.1	**0.064**
Radionuclides	Contamination of groundwater	Highly unlikely	0.1	impact on public health	Disastrous	1	Ongoing monitoring of stormwater inflows with the capacity to divert this water to streamflow	Excellent	0.1	**0.01**

Risk Areas	Risk descriptions	Likelihood		Consequence			Mitigation			Risk
				Description	Rating		Description	Rating		
Pressure, flow rates volumes and levels- Technical Risk	Low pressure in the groundwater bores	Will probably happen	0.8	Reduced capacity to inject and recover groundwater	Significant effect	0.8	Increase in the number and further testing to identify bores of higher pressure	Effective	0.3	**0.192**
Contaminant migration	various contaminants in the source water migrating to groundwater reserves	Unlikely to happen	0.3	reduced quality of groundwater, and potential compensation claims	Significant effect	0.8	Ongoing monitoring of stormwater inflows with the capacity to divert this water to streamflow	Excellent	0.1	**0.024**
Recovery below expected levels	Less than 80percent of injected water cannot be recovered	Unlikely to happen	0.3	Reduced economic capacity of the project	Moderate effect	0.5	Ongoing monitoring and potential installation of additional bore holes	Moderate	0.5	**0.075**
Commercial Risk	project is uneconomic to run	Could happen	0.5	Project costs are sunk	Significant effect	0.8	Install a small number of bores initially to monitor and guide further investment	Excellent	0.1	**0.04**

Figure 8 Graph of Identified and Assessed Risks



9 QUALITY MANAGEMENT PLAN

All work on this project will be completed to a high standard of quality. The Project Manager is responsible for delivering the outputs of the project within the scope defined by the Steering Committee. The Steering Committee is responsible for defining the fit-for-purpose of each output. The intent is to ensure the outcomes of the project are met.

Project Management methodology shall be based on the PMBoK (Project Management Institute, 2004), with modification for project governance, and focus on outcomes, in accordance with the ITO model of project management.

Monitoring and reporting shall be in accordance with the governance requirements elsewhere in this plan. It is important to note, for the purpose of achieving the project outcomes, the reporting requirements for work on this project hold precedent over reporting requirements in day to day operations.

A Risk and Issues Register is established for this project in accordance with the Risk and Issues chapter of this Business Case. A Risk and Issues Manager is accountable to the Project Manager for implementation and maintenance of these registers and plans.

The success of the project will be tested by the realisation of the target outcomes detailed in this Business Case. Performance indicators are presented in Table 16 Below.

Table 16 Project Performance Indicators

Outcome	Performance Indicator and Target
Increased operational knowledge of MAR in the Orange area as an effective water storage	A detailed operational plan, updated annually for the operation of the trial MAR
Known ability to store a retrievable volume of 20GL.	An annual report on the operations of the trial MAR and the extrapolation of data to confirm the storage capacity of aquifers in the Orange area.
Increased knowledge of the use of aquifers in Australia for storage and extraction	Annual reports are developed in conjunction with key stakeholders, especially the National Water Commission
Recovery rates (ML out for ML in) for a specific fractured rock aquifer;	A key metric to be reported in detail to the satisfaction of the NSW Office of Water and the National Water Commission
Storage capacity, for a specific fractured rock aquifer,	A key metric to be reported in detail to the satisfaction of the NSW Office of Water and the National Water Commission

10 References

Australian Bureau of Meteorology. (2011, May 24). *Climate Statistics for Australian Locations - Orange Agricultural Institute*. Retrieved May 24, 2011, from Australian Bureau of Meteorology: http://www.bom.gov.au/climate/averages/tables/cw_063254.shtml

Beatty, W. (2011, May 23). Water and Sewer Strategic Manager - Orange City Council. (P. Deamer, Interviewer)

C.M. Jewell & Associates Pty Ltd. (2011, February). Feasibility Study Managed Aquifer Recharge.

