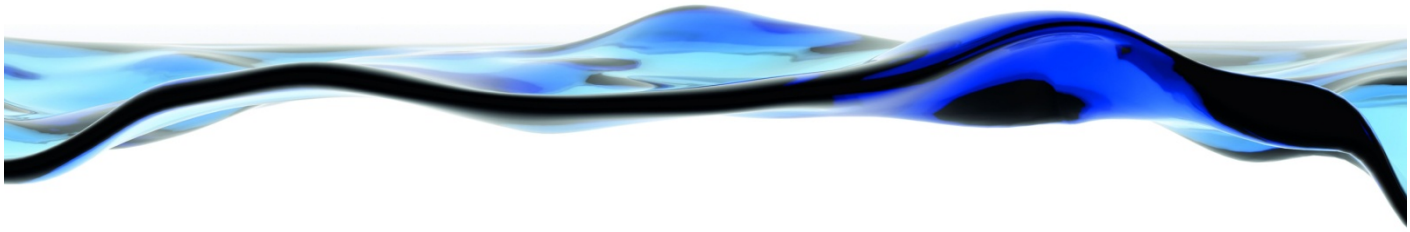
STORMWATER MANAGED AQUIFER RECHARGE RISK-BASED MANAGEMENT PLAN

PARAFIELD STORMWATER HARVESTING SYSTEM

Stormwater supply to the Mawson Lakes Recycled Water Scheme for dual reticulation and unrestricted municipal irrigation, and stormwater supply for industrial uses and restricted municipal irrigation

Page, D., Gonzalez, D., Naumann, B., Dillon P., Vanderzalm, J., and Barry, K



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The participants advise that the information contained in this publication comprises general statements based on scientific research and does not warrant or represent the completeness of any information or material in this publication. While SA Water has contributed information and advice that has been used to develop aspects of this Risk-based Management Plan, this does not constitute an endorsement of this plan.

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Acknowledgments

This is a Report of the Managed Aquifer Recharge and Stormwater Use Options (MARSUO) research project which is supported under the Raising National Water Standards Program through the National Water Commission, the Goyder Institute for Water Research, and by CSIRO Water for a Healthy Country Flagship Research Program, City of Salisbury, Adelaide and Mount Lofty Ranges Natural Resources Management Board, SA Water and the former United Water International. Data were provided by SA Water Corporation, City of Salisbury, CSIRO and University of South Australia. Particular thanks are due to Paul Carter (City of Salisbury), Rudi Regel (SA Water), Alex Keegan (SA Water) and Kylie Hyde (United Water, now Allwater) for their considerable help in producing this report.

Foreword

This report documents a risk management plan for the protection of public health and the environment for selected options for harvesting stormwater in the Parafield and neighbouring catchments of Salisbury, South Australia. This report focuses on two established uses involving aquifer storage of harvested stormwater with supply either to open space irrigation or to third pipe systems which blend the recycled stormwater with reclaimed water. Both supplies have already been in operation successfully for a number of years.

The Water Safety Expert Panel was formed to guide the work of the Managed Aquifer Recharge and Stormwater Use Options research project in producing authoritative risk assessment and risk management procedures for human health and the environment protection.

This risk management plan report is published with the consent of the Water Safety Expert Panel as an example of best current practice for risk management in stormwater harvesting and use. Although the plan is specific to a stormwater harvesting and managed aquifer recharge system in Salisbury, the methodology is broadly applicable in Australia and elsewhere.

The risk management plan is based on a risk assessment in accordance with the Australian Guidelines for Water Recycling of the National Water Quality Management Strategy (NWQMS). The plan is structured to address the twelve elements of the risk management framework (NWQMS) that aligns with the World Health Organisation Water Safety Planning approach.

Water Safety Expert Panel:

David Cunliffe, SA Department of Health and Ageing

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Executive Summary

This stormwater managed aquifer recharge risk-based management plan is an output of the Managed Aquifer Recharge and Stormwater Use Options (MARSUO) project. This is supported by the National Water Commission, Goyder Water Research Institute and partners to assess safety, public acceptance, economics and environmental impacts of alternative options for stormwater use in Australia.

The report documents a risk management plan for the protection of public health and the environment for existing uses of harvested stormwater in the Parafield and neighbouring catchments of Salisbury, South Australia. These involve aquifer storage of harvested stormwater with supply either to open space irrigation or to third pipe systems which blend the recycled stormwater with reclaimed water derived from treated sewage effluent for residential non-potable water use.

This report gives the context for a risk management plan in relation to urban water policies at three levels of government, key state legislation and national guidelines. Although the plan is specific to a stormwater harvesting and managed aquifer recharge system in Salisbury, the methodology is broadly applicable in Australia and elsewhere. It conforms to the Australian Guidelines for Water Recycling of the National Water Quality Management Strategy (NWQMS) and aligns with the WHO Water Safety Planning approach.

The plan is structured to address the twelve elements of the risk management framework (NWQMS) (Figure 1). This risk management plan relies on a risk assessment for these (and other) use options that cover elements 2 and 3 in much more detail and was also an output of the MARSUO project. By addressing all the elements of Figure 1, the risk management plan allows selection of suitable preventative measures so that the risks to human health and environment are managed.

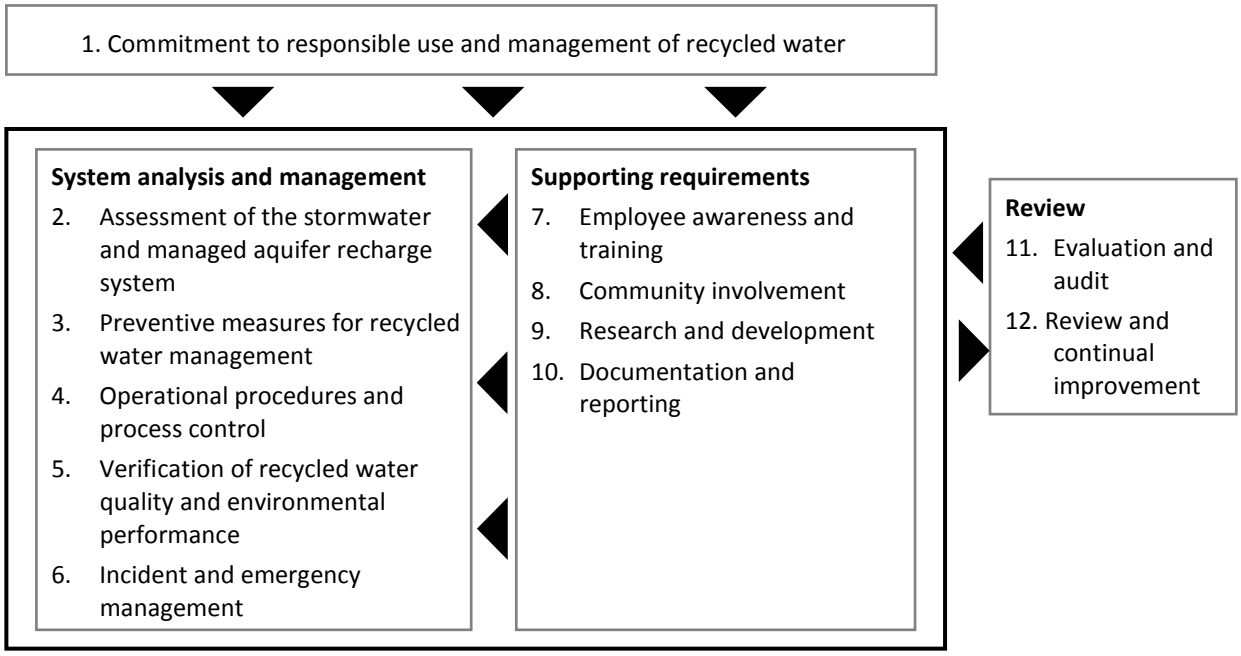

Figure 1 Elements of the framework for management of water quality and use (adapted from NRMMC-EPHC-AHMC 2006; NRMMC-EPHC-NHMRC 2009b).

The report focuses on the operator of the scheme, Salisbury Water, a subsidiary of the council of the City of Salisbury. Information on obligations of customers and details of their operating requirements are covered by other plans cited in the appendices. Appendix B summarises the activity schedule for Salisbury Water that results from implementation of this plan. A detailed Operations Manual is required to underpin this MAR risk-based management plan, assisting training and other requirements for implementation.

No previously published risk management plan for recycled water nor harvested stormwater was found by the researchers. Hence this plan is aimed at filling that void and is intended to serve as an example of best current practice for risk management in stormwater harvesting and use, including via aquifers.

Introduction

Objective

The objective of the Stormwater Managed Aquifer Recharge (MAR) Risk-Based Management Plan is to document a sequence of activities to manage identified water quality risks to human health, the environment and operations. Risk management in this plan is consistent with the Australian Guidelines for Water Recycling (phase 1 and phase 2) documents to ensure that water is fit for its intended end use. It therefore covers the whole stormwater harvesting and supply system from source to tap. In this case it covers management of the Parafield and Cobbler Creek catchments, the Parafield stormwater harvesting system and aquifer storage system, and delivery to SA Water at the Greenfields Mixing Tank or to public open space irrigation operated by the City of Salisbury. This current plan does not address non-potable residential use or potable use.

Scope

This document fits within part of a larger series of management plans, federal and state legislation and regulatory framework (Figure 2). This risk-based management plan has been developed as a means for identifying and managing health, environmental and operational risks associated with harvesting, treating and supplying urban stormwater for municipal open space irrigation and to the Mawson Lakes scheme. The scope of the current management plan includes:

- the regulatory and management framework for the scheme,
- the scheme's configuration, how it operates and how it is monitored,
- a list of the health and environmental hazards that exist,
- preventative measures and controls put in place to address these hazards,
- respective action plans in the event of incidents and emergencies, and
- review of scheme activities to identify where improvement areas are possible.

This risk-based management plan includes harvesting, treatment and supply of recycled stormwater for municipal (open space) irrigation and an industrial user (Michell Wool Pty. Ltd.), and supply to the Mawson Lakes recycled water scheme for blending with treated effluent at the Greenfields Mixing Tank. The plan refers to the Irrigation Management Plan (Hydroplan, 2004) in relation to unrestricted municipal irrigation within Mawson Lakes with blended recycled water from the Greenfields Mixing Tank. The City of Salisbury (City of Salisbury) has developed a stormwater management plan and Aquifer Storage and Recovery (ASR) scheme risk assessment and risk management plans which are integrated within this risk-based management plan. SA Water has developed similar risk-based management plans for the supply of treated effluent from the Bolivar sewage treatment plant to the Virginia Pipeline Scheme and to the Mawson Lakes Recycled Water Scheme. An overview of the relationship of this risk-based management plan to City of Salisbury (CoS), SA Water and Allwater management frameworks and water supply options is provided in Figure 3.

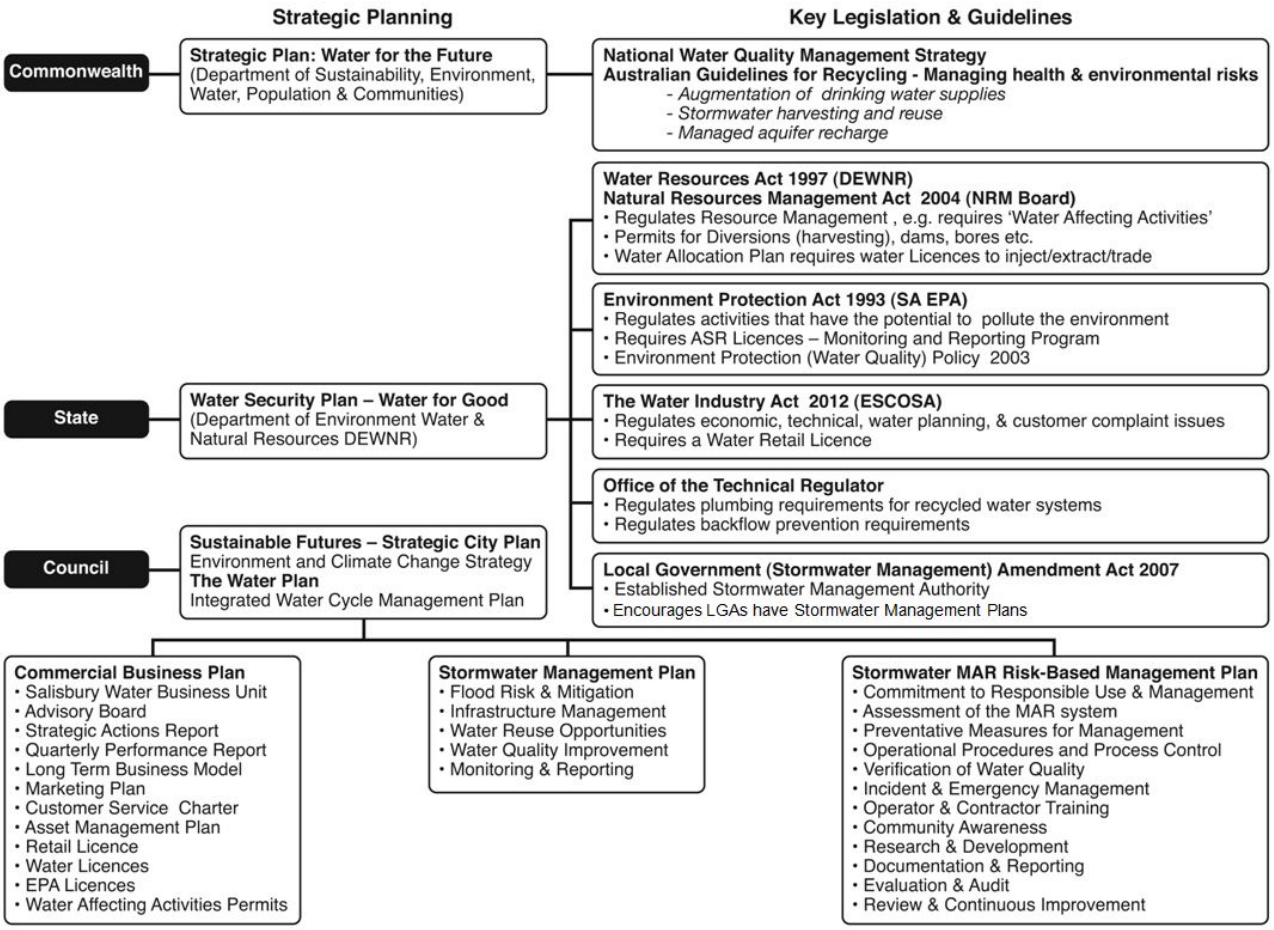

Figure 2 Stormwater MAR risk-based management plan assists City of Salisbury to meet State and Commonwealth strategic plans and legislative and regulatory requirements.

The Parafield scheme stormwater use risk management plan was prepared to cover all of City of Salisbury's responsibilities for:

- The Parafield and Cobbler Creek urban stormwater catchments
- The Parafield stormwater harvesting system including the in-stream basin, holding storage and wetland
- The Parafield ASR system
- The Parafield Aquifer Storage Transfer Recovery (ASTR) system
- The Parafield storage tanks
- Harvested stormwater reticulation system to
    a) The Greenfields Mixing Tank (for blending with recycled water)
    b) Open space irrigation (e.g. school ovals)
    c) Industrial process usage (e.g. Michel's wool processing plant)

This plan covers the stormwater supply side of the Mawson Lakes Recycled Water Scheme and dovetails with SA Water's risk management plan for the treated effluent supply to this scheme. Operational responsibilities of SA Water have not been included, as these are not under the City of Salisbury's control. These include: the recycled water treatment processes and source control measures prior to the Bolivar Dissolved Air Flotation Filtration (DAFF) plant; operation of the Greenfields pump station and mixing tank; the distribution for Mawson Lakes downstream of the mixing tank and non-local government uses of

blended recycled water at Mawson Lakes. Drinking water is used as a backup supply in the event that recycled stormwater or treated effluent is unavailable.

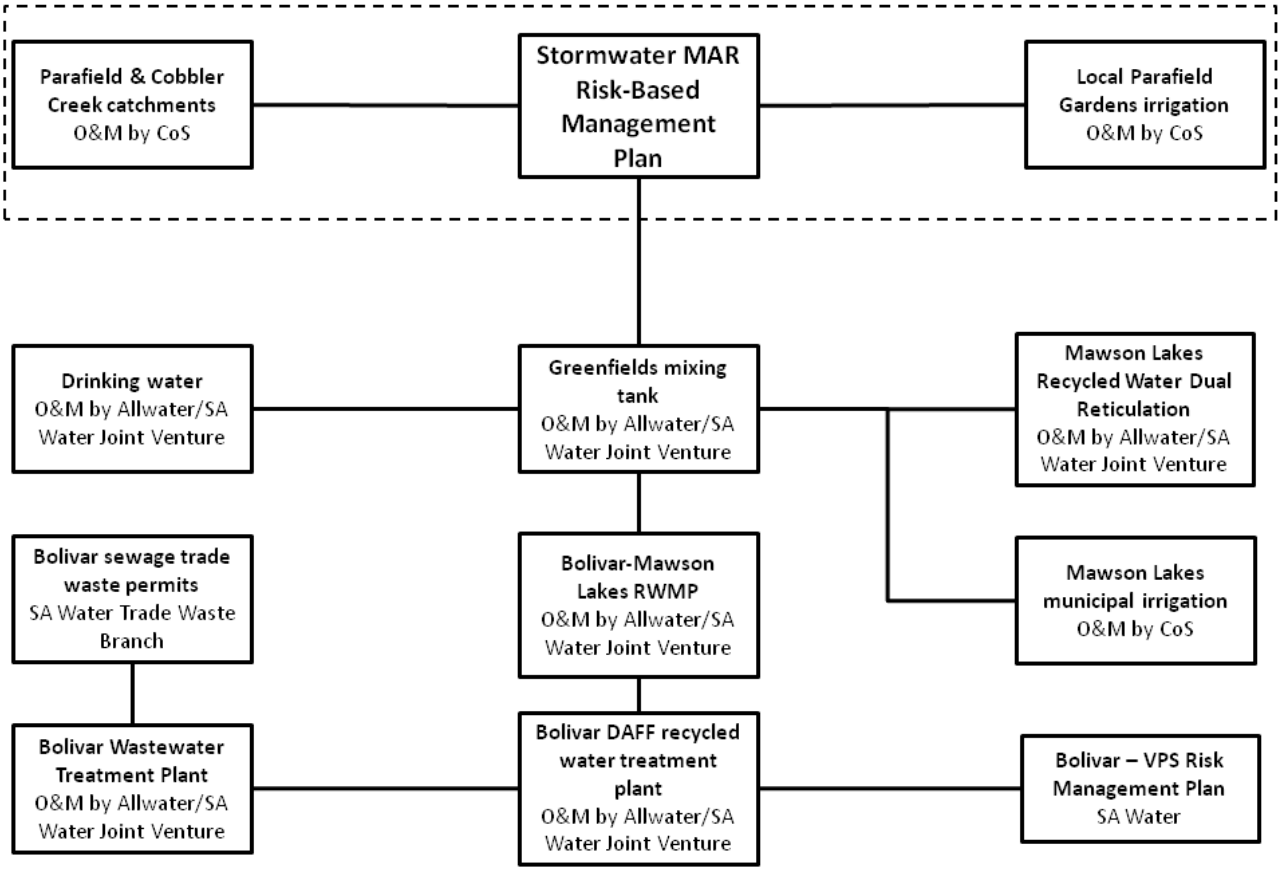

Figure 3 Relationship of this stormwater MAR risk-based management plan to City of Salisbury (CoS), SA Water and Allwater management framework and water supply options. Dashed box indicates the elements covered by this plan.

Overview of scheme

This document refers to four different water types:

1. Recycled stormwater –stormwater that has been harvested and recycled via an aquifer
2. Reclaimed wastewater – treated effluent from the Bolivar DAFF plant
3. Drinking water – potable water for the Adelaide mains distribution system
4. Recycled water – a blend of reclaimed wastewater, recycled stormwater and/or drinking water

Mawson Lakes is a residential and commercial development undertaken by the Mawson Lakes Economic Development Joint Venture. The venture is no longer current but initially consisted of the Land Management Corporation (now known as Renewal SA), Delfin Mawson Lakes and Lend Lease Development. Originally, an agreement was entered into on 19th April 2004 between the Joint Venture, Land Management Corporation, City of Salisbury and the SA Water to provide recycled water sourced from both harvested stormwater and reclaimed wastewater to the development using a dual reticulation system. The main purpose of mixing reclaimed wastewater with recycled stormwater is to dilute the salinity of the product water, thus providing a more sustainable and useful resource.

Operation and maintenance of the Mawson Lakes Recycled Water Scheme is contracted to Allwater on behalf of SA Water. The scheme is located approximately 11 km north of Adelaide, South Australia. The objective of the scheme was to provide over 50% of household water and 100% of public space irrigation

with recycled water. The development supplies recycled water to about 4,000 residences saving approximately 800 ML of mains water including water drawn from the River Murray. The recycled water scheme has been designed to supply residential, commercial and municipal users. The Department of Health and Ageing approved uses include:

- “watering lawns, parks and gardens
- flushing toilets
- washing cars
- filling ornamental ponds (with no fish) and water features
- watering your garden including fruit trees, vegetables and flowers
- washing pets
- evaporative coolers and air conditioners. *(Note: no matter what water source is used, ensure any bleed off does not enter rainwater tanks or drinking water systems)”* (SA Water 2013).

The Mawson Lakes development currently uses drinking water for fire-fighting purposes but this may be reassessed in the future.

Recycled stormwater from the Parafield Stormwater Harvesting Scheme is supplied for industrial use (Michell Wool Pty. Ltd., wool scouring plant), and for open space irrigation of parks and ovals by City of Salisbury. A map of the Parafield scheme and the Mawson Lakes development and their major components (stormwater catchment, Bolivar Wastewater Treatment Plant, Bolivar DAFF plant, DAFF to Greenfields reclaimed wastewater pipeline, Parafield to Greenfields recycled stormwater pipeline and Mawson Lakes) are shown in Figure 4.

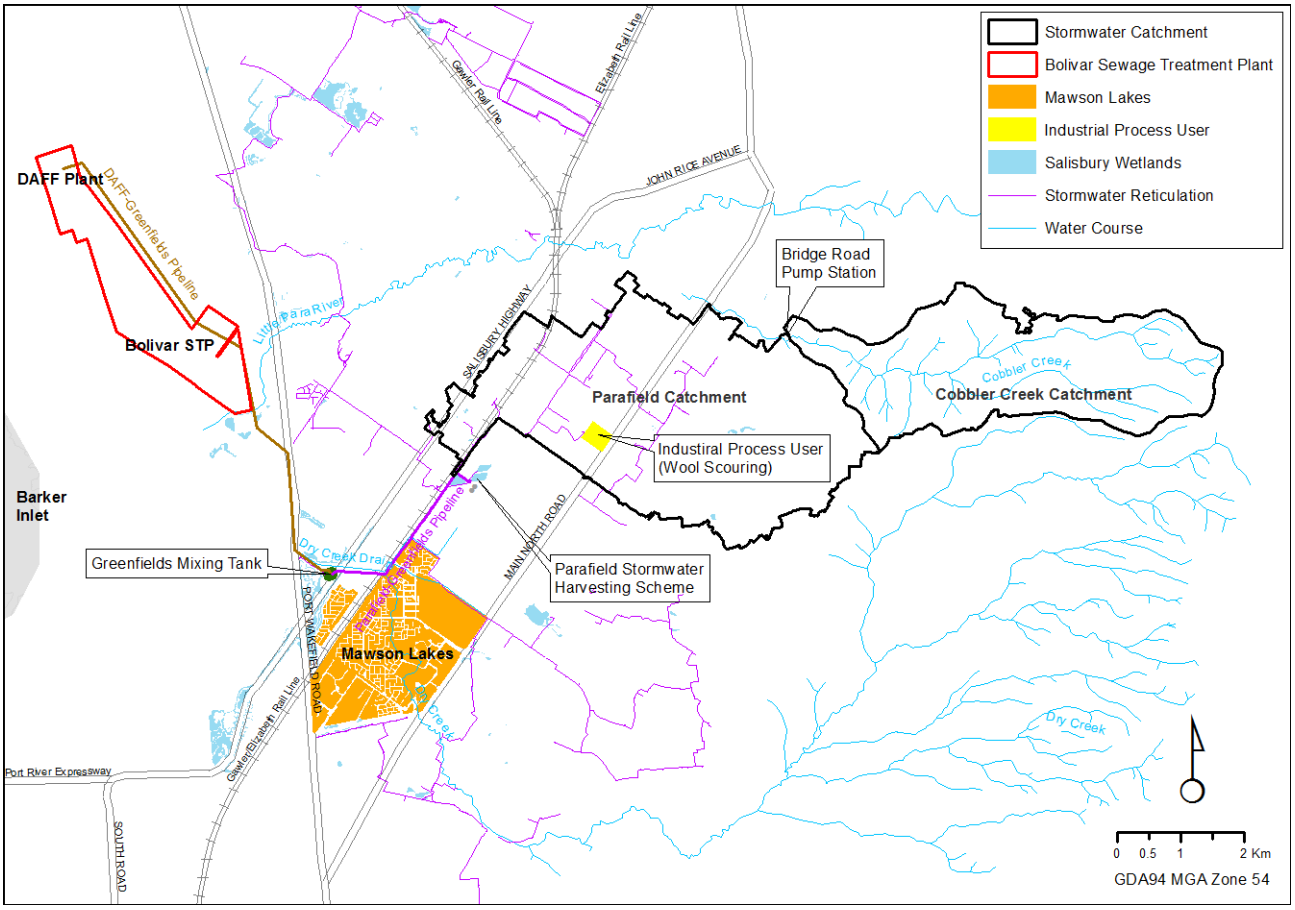

Figure 4 Location of stormwater catchment, Bolivar Wastewater Treatment Plant (WWTP) and DAFF-Greenfields reclaimed wastewater pipeline, Parafield-Greenfields stormwater pipeline and Mawson Lakes.