Centroc. (2011). *Central NSW Councils*. Retrieved June 3, 2011, from Home: http://www.centroc.com.au/home

CSIRO. (2010, April). *Managed Aquifer Recharge*. Retrieved May 2011, from CSIRO: http://www.csiro.au/resources/MAR-FAQ.html

Haege, M. (2011, May 26). Geolyse. (P. Deamer, Interviewer)

Jewell, C. (2011). CMJA Pty Ltd. (P. Deamer, Interviewer)

Land and Water Biodiversity Committee. (2003). *Minimum Construction Requirements for Water Bores in Australia.*

Meakin, S. S. (1997). *Orange First Edition 1:100,000 geological map 8731.* Sydney: Geological Survey of NSW and Australian Geological Survey Organisation, Canberra.

MWH Australia Pty Ltd. (2007). *Orange Integrated Water Cycle Management Concept Study.* Ornage: Orange City Council.

MWH. (2009). *CENTROC Water Security Study Component 2: Options Paper.* Sydney: MWH.

Natural Resource Management Ministerial Council. (2009). *Australian Guidelines 24 for Water Recycling: Managing Health and Environmental Risks (Phase 2). Managed Aquifer Recharge. Appendix 10 pp 199-200.* Canberra: Biotext.

Orange City Council. (2009). *Blackmans Swamp Stormwater Harvetsing Scheme*. Retrieved May 25, 2011, from Ornage City Council: http://www.orange.nsw.gov.au/site/index.cfm?display=147115

Orange City Council. (2011). *Community Profile*. Retrieved 20 May, 2011, from Orange City Council: http://profile.id.com.au/Default.aspx?id=262&pg=210

Orange City Council. (2011, May 20). *Macquarie Pipeline - Secring the City's Future*. Retrieved May 26, 2011, from Orange City Council: http://www.orange.nsw.gov.au/site/index.cfm?display=145038

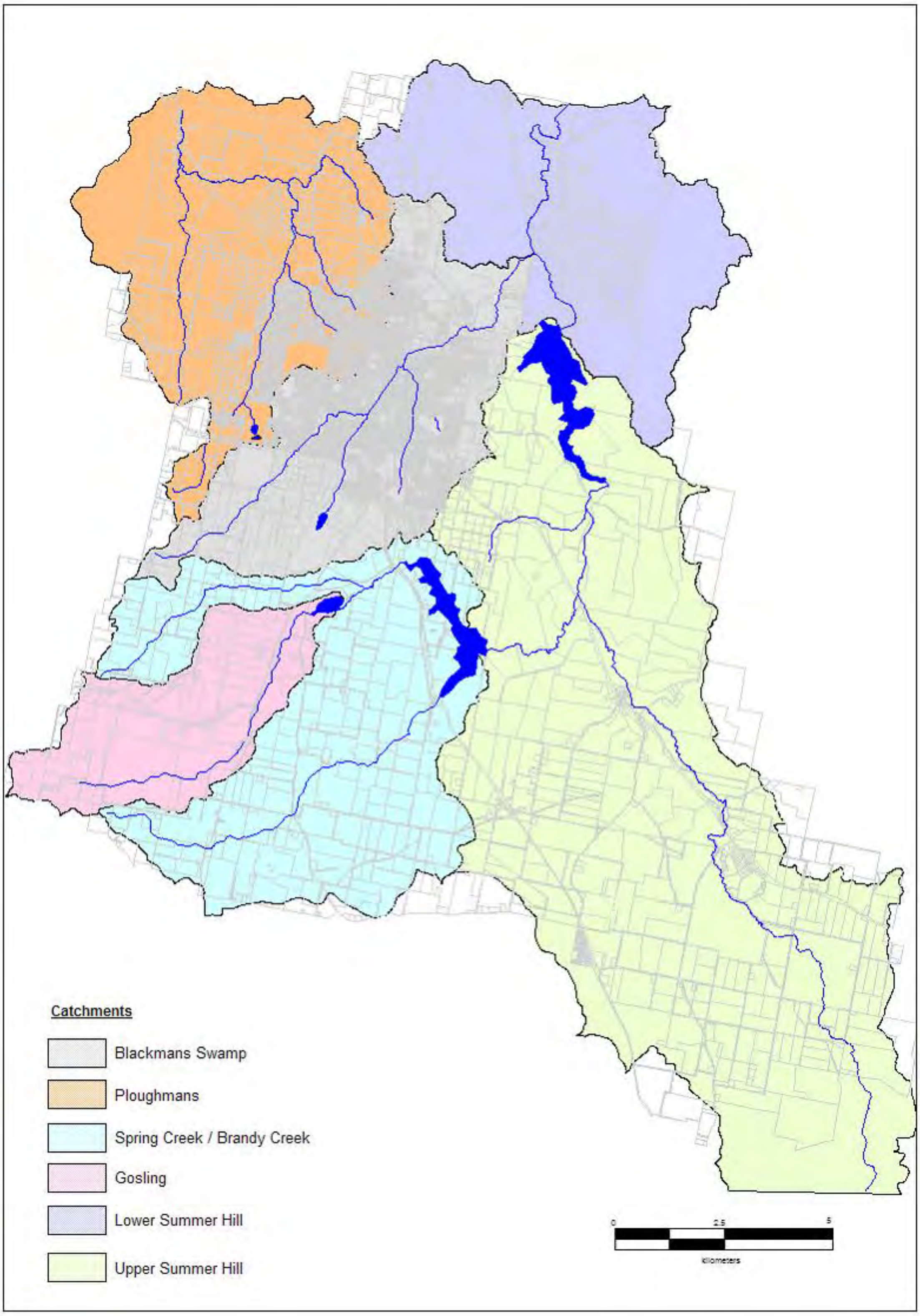
Orange City Council. (2010). *Orange City Council*. Retrieved June 3, 2011, from Water Use and Conservation: http://www.orange.nsw.gov.au/site/index.cfm?display=201687

Pratt Water. (2004). *The Business of Saving Water- the Report of the Murrumbidgee Valley Water Efficiency Project.* Melbourne: Pratt Water Pty Ltd.