Figure 4 includes all the components of the Parafield scheme operated by City of Salisbury as well as the SA Water operated Bolivar Wastewater Treatment Plant and recycled water pipelines. This includes the Parafield scheme which contains the gauging station at the Parafield drain, the instream basin and transfer pumps, the holding basin, the wetland, Aquifer Storage and Recovery and Aquifer Storage Transfer and Recovery systems and the Parafield recycled stormwater storage tank. The industrial process user (Michell Wool Pty. Ltd.) is also shown. The numerous parks and ovals irrigated with recycled stormwater from the Parafield scheme are not mapped.

1 COMMITTMENT TO RESPONSIBLE USE & MANAGEMENT OF STORMWATER & RECYCLED WATER

1.1 Responsible use of recycled water

In planning and undertaking the Parafield scheme the following key agencies were consulted:

- Department of Health and Ageing, South Australia (DHA),
- Environment Protection Authority, South Australia (EPA),
- South Australian Water Corporation (SA Water),

The DHA and the EPA were the responsible agencies for potential human health and environmental health requirements, respectively. The DHA has become involved because of the human health risks associated with the treated sewage blended with the stormwater for the Mawson Lakes scheme. The EPA is involved because they manage licences for MAR (i.e. discharge of stormwater to an aquifer) and also oversee the irrigation management plans. The "purple pipe" reticulation network for stormwater only is operated and maintained by the City of Salisbury.

The management, operation and maintenance of the Parafield scheme are undertaken by the City of Salisbury. City of Salisbury also has responsibility for the management of open space irrigation in the Mawson Lakes sub division which is covered under a separate irrigation management plan (Hydroplan 2004). This excludes the maintenance associated with the Parafield to Greenfields delivery pipeline which is owned and operated by SA Water. SA Water has the ability to control the supply and disinfection of the recycled stormwater to the Mawson Lakes scheme as long as a minimum pressure of 240 kPa is maintained in the stormwater system.

Statement of commitment (City of Salisbury Strategic Directions Report 2013)

The City is a leader in integrated water management practices and preservation of open space. The City continues to develop and maintain a diverse range of open space including sportsgrounds, parks, wetlands, linear parks, mangroves and coastline. These open space assets serve a myriad of roles including water catchment, drainage reserves, conservation habitats, recreation, landscape buffers and corridor linkages and are often host to areas of environmental, cultural and heritage significance.

The City has also created a dedicated business unit to deliver recycled stormwater solutions for the community, including a number of industrial and commercial customers. The business unit has the following objective. "The Salisbury Water Business Unit strives to be a sustainable and financially secure business that delivers multiple community benefits through improvement of the urban and ecological environment, without creating unnecessary risks for the Council." Further details, including governance arrangements can be found on the website at:

http://www.salisbury.sa.gov.au/Services/Salisbury_Water/Salisbury_Water_Management_Board

1.2 Regulatory & formal requirements

1.2.1 Legislation, regulations & industry standards

Stormwater harvesting and MAR sites in the City of Salisbury fall within the Adelaide Plains Prescribed Wells Area. Extraction of groundwater requires a licence from the Department of Environment, Water and Natural Resources (DEWNR) in addition to EPA licences to discharge water to underground aquifers (Australian Groundwater Technologies 2011c). Legislation compliance associated with the Parafield Stormwater Harvesting and Mawson Lakes recycled water schemes includes the:

- Pollution of Waters by Oil and Noxious Substances Act 1987
- Environment Protection Act 1993

- Environment Protection (Water Quality) Policy 2003 (under the EP Act 1993)
- Natural Resource Management Act 2004
- Water Industry Act 2012
- Safe Water Act 2012

In addition, the Australian Guidelines for Water Recycling (Phase 1 and Phase 2) are key documents that provide the 'framework for the management of recycled water quality and use' under the National Water Quality Management Strategy (NWQMS, 2013).

1.2.2 Approvals and licences

A licence from the EPA to discharge stormwater to the aquifer requires monitoring and reporting of water at specific points to assess compliance with environmental criteria. This authority is in compliance with the Environment Protection Act 1993 and the Environment Protection (Water Quality) Policy (2003) under the Act. The EPA licence 12983 for the Parafield stormwater harvesting and MAR scheme expired on the 28th February 2013 (see Appendix A). At the time of writing the scheme continues to be operated under the conditions of this licence. The DHA issued approval for certain uses of treated sewage and recycled stormwater to SA Water that remains the responsibility of SA Water to maintain and is not detailed as part of this risk management plan.

1.2.2.1 Human health

DHA approval was granted to SA Water to receive recycled stormwater from the City of Salisbury for supply to the Mawson Lakes scheme via the Greenfields Mixing Tank. Currently the City of Salisbury does not require DHA approval to supply stormwater for industrial uses, or municipal irrigation. A summary of the DHA approval conditions and incident and emergency criteria and their relevance to the City of Salisbury's Parafield stormwater recycling scheme are given in Table 1 and Table 21.

Table 1 Summary of SA Water DHA approval conditions (July 2012) relevant to use of City of Salisbury recycled stormwater in the Mawson Lakes recycled water scheme.

Condition	Description	Responsibility	Comment
Recycled stormwater			
2	Recycled stormwater from the Parafield Drain is to be provided by the City of Salisbury from the Parafield Stormwater Harvesting Scheme. Minimum stormwater treatment requirements are to be sequential passage through a 49 ML in-stream basin, 49 ML holding storage and 1.95 hectare reed bed. After treatment, water may be stored in the T2 aquifer prior to supply.	City of Salisbury	
3	Automatic monitoring of turbidity of water at pump station 1 located at the in-stream basin is to be maintained and subject to continuous monitoring with a remote alarm system. If turbidity exceeds 100 NTU transfer from the basin is to be stopped until turbidity falls below 100 NTU.	City of Salisbury	It is recommended this criterion be revised to include visual inspection procedures performed by City of Salisbury (see Section 3.1.1).
4	The catchment system is to be subject to a *Stormwater Quality Management Program* operated by the City of Salisbury. The open drain and Parafield pond system is to be protected from contamination by faecal material from humans and livestock. The pond system is to be protected by fencing and bird-proof netting.	City of Salisbury	
5	The chemical and physical quality of harvested stormwater supplied to the Mawson Lakes Recycled Water Scheme is to comply with requirements of the Environment Protection Authority (EPA) for supply of water from the Parafield Stormwater Harvesting Scheme to the T2 aquifer, refer Appendix B.	City of Salisbury	
6	Recycled stormwater (prior to chlorination) is to contain a median concentration of less than 100 *E. coli* per 100 mL. Monitoring (verification) is to be undertaken on a weekly basis.	Allwater	SA Water (Allwater) monitor weekly for *E. coli*, Cl, NH_2Cl, Fe, Mn, colour, temp., TDS, conductivity at the stormwater inlet to Greenfields Mixing Tank (sampling point SP14026).
7	Recycled stormwater supplied by the City of Salisbury is to be chlorinated after mixture with Bolivar reclaimed wastewater at a point prior to the Greenfields Balance Tank. Chlorination is to achieve a minimum free chlorine residual of 0.2 mg/L. Flow to the Greenfields Tank is to be stopped if the chlorinator falls to less than 0.2 mg/L for more than 60 minutes continuously. Operation of the chlorinator and achievement of the minimum free chlorine residual are to be subject to continuous monitoring with a remote alarm system.	Allwater	Operations by Allwater.
Recycled water system - uses			
8	Recycled water (mix of reclaimed water and recycled stormwater) can be provided for non-potable use including toilet flushing, garden watering, car washing and filling ornamental ponds. It is not to be used for any other internal uses including drinking, cooking, clothes washing, personal washing and showering and indoor cleaning. It is also not to be used in evaporative coolers, swimming pools or spa pools.	City of Salisbury/ SA Water	City of Salisbury have the option of filling ornamental ponds with recycled product water. This was done initially, but now ponds are augmented with groundwater from the T2 aquifer.
10	Recycled water can be provided for municipal (open space) irrigation and additional sites can be incorporated with agreement from the Department of Health and Ageing. Subject to approval from the Department, recycled water may also be provided for industrial (non-potable) use.	City of Salisbury	Operated by City of Salisbury.
Community Education			
18	General signage should be erected indicating that recycled water is used in the Mawson Lakes area.	City of Salisbury	Completed and checked by City of Salisbury annually.

Condition	Description	Responsibility	Comment
Reporting to the Department of Health and Ageing			
21	An annual report on the use of recycled water in accord with this approval and including monitoring results is to be provided by 30 September each year (for the period 1 July to 30 June) to the Minister for Health and Ageing (c/-Public Health, SA Health).	SA Water	
General			
22	Pursuant to the Public and Environmental Health (Waste Control) Regulations, the Department of Health and Ageing reserves the right to revoke all or any of the approval conditions and require the repair, replacement, rectification, or alteration of the system or part thereof: 22.1. At any time should the system or component thereof not be manufactured, installed and/or operated in accordance with the approval conditions; or 22.2. At any time the system is defective and not able to perform the function for which the approval is issued; or 22.3. At any time it is operated in a manner that is prejudicial to public and environmental health or raises environmental nuisance.	SA Water/City of Salisbury	
23	In regards to compliance and inspection: 23.1. Non-compliance with incident criteria listed in the Water/Wastewater Incident Notification and Communication Protocol are to be reported to agencies as per the specified timelines (refer Appendix A); or 23.2. Non-compliance with any other approval condition is to be rectified immediately and is to be reported to the Department as soon as practicable and within 24 hours or the failure being detected 23.3. The Department reserves the right to inspect the treatment of recycled water at any time.	SA Water/City of Salisbury	

1.2.2.2 Environment

The EPA granted the City of Salisbury a licence to allow aquifer injection activities to occur at the Parafield Stormwater Harvesting System. Licence conditions are set out in EPA Licence No. 12983 and include:

- Discharge of stormwater to the aquifers
- Water quality requirements of the discharge
- Protecting aquitards, surrounding aquifers and water bodies
- Water quality monitoring and reporting to the Authority.

Some examples of the licence conditions are listed in Table 2, the full licence is given in Appendix A.

Table 2 Examples of EPA conditions for the Parafield ASR scheme (EPA Licence No. 12983).

#	Description
101-7	2. that water discharged to the aquifer is of a higher quality than the unpolluted ambient groundwater quality as specified in the document entitled 'Parafield USI Ambient Groundwater, T2-Well No1, Well No.6628-20328' and attached to this licence as Attachment 1.
101-56	2. ensure that confining layers are not damaged; . 3. ensure that there are no adverse effects on aquifers or water bodies; 4. ensure that the activity does not affect the level of the watertable at any property beyond the Premises;
330-18	1. provide the Authority with the results of all analysis carried out in accordance with conditions of this licence at the completion of each sampling period; and 2. forward the analytical results to the Authority within 14 days of the Licensee's receipt of the results from the testing organisation.

The ambient groundwater quality report is attached to EPA Licence 12983. Results of over 85 different water quality parameters are shown including physical, inorganic and organic chemicals and microbiology.

Within the explanatory notes of the Licence, Item 6 states (see Appendix A):

'The licensee must be aware of, and comply with:

1.1 the requirements of the Environment Protection Policies which operate pursuant to the Act; and

1.2 the requirements of any National Protection Measure which operates as an Environment Protection Policy under the Act.

2. These requirements govern permissible procedures and protocols, emission or concentration levels, as well as operation and/or maintenance standards of plant and equipment.'

Other more recently issued EPA Licences for similar ASR operations define more clearly the permissible concentration levels for injectant water quality are. The City of Salisbury assess against the water quality criteria defined in the Environment Protection Policy (Water Quality) 2003 and it is not clear how this affects condition 101-7 (Table 2; Appendix A).

1.2.3 Agreements and contracts

The following key documents were central to the development and current operation of the Parafield scheme:

- Commitment to meet 'fit for purpose' values in the Australian Guidelines for Water Recycling (NRMMC-EPHC-AHMC 2006).
- Variation to the DHA approval for the Mawson Lakes Recycled Water Scheme including provisions for the supply of recycled stormwater to the scheme.

- Stormwater Supply Agreement between City of Salisbury and SA Water.
- Stormwater supply agreements between City of Salisbury and industrial users, and
- Stormwater supply agreements between City of Salisbury and schools

Informal communication protocols between the City of Salisbury, SA Water and Allwater in relation to stormwater quality and particularly *E. coli* results from Greenfields Mixing Tank inlet (SP14026) are updated as required. Each organisation agrees to keep each other informed regarding any changes which could affect water quality.

1.2.4 Scheme roles and responsibilities

1.2.4.1 City of Salisbury

The City of Salisbury is the asset owner and operator of the:

- Parafield Stormwater Harvesting Scheme including:
    - Parafield drain
    - In-stream basin & transfer pumps
    - Holding basin
    - Engineered wetland
    - Balance tank & distribution pump station
    - ASR production wells, observation wells & pumps within Parafield Stormwater Harvesting System
    - ASR/ASTR production wells, observation wells, pumps & pipe work within Parafield Gardens
    - Stormwater recycled water pipeline (excluding the Parafield to Greenfields pipeline system)
- Sir Douglas Mawson and Shearwater Lakes systems, and
- Municipal open space irrigated areas & irrigation equipment in public spaces

1.2.4.2 SA Water

SA Water is the asset owner of the:

- Parafield to Greenfields pipeline system (limited to the recycled stormwater pipeline known as the Parafield-Mawson Lakes pipeline, City of Salisbury owns the pump and controls pertaining to this pipeline).
- Greenfields Mixing Tank and Recycled Water Facility
- Mawson Lakes recycled water supply, and
- Mawson Lakes recycled water distribution network.

SA Water is responsible for the management of these areas, which includes the monitoring of performance requirements of recycled water quality and supplied pressures as obligated under the respective agreements. SA Water has accountability for compliance with the DHA approval conditions for the recycled water scheme. SA Water is also responsible for the management of final stage plumbing and cross connection auditing of residential and commercial properties in the Mawson Lakes development. As of January 2013, The Office of the Technical Regulator is responsible for the first stage of in-ground and second stage of in-wall plumbing inspections.

1.3 Partnerships & engagement of stakeholders

A comprehensive Communications Strategy was developed for the Mawson Lakes scheme in July 2004 (Mawson Lakes Economic Development Project: Reclaimed Water Scheme – Communications Strategy, LMC *et al.*, 2004). This strategy was prepared by Land Management Corporation for the Mawson Lakes scheme, in conjunction with City of Salisbury, the Mawson Lakes Joint Venture and the SA Water. At that time (2004) the communications strategy listed a number of stakeholders to be considered.

Supplementary to this work, City of Salisbury identified the key audiences for post-commissioning communications to be:

- Industrial users of harvested stormwater
- SA Water Board
- Mawson Lakes residents (including Mawson Lakes Residents Association), businesses & property owners
- Plumbers – Plumbing Industry Association & Master Plumbers Association
- Building industry – including Master Builders Association, Housing Industry Association
- State Government – in particular Ministers responsible for SA Water, Land Management Corporation and DEWNR.
- Key Stakeholders – Department of Environment, Water and Natural Resources, Renewal SA, EPA, DHA, Delfin Lend Lease, University of South Australia, Technology Park
- Visitors to Mawson Lakes, and
- Media.

A list of engagement mechanisms that allow on-going impacts of the MLRWS to be monitored are shown in Table 3.

Table 3 Methods used to monitor ongoing impacts to the Parafield Stormwater Harvesting System.

Engagement mechanism	Area(s) covered	Responsible agency	Available/issued to
City of Salisbury website http://www.salisbury.sa.gov.au/Our_City/Environment/Water/Salisbury_Water	Harvested stormwater information	City of Salisbury	Public
Mawson Lakes Community website http://www.mawsonlakes.com.au/	Recycled Water Information Sheets	Lend Lease	Public - Information sheets are downloadable from this internet site.
Reports	Parafield scheme operational reporting – annual monitoring program & results (Department of Health and Ageing conditions of approval).	City of Salisbury	Separate reports provided annually for Parafield ASR & ASTR systems.
	Environmental reporting as set out in the Mawson Lakes Irrigation Management Plan	City of Salisbury	This provided as part of the Mawson Lakes annual monitoring programme & results report.
	Incident & emergency reporting	SA Water (as appropriate)	Notifies relevant agencies in accord with the EPA & DHA notification & communication protocol.
	Property plumbing audit report	SA Water	A copy is provided to the recycled water customer at the completion of a plumbing audit.
	Self audit property plumbing audit report	Mawson Lakes residents	Customer asked to call SA Water if any 'no' answers occurred.
Meetings	City of Salisbury operational areas (refer Section 4 for other operational meetings undertaken by City of Salisbury)	City of Salisbury/SA Water	Twice yearly operation committee meeting is convened between City of Salisbury & SA Water senior management, where stormwater issues can be tabled.
Phone calls, Emails	Incident &emergency reporting	City of Salisbury, Allwater, SA (as appropriate)	Notifies relevant agencies, in accord with the DHA notification & communication protocol.

1.4 Recycled water policy

City of Salisbury's position on the provision of harvested stormwater is described on the City of Salisbury website (2009). The following links provide detailed information.

http://www.salisbury.sa.gov.au/Our_City/Environment/Water/Water_Recycling

http://www.salisbury.sa.gov.au/Services/Salisbury_Water

2 ASSESSMENT OF THE STORMWATER USE SYSTEM

In the management of risks in a stormwater catchment, an initial key objective was to collect information about the stormwater catchment for hazard analysis followed by risk assessment to enable identification of risk management options to mitigate the risks. An intimate knowledge of the stormwater catchment as well as the characteristics and operation of the harvesting and reuse system and end user requirements are critical for effective risk management.

2.1 Source of stormwater, intended uses of recycled product water, receiving environments & routes of exposure

2.1.1 Source water

Stormwater is harvested from the Parafield catchment through a diversion weir on the Parafield Drain. Runoff from the Cobbler Creek catchment is periodically pumped via the Bridge Road pump station on Cobbler Creek into the Parafield catchment to enhance catchment yield. Harvested water then passes through a series of two detention basins (in-stream, holding) and a constructed wetland prior to pressurised injection into the Parafield ASR or ASTR schemes into the T2 aquifer. Stormwater recovered from the aquifer is then pumped into two above ground storage balancing tanks adjacent the Parafield wetland from where it is distributed via dual reticulation for restricted municipal irrigation, industrial process use and supply to the Mawson Lakes Recycled Water Scheme via the Parafield-Greenfields pipeline (Figure 4).

The ASR system consists of 2 wells which are used interchangeably for both injection and recovery. The minimum residence time in the aquifer (time between injection and recovery) depends on operational schedules but historically has been around 28 days (Kremer *et al.*, 2010). The ASTR scheme (after initial site conditioning and development of fresh water plume) uses 4 outer wells dedicated to injection and only recovers water via either of 2 inner recovery wells. Minimum residence time, depending upon operation has been modelled at ~250 days between injection, transport and recovery (Kremer *et al.*, 2010).

The Parafield stormwater catchment (Figure 5) has an area of 1,590 ha and is primarily urban (73%). It is composed of mainly residential (36%) but also has vacant land (13%) and industrial areas (8%). Roads and rail lines account for 19% of the catchment area. A major rail line runs along the western side of the catchment. The industrial areas include a pharmaceuticals factory, wool processing plant, a dairy processing facility and a beverage manufacturing factory and a variety of small to medium metal and cement manufacturing industries. Sand quarries occupy 5% of the catchment. A variety of commercial properties (5%) are also found including a number of automotive service and repair businesses and numerous warehousing facilities. There are also a number of small market garden horticultural properties and one livestock grazing paddock adjacent the harvesting off take point. 'Recreational' land uses include mainly sports fields and 'institution' includes libraries and local government buildings.

The Cobbler Creek stormwater catchment (Figure 5) has an area of 1,017 ha and features a major water course (Cobbler Creek) that essentially defines the system as most runoff from this catchment drains to the creek with the rest flowing onto the Parafield catchment. Cobbler Creek features a dam that was built for flood mitigation purposes and whose operation is managed by the City of Salisbury. This dam collects water that can be released and pumped into the Parafield catchment if additional yield for the system is required. The Cobbler Creek catchment is predominantly a rural catchment (62%) and the urban component is mainly residential properties (22% of the catchment). Only 1.2% of the catchment is zoned as industrial or commercial. Sand and clay quarries occupy a large area of the catchment (16%). Roads account for 12% of the catchment area. A number of livestock (mainly sheep) production and horticultural properties exist in the east (11% area). There are also a number of unsewered rural residential properties (11%) with on-site waste water treatment systems (septic tanks). Some of these rural residential zoned properties were observed to have domestic livestock including horses and catteries. Three sewage pump stations are located within 35 m of Cobbler Creek, one adjacent to Middleton Crescent, another adjacent to Buryan Crescent, and another adjacent to Lachlan Street.