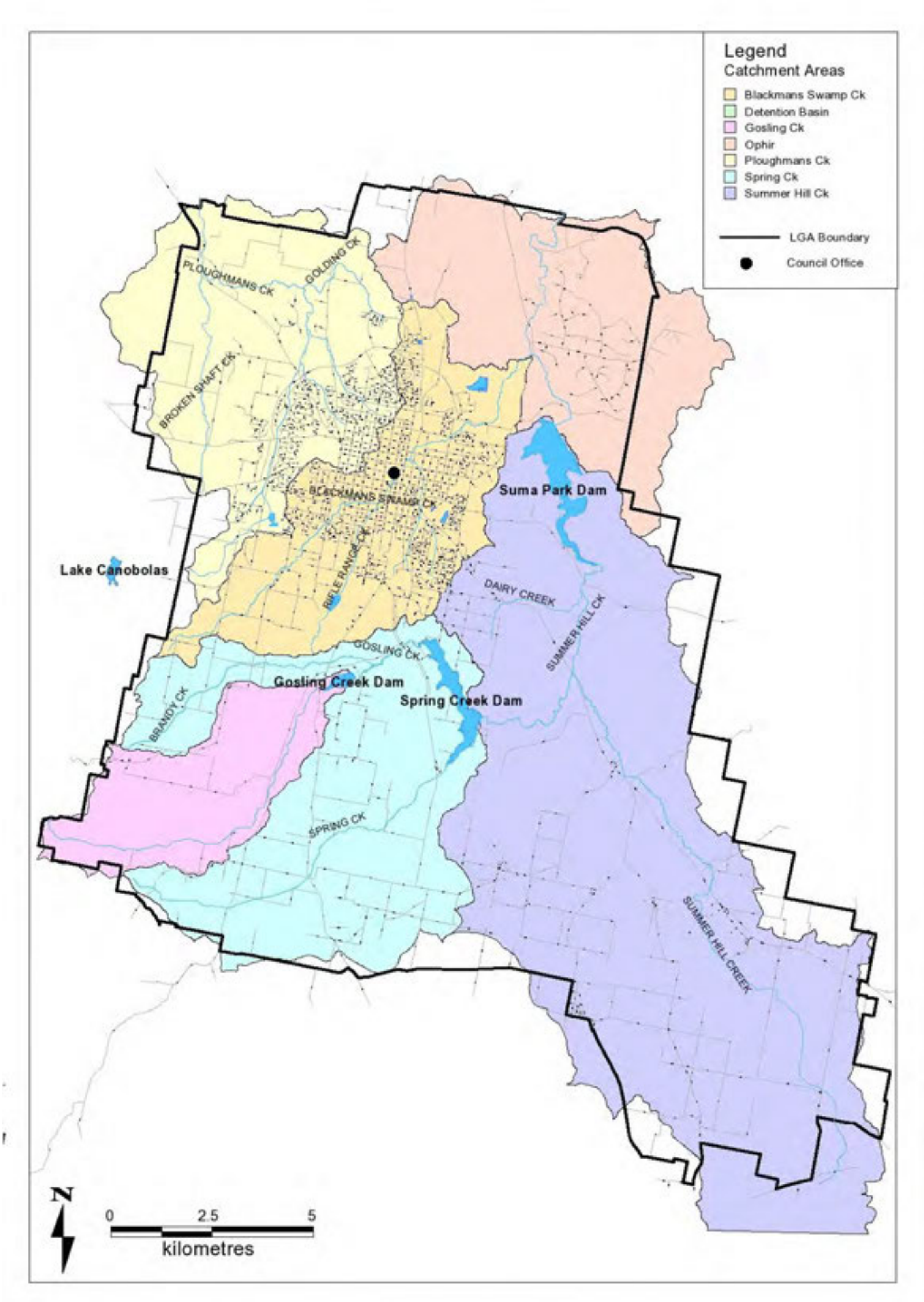
Project Management Institute. (2004). *A Guide to the Project Management Body of Knowledge. - 3rd Edition.* Newtown Square, Pensssylvania: Project Management Institute.

SEWPaC. (2011, May 2011). *Water for the Future*. Retrieved June 2011, from Menindee Lakes Project: http://www.environment.gov.au/water/policy-programs/srwui/menindee-lakes/index.html

Appendix A Orange City Council topography and catchment boundaries .