The Mawson Lakes Scheme sources its recycled water from a mix of reclaimed wastewater and recycled stormwater. The reclaimed wastewater is sourced from the Bolivar Recycled Water Treatment Plant, which has its source of supply from a large municipal treated sewage plant (Bolivar Wastewater Treatment Plant) (SA Water, 2012). The recycled stormwater is pumped directly from the Parafield storage tanks via a dedicated pipeline to the Greenfields Mixing Tank. This is stormwater that has passed through the detention basins and engineered wetland and has undergone ASR or ASTR. The hydrology and hydrogeology of the system are summarised in Sections 2.2.3 and 2.2.4

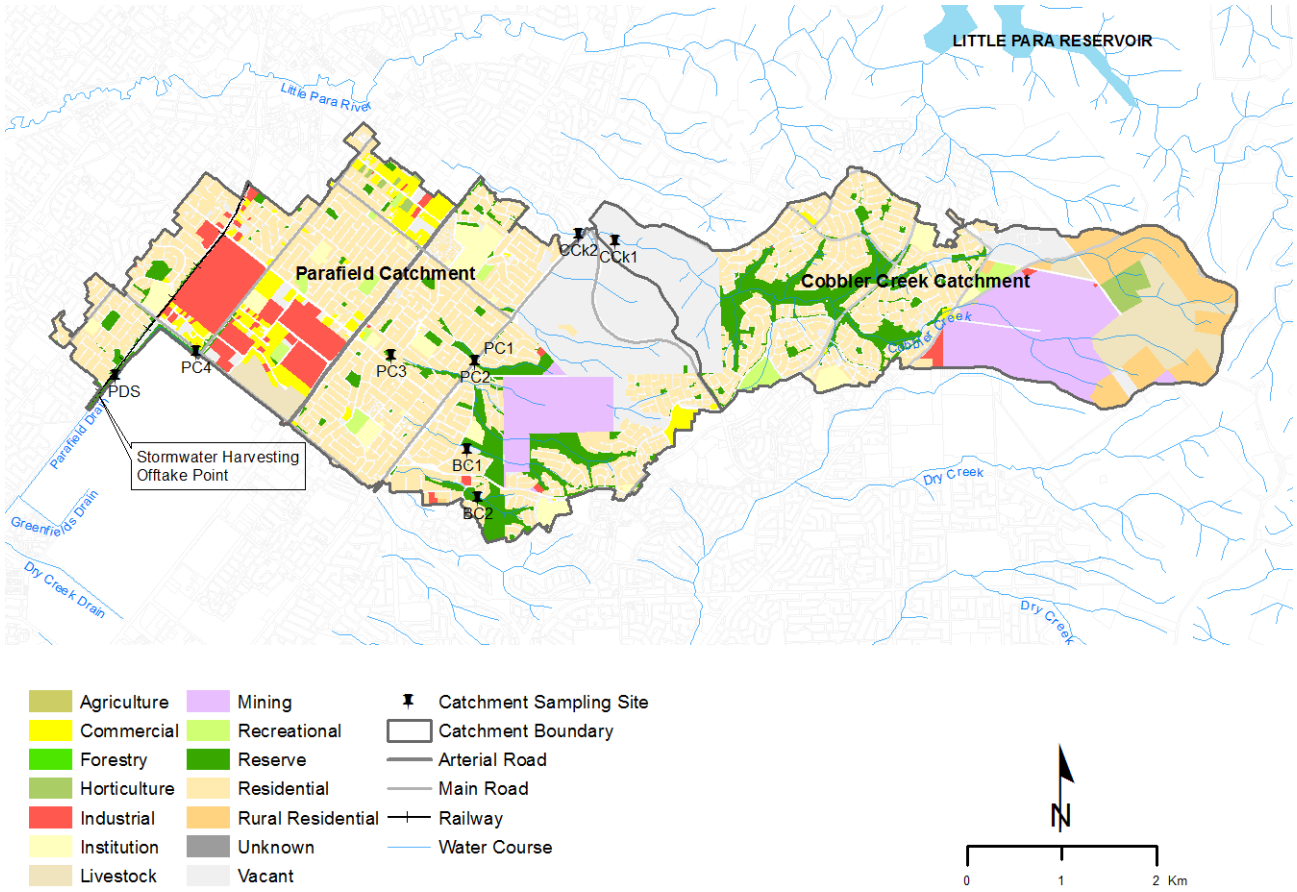

Figure 5 Parafield and Cobbler Creek stormwater catchment land uses related to the Parafield Stormwater Harvesting Scheme and locations of catchment sampling sites (Table 12).

2.1.2 Intended uses

A summary of intended uses of stormwater and recycled product water is listed in Table 4. SA Water's Treatment Group maintains a registry of the DHA's approvals of reuse for individual users for the Mawson Lakes Recycled Water Scheme. It is important to note that recycled water is not permitted for fire-fighting use at this time. However, this exclusion was not a DHA requirement. The DHA does not approve the following uses of non-potable water:

"Drinking, cooking or kitchen use (such as rinsing vegetables), clothes washing, personal washing, household cleaning, swimming pools or spas, recreational activities involving water (including children playing under sprinklers)" (SA Water 2013).

Table 4 Approved stormwater & recycled water use activities.

Use	Types of water			Type of activity
	Mains Water	Stormwater	Treated Sewage	
Municipal (open space) irrigation	X	X	X	Drip or spray irrigation confined within designated areas and times.
Municipal irrigation	X	X		Reserves in Parafield Gardens
Industrial non-drinking	X	X		Use for industrial processes (e.g. wool washing).
Residential non-drinking (through supply agreement with SA Water to Mawson Lakes Scheme)	X	X	X	• Toilet flushing • Garden watering (fruit trees, vegetables and flowers) • Car washing • Washing pets • Filling ornamental ponds (with no fish) and water features

2.1.2 Receiving environments

Receiving environments are listed in Table 5 and are limited to those which could experience longer term impacts. Environments that receive water through distribution of recycled stormwater or treated sewage are included. The management of the exposure of the receiving environments is governed by the Mawson Lakes irrigation management plan (Appendix E).

Table 5 Summary of the receiving environments of recycled stormwater.

Receiving environment	Details
Soils	Those located within the Salisbury & Mawson Lakes recycled water district
Plants and grasses	As used in residential gardens, landscaping & open irrigated areas (e.g. parklands, school ovals)
Ground waters	Local shallow watertable
	T2 aquifer currently used for ASR/ASTR purposes at Parafield
Engineered wetlands (within & in the vicinity of)	Parafield Airport Wetland, Greenfields Wetlands (Stages 1, 2, 3 – via intersection of Parafield Drain & Dry Creek near Stage 2 inflow point).

2.1.3 Routes of exposure

Based on the Australian guidelines for water recycling (NRMMC-EPHC-AHMC 2006), the Parafield stormwater harvesting scheme's exposure pathways may result from intended and unintended uses.

Table 6 and Table 7 examine the possible routes of exposure for human health, the environment and infrastructure considerations for the recycled stormwater and the recycled stormwater blended with treated sewage. Environmental considerations are mainly limited to the conditions associated with supply and distribution. Preventative measures including critical control points (CPPs) are also listed.

Table 6 Routes of exposure for human health considerations for the recycled stormwater scheme.

Water type	Groups Impacted	Exposure Locations	Exposure Routes	Exposure Events	Preventative Measure
Recycled Stormwater	• Users, passersby of municipal areas irrigated with recycled stormwater	• Municipal irrigation	• Ingestion, inhalation, dermal	• Accidental misuse (e.g. drinking), accidental inhalation/absorption of spray drift	• Signage on all recycled water systems • Lilac piping on all recycled water systems • Night time irrigation to minimise potential public exposure
Recycled Stormwater	• Industry workers exposed to recycled stormwater	• Factory process lines	• Ingestion, inhalation, dermal	• Accidental inhalation/absorption of water (spray, vapour)	• Factory specific Health and Safety procedures and additional water treatment • Factory specific training • *Occupational Health & Safety Act*
Recycled Stormwater / Treated Sewage	• Water carting operators	• Water trucks, filling stations	• Ingestion, inhalation, dermal	• Accidental inhalation/absorption of water (spray, vapour)	• Signage on all recycled water systems • Lilac piping on all recycled water systems • Approval issued by the DHA to carry and use water for approved uses (irrigation, washing buildings, to a tank on a property with backflow prevention) • Subject to a separate approval for each operator
Recycled Stormwater / Treated Sewage	• Residents in dual reticulation areas (Mawson Lakes Recycled Water Scheme)	• Homes and gardens	• Ingestion, inhalation, dermal	• Accidental misuse (e.g. drinking, cross-connection with potable mains), deliberate misuse (e.g. filling swimming pool with recycled water) • Accidental inhalation/adsorption of water spray	• Signage on all recycled water systems • Lilac piping (P23) on all recycled water systems • Plumbing codes (Water Industry Act 2012) • Plumbing education • Public education

Note: All Stormwater is harvested through an aquifer. Some information adapted from NRMMC-EPHC (2006). Deliberate and accidental misuse examples as listed on p.90 in (NRMMC-EPHC-AHMC, 2006).

Table 7 Routes of exposure for environmental considerations for the recycled stormwater scheme.

Water Type	Environmental Endpoint	Hazard	Exposure Routes	Potential Effects or Impacts	Preventative measures
Recycled Stormwater	• Soils in Salisbury,	• Hydraulic loading, nutrients	• Irrigation	• Water-logging, nutrient imbalance, pest & disease, eutrophication	• Irrigation management plan (Hydroplan, 2004)
Recycled Stormwater / Treated Sewage	• Soils in Salisbury, Mawson Lakes Recycled Water Scheme areas	• Hydraulic loading, nutrients	• Irrigation	• Water-logging, nutrient imbalance, pest & disease, eutrophication	• Irrigation management plan (Hydroplan, 2004)
Recycled Stormwater	• Wetlands (Parafield, Greenfields)	• Suspended solids, heavy metals, nutrients, pharmaceuticals	• Storage, passage	• Health of biota (e.g. fish, birds, plants)	• Water quality controls (e.g. salinity CCPs)
Recycled Stormwater	• Groundwater (T2 aquifer, local water table)	• Organic chemicals, nutrients	• Injection, infiltration	• Health of biota (e.g. stygofauna, groundwater dependent ecosystems)	• Water quality controls (e.g. turbidity CCPs)
Recycled Stormwater / Treated Sewage	• Groundwater (T2 aquifer, local water table)	• Organic chemicals, nutrients	• Injection, infiltration	• Health of biota (e.g. stygofauna, groundwater dependent ecosystems)	• Water quality controls (e.g. turbidity CCPs)
Recycled Stormwater	• Plants (grasses, trees)	• Hydraulic loading, salinity	• Irrigation	• Poor water quality; excess/insufficient nutrients, contamination (e.g. pesticides), excess salinity • Basin scrapings.	• Irrigation management plan (Hydroplan, 2004)
Recycled Stormwater / Treated Sewage	• Plants (grasses, trees)	• Hydraulic loading, salinity	• Irrigation	• Poor water quality; excess/insufficient nutrients, contamination (e.g. pesticides), excess salinity • Basin scrapings.	• Irrigation management plan (Hydroplan, 2004)

Note: Based on Table 4.2 on p. 130 in NRMMC-EPHC-AHMC (2006).

2.2 System analysis

2.2.1 Layout & process schematic

The configuration of the Parafield stormwater component relative to the Mawson Lakes supply system is shown in Figure 6.

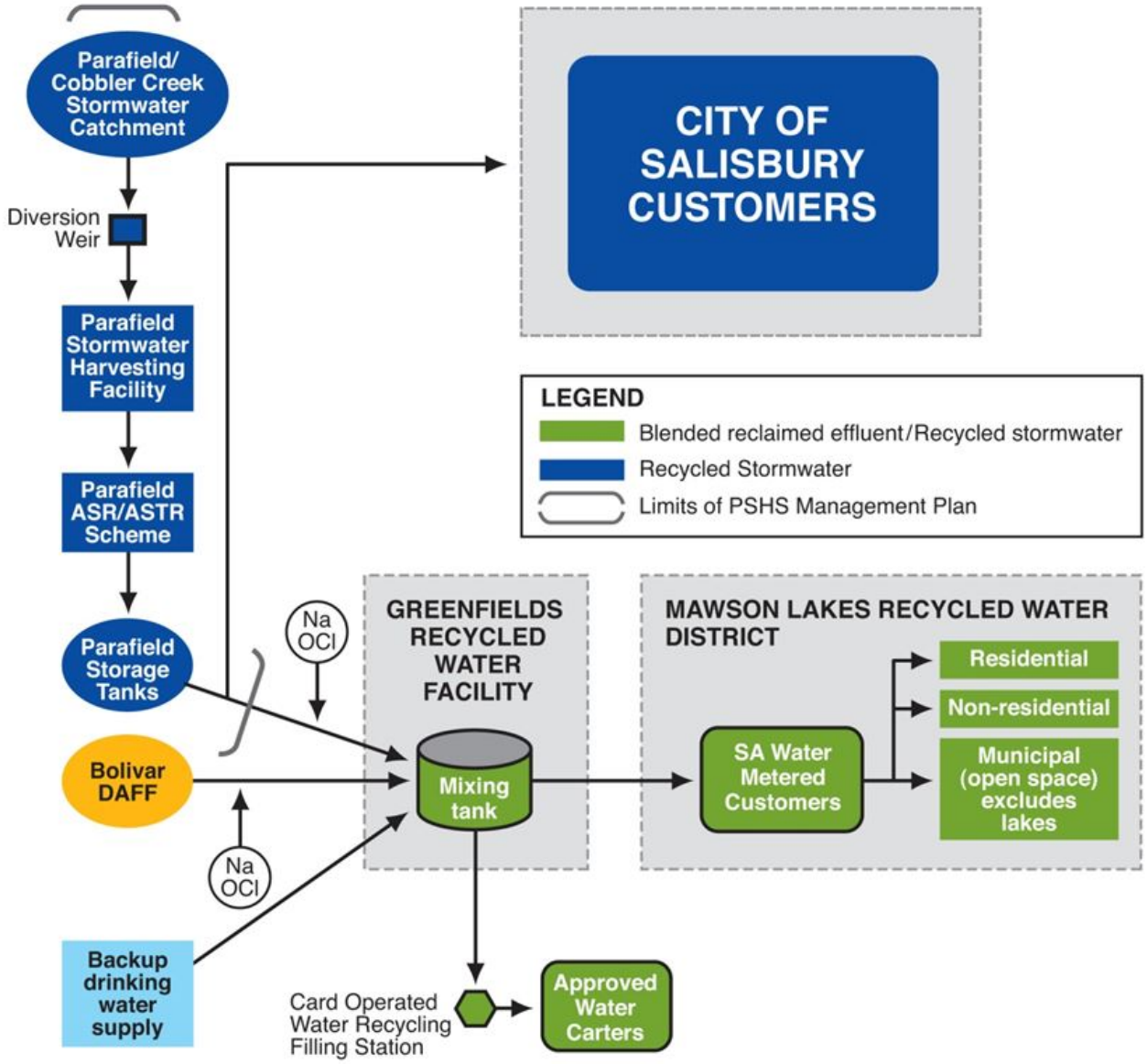

Figure 6 Schematic layout of the Parafield recycled stormwater water system.

Figure 7 Parafield recycled stormwater distribution pipeline (purple line), sampling points at inlet to Greenfields Mixing Tank (SP14026) and Michell Wool (MW1). Parafield-Greenfields Pipeline is a dedicated pipeline from the Parafield header tanks to the Greenfields Mixing Tank.

Figure 7 shows the Parafield stormwater harvesting system distribution pipeline sampling points. Sampling point SP14026 is a tap on the stormwater inlet line located prior to the chlorinator at the Greenfields Mixing Tank. Sampling point MW1 is a tap on the stormwater distribution pipeline inside a lockable enclosure located on Rundle Road Reserve adjacent Michell Wool Pty. Ltd.

Figure 8 Parafield stormwater harvesting system layout showing scheme sampling points.

An aerial view of the Parafield stormwater harvesting structures, ASR and ASTR components and sampling points throughout the scheme are annotated in Figure 8. A schematic piping and instrumentation diagram is given in Figure 9 and an example SCADA screen is shown in Figure 10.

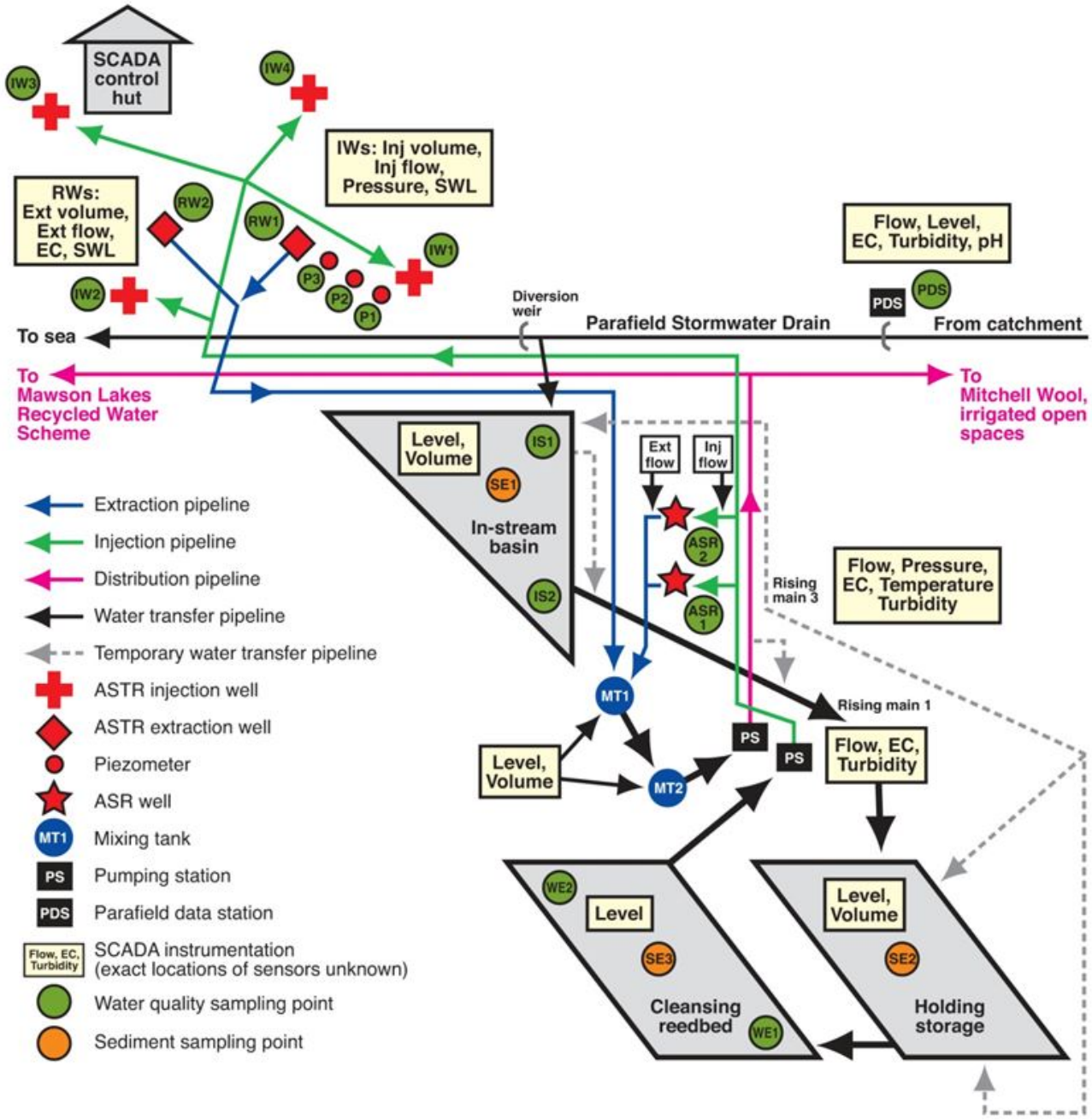

Figure 9 Piping and instrumentation diagram for the Parafield Stormwater Harvesting Scheme.

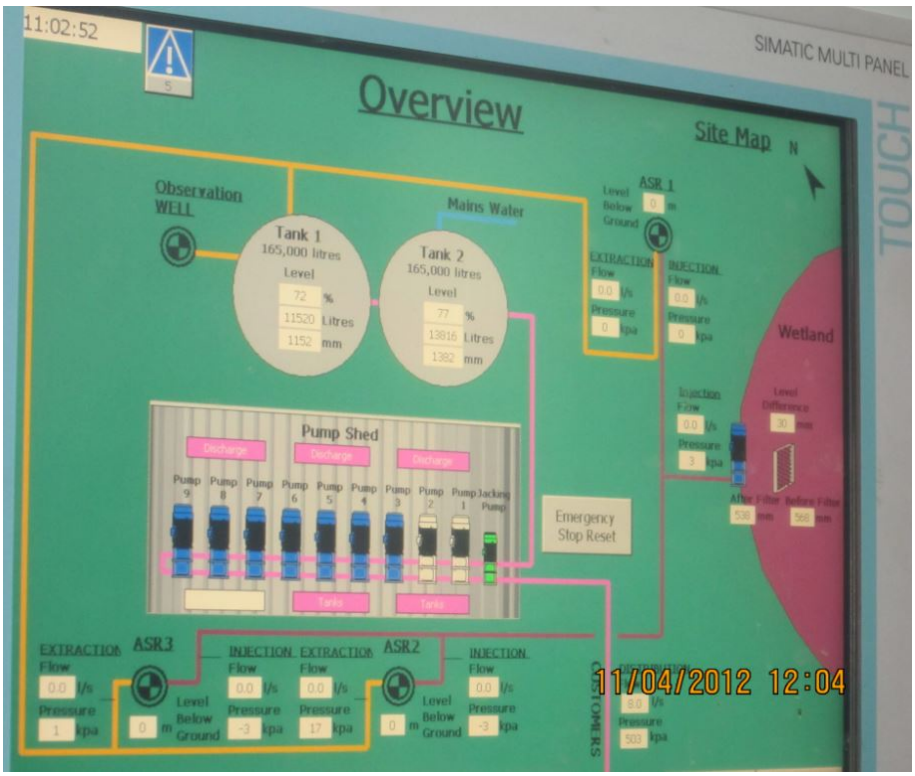

Figure 10 Example of SCADA operations overview screen.

2.2.2 In-stream basin, holding basin & constructed wetland

The in-stream and holding basin each have a capacity of 50 ML and are lined with a 2m thick layer of compacted clay. Residence times in the in-stream and holding basins varies with system use. The constructed wetland has an area of 2 ha and a capacity of 25 ML and is planted with seven different species of macrophytes in rows perpendicular to flow. The composition of the reed bed is dominated by *Phragmites australis*. Water depth (volume) is maintained above 7.5 ML (to maintain the health of the vegetation). The designed minimum residence time in the wetland is 7 days but varies with use (Swierc *et al.*, 2005) and is historically around 10-12 days (Page *et al.*, 2008). Part of the DHA approval conditions for the Parafield scheme is that the basins and wetland are protected from faecal contamination by humans and wildlife through fencing and bird proof netting. Bird-proof netting also reduces risks of bird-strike incidents at the Parafield Airport (Marks *et al.*, 2005).

2.2.3 Stormwater availability

The Parafield and Cobbler Creek stormwater catchments, Parafield airport wetlands and ASTR and ASR sites are located in the Dry Creek and Cobbler Creek hydrological catchment which is part of the Torrens River Basin. The Parafield stormwater catchment has an area of 1,590 ha and topographically is generally westerly sloping with a shallow gradient. The Cobbler Creek stormwater catchment has an area of 1,017ha and has a greater topographic relief than Parafield also sloping to the west and features a major water course (Cobbler Creek). The Cobbler Creek Catchment has been modified to drain into the Little Para River but water is transferred via a pump to the Parafield catchment.

From January 2003 to December 2011 the annual rainfall at the Parafield Airport weather station (station 23013, latitude 34.80 □S longitude 13
annual rainfall received from 2006-2008 was significantly lower than the annual average of 453 mm (Table 8). Initial hydrological modelling suggested an average annual runoff volume of 1497 ML from the combined Parafield and Cobbler Creek catchments and a harvestable annual volume of 1025 ML (Myers *et al.,* 2013).

On average 878 ML/yr was captured by the Parafield stormwater harvesting system between 2003 and 2011, varying between 500 ML in 2006 with minimum rainfall to 1,462 ML in 2009 with a return to above average rainfall and the addition of harvesting from Cobbler Creek catchment.

Table 8 Annual rainfall and volumes harvested in Parafield catchment from 2003 to 2011.

Year	Rainfall (mm)	Harvested volume Parafield [1] (ML)	Volume transferred from Cobbler Creek (ML)	Harvested volume over catchment (ML)	% rainfall harvested [2]
2003	445	422	0	422	4
2004	440	857	0	857	7
2005	456	1,034	0	1,034	9
2006	259	500	0	500	7
2007	380	749	0	749	8
2008	329	677	0	677	8
2009	475	1,187	275	1,462	12
2010	483	1,097	206	1,303	10
2011	470	856	41	897	7
Mean	**415**	**820**	**174***	**878**	
Total	**3,738**	**7,379**	**521**	**7,900**	

Based on: [1]volume recorded pumped to holding storage; [2]combined total catchment area of 2,607 ha for Parafield and Cobbler Creek ; * mean of 3 years operation.

2.2.4 ASR and ASTR hydrogeology and infrastructure

2.2.4.1 Hydrogeological setting

The target aquifer for the Parafield ASR and Parafield Gardens ASTR is a confined limestone Tertiary aquifer approximately 60 m thick, known as the T2 aquifer, which can be divided into three units called T2a, T2b and T2c (Gerges, 2005) (see Table 9 and Figure 11). The Parafield ASR aquifer storage site is a two production well field with observation wells in the T1 and Q1. The Parafield Gardens aquifer storage site has 6 production wells in a quadrilateral configuration with 3 observation wells (piezometers). A summary of all of the production and observation wells is provided in Table 10.Further details of the Parafield Gardens well-field and local hydrology can be found in Pavelic *et al.* (2004) and Kremer *et al.* (2008; 2010).

Table 9 Generalised hydrogeological units at Parafield ASR and Parafield Gardens ASTR sites.