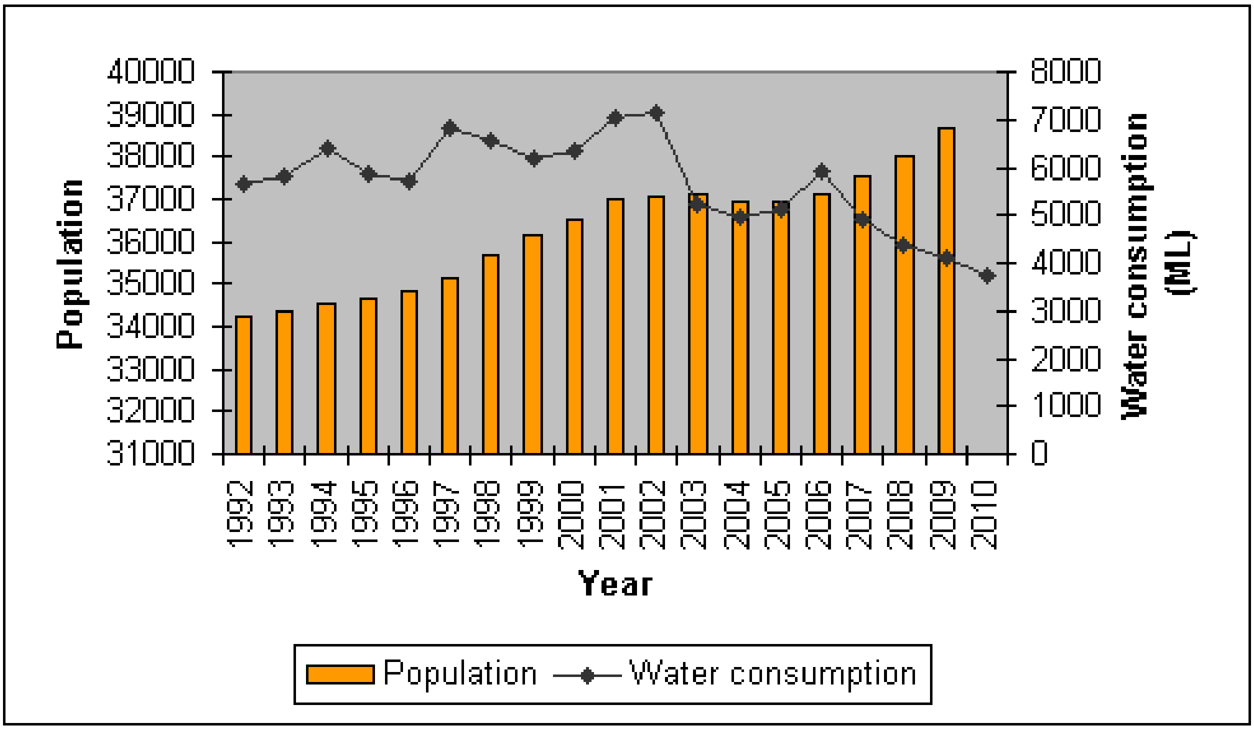


Appendix B Water Storages in Orange City Council



Appendix C Annual Water Use and Population.

Orange City Council



8 Risk Management

A risk assessment and mitigation table is included below. Risks are represented graphically.
There are three risks assessed as high after the proposed mitigation practice;

- Regulatory, a social risk,
- Funding, a commercial risk
- Pressure, flow rates volumes and levels- Technical Risk

The mitigation factors are assessed as effective however the above risks will be a potential cause of project slippage and cost escalation if not managed effectively from the beginning of the project.
The risk of impacted stakeholders exerting influence on the project is a major risk that can only be managed through an extensive, professional and well planned communication plan, initiated at the very beginning of the project. The success of the project depends on the execution of this communications plan.

Table 15 Risk Assessment and Mitigation; Orange City Council Managed Aquifer Recharge

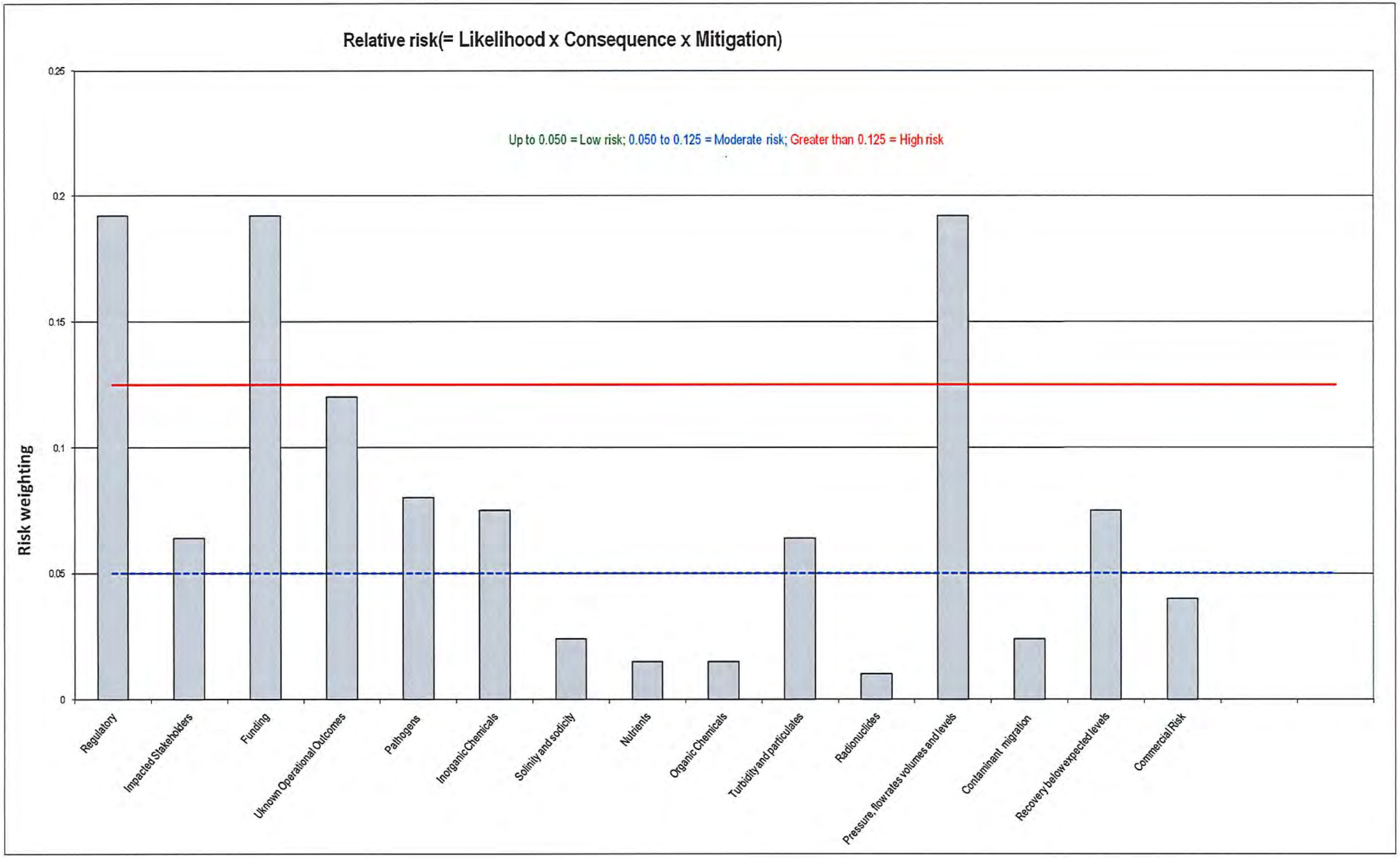
Risk Areas	Risk descriptions	Likelihood		Consequence			Mitigation			Risk
				Description	Rating		Description	Rating		
Regulatory – Social Risk	Difficulty obtaining regulatory approvals from government health department and office of water	Will probably happen	0.8	Project cannot become operational; investment to date becomes sunk cost	Significant effect	0.8	Establish relationship with all levels of NSW government at project commencement highlighting project and risk management	Effective	0.3	**0.192**
Impacted Stakeholders – Social Risk	Impactees will use all means of influence to impede project	Will probably happen	0.8	Project will become bogged in conflict, issue management and reactive messages	Significant effect	0.8	At project initiation engage a suitably experienced communication group to identify impactees, and consult with them. This will include local field workers and a high level communication plan.	Excellent	0.1	**0.064**
Funding	Funding is not available	Will probably happen	0.8	Project stalls; water security options for Orange remain limited, project cost potentially sunk	Significant effect	0.8	Identify likely funding sources and develop a common compelling story within the community to promote funding for the project	Effective	0.3	**0.192**