Interval (m bgs)	Lithology	Aquifer	Stratigraphic name
0-2	Soil	Confining bed	*Recent to Quaternary*
2-55	Clay containing up to 3 thin quaternary aquifers	Confining bed	*Hindmarsh Clay*
55-100	Sand	Q4	*Carisbrooke Sand*
80-110	Limestone	T1a	*T1*
100-152.5	Limestone	T1b	*T1*
152.5-160	Clay	Confining bed	*Munno Para Clay*
160-172	Limestone (grey to white) moderately cemented	T2a unit	
172-187	Limestone (grey to yellow) well cemented interbedded with sand/ silt	T2b unit	*T2 Lower Port Willunga Formation*
187-220	Limestone, sand, highly fossilifereous containing a thin high *K* unit of friable sand.	T2c unit	
220->222*	Clay	Confining bed	*Ruwarung member*

*Drilling confirmed presence of clay to 222 m bgs. Maximum thickness of Ruwarung member is 22 m (Geoscience Australia website).

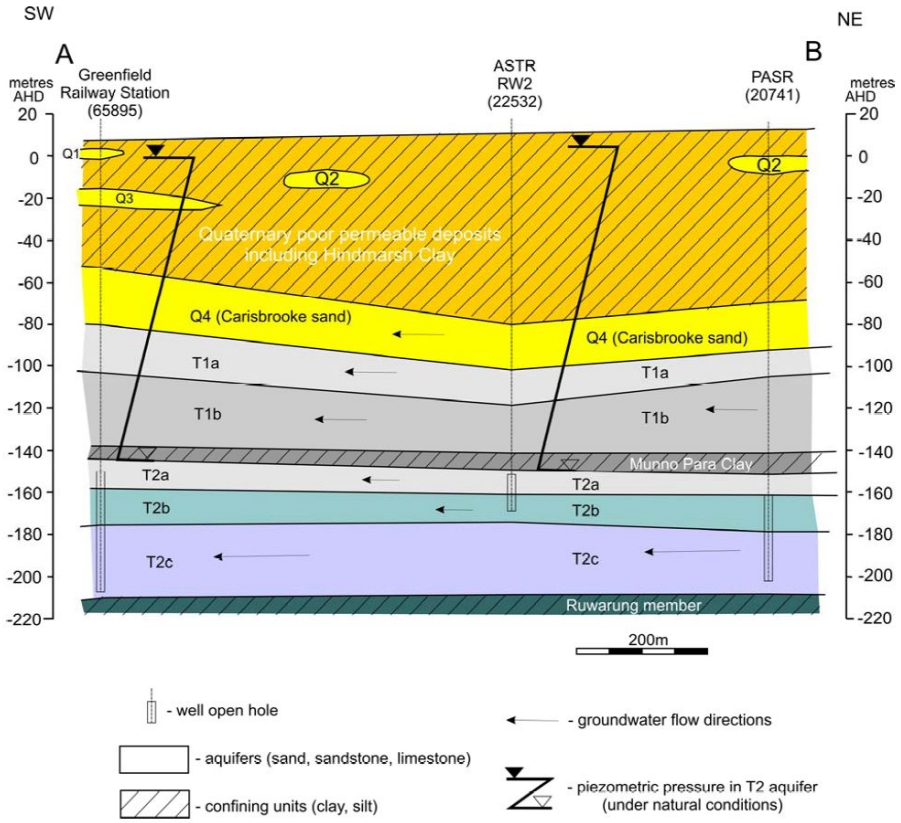

Figure 11 Hydrogeological cross-section through Quaternary and Tertiary aquifers at the ASR and ASTR sites (after Kremer *et al.*, 2010). Groundwater flow directions and pressures are relevant for natural conditions.

Table 10 Details of Parafield ASR and ASTR production (Prod) and observation (Obs) wells.

Site	Well	Unit No.	Permit No.	Purpose	Aquifer	Yield (L/s)	Max. depth (m)	Casing depth (m)	Open Section (m)	Date of construction
Parafield ASR	ASR1	6228-20743	56888	Prod	T2a,b,c	>10*	198	171	27	12/12/2001
	ASR2	6228-20943	56887	Prod	T2a,b,c	>10*	180	171	9	05/05/2002
	POBS	6228-20741	56856	Obs	T2a,b,c	6	216	174	42	06/12/2001
Parafield Gardens ASR/ASTR	IW1	6228-23047	126353	Prod	T2a,b	18	184	165	19	15/01/2007
	IW2	6228-23053	126354	Prod	T2a,b	18	184	165	19	22/01/2007
	IW3	6228-22535	117711	Prod	T2a,b	12.5	182	165	17	22/05/2006
	IW4	6228-23045	126355	Prod	T2a,b	18	184	165	19	05/02/2007
	RW1	6228-22533	119379	Prod	T2a,b	12.5	183	168	15	29/05/2006
	RW2	6228-22532	117712	Prod	T2a,b	12.5	180	164	16	12/05/2006
	P1	6228-24537	149448	Obs	T2a	3	172	168	4	25/07/2008
	P2	6228-24539	149449	Obs	T2c	1.5	214	209	5	18/07/2008
	P3	6228-24538	149450	Obs	T2b	2	171	168	3	31/07/2008

Well information taken from Waterconnect Groundwater Data (DEWNR, 2012). * Airlifted yield taken from AGT (2011b).

2.2.4.2 Pump station capacity

Injection and recovery for the Parafield ASR and ASTR operations is driven by a pump station at the Parafield Wetlands site. EPA Licence 12983 states that no adverse effects to other aquifers or water bodies occur as a result of MAR operations. This includes maintaining the integrity of confining layers and the injection pressure is limited depending on standing water levels and the thickness of the overlying burden (AGT, 2011c).

2.2.4.3 Wells & well head construction materials

Production wells at Parafield ASR and ASTR sites (Figure 12) are constructed by operators licensed by DEWNR according to the *Natural Resource Management Act (NRM) 2004*. Minimum well diameters are 250 mm (ASR) and 200 mm (ASTR), pressure cemented from ground level, cased with PVC to the top of the

target zone in the T2 aquifer (details in Table 10). Injection is driven from the pump shed at the Parafield Airport Wetlands site. Well head instrumentation includes a water quality sampling port, pressure transducer, flow meter and volume totaliser. A lockable enclosure is installed on each ASTR well.

Figure 12 Production well at Parafield ASTR site showing injection and extraction pipework, flow meter (totaliser) and lockable enclosure.

2.2.5 Operational scenarios

An outline of the operation of the Parafield scheme is given below in Table 11. Further detail is given in Section 4.

Table 11 Operational scenarios for harvesting, injection, back-flushing, extraction & supply.

Process	Description
Stormwater harvesting	Flows above height of in stream basin weir are diverted into Parafield scheme
Stormwater pumping from Cobbler Creek	Pump station at Bridge Road is manually triggered
Transfer from in-stream basin to holding basin	Pumped automatically if volume available in holding basin and CCP met
Transfer from holding basin to engineered wetland	Gravitational flow through wetland
ASR injection	Injection into aquifer (~20L/s), max. pressure 1150 kPa
ASR well scouring	At start of each injection cycle (>30 L/s) to the sand trap and the in-stream basin.
ASR extraction	Aquifer recovery to Parafield storage tanks (10-15 L/s per well)
ASTR injection	Injection into aquifer (5-15L/s), max. pressure 1100 kPa
ASTR extraction	Aquifer recovery to Parafield storage tanks (10-15 L/s per well)
ASTR well scouring	At start of each injection cycle (20-30 L/s) spread onto the oval for infiltration or into in-stream basin.
Supply to industrial users	Pumping from Parafield storage tanks via Salisbury ring main
Supply to municipal open space irrigation	Pumping from Parafield storage tanks via Salisbury ring main
Supply to Greenfields Mixing Tank	Pumping from Parafield storage tanks via Parafield-Greenfields pipeline at constant supply pressure of 600 kPa

2.2.6 Supply and use

A map showing the stormwater distribution pipes to local reserves, industrial users and pipeline to the Greenfields Mixing Tank is shown in Figure 4. A schematic of the Parafield scheme in relation to the reclaimed waste water schemes operated by SA Water is given in Figure 6.

2.2.6.1 Industrial process use

Industrial uses are only covered in this plan to the point of supply for the specific industry. For example, Parafield ASR/ASTR recovered stormwater from the Parafield storage tanks is distributed to Michell Wool Pty Ltd via the Salisbury stormwater distribution ring main for use in wool processing (scouring). The plant uses this water in place of potable mains water.

2.2.6.2 Municipal open space stormwater irrigation

The vast majority of municipal open space irrigation in Salisbury is on lawn areas of parks and sports fields including school ovals. Recovered ASR/ASTR water from the Parafield storage tanks is distributed via the Salisbury ring main. Above ground irrigation systems e.g. impact or large turf rotor sprinklers, with high flows suited to irrigating large open spaces are most commonly used. The City of Salisbury only irrigates with recycled stormwater at night with limited buffer zones according to the Recycled Water Guidelines (DHA, 2012) and Australian Guidelines for Water Recycling Phase 1 (NRMMC-EPHC-AHMC, 2006).

2.2.6.3 Mawson Lakes recycled product water

Reserves in Mawson Lakes are irrigated with recycled water (treated effluent blended with recovered stormwater). Above ground irrigation sprinkler systems e.g. impact or large turf rotors are used for large lawn areas but also pop-up sprinkler heads and gear driven rotors are used for smaller areas. Recycled water is distributed via dual reticulation from the Greenfields Mixing Tank to residences in Mawson Lakes. Uses include irrigation of gardens, car washing, toilet flushing and for ornamental ponds and water features (without fish). Water carting using recycled water also operates from a filling station at the Greenfields site.

2.3 Assessment of Water Quality Data

Water quality has been and continues to be monitored at several locations throughout the stormwater harvesting system. Extensive scientific reviews and compliance reporting have been carried out on the water quality data. The scientific investigations have included risk assessments and studies to characterise raw stormwater quality and determine the efficiency of the treatment barriers to remove microbiological and chemical hazards (Page *et al*. 2013). Compliance reporting has involved annual EPA reports as per licence conditions. A summary of the sampling locations for which analyses are or have been reported are shown in Table 12. Maps showing the locations of the sampling points are given in Figure 7 and Figure 8.

For the purposes of supply to the Mawson Lakes Recycled Water Scheme, industrial process use and municipal open space irrigation, the key water quality datasets are those representing aquifer recovered stormwater. This includes stormwater supplied to the Greenfields Mixing Tank at sampling point SP14026, stormwater supplied to Michell Wool Pty. Ltd. at sampling point MW1, aquifer recovered stormwater pumped to Parafield storage tanks at sampling points ASR1, ASR2, RW1, and RW2.

Table 12 Summary of water quality sampling locations and monitoring frequency.

Sampling Name	AWQC Sample ID	Description	Type	Driver	Frequency	Analytes monitored	Reported
PDS	14128	Parafield drain station (see Figure 5)	Raw stormwater	CSIRO - Public health risk assessment	Ad hoc (event based)	General, nutrients, metals, microbiological, pesticides	CSIRO reports
PC 1/2/3/4, BC1/2, CCk1/2	14122, 14123, 14124, 14125, 14126, 14127, 14120, 14121	Parafield & Cobbler Creek catchment sampling sites (see Figure 5)	Raw stormwater	CSIRO – Public health risk assessment	Ad-hoc (event based)	General, nutrients, metals, microbiological, pesticides	CSIRO reports
IS1		Entry to in-stream basin	Raw stormwater	CSIRO – micropollutant/ pathogen removal studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
WE1	14094	Entry to wetland	Settled stormwater	CSIRO – treatment monitoring studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
WE2	14096	Exit of engineered wetland	Injectant water	EPA license condition;	Every 100 ML	General, metals, microbiological	Results to EPA after each sampling period as verification monitoring
SE1/2	994719/994720*	Instream basin sediments	Sediment core	CSIRO – micropollutant/ pathogen removal studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
SE2/3	994721/994722*	Holding storage sediments	Sediment core	CSIRO – micropollutant/ pathogen removal studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
SE3/4	994723/994724	Wetland sediments	Sediment core	CSIRO – micropollutant/ pathogen removal studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
ASR1		Extracted ASR well 1	Recycled stormwater	EPA license condition;	Every 50 ML	General, nutrients, metals, microbiological, Pesticides, Langelier Index	Results to EPA after each sampling period as verification monitoring
ASR2		Extracted ASR well 2	Recycled stormwater	EPA license condition;	Every 50 ML	General, nutrients, metals, microbiological, Pesticides, Langelier Index	Results to EPA after each sampling period as verification monitoring
IW1	14099	ASTR injection well 1	Wetland treated	CSIRO – various studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
IW2	14100	ASTR injection well 2	Wetland treated	CSIRO – various studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
IW3	14101	ASTR injection well 3	Wetland treated	CSIRO – various studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
IW4	14102	ASTR injection well 4	Wetland treated	CSIRO – various studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
RW1	14097	ASTR recovery well 1	Recycled stormwater	EPA license condition;	Every 50 ML	General, nutrients, metals, microbiological, Pesticides, Langelier Index	Results to EPA after each sampling period as verification monitoring
RW2	14098	ASTR recovery well 2	Recycled stormwater	EPA license condition;	Every 50 ML	General, nutrients, metals, microbiological, Pesticides, Langelier Index	Results to EPA after each sampling period as verification monitoring
PP1	14108	ASTR piezometer 1	Groundwater	CSIRO – various studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
P2	14109	ASTR piezometer 2	Groundwater	CSIRO – various studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
P3	14110	ASTR piezometer 3	Groundwater	CSIRO – various studies	Ad hoc	General, nutrients, metals, microbiological,	CSIRO reports

Sampling Name	AWQC Sample ID	Description	Type	Driver	Frequency	Analytes monitored	Reported
						pesticides	
POBS	14131	ASR piezometer	Groundwater	CSIRO – various studies	Ad hoc	General, nutrients, metals, microbiological, pesticides	CSIRO reports
SP14026	14026	Recycled stormwater supplied to Greenfields Mixing Tank	Recycled stormwater	DHA compliance, incident response & process optimisation	Weekly	*E. coli*	Allwater informs DHA & City of Salisbury when *E. coli* ≥100 cfu/100 mL
MW1	14132	Salisbury ring main (Michell Wool)	Recycled stormwater	CSIRO – public health risk assessment	Ad hoc	General, nutrients, metals, microbiological, pesticides	

* Ecowise laboratory sample number.

2.3.1 Stormwater quality

Raw stormwater, wetland treated stormwater, ASR and ASTR recycled stormwater quality has previously been described in Page *et al.* (2008) and Page *et al.* (2009). A further comprehensive companion report is in progress (Page *et al*. 2013). This risk management plan for the Parafield Stormwater harvesting scheme evaluates considerable additional data that was acquired after the commissioning of the system that would not be typically available for new schemes.

2.3.1.1 Stormwater quality supplied to Greenfields Mixing Tank

City of Salisbury supplies a constant pressure (600 kPa) in the stormwater inlet line to the Greenfields Mixing Tank. SA Water takes recycled stormwater as required for blending with reclaimed wastewater. Table 13 summarises the recycled stormwater quality as monitored by Allwater (on behalf of SA Water) at sampling point SP14026 (at the inlet line prior to chlorination and blending) from January 2010 to January 2013. The recycled stormwater is characterised by:

- Low salinity (as TDS by EC) in the range of 82-420 mg/L. Mean and median TDS are low at 226 mg/L and 220 mg/L, respectively.
- Chlorine (free, total or monochloramine) was not detected in any sample.
- Generally high in colour with range of 5-174 HU and mean and median of 27 and 20 HU, respectively.
- Generally high in iron with soluble and total iron in the ranges of 0.002-1.1 mg/L and 0.05-1.9 mg/L, respectively.
- Occasionally high in manganese with soluble and total manganese in the range of 0.0002-0.18 mg/L and 0.003-0.3 mg/L respectively.
- A variable microbiological quality with an *E. coli* concentration range of <1-3400 cfu/100 mL. The long term median *E. coli* concentration was 3 cfu/100 mL. For the most recent 12 months (31/01/2012-29/01/2013) the median was 1 cfu/100mL which is compliant with the DHA requirement of <100 cfu/ 100 mL (annual median). This reflects the change in operations whereby all stormwater undergoes ASR or ASTR. Across the 3 year dataset there have been 19 samples over 100 cfu/100 mL (Type 2 incident level, see Section 6) and 2 samples over 1000 cfu/100 mL (Type 1 incident level, see Section 6). In the most recent 12 months there was 1 sample over 100 cfu/100 mL and zero over 1000 cfu/100 mL.

Table 13 Recycled stormwater quality at sampling point SP14026 at the inlet of Greenfields Mixing Tank (SA Water dataset, from WaterScope, period 1st Jan 2010 to 31th Jan 2013).

Parameter	unit	count	min	max	mean	median
Chlorine*	mg/L	160	<0.1	<0.1	<0.1	<0.1
Colour - True (456 nm)	HU	159	5	174	27	20
E. coli	cfu/100mL	160	< 1	3400	79	4
Iron - Soluble	mg/L	159	0.002	1.1	0.1	0.1
Iron - Total	mg/L	159	0.05	1.9	0.5	0.5
Manganese - Soluble	mg/L	159	0.0002	0.18	0.04	0.03
Manganese - Total	mg/L	159	0.003	0.3	0.06	0.04
TDS (by EC)	mg/L	159	82	420	226	220

Sampling point SP14026 is located prior to chlorination and blending with reclaimed wastewater.
*No free or total chlorine or monochloramine was detected in any sample.

2.3.1.2 Wastewater quality

An assessment of water quality data for the Bolivar sewage and reclaimed wastewater from the Bolivar Dissolved Air Floatation and Flocculation (DAFF) plant is provided in the Bolivar-Virginia Pipeline Scheme Recycled Water Management Plan and the Bolivar-Mawson Lakes Risk Management Plan both published by SA Water.

2.3.1.3 Recycled water quality

An assessment of recycled water quality data is reported by SA Water in the Bolivar-Mawson Lakes Recycled Water Management Plan. Recycled stormwater supplied to the Mawson Lakes Recycled Water Scheme is monitored at sampling point SP14026 (at the supply pump station at Greenfields Mixing Tank).

2.3.2 Major treatment pathogen barriers & removal efficiencies

2.3.2.1 Holding storage and reedbed

Page *et al.* (2008) determined the removal efficiency of various physical, chemical and bacterial parameters in the Parafield stormwater harvesting holding storage and reedbed combined by intensive sampling over several weeks in winter-spring 2006 (Appendix D).

2.3.2.2 Pathogen removal in reedbed and aquifer storage

A study was undertaken by Sidhu *et al.* (2010) to determine the potential inactivation rates of selected enteric microorganisms in captured urban stormwater within a constructed reedbed and in tertiary carbonated aquifer during an Aquifer Storage, Transfer and Recovery scheme. The study was undertaken in-situ in the Parafield Stormwater Harvesting Scheme constructed reedbed and target aquifer using diffusion chambers. The results showed that all tested bacteria had 1.0 $\log_{10}$ reduction time of less than 6 and 2.5 days in the constructed reedbed and aquifer respectively. This reduced the risk of bacteria in recycled stormwater. However, adenovirus and *Cryptosporidium* oocysts showed lower inactivation rates with 1.0 $\log_{10}$ reduction times of > 33 days in the constructed reedbed. This means that the constructed reedbed with a mean residence time 10 days cannot be relied upon as an efficient treatment barrier for virus and protozoa. Storage of stormwater in the aquifer with brackish water resulted in slow inactivation of enteric viruses over the 35 day incubation period with adenovirus and rotavirus showing slowest inactivation times (extrapolated T_{90} of ~100 days). *Cryptosporidium* oocysts showed similar inactivation rate in the constructed reedbed and aquifer.

2.3.2.3 Pathogen treatment $\log_{10}$ removal values

Pathogen $\log_{10}$ removal values assigned to the aquifer are small according to the above results following the procedure provided in the Australian Guidelines for Water Recycling (NRMMC-EPHC-AHMC, 2006). However no allowance is made for the pathogen attenuation via attachment in aquifers, as this has not yet been validated.

2.4 Performance criteria for scheme

2.4.1 Health criteria

For municipal irrigation with recycled stormwater, a 1.3 $\log_{10}$ reduction is required for viruses and bacteria and 0.8 $\log_{10}$ for protozoa (NRMMC-EPHC-NHMRC, 2009a, Table A3.3 p. 61). A 2.0 $\log_{10}$ reduction can be achieved through reduced exposure simply by restricting public access during irrigation, and a 1.0 $\log_{10}$ is

allowed through withholding periods for irrigation or applying spray drift control (NRMMC-EPHC-AHMC, 2009a, Table A3.4 p. 62). Target inactivation credits for restricted irrigation and dual reticulation are shown below in Table 14. Water supply agreements oblige customer use in accordance with *Operational Guidelines* (reWater Guidelines for installation and use) (City of Salisbury, 2008).

Table 14 Target inactivation credits for restricted irrigation and dual reticulation.

End Use	Target Pathogen LRV (log_{10})			Barrier (log_{10} inactivation credit)	Comment
	Virus	Protozoa	Bacteria		
Restricted municipal irrigation	1.6	0.6	1.2	Spray drift control (1 log_{10}), withholding period (1 log_{10}), aquifer treatment	Requirements met
Dual reticulation*	2.7	1.8	2.3	Chlorination at Mixing tank (3 log $_{10}$), Withholding period (1 log_{10}), Spray drift control (1 log_{10}), aquifer treatment	Requirements met

*includes blending of recycled stormwater with reclaimed wastewater.

It should be noted that part of DHA's approval for the Mawson Lakes Recycled Water Scheme includes stormwater source control conditions. This involves City of Salisbury operating a catchment management program as well as protecting the drain and pond system against faecal contamination (see Section 3.1).

According to Section 3.5.5 of the Australian Water Recycling Guidelines Phase 1 (NRMMC-EPHC-AHMC, 2006) and Section A3.5 of the Phase 2 Guidelines for Stormwater Harvesting (NRMMC-EPHC-NHMRC, 2009a) the types of preventative measures that would be considered adequate to manage chemical risks to human health exposure controls which include:

- For stormwater – the *Stormwater Quality Management Program* in the Parafield stormwater catchment area (NRMMC-EPHC-NHMRC, 2009a).
- For sewage – the trade-waste program and the standards of acceptance for liquid waste as required by the Water Industry Act 2012 in the Bolivar Wastewater Treatment Plant drainage area (as managed by SA Water Trade Waste Group and the Trade Waste Permit system) (NRMMC-EPHC-AHMC, 2006).

2.4.2 Environmental criteria

Key environmental objectives for the Parafield scheme are based on the City of Salisbury's EPA license No. 12983 'Discharge of stormwater to the underground aquifer'. Examples of some of the conditions are given in Section 1.2.2.2 (full licence conditions, notes and reports attachments are given in Appendix A).

SA Water is accountable for the recycled water in Mawson Lakes. Those parameters corresponding to the receiving environment are listed in the Mawson Lakes Irrigation Management Plan (see Appendix E). Additionally, the DHA approval conditions for the supply of recycled stormwater to the Mawson Lakes scheme state:

"The chemical and physical quality of reclaimed stormwater supplied to the Mawson Lakes Recycled Water Scheme is to comply with the requirements of the Environment Protection Authority (EPA) for supply of water from the Parafield Stormwater Harvesting Scheme to the T2 aquifer."

The key legislation is the *Environmental Protection (EP) Act 1993* and environment protection policies made under it. The Environment Protection (Water Quality) Policy 2003, under the *EP Act 1993*, gives trigger values for a range of water quality parameters relating to freshwater ecosystems. These are the values with which stormwater injectant water quality is compared against, this is provided for the Parafield stormwater harvesting scheme in

Table 15 provides a comparison of Parafield injectant (wetland outlet) water with the EPP (2003) fresh aquatic ecosystem protection values. A number of parameters exceeded the water quality criteria:

- TOC exceeded 15 mg/L in 2% of samples.
- Suspended solids exceeded 20 mg/L in 2% of samples.
- Total iron, lead, selenium, silver and zinc exceeded their respective values in 11, 5, 5, 6, and 12% of samples respectively.
- Various pesticides exceeded their zero limits in 2-68% of samples.

TOC was above 15 mg/L in only 2 of 100 samples so can be regarded as a relatively low risk although low levels of organic matter injected will prevent reactions with aquifer mineralogy (NRMMC-EPHC-NHMRC 2009b). Organic matter sources are ubiquitous throughout the catchment e.g. deciduous drop, matter from residential, commercial, rural and industrial properties.