Risk Areas	Risk descriptions	Likelihood		Consequence			Mitigation			Risk
				Description	Rating		Description	Rating		
Unknown Operational Outcomes – Technical Risk	This is a new concept to the area and unknown impacts, such as reduced pressure for existing users, increases in spring flows, unintended water logging etc.	Could happen	0.5	Project stops, costs potentially sunk	Significant effect	0.8	Negotiate an initial test bore to commence as soon as possible; Consult with the community on indicators for operational problems; include feedback to communications plan.	Effective	0.3	**0.12**
Pathogens	Microbiological quality of source water below AGMAR standards	Will probably happen	0.8	Epidemic	Disastrous	1	Treatment to drinking water standard both pre and post injection.	Excellent	0.1	**0.08**
Inorganic Chemicals	Potential for precipitation of iron and manganese hydroxides when recharge water is mixed with existing groundwater	Could happen	0.5	exfiltration of bore holes, reducing recharge and reduction capacity	Moderate effect	0.5	Increased settling time and revised treatments prior to injection, as indicated by ongoing water quality tests	Effective	0.3	**0.075**
Salinity and sodicity	Existing groundwater may increase surface salinity	Unlikely to happen	0.3	Impact on plants growing in the recharge area	Significant effect	0.8	Installation of piezometers to monitor groundwater depth and quality, providing guidance on the injection rate to mitigate any effect	Excellent	0.1	**0.024**

Risk Areas	Risk descriptions	Likelihood		Consequence			Mitigation			Risk
				Description	Rating		Description	Rating		
Nutrients	Recharge water and existing groundwater may include high levels of nutrients such as nitrogen and phosphorus	Unlikely to happen	0.3	Impact on maintaining the quality of stored water, particularly in relation to algal blooms	Moderate effect	0.5	Installation of piezometers to monitor groundwater depth and quality, providing guidance on the period of holding and pretreatment required for injection, and the rate of mixing with the recovered water	Excellent	0.1	**0.015**
Organic Chemicals	Organic levels such as residual herbicide could contaminate other waters	Unlikely to happen	0.3	Potential for contamination of groundwater from recharge water	Moderate effect	0.5	Ongoing monitoring of stormwater inflows with the capacity to divert this water to streamflow	Excellent	0.1	**0.015**
Turbidity and particulates	Turbid water from stormwater and Macquarie River water	Will probably happen	0.8	Turbid water will clog bore holes and the voids within the fractured rock aquifer	Significant effect	0.8	Pretreatment including holding and batch treatment with coagulant	Excellent	0.1	**0.064**
Radionuclides	Contamination of groundwater	Highly unlikely	0.1	impact on public health	Disastrous	1	Ongoing monitoring of stormwater inflows with the capacity to divert this water to streamflow	Excellent	0.1	**0.01**

Risk Areas	Risk descriptions	Likelihood		Consequence			Mitigation			Risk
				Description	Rating		Description	Rating		
Pressure, flow rates volumes and levels-Technical Risk	Low pressure in the groundwater bores	Will probably happen	0.8	Reduced capacity to inject and recover groundwater	Significant effect	0.8	Increase in the number and further testing to identify bores of higher pressure	Effective	0.3	**0.192**
Contaminant migration	various contaminants in the source water migrating to groundwater reserves	Unlikely to happen	0.3	reduced quality of groundwater, and potential compensation claims	Significant effect	0.8	Ongoing monitoring of stomwater inflows with the capacity to divert this water to streamflow	Excellent	0.1	**0.024**
Recovery below expected levels	Less than 80percent of injected water cannot be recovered	Unlikely to happen	0.3	Reduced economic capacity of the project	Moderate effect	0.5	Ongoing monitoring and potential installation of additional bore holes	Moderate	0.5	**0.075**
Commercial Risk	project is uneconomic to run	Could happen	0.5	Project costs are sunk	Significant effect	0.8	Install a small number of bores initially to monitor and guide further investment	Excellent	0.1	**0.04**