Metals generally cannot be permanently removed within aquifers as is possible with biodegradable organics so injecting water with high levels of metals warrants concern. It is advisable to limit inputs, before relying on sorption which can be reversed (NRMMC-EPHC-NHMRC, 2009b).

According to EPA licence 12983 conditions, pesticides should not be detected in injectant water. A number of pesticides were detected however 95th percentile concentrations did not exceed the Australian Drinking Water Guidelines health guideline values and were below Australian and New Zealand Environment Conservation Council (ANZECC) trigger values for protection of 99% of freshwater species. It is suggested that the existing criteria of zero pesticide detections be adjusted to be consistent with other Australian risk-based guidelines.

Notably, no benzene, phenol or toluene was detected in any samples. The DO minimum criteria concentration of 6 mg/L should be regarded cautiously as the water is being injected into an anaerobic confined aquifer as opposed to a surface water body. Significant differences in DO between injected stormwater and ambient groundwater may lead to mobilisation of metals (e.g. arsenic) from the aquifer matrix (Vanderzalm *et al.*, 2010). The total dissolved solids (TDS) criteria should also be regarded as a maximum rather than +/- 10% of receiving water body for MAR operations in confined aquifers or aquifers remotely connected to groundwater dependant ecosystems. Stormwater is relatively low salinity water compared to the native groundwater in the T2 aquifer and the aim is to sustain a fresh water plume in the aquifer to maintain recovery efficiency. Hence the injectant is almost always much fresher than the ambient groundwater.

Maximum injection pressures for the ASR and ASTR wells are detailed in Australian Groundwater Technologies (2011c). Pressure is monitored continuously and controlled automatically by the SCADA system that controls the pumps. There is no risk of over-pressurisation of the aquifer based on pump selection and use of pressure reduction valves.

2.4.3 Operational criteria

No aesthetic water quality criteria were specified for the Parafield scheme. However, operational experience has shown that Mawson Lakes scheme customers are sensitive to the physical appearance of the recycled water supplied and periodic complaints have been received by SA Water in relation to colour (Hurlimann, 2008).

DAFF treated reclaimed wastewater sampled at Greenfields Mixing Tank (sampling point SP14030) from January 2010 to January 2013 had an average salinity of 1100 mg/L TDS (SD = 118 mg/L; n = 158). The recycled stormwater used to blend with reclaimed wastewater must be relatively fresh in the range of 300-650 mg/L TDS in order maintain the salinity of the recycled (blended) water to acceptable levels. According to the draft recycled stormwater supply agreement for the Mawson Lakes Recycled Water Scheme, stormwater must be below 600 mg/L TDS.

Recent work to develop aesthetic water quality standards for a dual reticulation supply at Lochiel Park has been undertaken by SA Water. This scheme involves only recycled stormwater and the aesthetic guidelines developed may also be applicable to the Mawson Lakes Recycled Water Scheme and the Parafield Stormwater Harvesting Scheme. The current aesthetic criteria used by SA Water that are considered suitable for third pipe systems are as follows:

- Turbidity <5 NTU
- Colour (true) <25 HU
- Iron (soluble) before chlorination <0.1 mg/L
- Iron (total) <0.3 mg/L
- Manganese (soluble) before chlorination <0.03 mg/L
- Manganese (total) <0.1 mg/L

It is important to note that the above aesthetic standards do not form part of the DHA approval or EPA licence conditions for the Parafield scheme and hence are not a regulatory requirement. It has been included to demonstrate the ongoing investigation into this aspect of water quality.

Recycled stormwater quality was sampled on a weekly basis by SA Water at sampling point 14026 at the inlet to the Greenfields Mixing Tank (prior to chlorination) from January 2010 to January 2013 (see Section 2.3.1.1). Recycled stormwater exceeded the SA Water aesthetic criteria (above) in 31% (n=159), 43% (n=159), 78% (n=159), 56% (n=158), and 19% (n=159), for colour, soluble Fe, total Fe, soluble Mn and total Mn respectively.

The current DHA approval conditions specify only that turbidity in the instream basin must be <100 NTU before being pumped to the holding storage basin. This is to be measured automatically on a continual basis and incorporate a remote alarm system. There is no known scientific basis for this turbidity limit and currently this Critical Control Point is unused and does not limit harvesting as the holding basin and the wetland of the Parafield stormwater harvesting system provide additional treatment for suspended solids/turbidity (Appendix D) prior to aquifer injection. To avoid injection well clogging at Parafield a limit of 5 NTU automatically monitored at the well head was set by the City of Salisbury (B. Naumann, pers. comm.). Continued exceedance (>30 min) of 5 NTU triggers automatic injection shutoff (see Table 17 in Section 3.2).

To limit corrosion, fouling or scaling of infrastructure (e.g. pipes, irrigation, pumps, wells etc.) the ANZECC irrigation guidelines (ANZECC-ARMCANZ 2000) and drinking water guidelines (NHMRC-NRMMC 2011) contain a set of criteria. The ANZECC guidelines also provide trigger values for cumulative soil contamination and plant salt tolerances. These include (but are not limited to):

- Fouling or corrosion where pH is <6.0 or >8.5 (ANZECC-ARMCANZ, 2000)
- Fouling or scaling where hardness (as $CaCO_3$) is <60 or >200 mg/L (NHMRC-NRMMC, 2011)
- Cumulative soil contamination where iron (total) <10 mg/L (short term use value, long term use value 0.2 mg/L) (ANZECC-ARMCANZ, 2000)
- Salt tolerance of sensitive crops 950 μScm^{-1} (≈630 mg/L TDS); moderately sensitive crops <1900 μScm^{-1} (≈1200 mg/L TDS) (ANZECC-ARMCANZ, 2000)
- Bioclogging of irrigation where phosphorus <0.8-1.2 mg/L (requires site specific assessment) (ANZECC-ARMCANZ, 2000)

Aquifer injection pressures and flow rates, volumes and water levels in wetlands and aquifer were determined to protect the integrity of the aquitards and health of the wetland vegetation. These are detailed in Australian Groundwater Technologies (2011c).

2.5 Hazard identification & risk assessment

Various risk assessments have been conducted for the Parafield scheme including targeted CSIRO research studies (Sweirc *et al.,* 2005; Page *et al.,* 2008; Page *et al.,* 2009) and consultant reports to the City of Salisbury (e.g. AGT, 2011b; c). These reports have focused on operational, microbial and catchment land use risks from infrastructure and operations, public health and environmental protection perspectives. A recent CSIRO internal report for the Goyder Institute (Page *et al.*, 2013) presented results of a comprehensive stormwater catchment hazard identification and risk assessment. This included a series of stakeholder workshops, literature reviews, water quality data analysis, land use assessment and spatial hydrological analysis to define catchment boundaries and identify and assess potential risks. Hydrological modelling to determine travel times (Meyers *et al*. 2013) revealed that this was insufficient to allow manual intervention in stormwater harvesting to avoid hazards.

The following three sections summarise the significant identified hazards and risks reported in previous risk assessment reports conducted for the Parafield scheme (Page *et al*. 2013). These are presented as public health, environmental and operational risks for open space irrigation and non-potable use via dual reticulation distribution systems.

2.5.1 Public health risks

Exposure pathways for the current end-uses are through inhalation of spray drift from irrigation or toilet flushing and accidental ingestion (drinking) of recycled stormwater or recycled wastewater. The primary risk to human health and the quality of harvested stormwater is the potential pathogen contamination arising from untreated sewage entering the stormwater system. This may occur when sewers overflow and and enter stormwater drains as well as septic tank leaks and overflows. Risks also arise from runoff from livestock faeces (e.g. sheep grazing paddocks) around the head waters of Cobbler Creek and on the northern side of Parafield Drain.

Page *et al.* (2013) calculated that this requires pathogen inactivation credits of 1.6 $\log_{10}$ for viruses, 0.5 $\log_{10}$ for protozoa and 1.2 $\log_{10}$ for bacteria for municipal open space irrigation. The risk is managed by passing the harvested stormwater through the ASR/ASTR systems and restricted access of irrigated municipal open spaces which provides > 2.0 $\log_{10}$ total inactivation credits.

For the Mawson Lakes scheme third pipe scheme, 2.7 $\log_{10}$ for viruses, 1.6 $\log_{10}$ for protozoa and 2.3 $\log_{10}$ for bacteria inactivation credits are required. Risks for this exposure are managed by additional blending with reclaimed water or drinking water and chlorination at the Greenfields Mixing Tank. SA Water/Allwater undertakes weekly *E. coli* monitoring of recycled stormwater and applies chlorination at the Greenfields Mixing Tank prior to reticulation to monitor microbial risks in the Mawson Lakes scheme In addition, an audit of cross connections of the third pipe scheme has been undertaken (20% of all connections per year, for 5 years and during change in ownership).

AGT (2011c) identified turbidity as a moderate health risk indirectly through the potential to reduce disinfection efficiency e.g. chlorination at the Greenfields Mixing Tank, and increased chance of transporting a range of harmful contaminants e.g. metals, organic chemicals etc. Turbidity can at times exceed the guideline values but can be managed by passing the recovered water through the engineered wetland again.

Human health risks from inorganic chemicals e.g. heavy metals could potentially arise through accidental ingestion of recycled water for example through cross connections. Arsenic mobilisation in groundwater systems through redox reactions with injectant water is acknowledged (NRMMC-EPHC-NHMRC, 2009b) so monitoring of total organic carbon (TOC), nitrates and nitrites, dissolved oxygen (DO) and metals is recommended (AGT, 2011c). High levels of iron can also impact on aesthetic water quality.

No other direct public health risks were associated with organic chemicals, salinity and sodicity, nutrients or radionuclides for the current non-potable end uses of recycled stormwater or reclaimed wastewater.

2.5.2 Environmental risks

Table 15 provides a comparison of Parafield injectant (wetland outlet) water over 10 years of operation against the EPP (2003) fresh aquatic ecosystem protection values. A number of parameters exceeded the water quality criteria:

- Total organic carbon (TOC) exceeded 15 mg/L in 2% of samples.
- Total suspended solids (TSS) exceeded 20 mg/L in 2% of samples.
- Total iron, lead, selenium, silver and zinc exceeded their respective values in 11, 5, 5, 6, and 12% of samples respectively.
- Various pesticides exceeded their zero limits in 2-68% of samples.

TOC was above 15mg/L in only 2 of 100 samples across the 10 years of operational data (Table 15) however from 2010 to 2012, TOC was not recorded above 13.8 mg/L and a median of 6.6 mg/L (n = 14). TOC can be regarded as a relatively low risk although low levels of organic matter injected will reduce reactions with aquifer mineralogy (NRMMC-EPHC-NHMRC, 2009b). Organic matter sources are ubiquitous throughout the catchment e.g. deciduous drop, matter from residential, commercial, rural and industrial properties.

TSS exceeded 20 mg/L in 2 of 103 samples (Table 15) and from 2010 to 2012 was above the EPP (2003) limit in 2 out of 14 samples (maximum of 84 mg/L). On average however, TSS was below 6 mg/L and turbidity was below 5 NTU across the 10 years of operational data (Table 15). Occasional pulses of high TSS/turbidity are managed through automatic pump shut off after 30 minutes of turbidity sustained above 5 NTU at the injection well (see Table 17 and Section 4.3.1).

A number of metals occasionally exceeded EPP (2003) trigger levels however only total zinc had a mean above the guideline value of 0.05 mg/L (Table 15). Metals generally cannot be permanently removed within aquifers as is possible with organics so injecting water with high levels of metals warrants concern. It is advisable to limit inputs, before relying on sorption which can be reversed (NRMMC-EPHC-NHMRC, 2009b).

According to EPA licence 12983 conditions, pesticides should not be detected in injectant water. A number of pesticides were detected however 95th percentile concentrations did not exceed the Australian Drinking Water Guidelines health guideline values and were below ANZECC trigger values for protection of 99% of freshwater species. It is suggested that the existing criteria of zero pesticide detections be adjusted to be consistent with Australian NWQMS risk-based guidelines.

Notably, no benzene, phenol or toluene was detected in any samples. The DO minimum criteria concentration of 6 mg/L should be regarded cautiously as the water is being injected into an anaerobic confined aquifer as opposed to a surface water body. Low DO however may be an indicator of high TOC, which may be problematic as discussed above. Significant differences in DO between injected stormwater and ambient groundwater may lead to mobilisation of metals from the aquifer matrix (Vanderzalm *et al.*, 2010).

The SA EPA's current approach adopts for injectant a maximum of 10% more than the TDS of the native groundwater but does not enforce the minimum of TDS of 10% less than native groundwater (from EPP 2003). It is recommended that this approach continue to be applied for all recharge to confined aquifers and for unconfined aquifer where the storage zone does not discharge directly into groundwater dependent ecosystems. Stormwater is relatively low salinity water compared to the native groundwater in the T2 aquifer and the aim is to sustain a fresh water plume in the aquifer to maintain recovery efficiency. The environmental risks of salinity and sodicity and their effects on soil structure and agricultural production are discussed in Chapter 4 of the Phase 1 Guidelines for Water Recycling (NRMMC-EPHC-AHMC 2006). The maximum salinity of aquifer recovered water supplied to the Mawson Lakes Recycled Water Scheme is 420 mg/L TDS (n = 160; Table 13) and therefore never exceeded the lowest threshold of ~600 mg/L TDS for "sensitive crops" given in the ANZECC irrigation guidelines (ANZECC-ARMCANZ 2000). Hence, environmental risks for salinity are low.

Maximum injection pressures for the ASR and ASTR wells are 1150 KPa and detailed in Australian Groundwater Technologies (2011c). Pressure is monitored continuously and controlled automatically by

the City of Salisbury SCADA system that controls the pumps. There is no risk of over-pressurisation of the aquifer based on pump selection nor of lowering pressures excessively due to the depth at which pumps are placed in wells.

2.5.3 Operational risks

The main operational water quality risks for stormwater harvesting are detailed in Section 3.3.2 of the Australian Water Recycling Guidelines for Stormwater Harvesting (NRMMC-EPHC-NHMRC, 2009a). These risks include high concentrations of suspended solids, phosphorous, nitrogen, iron and hardness which can lead to irrigation system clogging. For schemes using MAR, further operational risks are detailed in Section 6 of the Australian Water Recycling Guidelines for Managed Aquifer Recharge (NRMMC-EPHC-NHMRC, 2009b) including clogging of injection wells and basins, poor recovery efficiency, affecting neighbouring wells and management of waste (purge water, basin scrapings) (NRMMC-EPHC-NHMRC, 2009b).

Gross pollutants are prevented from entry by a grate on the inlet to the in-stream basin. Other gross pollutants settle and are removed from the in-stream basin in annual cleaning operations. A visual inspection of water in the in-stream basin is performed prior to pumping to the holding storage. Risk of degrading the constructed wetland through drying is reduced by an automatic low level trigger that stops pumping from the wetland. Turbidity, salinity and pH are monitored continuously during aquifer injection and injection can be shut down if thresholds levels are exceeded. This controls risks of clogging and reducing recovery efficiency. Water outside of set boundaries is recirculated through the in-stream and holding basins and through the wetland.

Elevated iron concentrations in wetland and aquifer-recovered water increases potential for fouling of pumps, pipes and irrigation equipment (NRMMC-EPHC-NHMRC, 2009a). For supply to the Mawson Lakes scheme, dilution of harvested stormwater through blending with treated effluent and oxidation through chlorination reduces iron to acceptable levels. Total iron concentration of Parafield ASR recovered stormwater commonly exceeds the long term irrigation guideline value of 0.2mg/L but never exceeds the short term value of 10 mg/L. Mean, median and 95th percentile values from ASR in recovered water are 0.7, 0.4 and 2.8 mg/L respectively (n=32). The short term irrigation guideline value is considered adequate for protection of irrigation equipment for up to 20 years. The risk to irrigation equipment is therefore acceptable.

Excess nutrients can elevate the levels of microbial activity in aquifers and lead to clogging or reduced permeability (NRMMC-EPHC-NHMRC, 2009b). Growth of biofilms in the infrastructure is currently under research at the Greenfields Mixing Tank. Some nutrient is removed in the basin/wetland components of the scheme (Page *et al.,* 2008).

Table 15 Injectant water quality (Nov 2002 – November 2012) compared to Environment Protection Policy (Water Quality) 2003 fresh aquatic ecosystem water quality criteria (from sampling site WE2 at wetland outlet).

	Unit	EPP 2003	n	Detects	Max	Mean	SD	Median	95th %	n > EPP	% > EPP
Field Readings											
DO	mg/L	>6	39	39	9.35	3.83	1.94	3.83	7.24	**35**	**90**
pH	pH units	6.5-9.0	39	39	8.76	7.11	0.63	6.88	8.14	0	0
Physical characteristics											
Colour - True (456nm)	HU	30	59	59	**174**	**38**	29.08	26.00	**83.30**	0	0
pH	pH units	6.5-9.0	104	104	8.20	7.04	0.31	7.00	7.50	0	0
Suspended Solids	mg/L	20	103	103	**30**	5.26	4.86	4.00	13.80	**2**	**2**
Total Dissolved Solids (by EC)	mg/L	(+/-) 10%	102	102	790	145	87.17	130.00	200.00		
Turbidity	NTU	20	101	101	13	4.55	3.19	3.50	11.00	0	0
Nutrients											
Ammonia (NH3 as N)	mg/L	0.01	0								
Ammonia (total as N)*	mg/L	0.5	91	91	0.29	0.02	0.04	0.01	0.10	0	0
Nitrogen - Total	mg/L	5	89	89	1.18	0.42	0.19	0.36	0.83	0	0
Oxidised nitrogen (nitrate + nitrite as N)	mg/L	0.5	94	37	0.15	0.01	0.03	0.01	0.06	0	0
Phosphorus - Filterable Reactive as P*	mg/L	0.1	62	62	0.05	0.01	0.01	0.01	0.04	0	0
Phosphorus - Total	mg/L	0.5	94	94	0.21	0.05	0.03	0.04	0.10	0	0
Total Organic Carbon	mg/L	15	100	100	**26.00**	6.57	3.33	5.25	11.95	**2**	**2**
Biochemical Oxygen Demand*	mg/L	10	24	24	5.00	1.75	1.11	1.00	3.85	0	0
Metals and metalloids											
Aluminium - Soluble*	mg/L	0.1	42	42	0.09	0.02	0.02	0.01	0.07	0	0
Antimony - Total*	mg/L	0.03	20	20	0.01	0.001	0.004	0.001	0.007	0	0
Arsenic - Total*	mg/L	0.05	101	101	0.01	0.001	0.002	0.001	0.006	0	0
Beryllium - Total	mg/L	0.004	23	0						0	0
Cadmium - Total	mg/L	0.002	96	7	0.002	0.001	0.001	0.0004	0.001	0	0
Chromium (VI) - Soluble	mg/L	0.001	29	0						0	0
Copper - Total	mg/L	0.01	79	65	0.01	0.002	0.001	0.002	0.01	0	0
Iron - Total	mg/L	1	103	103	**2.84**	0.57	0.44	0.44	**1.19**	**11**	**11**
Lead - Total*	mg/L	0.005	101	101	**0.01**	0.001	0.002	0.001	**0.01**	**5**	**5**
Mercury - Total	mg/L	0.0001	44	1	0.00004					0	0
Nickel - Total	mg/L	0.15	68	56	0.01	0.001	0.001	0.001	0.003	0	0
Selenium - Total	mg/L	0.005	22	6	**0.01**	0.004	0.002	0.004	**0.01**	**1**	**5**
Silver - Total	mg/L	0.0001	18	1	**0.0006**					**1**	**6**
Thallium - Total	mg/L	0.004	20	0						0	0
Zinc - Total	mg/L	0.05	101	99	**4.02**	**0.11**	0.48	0.02	**0.22**	**12**	**12**

	Unit	EPP 2003	n	Detects	Max	Mean	SD	Median	95th %	n > EPP	% > EPP
Pesticides											
2 4-D	µg/L	0	23	2	**0.01**					**2**	**9**
Atrazine	µg/L	0	47	5	**1.80**	**0.61**	0.78	**0.20**	**1.64**	**5**	**11**
Azinphos-methyl	µg/L	0	46	0							
Dalapon	µg/L	0	12	1	**0.19**					**1**	**8**
Desethyl Atrazine	µg/L	0	12	2	**0.02**					**2**	**17**
Desisopropyl Atrazine	µg/L	0	12	1	**0.21**					**1**	**8**
Diazinon	µg/L	0	42	0							
Dicamba	µg/L	0	16	6	**0.35**	**0.10**	0.12	**0.05**	**0.28**	**6**	**38**
Diuron	µg/L	0	25	5	**0.14**	**0.12**	0.02	**0.13**	**0.14**	**5**	**20**
Fenitrothion	µg/L	0	42	0							
Heptachlor	µg/L	0	37	1	**40.00**	**40.00**				**1**	**3**
Hexazinone	µg/L	0	48	1	**10**					**1**	**2**
Linuron	µg/L	0	13	1	**29.00**					**1**	**8**
Malathion	µg/L	0	44	1	**100**					**1**	**2**
MCPA	µg/L	0	17	6	**0.27**	**0.20**	0.06	**0.22**	**0.26**	**6**	**35**
Mecoprop	µg/L	0	12	6	**0.02**	**0.02**	0.01	**0.02**	**0.02**	**6**	**50**
Metolachlor	µg/L	0	25	17	**0.12**	**0.01**	0.03	**0.00**	**0.03**	**17**	**68**
Parathion	µg/L	0	47	0							
Parathion methyl	µg/L	0	47	1	**0.30**					**1**	**2**
Prometryne	µg/L	0	45	0							
Simazine	µg/L	0	47	9	**0.57**	**0.21**	0.22	**0.12**	**0.53**	**9**	**19**
Triclopyr	µg/L	0	17	5	**0.03**	**0.03**	0.00	**0.03**	**0.03**	**5**	**29**
Other Organic Pollutants											
1,2,3,4-tetrachlorobenzene	µg /L	0.1	0								
1,2,3,5-tetrachlorobenzene	µg /L	0.1	0								
1,2,3-trichlorobenzene	µg /L	0.9	0								
1,2,4,5-tetrachlorobenzene	µg /L	0.2	0								
1,2,4-trichlorobenzene	µg /L	0.5	0								
1,2-dichlorobenzene	µg /L	2.5	0								
1,3,5-trichlorobenzene	µg /L	0.7	0								
1,3-dichlorobenzene	µg /L	2.5	0								
1,4-dichlorobenzene	µg /L	4	0								
2, 3, 7, 8 tetrachlorodibenzodioxin	µg /L	0	0								
2,4-dichlorophenol	µg/L	0.2	0								
Benzene	µg /L	300	10	0						0	0
Hexachlorobenzene	µg /L	0.007	0								
Monochlorobenzene	µg /L	15	0								

	Unit	EPP 2003	n	Detects	Max	Mean	SD	Median	95th %	n > EPP	% > EPP
Monochlorophenol	µg/L	7	0								
Oil and grease	µg /L	10000	1	1	3					0	0
Pentachlorobenzene	µg /L	0.03	0								
Pentachlorophenol	µg /L	0.05	0								
Phenol	µg /L	50	6	0						0	0
Polyaromatic hydrocarbons (PAHs)	µg /L	3	0								
Polychlorinated biphenyls (PCBs)	µg /L	0.001	0								
Tetrachlorophenol	µg/L	1	0								
Toluene	µg /L	300	11	0						0	0
Tributyltins	µg /L	0.08	0								
Trichlorophenol	µg/L	18	0								

*Half detection limits used where detects >=50% of n. **Bold** values highlight parameters exceeding EPP (2003) criteria.

3 PREVENTIVE MEASURES FOR URBAN STORMWATER QUALITY MANAGEMENT

Preventive measures for stormwater quality management include all actions, activities and processes used to:

- Exclude hazards (e.g. exclusion barriers)
- Reduce hazard concentrations (e.g. treatment above or below ground)
- Manage water usage / exposure (e.g. end-use restriction barriers such as withholding periods); see Table A3.5 in NRMMC-EPHC-NHMRC (2009a).

3.1 Preventative measures & multiple barriers

Specific treatments such as use of stormwater harvesting wetlands, bioretention basins, and elements of water sensitive urban design and MAR are preventative measures and part of the multi barrier scheme.