Figure 8 Graph of Identified and Assessed Risks



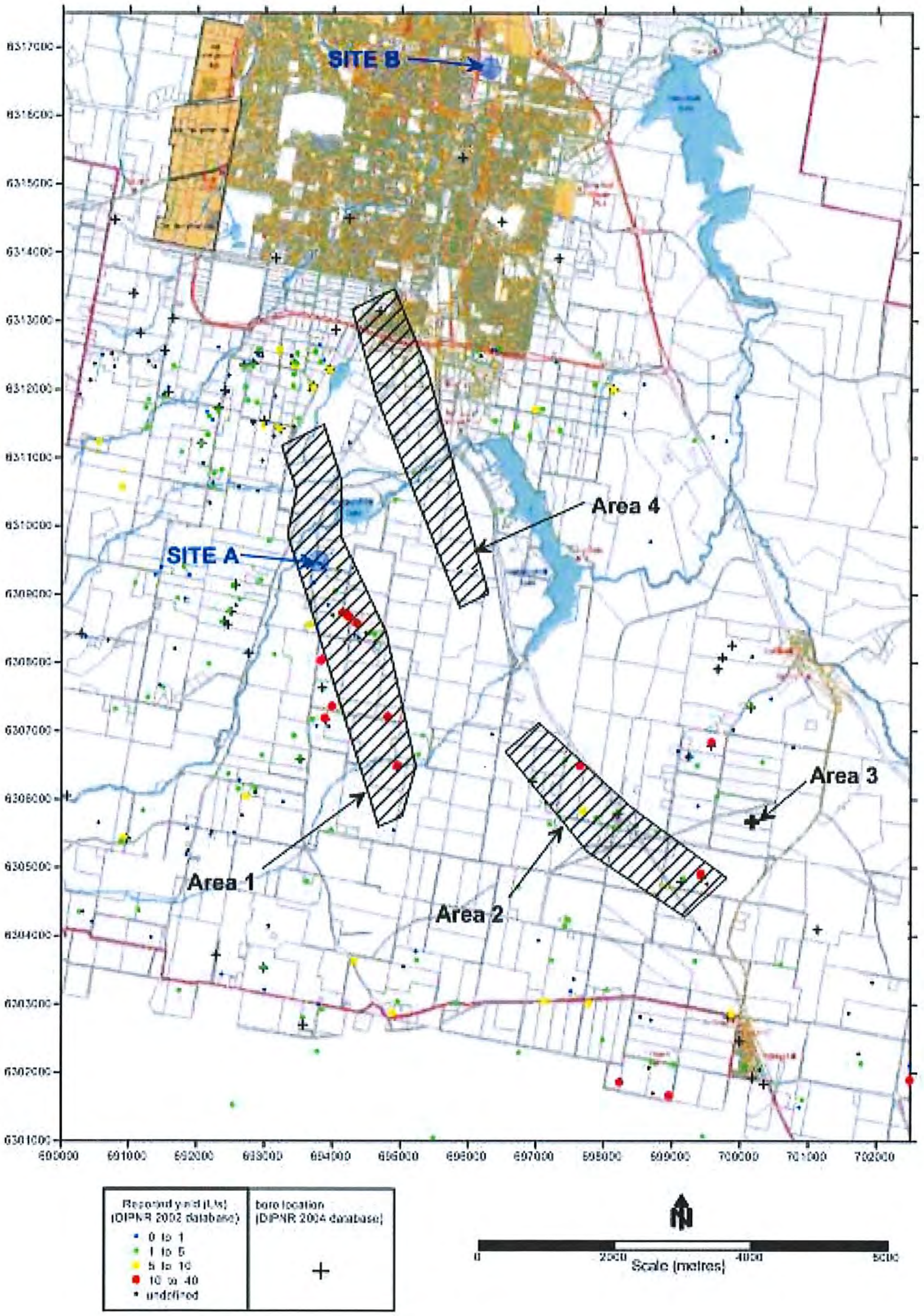


Figure 8-1 : Short-listed sites