Employing on-site controls to reduce exposure augments existing barriers and may substitute for more expensive treatment. Examples of controls specific but not exclusive to irrigation are given in the Australian Guidelines for Water Recycling (NRMMC-EPHC-AHMC, 2006) and can be used in combination with treatment processes to meet the required pathogen inactivation credits $\log_{10}$ reduction targets.

The Parafield scheme applies a multiple barrier to approach minimise the risks to public health and the environment. The major barriers for the protection of human health include:

- Engineered wetland (via processes described in Section 2.2.2)
- Aquifer storage (via processes described in Section 2.2.4)
- Exposure reduction through irrigation of public open spaces at night (Section 2.2.6.2), placement of warning or prohibition signage in accordance with AS1319, and removable handles on external taps, purple powder coated taps according to reWater Guidelines (City of Salisbury, 2008)

AGT (2011c) identified a number of preventative measures that were integrated with those identified from the stakeholder risk management workshop (17/11/2011) and are summarised Table 16.

Table 16 Summary of preventative measures.

Preventative measure	Risks managed	Where applied	Responsibility	Comments
Enhanced sewer overflow alert program	Pathogens	Catchment	City of Salisbury	Agreement for Mawson Lakes not harvest stormwater when a sewer has overflowed > 100 kL into the catchment.
Catchment cleaning and maintenance	All	Catchments	City of Salisbury	AGT (2011c) identified street sweeping, maintenance of parks, rubbish collection and riparian zone restoration.
Catchment planning	All	Catchments	City of Salisbury	AGT (2011c) identified local government initiatives through planning legislation. Requirement that stormwater quality be explicitly covered in planning approvals.
Community education and involvement	Organic chemicals and nutrients	Catchment	City of Salisbury, NRM Board	AGT (2011c) identified community engagement as a potential preventative measure to reduce dumping of chemicals and garden waste into the stormwater system.
Enhanced SES Spill management program	Organic Chemicals	Catchment	State Emergency Services, City of Salisbury, EPA	An improved monitoring program to ensure minimisation of spills to the stormwater system and notification of stormwater harvesters
EPA Building & Construction Management	Turbidity	Catchment	EPA, City of Salisbury	Currently applied practice to mitigate TSS in stormwater runoff from construction sites. Reinforce inspection and compliance monitoring.
Draining and harvesting	Turbidity, nutrients	Wetlands	City of Salisbury	AGT (2011c) recommended periodic draining and thinning to manage carp; this should be done every 2-3 years*.
Waterfowl management	Pathogens	Wetlands	City of Salisbury	AGT (2011c) recommended a water fowl management program and strengthening of the bird proof netting.
Irrigation management to prevent clogging	Nutrients, Turbidity, Inorganic Chemicals	End use	City of Salisbury	Flushing of irrigation lines to prevent clogging.
Additional signage	Pathogens	End use	City of Salisbury	AGT (2011c) recommended additional signage to minimise risk of accidental ingestion by the public. Signage must comply with AS1319.
Purple pipework and purple powder coated taps with removable handles	Pathogens	End use	City of Salisbury	To avoid misuse and cross connections; identification of recycled water pipework and taps in accordance with AS2700, use of products in accordance with AS/NZS3500.
Manage public access to irrigated ovals	Pathogens	End use	End User (e.g. school)	A withholding period >1 hr to restrict public access and irrigate only at night; equivalent to 2.0 $\log_{10}$ pathogen inactivation credits. This is a requirement under individual water supply contracts. Reinforce inspection and compliance monitoring.
Industrial process water agreement	All	End use	End User (e.g. Michell Wool)	Requirement under individual water supply contracts. Reinforce inspection and compliance monitoring.

* Based on carp physiology showing that they do not disturb the sediment until they are around two to three years old (SA Water, pers. comm.).

3.2 Critical control points

The initial critical control points (CCPs) for the Parafield stormwater harvesting system were identified by Swierc *et al.* (2005) assessing the medium or greater level hazards using the critical control point decision tree as outlined in Australian Guidelines for Water Recycling (NRMMC-EPHC-AHMC 2006). These were subsequently expanded on and were reassessed in January 2012 taking into account the permanent infrastructure installed at the Parafield site which feeds the Mawson Lakes Recycled Water Scheme.

Existing and proposed alert and critical limits for each CCP are given in Table 17. Alert limits are more stringent and allow the operator time to adjust the process or check calibration of measurements prior to breaching the critical limit. Exceedance of a critical limit involves immediate corrective action to prevent transfer of risks to customers and may include automatic shutdown of processes, e.g. through the Supervisory Control and Data Acquisition (SCADA) system causing greater disruption to operations.

Environmental and health risks associated with source stormwater (instream basin) are controlled through monitoring and visual inspection prior to transfer to the holding basin. Automated monitoring and alarms ensure that the DHA approval condition of <100 NTU at the instream basin to holding basin transfer pump is satisfied (CCP1). Environmental risks associated with over-pressurising the aquifer are managed by the Supervisory Control and Data Acquisition system and engineering specifications (CCP2). A CCP for ensuring injection turbidity is <5 NTU is proposed to manage well clogging (CCP3). A CCP for ensuring salinity meets the requirements of the water supply agreement to the Mawson Lakes Recycled Water Scheme is also proposed (CCP4). Conditions under existing customer water supply agreements are used to manage pathogen risks through exposure controls (CCP5).

Table 17 Critical control points, alert limits, critical limits and corrective actions for the Parafield stormwater harvesting scheme.

	CCP	Hazard	Alert limit	Critical limit	Corrective action
1.	Instream basin**	Turbidity	>90 NTU sustained for >30 min	>100 NTU sustained for >30 min	No water will be transferred to the holding storage
2.	ASR/ASTR wells (injection)	Pressure	>1035 kPa sustained for >5 min	>1150 kPa sustained for >5 min	City of Salisbury slow injection flow rate to maintain pressure below 1150 kPa (as per AGT 2011c). *Automatically regulated by SCADA system.* Pump selection and engineering control does not allow this pressure to be exceeded.
3.	*ASR/ASTR wells (injection)**	Turbidity	>5 NTU as single reading	>5 NTU sustained for >30 min	Injection pump automatically shuts off. Extra time allowed for settling in wetland and re-commence injection once within specification.
4.	*Parafield storage tanks**	Salinity	TDS (by EC) >500 mg/L sustained for >30 min	TDS (by EC) >600 mg/L ***sustained for >30 min	City of Salisbury stop distribution pump, inject more wetland water into aquifer, purge tanks to instream basin if needed, re-test extracted water and re-commence distribution once within specification.
5.	Exposure controls	Pathogens	Withholding period <1 hr, daylight irrigation†	Minimum withholding period of 1 hr, night irrigation only†	City of Salisbury to cease supply to end user as per supply agreement

Proposed CCP*; † Controlled through balancing supply demands (pressure drops). ** No health-based evidence for this critical limit was found. It is recommended that a proposed operational control point for turbidity with an operational basis be used to replace CCP1 (see Figure 12). * This value is currently under revision as part of a revised water supply contract with SA Water.

The development of a water quality reference group to review exceedances and also develop more sophisticated Critical Control Points is warranted. This will initially be performed by the Water Safety Expert Panel of the Managed Aquifer Recharge and Stormwater Use Options project during the trial implementation of the plan. During the implementation a more permanent water quality reference group will be formed between the City of Salisbury and SA Water. Figure 13 shows a schematic of the current critical control points (13a) and those proposed for the future operation of the system (13b).

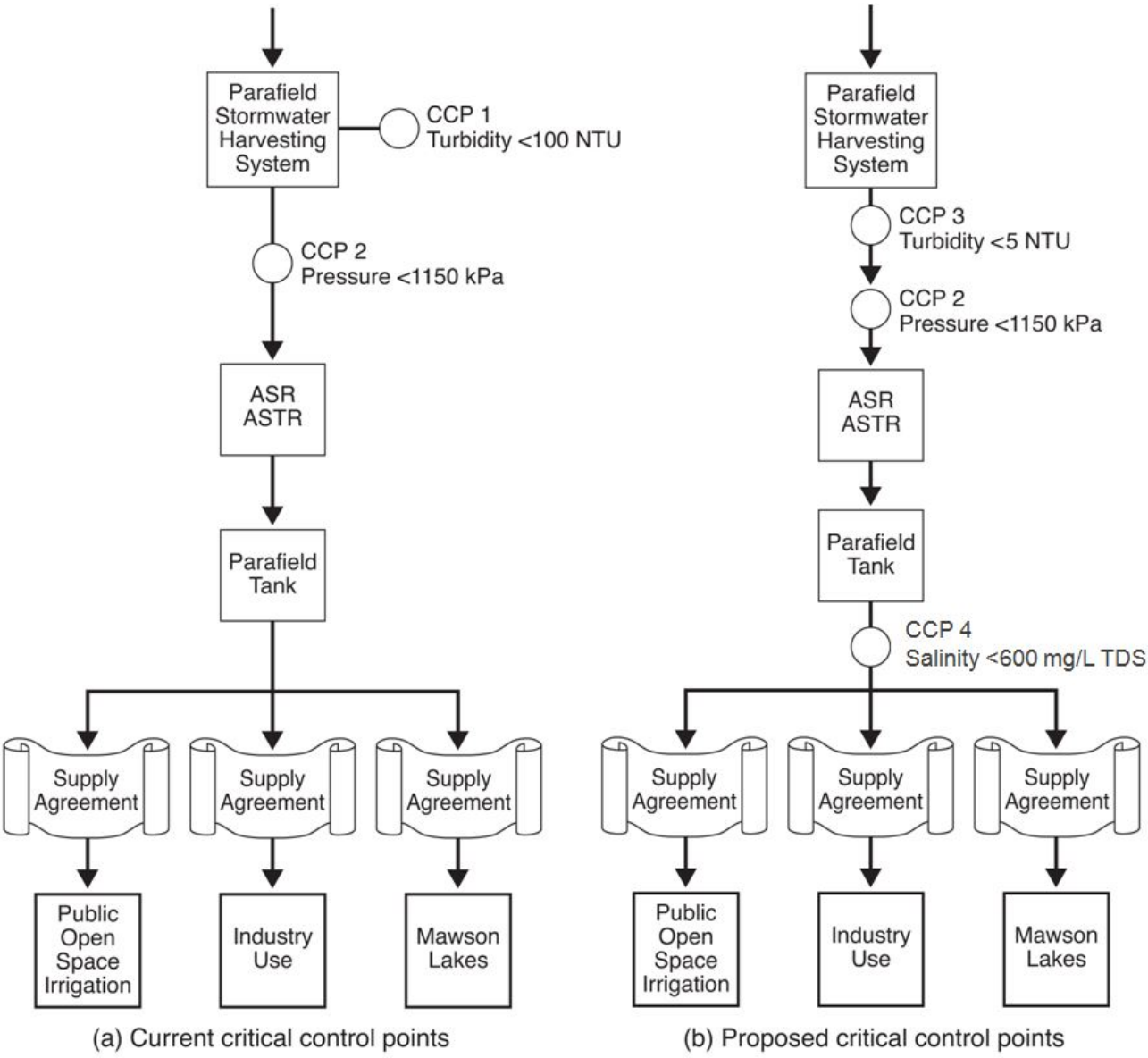

Figure 13 Current critical control points (a) and proposed critical control points (b).

3.3 Quality monitoring points

The preventative measures reported in Table 16 contribute to reducing the risks to human health and importantly to consumer confidence and public support for the Parafield Stormwater Harvesting Scheme. This is especially true of catchment-based activities which have a high public visibility, e.g. water sensitive urban design (WSUD). Many of these activities such as best practice for environmental management or public participation are outside the direct control of the plan. Table 18 summarises the existing quality monitoring points for the Parafield scheme. These should be strengthened where possible and formally linked to the plan and captured in the operations manual to ensure best management of risk.

Table 18 Quality monitoring points for the Parafield stormwater harvesting scheme.

Quality Monitoring Point	Hazards	Process	Barrier
Stormwater catchment	Pathogens, inorganic chemicals, organic chemicals, turbidity, nutrients	EPA guidelines for catchment activities, water sensitive urban design, spill response and clean up	Source control
Instream/holding storage (sedimentation) basin	Pathogens, inorganic chemicals, organic chemicals, turbidity, nutrients	Sedimentation, die off, degradation	Wetland treatment
Aquifer	Pathogens, inorganic chemicals, organic chemicals, turbidity, nutrients	Residence time (die off, degradation, net attachment, sequestration)	Aquifer treatment
Plumbing and distribution system	Pathogens	Auditing of controls in recycled water codes and standards e.g. infrastructure design standards (WSAA Dual Water Supply Systems Supplement Code), plumbing and drainage code AS/NZS 3500 e.g. backflow prevention	On-site controls

4 OPERATIONAL PROCEDURES & PROCESS CONTROL

Operational monitoring involves observational, water quality, water quantity and on-line monitoring of control parameters and is undertaken to support the management and sustainability of the stormwater MAR scheme.

4.1 Operational procedures

The operational procedures corresponding to the preventative measures, quality monitoring and CCPs are detailed in Section 3 and are made accessible to all City of Salisbury employees by means of the City of Salisbury intranet. These procedures and supporting documentation have been developed by City of Salisbury to undertake operational and maintenance activities. They cover specific and generic procedures, non-routine operational procedures, emergency response plans and standard operating procedures.

An Activities Schedule (Appendix B) shows activities required to be undertaken monthly, quarterly and annually by City of Salisbury staff in order to address the operating plan and demonstrate the risk management plan is fully implemented. This schedule covers all elements of the risk management framework.

Meetings twice per year between City of Salisbury and SA Water/Allwater senior contract operations staff are proposed. This allows opportunity to discuss any issues pertaining to the recycled stormwater operations and other contract related issues for the Mawson Lakes system.

4.2 Operational monitoring

Operational monitoring does not solely encompass treatment indicators; it also includes aspects of the system that require regular checking and observational monitoring to ensure that preventive measures are applied. Examples include operating pressures, groundwater levels, subsurface residence times for ASR wells, inspection of well infrastructure and wetland bird netting and checking of signage at irrigation sites. Table 19 contains the human health and environmental performance operational monitoring undertaken for the Parafield scheme.

Operational and environmental risks of injection of wetland-treated stormwater are controlled through automatic injection pump shut down and are managed through a proposed CCP (CCP3, Table 17, Figure 13). Operational monitoring points to check turbidity and *E. coli* levels of recovered water at the Parafield tank are proposed (Table 19). Visual inspections are performed to identify water quality issues (e.g. foam events, oil slicks). Failing inspection means that the captured water will not be progressed through the harvesting system and can be treated to remove the hazard.

The on-line monitored data listed in this table can be accessed through the City of Salisbury SCADA system. The Activities Schedule (Appendix B) lists the observational monitoring activities in addition to sampling, calibration, reporting and other scheduled activities.

There is a need to develop an Operations Manual that codifies actions under the activities schedule (Appendix B). The Operations Manual should contain a range of standard procedures governing calibration of equipment, water quality sampling, response to exceedances of CCPs, corrective actions and documentation and reporting protocols.

Table 19 Operational monitoring points for the Parafield scheme.

Location	Parameter	Target Criteria	Monitoring frequency	Analysis Type	Calibration frequency	Responsibility	Corrective action/s	Reporting
*Parafield drain station (PDS)**	Turbidity	<100 NTU	Continuous	On-line	As recommended by manufacturer	City of Salisbury	Potentially install and activate a closable weir at the in-stream basin harvesting point	• SCADA • Water quality reference panel • City of Salisbury Annual Reports
Instream basin	Visual quality	Foam < 5cm; oil slick <50% area	Batch (each individual transfer)	Visual inspection	N/A	City of Salisbury	Transfer to holding storage not allowed, allow time for dissipation/degradation	• Water quality reference panel • City of Salisbury Annual Reports
Wetland outlet (WE2)	Salinity (TDS)	<600 mg/L	Continuous	On-line	As recommended by manufacturer	City of Salisbury	Cease injection, check sensor calibration, recirculate water and retest, recommence once quality is within specification	• SCADA • Water quality reference panel • City of Salisbury Annual Reports
Wetland outlet (WE2)	pH	6.5-8.5	Continuous	On-line	As recommended by manufacturer	City of Salisbury	Cease injection, check sensor calibration, recirculate water and retest, recommence once quality is within specification	• SCADA • Water quality reference panel • City of Salisbury Annual Reports
ASR and ASTR systems	Aquifer Residence Time	>10 days	Continuous	Calculated by SCADA	N/A	City of Salisbury	Cease recovery and wait until minimum residence time is achieved	• SCADA • Water quality reference panel • City of Salisbury Annual Reports
*Parafield Tank outlet**	Turbidity	<5 NTU	Every 50 ML recovered	Field/Lab	As recommended by manufacturer	City of Salisbury	Cease supply, recirculate water and retest, recommence once quality is within specification	• SCADA • Water quality reference panel • City of Salisbury Annual Reports
*Parafield Tank outlet**	*E. coli*	<100 cfu/100mL (annual median)	Every 50ML recovered	Lab	As required by NATA	AWQC	Cease supply, allow time for die –off or recirculate, retest, recommence once quality is within specification	• Water quality reference panel • City of Salisbury Annual Reports

**Proposed operational monitoring point*.

4.3 Operational corrections

Operational corrections for the Parafield scheme address the conditions when unexpected events occur in addition to performing corrective actions if the system is operating outside normal operating conditions. Table 19 lists the location where the corrective actions can be applied for each operational monitoring point.

Operational target criteria and critical limits for stormwater harvesting and ASR operations are set and adjusted by City of Salisbury's senior management in consultation with the water quality reference panel.

4.3.1 Overview of key automatic controls

The Parafield stormwater harvesting scheme control system is designed to maintain sufficient flows to meet customer demand from the Parafield storage tank at the required water quality and distribute this water to customers. Automatic controls include:

(a) Instream and holding basin level control

Once the pump is manually triggered to pump water from the instream basin to the holding basin, the transfer pumping ceases automatically once a minimum level in the instream basin or a maximum level in the holding basin is reached.

(b) Wetland level control

Once an injection cycle is initiated, pumping from the wetland will automatically cease once a minimum water level is reached.

(c) Parafield tanks level control

The water levels in the Parafield storage tanks are controlled by pumps that operate over a local telemetry link. When the water level in the tank falls, the pumps to the ASR or ASTR systems will start to maintain an optimum tank water level which is set above the pump start levels and below the pump stop levels.

(d) Injection pressure control

The supervisory control and data acquisition system is set up to automatically control injection pressures by adjusting the pump flow rate through online sensors and local telemetry. Injection pressure is managed through an existing CCP (CCP2, Table 17).

(e) Injection turbidity control

If turbidity at an injection well exceeds 5 NTU for longer than 30 continuous minutes, injection is automatically stopped. Injection turbidity could be managed with the proposed CCP (CCP3, Table 17).

(f) Recovered stormwater salinity control

An automatic shutoff trigger limit for salinity of 1200 mg/L TDS exists at the inlet to the Greenfields Recycled Water Distribution Centre. This is the responsibility of Allwater so is not technically part of this plan. If recycled stormwater salinity exceeds this limit (for mixing with reclaimed water), Allwater switch to mains water until the recycled stormwater quality improves. This current limit is being revised as part of a water supply agreement for stormwater supplied to the Greenfields Recycled Water Distribution Centre. A CCP for salinity control at the Parafield Storage Tanks is proposed to ensure water meets customer's requirements (CCP4, Table 17) but this figure is subject to future revision.

(g) pH controls

An automatic shutoff trigger for out of specification pH also exists at the inlet to the Greenfields Recycled Water Distribution Centre and is the responsibility of Allwater. If pH is out of specification for the mixing with treated effluent, Allwater switch to mains water until the recycled stormwater quality improves.

4.3.2 Communication process for operational incidents: Stakeholders, Customers & Media

Operational incidents are reported in the form of incident notifications (*FM008 Incident, Injury, Near Miss Report*). This form is to be used for the reporting of a Council related incident that resulted in either: Death, personal injury/illness, notifiable incident (refer Section C:7a), damage to property, plant, equipment, harm to the environment and/or a near miss situation). Incident notifications are issued whenever unplanned work or events occur that are outside normal everyday operations. Most of the communications are internal however, some communications will include external stakeholders. Here, the intention is to provide early notification and to share detail of the event thus minimising risk and maximising the opportunity for control of any incident that may arise. Some of these may be distributed to SA Water and other Authorities where required by the Council investigation and follow-up process. Incident notifications are issued when the trigger levels or criteria for key parameters are exceeded. Depending of the severity of the incident, the process can move from the local incident level and be progressively escalated to an emergency, which may be beyond the scope of City of Salisbury.

4.4 Equipment Capability & Maintenance

City of Salisbury employs qualified consultant engineers and technicians to ensure all equipment is capable of performance within specification. All equipment used either directly or indirectly undergoes regular planned calibration and scheduled preventative maintenance. Regular inspection and maintenance of all equipment from stormwater catchment to customer is required to ensure continuing process capability. A maintenance program has been established and documented, detailing:

- operational procedures and records for the maintenance of equipment, including the calibration of monitoring equipment;
- schedules and timelines;
- responsibilities;
- resource requirements.

Maintenance is performed by both City of Salisbury trained employees and qualified contractors (Water Data Services). All maintenance and calibration activity is recorded in the maintenance logs according to the City of Salisbury procedures.

4.5 Materials & Chemicals

The selection of materials and chemicals used in the Parafield system is an important consideration as potentially they may have an adverse effect on water quality. No chemicals are currently added for water treatment but some chemicals are used as part of the operation of the system. Section 6.7 of AGT (2011c) details the materials and chemicals used or potentially used in the Parafield scheme and MAR operations and maintenance. Briefly summarised they include drilling fluids, grouting, cement (including bentonite cement), and clay dispersants (e.g. Kalgon) used in the well construction phase. Hydrochloric acid may be used in acidizing for well redevelopment and chlorine shock dosing for treatment of iron bacteria.

All chemicals used have been evaluated for potential contamination. General considerations include data on impurities, chemical and physical properties, maximum dosages, behaviour in water, migration and concentration build-up. Only chemical certified in accordance with required specifications and associated quality standards (AS/NZS ISO9001:2008) were selected. This included the use of documented procedures for the control of chemicals, including purchasing, verification, handling, storage and maintenance. These were established to assure the safety and quality of the chemicals in use at the point of application.

Responsibilities for testing and quality assurance of chemicals by the supplier have been defined in purchase contracts. Material safety data sheets have been supplied for each chemical used.

Contaminants may also be introduced when water comes into contact with materials such as protective coatings, linings and liners, joining and sealing products, pipes and fittings, valves, meters and other components. Materials used meet the Australian Standard AS/NZS 4020:2005 for products used in contact with drinking water and/or pipework and products complying with Australian Standard AS/NZS 3500 Section 2 where recycled stormwater is used.

5 VERIFICATION OF RECYCLED WATER QUALITY & ENVIRONMENTAL PERFORMANCE

5.1 Stormwater Quality Monitoring

Element 5 verifies that the Parafield scheme provides safety for human health and the environment. Verification of the recovered water quality assesses the overall performance of the system in relation to specific uses of the water. Water quality monitoring is undertaken to meet a licence condition by the SA EPA. This information is later used to audit the performance of the Parafield scheme (see Element 11). SA Water undertakes their own sampling program to verify water quality of the blended recycled water quality supplied to the Mawson Lakes Recycled Water Scheme in accordance with the DHA conditions. SA Water also undertakes sampling of the stormwater supplied to the Greenfields Mixing Tank to verify its quality, in addition to what is carried out by the City of Salisbury.

All stormwater quality monitoring is consistent with the *Standard Methods for Examination of Water and Wastewater* (APHA-AWWA-WEF, 1998). Water quality samples are sent to the Australian Water Quality Centre (AWQC) for analysis. Analysis undertaken by the AWQC is governed under their NATA-certified business systems (NATA Accreditation No: 1115 for chemistry, microbiology and biology).

The verification monitoring program, as shown in Table 20, has been developed to confirm compliance with this recycled water quality management plan is achieved, and to also determine where modifications to the Mawson Lakes scheme management plan is needed.

Table 20 Verification monitoring of the recycled water for the Parafield scheme.

Location	Sample Point	Frequency	Analysis	Analytes	Product specification for notification	Responsibility
Parafield well outlet	WE02	Every 50 ML recovered from each well	Grab sample	General, nutrients, metals, microbiological, organic chemicals, Langelier Index*	As per EPA Lic. 19283	City of Salisbury
Parafield storage tanks	Tank 1, Tank 2‡	Continuous	On-line analyser recorded to SCADA	Electrical conductivity	Refer to operational monitoring	City of Salisbury
T1 aquifer	20742†	Annually	Grab sample	General, nutrients, metals, microbiological, organic chemicals, Langelier Index*	As per EPA Lic. 19283	City of Salisbury
Inlet to Greenfields Mixing Tank	SP14026	Weekly	Grab sample	*E. coli*	>100 cfu/100mL (Type 2), >1000 cfu/100 mL (Type 1)	SA Water
Inlet to Greenfields Mixing Tank	SP14026	Weekly	Grab sample	Cl, Colour, EC, Fe, Mn, Temp., TDS,	Not applicable	SA Water
All customers	N.A.	On going	Observation by public	Public comments	Not applicable	SA Water (Mawson Lakes) City of Salisbury (Open space irrigation and Industry)

* Full list of parameters and sampling program given in Appendix C.†City of Salisbury sample number.‡ City of Salisbury SCADA name.

5.2 Irrigation sites and receiving environment monitoring

A number of activities exist that focus on the monitoring of application sites and the receiving environment for the Mawson Lakes scheme. City of Salisbury has a monitoring program which is consistent with the requirements of the Irrigation Management Plan (Hydroplan, 2004; Appendix E). City of Salisbury is responsible for administering the Irrigation Management Plan (Hydroplan, 2004) and a monitoring program is contained which covers:

- Watercourses
- Aquifers
- Municipal (open space) irrigation sites

This monitoring program consists of a suite of sampling locations, such as:

- Dry Creek – based on suite of determinants taken upstream (from Mawson Lakes entrance) and downstream (from Greenfields Wetland)
- Aquifers – injection pressure and dissolution of the matrix.
- Plants – visual assessment of landscaping plant health,
- Soils – chemistry (inorganic chemicals, nutrients, sodicity) and physical properties as well as water application rates,
- Groundwater – salinity levels and perched water table levels (18 observation wells).

SA Water is provided a copy of City of Salisbury monitoring reports on an annual basis. See the Mawson Lakes Recycled Water Scheme Risk Management Plan (2012) for a detailed list of the monitoring programs performed. SA Water is also notified automatically of exceedances (e.g. *E. coli*) from City of Salisbury recovered stormwater quality monitoring (every 50 ML recovered).

5.3 Documentation & reliability

The City of Salisbury monitoring program is centred on supply of recycled stormwater to the Mawson Lakes scheme, industry users and the environmental performance of receiving environments and irrigated areas. For operational and regulatory requirements, SA Water also monitors the recycled stormwater, which occurs from the stormwater inlet pipeline at the Greenfields Mixing Tank (i.e. SP14026). A summary of City of Salisbury monitoring procedures are provided in their monitoring program (see Table 20).

5.4 Satisfaction of users and customer feedback

Customer complaints will be compiled on an annual basis and reported into the water quality report for the Parafield scheme for review by the Water Quality Reference group.

While it is not within the scope of the Parafield scheme to implement a system like SA Water's MAXIMO® system (which schedules water quality sampling, maintenance, calibration schedules and records customer complaints) a simplified structure for documenting and reviewing customer complaints and feedback is needed to address the shortfalls. Some training of operators in response protocols and documentation particularly where exceedances of reporting criteria may be involved is warranted to ensure quality of supply and customer satisfaction. Documented feedback can periodically be reviewed by a water quality reference panel.

The Council can be contacted at any time on 8406 8222, or via email form at <http://www.salisbury.sa.gov.au/Contact_Us> (Apr. 29, 2013)

During work hours this number goes to the Customer Service Unit who will determine the appropriate staff member to deal with the issue. After hours this number diverts to an external Call Centre. A text message is sent to a call-out officer. If a response is not received in 20 minutes, the test message is sent to an escalating 'chain of command' until the message is responded to. For events such as sewer overflows or pollutant spills in the catchment, the call-out officer has an instruction folder which requires them to notify

the Water Business Unit and the Environmental Health Unit. A contract (10228) is in place for emergency Water Collection and Sample Analyses, with the Australian Water Quality Centre and Environmental Business Solutions (EBS) which can be implemented at short notice.

5.5 Short-term evaluation of results

Data from the Parafield Scheme are compiled into excel spreadsheets and reviewed in accord with the SA EPA reporting requirements. Management is by exception, where a water quality guideline is exceeded follow-up corrective responses will be initiated. In addition there is an annual review of water quality data across the site as part of the on-going improvement of the risk management plan.

5.6 Corrective responses

Corrective responses in relation to verification monitoring parameters depend upon the specific parameter. Verification monitoring is used to detect longer term trends and is not used for critical control point or operational monitoring.

Water quality results from verification monitoring are currently sent to the SA EPA within 14 days of receipt of the results as part of the licence agreement. The corrective responses are determined by the SA EPA which may impose or vary a condition of the licence at any time where the EPA is satisfied that the licensee is in breach of the general environmental duty to take all reasonable practical measures to prevent or minimise harm to the environment. Specific corrective actions to verification monitoring are determined by the SA EPA.

Recycled stormwater *E. coli* results from verification monitoring undertaken by Allwater at the Greenfields Mixing Tank (SP14026) have an AWQC product specification of 100 cfu /100 mL (Table 20). If numbers are equal to or exceed this amount, the AWQC Laboratory Information Management System (LIMS) automatically notifies Allwater, SA Water and DHA and the City of Salisbury. Type 1 incidents (*E. coli* >1000 cfu/100 mL) are required to be investigated through a root cause workshop by Allwater (see Section 6) and use temporarily discontinued and/or switched to main water.

6 INCIDENT AND EMERGENCY MANAGEMENT

Responses to incidents or emergencies can compromise the operation of a MAR system. The development of preventive measures appropriate to the risks should be documented as part of Elements 2 and 3 in the MAR system's risk management plan. The DHA approval conditions for SA Water's operation of the Mawson Lakes Recycled Water Scheme, as at July 2012, include Appendix A: *Water/Wastewater Incident Notification and Communication Protocol*. Table 21 is a subset of these protocols and outlines the City of Salisbury responses to incidents as relevant to the Parafield stormwater recycling scheme. It is noted that *E. coli* is monitored in stormwater supplied to the Greenfields Mixing Tank by both the City of Salisbury and SA Water. The two grab samples are collected generally on the same day by the AWQC samplers. The City of Salisbury will inform the DHA and Allwater if *E. coli* ≥100 / 100 mL in stormwater at the inlet to the Greenfields Mixing Tank (SP14026).

Table 21 Summary of DHA incident criteria (as at July 2012) related to the Parafield Stormwater Harvesting Scheme.

PARAMETER	TYPE 1 INCIDENT	TYPE 2 INCIDENT	Responsibility/Comments
E. coli[PH] Recycled stormwater prior to chlorination (SP14026)	• >1,000 organisms per 100 mL	• >100 organisms per 100 mL	• Allwater, City of Salisbury must also be notified
Sewage spills[PH] Parafield Stormwater Catchment	• Sewage spills of ≥100 kL discharged to a natural watercourse or wetland either directly or through Parafield stormwater catchment.	• Sewage spills of <100 kL discharged to a natural watercourse or wetland either directly or through Parafield stormwater catchment.	• Allwater, City of Salisbury must also be notified by SA Water/Allwater
Chemical and physical quality[PH] Recycled stormwater		• Any exceedance of requirements specified by EPA for the ASR scheme.	• City of Salisbury, Allwater must also be notified

[PH] Public health wastewater incident

Type 1 incidents must be reported to agencies, logged and investigated as follows:

- Water Incident Coordinator and DHA reported to immediately by telephone and within 24 hours by email/hard copy.
- SA EPA for sewage spills ≥100 kL reported to immediately by telephone and within 24 hours by email/hard copy.
- All Type 1 incidents are logged by Allwater.
- Root cause workshop is undertaken by Allwater to investigate the incident.

Type 2 incidents must be reported to agencies and logged as indicated below:

- EPA within 24 hours by telephone or email/hardcopy.
- DHA within 24 hours by telephone or email/hardcopy.
- All Type 2 incidents are logged by Allwater.

Management of incidents and emergencies for stormwater harvesting and MAR systems also includes responses to the following incidents according to existing protocols:

- Spills of hazardous substances within the stormwater catchment are reported to the City of Salisbury by State Emergency Services immediately.
- Sewer overflows of over 10 kL within the stormwater catchment are reported to the City of Salisbury by SA Water immediately.

- High turbidity in the in-stream basin currently must be allowed to fall below 100 NTU prior to pumping to the holding basin.
- Observed foam events or oil slicks in the in-stream basin must be allowed to dissipate prior to pumping to the holding basin (as per CCP#1 , Section 3.2).
- High *E. coli* counts (>100 cfu/100 mL) in the recovered stormwater as measured by the City of Salisbury must be reported to Allwater within 24 hours of return of test result.

6.1 Communication

Responses to incidents or emergencies can compromise the operation of a MAR system. The development of preventive measures appropriate to the risks is documented as part of Elements 2 and 3 in this risk-based management plan. Australian Groundwater Technologies (2011c) developed management responses to identified hazards from a risk assessment (Australian Groundwater Technologies 2011b) for City of Salisbury ASR schemes. Many of them have been encapsulated into the CCPs (see Section 3.2).

Specific plans are in place in the event of the need for a response to the media in accordance with the established communications plan already implemented by the City of Salisbury. The City of Salisbury has also created a dedicated business unit to deliver recycled stormwater solutions for the community, including a number of industrial and commercial customers. The business unit has the following objective. *"The Salisbury Water Business Unit strives to be a sustainable and financially secure business that delivers multiple community benefits through improvement of the urban and ecological environment, without creating unnecessary risks for the Council."* Further details, including governance arrangements can be found on the website at:
http://www.salisbury.sa.gov.au/Services/Salisbury_Water/Salisbury_Water_Management_Board

City of Salisbury has a Customer Service Charter available:
(http://www.salisbury.sa.gov.au/Services/Compliments_Comments_and_Complaints/Customer_Service_Charter)

This establishes procedures to ensure all customer complaints are dealt with daily. A summary of the complaints is reported at the biannual meeting with SA Water and other stakeholder groups.

Trigger levels for environmental and health incidents are defined in this protocol. Reporting timeframes and who to advise when incident triggers are reached are also set out. There are two classification levels of incident reporting relevant to the City of Salisbury and the Parafield scheme as set out in the DHA approval; Type 1 and Type 2. The primary difference between a Type 1 and Type 2 incident is response time (see Section 6.2).

A Priority Type 1 incident is also defined in the DHA approval conditions for the MLRWS that relates to detection of plumbing cross-connections in Mawson Lakes with the potential to contaminate the drinking water network or drinking water supply of a third party. Priority Type 1 incident management only applies to SA Water.

6.2 Incident and Emergency Response Protocols and Procedures

Mawson Lakes Recycled Water Scheme

All incidents in the Parafield stormwater harvesting system are managed using the incident notification and communication protocol in relation to the Mawson Lakes Recycled Water Scheme (see Table 21) and reported by SA Water to the DHA and EPA. In some instances actions may vary based on the nature of the event. Discussions on appropriate corrective actions involved key stakeholders such as SA Water, DHA and the EPA.

City of Salisbury owned & operated municipal irrigation areas

All incidents reported for City of Salisbury owned and operated municipal areas are recorded on an incident register (along with customer complaints). In some instances actions may vary based on the nature of the

event. Discussions on appropriate corrective actions involved key stakeholders such as SA Water, DHA and the EPA.

Non-City of Salisbury owned & operated irrigation areas

All incidents reported for other customers of the scheme are recorded by City of Salisbury on an incident register (e.g. irrigation without restriction of public access). Generally these incidents can be related to the water supply agreements and actions may vary based on the nature of the event. Discussions on appropriate corrective actions involved key stakeholders such as SA Water, DHA and the EPA.

Spill of a substance in the stormwater catchment

Whenever a spillage occurs within the catchment the aim of the response is to contain the spillage, notify stakeholders and undertake any clean up operations as quickly as possible. Generally the response to spillage of large quantities of liquids or other wastes that could potentially enter the stormwater network include:

1. Contain the spill using either bunding or appropriate spill containment measures and prevent further spillage entering into the stormwater network. This is done as a priority within 4 hours of spill notification to City of Salisbury.
2. Notify DHA and EPA within 4 hours of the spill.
3. Clean spill with appropriate measures using an adsorbent if required. Timing will be dependent on the spill size, location and nature.
4. Schedule additional water quality monitoring as required by DHA or EPA. Type of monitoring will be dependent on the nature of the spill. Results from the monitoring will be reported to the EPA within 14 days of receipt of the results.
5. Record activities undertaken in the *Parafield Stormwater Harvesting System Incident Log* for annual review after completion of the incident.

Sewage overflows and leaks into the environment

Sewage spills/leaks of <100 kL (Type 2 Incident) and ≥100 kL (Type 1 Incident) entering the environment e.g. water course, wetland directly or through the stormwater drainage system can increase pathogen risks for stormwater harvesting activities. These incidents can be managed by:

1. Immediate notification by SA Water/Allwater to City of Salisbury within (4 hours).
2. City of Salisbury inspect and take water samples independently of SA Water and send samples directly to the laboratory for *E. coli* analysis.
3. SA Water/Allwater apply chlorine shock treatment to area of spill.
4. Increasing monitoring of *E. coli* (as an indicator) in wetland outlet (injectant) and recovered stormwater for the next week.
5. Allowing additional detention time in wetland and/or aquifer for pathogens to die off if high numbers > 100 cfu/ mL of *E. coli* detected.
6. Recording activities undertaken in the incident log for annual review.

High turbidity in in-stream basin inlet

High turbidity in the instream basin can be caused by a number of catchment based activities or nature of the stormwater flow event. Turbidity can be managed by:

1. Allowing additional time for settling in the instream basin and/or holding storage. Continue to check the water quality the next day to see if there is visual turbidity improvement.
2. Investigating potential catchment sources (e.g. construction activities) and ensuring EPA guidelines for management of these activities are adhered to.
3. Ensuring erosion management activities are in place at key catchment locations known to be land use risks to turbidity.
4. Recording activities undertaken in the incident log for annual review.

Observed high levels of foam or oil in the in-stream basin

High foam events (>5 cm) or visible oil slicks are usually the result of contamination in the stormwater catchment and can be managed by:

1. Stopping transfer of water to the holding station.
2. Allowing 24 hours for degradation and subsequent reinspection. Hold for an additional 24 hours until foam has subsided. Catchment-based investigation and water quality sampling if foam has not subsided within 24 hours.
3. Recording activities undertaken in the incident log for annual review.

High *E. coli* counts in recovered stormwater

High *E. coli* counts (Type 2 Incident >100 n/100 mL; Type 1 Incident > 1000 n/100 mL) are usually the result of contamination by more recently injected stormwater as *E. coli* has a relatively rapid aquifer decay rate. *E. coli* levels are often variable and a single high measure may not be repeatable. *E. coli* levels can be managed by:

1. Immediate re-sampling to check for anomalous readings (laboratory results take a minimum of 24 hours to be returned).
2. Recirculating water back through the Parafield wetland and reinject
3. Recovering water from a different well.
4. Checking well infrastructure, wetland and Parafield storage tanks for obvious signs of contamination or breaches in well integrity and repair if required.
5. Recording activities undertaken in the incident log for annual review.

High or low pH in recovered stormwater

High or low pH may be the result of a significant acid or caustic chemical spill in the catchment.

1. Immediately check calibration log of pH meter, recalibrate and obtain a manual field measurement.
2. Monitor until pH is acceptable. If unacceptable notify SA EPA for advice within 24 hours.
3. Record activities undertaken in the incident log for annual review.

High salinity in recovered stormwater

High salinity is the result of entrained groundwater and management of recovery efficiency.

1. Immediately switch recovery to a different production well to dilute in mixing tank and achieve target salinity as monitored by the supervisory control and data acquisition system purging Parafield storage tanks if necessary.
2. Inject more water into the saline well and monitor observation well until salinity is acceptable.
3. Record activities undertaken in the incident log for annual review.

High turbidity in recovered stormwater

1. Immediately switch recovery to a different production well to dilute in mixing tank and achieve target turbidity as monitored by the supervisory control and data acquisition system
2. Begin purge cycle of the Parafield storage tanks into basins/wetland if necessary.
3. Recirculate the water back through the Parafield wetland and reinject into the ASR well.
4. Resample for turbidity.
5. If high initiate back flushing procedure.
6. Record activities undertaken in the incident log for annual review.

7 OPERATOR, CONTRACTOR & END USER AWARENESS AND TRAINING

This element involves awareness and training for operators, contractors and end users of harvested stormwater. This area is important, because the knowledge, skills, motivation and commitment of operators, contractors and end users ultimately determine:

- a harvested stormwater supplier's ability to successfully operate a water supply system and maintain the exclusion barriers used for preventive measures
- the effectiveness of end-use restriction barriers used as preventive measures

7.1 Operator awareness and training

City of Salisbury employees and contractors must be appropriately skilled and trained in the management and operation of the stormwater harvesting systems, as their actions can have a major impact on water quality and public health. All City of Salisbury employees should have a sound knowledge base from which to make effective operational decisions.

This requires training in the methods and skills required to perform their tasks efficiently and competently, as well as knowledge and understanding of the impact their activities can have on water quality. This is achieved by all undergoing a certified training course on stormwater harvesting and Managed Aquifer Recharge. For example, operators understand water treatment concepts and be able to apply these concepts and adjust processes appropriately to respond to variations in water quality. Training includes Examples of relevant areas to address are:

- general stormwater quality;
- water biology and water chemistry;
- specific training to optimise the Parafield system performance in areas such as:
    - reticulation management
    - sampling, monitoring and analysis
    - interpretation and recording of results
    - maintenance of equipment

Employees are also trained in other aspects of drinking water quality management, including incident and emergency response, documentation, record keeping, reporting, and research and development. City of Salisbury uses in-house developed formal training courses accredited by TAFE (Certificate 3 in Water Operations), in-house training, on-the-job experience, mentor programs, workshops, demonstrations, seminars, courses and conferences. The training programs encourage employees to communicate and think critically about the operational aspects of their work. The training is documented, and records are maintained of all employees who have participated in training.

7.2 Contractor awareness and training

Guidelines for installation of recycled water services including plumbing technical regulation is covered by the Office of the Technical Regulator (<http://www.sa.gov.au/government/entity/959/> (Apr. 29, 2013). Only licensed contractors are used to perform plumbing and electrical work on the Parafield scheme. All plumbing work and products must comply with the Australian Standards AS/NZS3500 and AS2700 and be clearly marked with a warning or prohibition sign in accordance with AS1319.

7.3 End user awareness and training

Recycled water customers are provided with information packs along with the details of supply and use restrictions contained within individual water supply agreements both through the City of Salisbury and SA

Water). A range of information sources mainly related to recycled stormwater (termed 'Salisbury Water' by the Council) are made publicly and freely available from the City of Salisbury's website:

<http://www.salisbury.sa.gov.au/Services/Salisbury_Water/Water_Services> (Apr. 29, 2013).

This website includes details of:

- Pricing
- Current recycled water use guidelines (covering appropriate use, guidelines on installation, metering, commissioning the system and approved products)
- Water quality (indicative information to be used as a guide only)
- Water pressure and restrictions (potential impact to design of irrigation systems through lower pressure of recycled stormwater supply compared to drinking water reticulation)
- Examples of water supply agreements for residential and industrial/agricultural users
- Telephone contact details and email contact form

Additionally, vendor training occurs to educate users in the event new equipment is brought on line.

At the change of home ownership within the Mawson Lakes recycled water distribution network the following procedures are in place:

- SA Water conducts an audit to check for any cross-connections.
- A sticker with the inspection date is fixed inside the electricity meter box.
- The SA Water Residential Recycled Water Household Guide is provided.

The trigger for the audit at the change of ownership is by SA Water having an encumbrance (i.e. interest) on the title (i.e. all those in Mawson Lakes). The encumbrance flags the selling conveyancer to notify SA Water of the change in ownership. Sellers have some responsibility to pass on relevant planning information and manuals for equipment. The audit and provision of the Recycled Water Household Guide is done with the seller and is left on the property for the new owner.

There is currently no formal process for notifying renters. It is understood that the obligation sits with the landlord/ property agency to provide all appropriate instruction on the household's equipment to the new tenant.

The SA Water Residential Recycled Water Household Guide, self-audit form and supply agreement are publicly available at: <http://www.sawater.com.au/SAWater/YourHome/RecycledWaterCustomers> (Apr. 29, 2013).

8 COMMUNITY INVOLVEMENT AND AWARENESS

Consultation with users of harvested stormwater, stakeholders (e.g. residents of Mawson Lakes) and the general community is normally an essential component of the development of stormwater harvesting schemes, and needs to be started as early as possible. Public and stakeholder concerns can be very powerful, and can mean the difference between acceptance and rejection of recycled water schemes.

8.1 Consultation with users of recycled water and the community

A detailed communications strategy was developed for the MLRWS in July 2004. Preceding this strategy, a post-commissioning strategy was also initiated but has not yet been made publically available.

8.2 Communication and education

The methods that currently exist for communicating with and informing City of Salisbury customers are shown in Table 22.

Table 22 Current communication and education methods available to MLRWS residents

Communication and/or education tool	Description
City of Salisbury Corporate Website	Provides specific stormwater harvesting webpage, outlining overview of the recycled water system and links to the recycled water plumbing guide, self-audit checklist and the customer agreement.
Mawson Lakes Website	Provides overview of recycled water system, with link to City of Salisbury corporate website for further details.
Mawson Lakes Community Website	Provides information on recycled water system, with links to download Information Sheets 1-4.
Customer agreement	An agreement exists with each customer supplied with recycled water.
Call centre	General inquiries are fielded by the City of Salisbury Customer Call Centre.
Local newspaper	Provides an avenue to convey any changes made to the system.
Customer Request for Recycled Water Metered Water Connection	City of Salisbury information sheet which provides recycled water information such as plumbing requirements, recycled water uses, etc to prospective customers.

9 VALIDATION, RESEARCH & DEVELOPMENT

This element covers validation monitoring, research and development. It is important that corporations, regulators and resource managers are committed to research and development activities on recycled stormwater quality issues, including investigation of innovative processes and solutions, and validation of outcomes.

9.1 Validation of process

9.1.1 Objective of validation monitoring

This is defined as the monitoring undertaken to demonstrate that the preventive measures/barriers, critical limit set-points, operational configuration and operating procedures implemented will achieve the required water quality.

9.1.2 Reclaimed wastewater

Validation monitoring activities have been carried out at the Bolivar WWTP and RWTP to confirm that the minimum pathogen $\log_{10}$ removal values have been achieved through activated sludge treatment, stabilisation lagoons, media filtration and chlorination for commercial food crop irrigation and dual reticulation (and therefore unrestricted municipal irrigation) end uses. These activities have been documented in research reports and consolidated in the Bolivar-VPS Recycled Water Management Plan.

9.1.3 Recycled stormwater

The stormwater quality and controls set by DHA (see DHA variation to Mawson Lakes approval, July 2012) is centred on:

- Stormwater source control measures – primary preventative measures for virus and protozoa control
- *E. coli* – harvested stormwater prior to chlorination to contain < 100 *E. coli* / 100 mL
- Turbidity – not to exceed 100 NTU at Pump Station 1 located at the in-stream basin. No validation monitoring was undertaken to verify that this produced an acceptable recycled stormwater quality for dual reticulation reuse.
- CSIRO studies have assisted in assessing and quantifying the wetland and aquifer treatment processes (Page *et al.,* 2008; 2009; Sidhu *et al.,* 2008; 2010; Vanderzalm *et al*. 2010). However to date these natural treatments for pathogen removal by net attachment to aquifer matrix have not been validated and are therefore not assessed as a barrier when managing the system. Validation methodologies need to be developed and applied. Similarly treatment in unprotected wetlands warrants further study.

9.1.4 Recycled water

No validation monitoring was undertaken on the final recycled water blend.

9.2 Design of equipment

Information relating to authorised products and materials are contained in the Water Supply Code of Australia – Dual Water Supply Supplement (WSA 03 – Code Supplement) or SA Water's 'additional requirements' document.

9.3 Investigative studies and research monitoring

A series of research projects have been undertaken including ASTR a project to assess viability of aquifer storage transfer recovery in a brackish aquifer. This was subsequently expanded under auspices of United Water as part of the RECLAIM WATER European Commission project 2005-2009 (Kazner *et al*. 2012). This was further developed into the MARSUO project by the partners listed in the Acknowledgements.

CSIRO studies have helped evaluate hazard sources in the catchments and quantify raw stormwater quality parameters such as pesticides (Page *et al*. 2010), flushing effectiveness of the aquifer (Miotlinski *et al*. 2013), effects of harvested stormwater on infrastructure networks and water quality in distribution systems (Tjandraatmadja *et al*. 2012) and social research issues on stormwater acceptance by the community for different end uses (Mankad *et al*. 2013). Most of the previous work has focussed on risk assessment and is documented in the CSIRO Managed Aquifer Recharge and Stormwater Use Options (MARSUO) Public and Environmental Health Risk Assessment Report (Page *et al.,* 2013).

9.3.1 Future projects

The current Managed Aquifer Recharge and Stormwater Use Options (MARSUO) project has investigated stormwater quality risks at the Parafield site related to different end uses. Economic modelling by the City of Salisbury has suggested that larger scale operations are warranted. Future work is also intended to assess the net attachment of pathogens to aquifer sediments.

10 DOCUMENTATION AND REPORTING

This element of the framework for management of stormwater quality and use is part of the general area of 'supporting requirements'. Appropriate documentation provides a foundation for establishing and maintaining effective recycled water quality management systems. It is intended that the Activities Schedule in Appendix B, along with tables and figures in this report provide suitable documentation for the Parafield scheme. There will be further published reports in the form of risk assessment, infrastructure assessment, economics evaluation and public perception during 2013 to supplement information contained in this report. These will be available on the Goyder Institute website. Peer reviewed journals will also be produced and referenced on this website.

10.1 Management of Documentation and Records

Management of documentation and records relating to the Parafield system include:

- Contractual, operational and incident/emergency reporting – managed by City of Salisbury
- Annual reporting – Australian Groundwater Technologies produces an annual report on behalf of City of Salisbury.

These are covered under the activities schedule (Appendix B).

The Goyder institute portal will also document the sources of data used for the series of research reports referenced in element 9.

10.2 Reporting

City of Salisbury regulatory reporting obligations include:

- Reporting to the EPA according to licence conditions (EPA 12983, Appendix A) that states:
    - 'provide the Authority with the results of all analysis carried out in accordance with conditions of this licence at the completion of each sampling period; and
    - 'forward the analytical results to the Authority within 14 days of the Licensee's receipt of the results from the testing organisation.'
- Other internal reporting (also included in evaluation processes in Section 11) includes:
    - Annual scheme performance report
    - Incident log contained within annual report
    - Quarterly volume and quality report

11 EVALUATION AND AUDIT

Long-term evaluation of harvested stormwater quality results and audit of water quality management are required to determine whether preventive strategies are effective and whether they are being implemented appropriately. This long-term evaluation allows performance to be measured against objectives and helps to identify opportunities for improvement. Auditing could involve active participation by users of harvested stormwater, particularly in relation to the application of on-site control measures and in assessment of on-site impacts.

11.1 Long Term Evaluation

This is mainly achieved through the review of the Parafield Annual Monitoring and Results Report. It contains results spanning over the previous year and reports on the harvested stormwater compliance conditions. The water quality reference panel include these reports on its agenda of multi-year reviews of operations.

Additionally, quarterly City of Salisbury (Salisbury Water) board meetings are conducted to review volumes transferred in the system and water quality exceedances.

11.2 Audit of Recycled Water Quality Management

The Parafield Stormwater Management Plan will be integrated into City of Salisbury's business system processes. City of Salisbury's intention is to undertake a biennial review of the plan. A procedure to manage this review has yet to be developed, it will be necessary to incorporate specific auditing elements that verify the plan and DHA approval for this scheme.

12 REVIEW AND CONTINUOUS IMPROVEMENT

Senior management support, commitment and ongoing involvement are essential to the continuous improvement of the organisation's activities. Senior managers should regularly review their approach to recycled water quality management, develop action plans and commit the resources necessary to improve operational processes and overall recycled water quality.

12.1 Senior Management Review

Revisions to the Parafield risk management plan will be reviewed and approved by City of Salisbury senior management in consultation with the water quality reference panel on a three-yearly basis.

12.2 Recycled Water Quality Management Improvement Plan

The Improvement Plans are typically generated through City of Salisbury's capital and asset improvement processes which centre on:

- Infrastructure condition and performance programs,
- Operational issues,
- Corporate direction,
- Regulatory requirements,
- System growth, and
- Customer complaints.

Since the commissioning of the Parafield system two major improvement strategies have been implemented. Table 23 outlines a summary of risk management activities that have generated risk minimisation strategies.

Table 23 City of Salisbury risk management activities that have generated minimisation strategies.

Process Component	Activity	Summary of actions to minimise risks	Resulting investigation(s) or where the activity has had an impact on operational documentation
Parafield storage tanks	Building of 3-pipe system	All water is routed through the aquifer	• Has resulted in a lower annual median *E. coli* concentration at the stormwater inlet line at the Greenfields Mixing Tank (see Section 2.3.1.1). • Has reduced harvestable volumes.
SCADA system	Upgrade	Additional alarms and archiving of data	• No investigations to date.

12.3 Summary of recommendations for improvement

Recommendations of actions to be performed prior to the next revision of this plan include:

- Revision of water quality monitoring program to decrease the number of non operational based analytes to once annually.
- Review of the SA EPA licence water quality criteria and EPP (2003) to be consistent with the Australian risk-based framework.
- A repository of operational and water quality data be established for MAR projects in Australia (Martin and Dillon 2002). This would allow synthesis of data within and among sites enabling knowledge to grow and continuous improvement to occur.

REFERENCES

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GLOSSARY

ANZECC	Australian and New Zealand Environment Conservation Council
anaerobic	Conditions where oxygen is lacking; organisms not requiring oxygen for respiration.
aquifer	A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water. Aquifer types include confined, unconfined and artesian.
aquifer storage and recovery (ASR)	The recharge of an aquifer via a well for subsequent recovery from the same well.
aquifer storage transfer and recovery (ASTR)	The recharge of an aquifer via a well for subsequent recovery from another well, to allow a minimum residence time in the aquifer before recovery.
aquitard	A geological layer that has low permeability and confines or separates aquifers.
Australian Drinking Water Guidelines	The Australian Drinking Water Guidelines undergoes rolling revision to ensure it represents the latest scientific evidence on good quality drinking water.
AWQC	Australian Water Quality Centre
beneficial use	The value of water in sustaining ecological systems, as well as the economic uses of water (e.g. drinking water, irrigation, industrial and mining water supplies). Water-quality requirements are determined by the class of beneficial use.
Campylobacter	A genus of bacteria that is a major cause of diarrhoeal illness.
catchment	Area of land that collects rainfall and contributes to surface water (eg streams, rivers, wetlands) or to groundwater.
conductivity or electrical conductivity (EC)	A measure of the conduction of electricity through water; can be used to determine the total dissolved soluble salts content. EC is measured in µS/cm.
critical control point (CCP)	A step or procedure at which controls can be applied and a hazard can be prevented, eliminated or reduced to acceptable (critical) levels.
critical limit	A prescribed tolerance that must be met to ensure that a critical control point effectively controls a potential health hazard; a criterion that separates acceptability from unacceptability.
Cryptosporidium	Microorganism that is highly resistant to disinfection; commonly found in lakes and rivers. Cryptosporidium has caused several large outbreaks of gastrointestinal illness with symptoms such as diarrhoea, nausea and stomach cramps. People with severely weakened immune systems are likely to have more severe and more persistent symptoms than healthy individuals (adapted from United States Environmental Protection Agency).
CSIRO	Commonwealth Scientific and Industrial Reserach Organisation
Defence, Science and Technology Organisation (DSTO)	The Defence Science and Technology Organisation (DSTO) is part of Australia's Department of Defence. DSTO is the Australian Government's lead agency charged with applying science and technology to protect and defend Australia and its national interests.
DEWNR	Department for Environment, Water and Natural Resources, South Australia
DHA	Department of Health and Ageing, South Australia
Disability adjusted life years (DALY)	DALYs are used to set health-based targets and assess risks for human health in relation to pathogens. DALYs are used to convert the likelihood of infection or illness into burdens of disease; one DALY represents the loss of one year of equivalent full health.
disinfection	The process designed to kill most microorganisms, including essentially all pathogenic bacteria. There are several ways to disinfect; chlorine is most frequently used in water treatment.

Dissolved Air Floatation Filtration (DAFF)	Dissolved air flotation filtration (DAFF) is a water treatment process that clarifies wastewaters by the removal of suspended matter. The removal is achieved by dissolving air in the wastewater under pressure and then releasing the air at atmospheric pressure in a flotation tank or basin. The released air forms tiny bubbles which adhere to the suspended matter causing the suspended matter to float to the surface of the water where it may then be removed by a skimming device.
Distribution system	A network of pipes leading from a treatment plant to customers' plumbing systems.
DO	Dissolved Oxygen
Drinking water	potable water for the Adelaide mains distribution system
E. coli	*Escherichia coli*; bacterium found in the gut. Used as an indicator of faecal contamination of water.
effluent	The outflow water or wastewater from any water processing system or device.
EPA	Environment Protection Authority, South Australia
Geographical Information System (GIS)	A geographic information system is a system designed to capture, store, manipulate, analyse, manage, and present all types of geographical data.
guideline value	guideline value The concentration or measure of a water quality characteristic that, based on present knowledge, either does not result in any significant risk to the health of the consumer (health-related guideline value), or is associated with good-quality water (aesthetic-guideline value).
hazard	A biological, chemical, physical or radiological agent that has the potential to cause harm.
hazard control	The application or implementation of preventive measures that can be used to control identified hazards.
hazard identification	The process of recognising that a hazard exists and defining its characteristics.
hazardous event	An incident or situation that can lead to the presence of a hazard (what can happen, and how it can happen).
indicator	Measurement parameter or combination of parameters that can be used to assess the quality of water; a specific contaminant, group of contaminants or constituent that signals the presence of something else.
inherent risk	The level of risk in the absence of preventive measures; also referred to as maximum or unmitigated risk.
injectant	The water injected (pumped or fed by gravity) into an ASR or ASTR injection well.
irrigation	Provision of sufficient water for the growth of crops, lawns, parks and gardens; can be by flood, furrow, drip, sprinkler or subsurface water application to soil.
Langelier Index	The Langelier Saturation Index (LSI) is an indicator of the degree of saturation of water with respect to calcium carbonate. It depends on temperature, pH, alkalinity and calcium hardness. Positive values indicate potential for calcite precipitation and negative values can indicate corrosion potential.
LGA	Local Government Authority
log reduction or removal	Logarithmic (base 10) concentration reductions, effectively reduction by a factor of 10. Used in reference to the physical–chemical treatment of water to remove, kill, or inactivate microorganisms such as bacteria, protozoa and viruses.
managed aquifer recharge (MAR)	The intentional recharge of water to aquifers for subsequent recovery or environmental benefit.
MARSUO	Managed Aquifer Recharge Stormwater Use Options
MLRWS	Mawson Lakes Recycled Water Scheme
monitoring	Systematically keeping track of something, including sampling or collecting and documenting information.
multiple barriers	Use of more than one preventive measure as a barrier against hazards.
Native groundwater	Groundwater that was present before recharge operations.
Nephelometric	A measure of turbidity.

turbidity unit (NTU)	
NRM	Natural Resource Management
observation well	A narrow bore, well or piezometer; its sole function is to permit measurement of water level and water quality.
pathogen	A disease-causing organism (e.g. bacteria, viruses, protozoa).
pre-treatment	Any treatment (e.g. detention, filtration) that improves the quality of water before injection.
Preventive measure	Any planned action, activity or process that is used to prevent hazards from occurring, or reduce them to acceptable levels of risk.
PSHS	Parafield Stormwater Harvesting Scheme
quality	The totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs; the term 'quality' should not be used to express a degree of excellence.
quality assurance	All the planned and systematic activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that an entity will fulfil requirements for quality.
quality control	Operational techniques and activities that are used to fulfil requirements for quality.
Quantitative Microbial risk Assessment (QMRA)	A method for assessing risks from microbial agents in a framework that defines the statistical probability of an infection from the environmental.
reclaimed wastewater	Treated effluent from the Bolivar DAFF plant
recycled stormwater	Stormwater that has been harvested and recycled via an aquifer
recycled water	A blend of reclaimed wastewater, recycled stormwater and/or drinking water
residual risk	The risk remaining after consideration of existing preventive measures.
reuse	Using water that would otherwise be discharged to wastewater or stormwater systems, for domestic, commercial, agricultural or industrial purposes.
risk	The likelihood of a hazard causing harm to exposed populations in a specified timeframe; includes the magnitude of that harm.
risk assessment	The overall process of using available information to predict how often (likelihood) hazards or specified events may occur and the magnitude of their consequences.
risk management	The systematic evaluation of the water supply system, the identification of hazards and hazardous events, the assessment of risks, and the development and implementation of preventive strategies to manage the risks.
runoff	Surface overland flow of water resulting from rainfall or irrigation that exceeds the soil's infiltration capacity.
SA Water	South Australian Water Corporation
salinity	The presence of soluble salts in soil or water. Electrical conductivity and total dissolved salts are measures of salinity.
SCADA	Supervisory Control and Data Acquisition
sewage or wastewater	Material collected from internal household and other building drains; includes faecal waste and urine from toilets, shower and bath water, laundry water and kitchen water.
sodicity	A condition in which positively charged sodium ions cause the soil particles to repel each other, resulting in soil swelling, dispersion and reduced soil permeability.
source water	Water as harvested, before any treatment and before recharge.
stakeholder	A person or group (eg an industry, a government jurisdiction, a community group, the public) that has an interest or concern in something.
stormwater	Rainwater that runs off all urban surfaces such as roofs, pavements, car parks, roads, gardens and vegetated open space.
surrogate	Surrogate analytes are used to improve monitoring cost efficiency or reliability for classes of hazards for which representative surrogates are easier to measure or have lower detection levels.

target criteria	Quantitative or qualitative parameters established for preventive measures to indicate performance; performance goals.
Thermotolerant coliforms	Coliform bacteria that originate from the gut of warm-blooded animals and whose presence in drinking water can be used as an indicator for operational monitoring.
TOC	Total Organic Carbon
Total dissolved solids (TDS)	Total Dissolved Solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in: molecular, ionized or micro-granular (colloidal sol) suspended form.
turbidity	The cloudiness of water caused by the presence of fine suspended matter.
virus	Protein-coated molecules of nucleic acid (genetic material) unable to grow or reproduce outside a host cell.
water recycling	A generic term for water reclamation and reuse. Can also describe a specific type of reuse where water is recycled and used again for the same purpose (eg recirculating systems for washing and cooling), with or without treatment in between.
WSUD	Water Sensitive Urban Design

Appendix A EPA Licence No. 12983

ENVIRONMENT PROTECTION AUTHORITY
SOUTH AUSTRALIA

Environmental Authorisation under Part 6 of the Environment Protection Act 1993

LICENCE
EPA 12983

The City of Salisbury

PO Box 8
SALISBURY SA 5108

Location

Parafield ASR Project Parafield Drainage Reserve, Adjacent Railway Station Greenfields, SA

Licensed Activities

The Licensee(s)

- The City of Salisbury

is (are) authorised to undertake the following activities of environmental significance under Schedule 1 Part A of the Environment Protection Act 1993 (the Act), subject to the conditions of licence set out in the attached pages:

4(2)(c) Discharge of Stormwater to Underground Aquifers

Term of Licence

Commence Date: 01-MAR-2008

Expiry Date: 28-FEB-2013

Environment Protection Authority 09 April 2008
This licence is not valid unless signed Conditions of licence to follow

Page 1 of 7

Definitions

"the Act" means the Environment Protection Act 1993.

"the Authority" means the Environment Protection Authority established under Division 1 of Part 3 of the Act.

"the Premises" means, at the time of issue of this authorisation, the whole of the land comprised in Titles Register - Certificate of Title, Crown Lease and Crown Record:

List of Titles

CT 5923/144
CT 5984/76
CT 5984/79

"Authorisation Fee Payment Date" means the anniversary of the grant or renewal of this licence.

Acronyms

"EIP" means Environment Improvement Programme.

"NATA" means National Association of Testing Authorities.

Explanatory Notes

(NB. - Explanatory Notes do not constitute a part of this Authorisation)

1. This licence does not permit any activity in breach of any other approval by any other authority. For example, this licence does not permit any activity on the Premises which is not authorised under the Development Act 1993. It is the responsibility of the Licensee to ensure that any action or activity referred to in this licence is permitted by, and is carried out in compliance with, statutory requirements.

2. This licence is subject to the Act.

3. Conditions of this licence can be varied by the Authority in accordance with section 45 of the Act.

4. This licence can be suspended, cancelled or surrendered during the term of the licence in accordance with sections 55 and 56 of the Act.

5. The Licensee must report to the Authority all incidents causing or threatening serious or material environmental harm, upon becoming aware of the incident, in accordance with section 83 of the Act.

6. 1. The Licensee must be aware of, and comply with:

   1.1 the requirements of the Environment Protection Policies which operate pursuant to the Act; and
   1.2 the requirements of any National Environment Protection Measure which operates as an Environment Protection Policy under the Act.

   2. These requirements govern permissible procedures and protocols, emission or concentration levels, as well as operation and/or maintenance standards of plant and equipment.

7. Should the conditions of this licence require that the Licensee submit a report or other information to the Authority, then that report or that information becomes the property of the Authority.

8. The Authority undertakes to provide written advice within 14 days of receipt of all information required for assessment.

CONDITIONS OF LICENCE

The Licensee is authorised to conduct the prescribed activities as described in this licence on the Premises nominated, subject to the following conditions:

			Compliance Date
1.	(101-7)	The Licensee must ensure that only stormwater which has passed through the artificial wetland and the filtration system is discharged into the Tertiary aquifer recharge wells specifically constructed for this project.	
2.	(101-55)	The Licensee must ensure:	
	1.	that water discharged to the aquifer at the Premises is only done so via the recharge wells PWPS-1 and PWPS-2 as identified in the report entitled 'Parafield Stormwater Reuse Project, Supplementary Information for EPA Licensing, ASR Water Quality Monitoring Programme' written by Australian Groundwater Technologies in conjunction with Halliburton KBR dated January 2002; and	
	2.	that water discharged to the aquifer is of a higher quality than the unpolluted ambient groundwater quality as specified in the document entitled 'Parafield USI Ambient Groundwater, T2-Well No1, Well No. 6628-20328' and attached to this licence as Attachment 1.	
3.	(101-56)	The Licensee must:	
	1.	monitor the discharge water leaving the wetlands filtration system and the groundwater in accordance with the report entitled 'Parafield Stormwater Reuse Project, Supplementary Information for EPA Licensing, ASR Water Quality Monitoring Programme' written by Australian Groundwater Technologies in conjunction with Halliburton KBR dated January 2002;	
	2.	ensure that confining layers are not damaged;	
	3.	ensure that there are no adverse effects on aquifers or waterbodies;	
	4.	ensure that the activity does not affect the level of the watertable at any property beyond the Premises;	
	5.	ensure that the water injected into the aquifer meets the requirements set by conditions of this licence;	
	6.	cease discharge into the aquifer if the water quality does not meet the requirements set by conditions of this licence; and	
	7.	not resume discharge into the aquifer until such time as the water to be injected meets the requirements set by conditions of this licence.	

4. (330-17) The Licensee must ensure that all sample analysis required by conditions of this licence are carried out by a NATA registered organisation, or an organisation with a quality system acceptable to the Authority using nationally or internationally acceptable methods.

5. (330-18) The Licensee must:

1. provide the Authority with the results of all analysis carried out in accordance with conditions of this licence at the completion of each sampling period; and

2. forward the analytical results to the Authority within 14 days of the Licensee's receipt of the results from the testing organisation.

6. (400-211) If the Licensee's name or address (or both) changes, then the Licensee must inform the Authority within one month of the change occurring.

7. (400-212) PROCESS CHANGE - CONSENT FOR CERTAIN WORKS

1. The Licensee must not carry out works for the construction or alteration of a building or structure, or the installation or alteration of plant or equipment for use in the course of any activity undertaken pursuant to this licence, where such works, installations or alterations are likely to result in:

1.1 an alteration of the process by which the pollution or waste arising from the activity occurs; or

1.2 an increased level, or change in the nature, of the pollution or waste arising from the activity; or

1.3 a relocation of the point of discharge of pollution or waste at the Premises,

without application for, and subsequent approval from, the Authority.

2. The Licensee must, upon application for the construction, installation or alteration of works, provide details to the Authority to enable the Authority to make an assessment of the environmental impact of the proposed works to be undertaken.

8. (400-214) The Licensee must display a copy of this licence on a notice board or other suitable place at the Premises.

9. (400-215) The Licensee must ensure that every employee, agent or contractor responsible for carrying out any task controlled by this licence is properly advised as to the requirements of this licence and the general environmental duty under section 25 of the Act that relate to that person's tasks and responsibilities as employee, agent or contractor.

10. (400-201) The Authority may during the term of this licence impose or vary conditions:

1. in relation to testing, monitoring and reporting referred to in section 52(1)(a) of the Act;
2. which require the Licensee, in accordance with section 53 of the Act, to prepare a plan of action to be taken in the event of an emergency;
3. which require the Licensee to develop an EIP as set out in section 54 of the Act and to comply with the requirements of the EIP;
4. which relate to provision of information relating to the Licensee or any agent or contractor undertaking any activity on behalf of the Licensee pursuant to this licence; and
5. which relate to provision of information relating to the activity subject to the licence including the levels of inputs and outputs and the amounts of pollutants or waste generated by the activity.

11. (400-78) The Licensee must:

1. Pay the annual authorisation fee by the authorisation fee payment date.
2. If this licence is for a term of 2 years or more, submit an annual return at least 90 days before the authorisation fee payment date.

12. (400-79) An application for renewal of this licence must be made at least 90 days before the expiry date of this licence.

13. (320-19) The Authority may vary or impose a condition of licence within 90 days of every second anniversary of the date of this licence.

14. (320-49) The Authority may impose or vary a condition of this licence at any time during the term of the licence where the Authority is satisfied that the Licensee is in breach of the general environmental duty to take all reasonable and practicable measures to prevent or minimise

resulting environmental harm.

Environment Protection Authority

Date 9 APRIL 2008

There are 1 attachments to this Licence

ATTACHMENT 1
AUTHORISATION 12983
CITY OF SALISBURY
PARAFIELD ASR PROJECT,
GREENFIELDS SA

AUSTRALIAN WATER QUALITY CENTRE

QUALITY MANAGEMENT SYSTEM

PARAFIELD USI
AMBIENT GROUNDWATER

ANALYTICAL REPORT

20-NOV-2000

T2 - WELL N°1,

Report No : R029915
Account : 108874 DEPT FOR WATER RESOURCES - AWQC 187
Project : 1088740072 C 6937
Job ID : 1062432
Sample Point : 11161 NAP P/N 53463, PARAFIELD AIRPORT
Date Sampled : 07-NOV-2000 11:45

WELL N° 6628-20328

FILE: 280/1/10.

Copies - M.J. S.L.

Analysis	Component name	Result	Unit
General Data			
[10-01]	pH	7.3	pH UNITS
[116-02]	Dissolved Organic Carbon	0.5	mg/L
[5-01]	Total dissolved solids (by EC)	1900	mg/L
[158-05]	Total Organic Carbon	0.4	mg/L
[16-01]	Conductivity	3390	uS/cm
[160-01]	Suspended Solids	< 1	mg/L
[211-01]	Dissolved solids by calculation	1990	mg/L
Physical Characteristics			
[18-01]	Turbidity	7.9	NTU
Cations			
[520-01]	Calcium	80.2	mg/L
[555-01]	Magnesium	56.3	mg/L
[580-01]	Potassium	16.0	mg/L
[600-01]	Sodium	535	mg/L
Anions			
[102-01]	Bicarbonate	472	mg/L
[104-02]	Chloride	736	mg/L
[105-01]	Fluoride	0.47	mg/L
[110-31]	Sulphate	336	mg/L
Nutrients			
[100-01]	Ammonia as N	0.052	mg/L
[108-01]	Filt Reactive Phosphorus as P	<0.005	mg/L
[109-01]	Phosphorus - Total as P	0.016	mg/L
[112-01]	TKN as Nitrogen	0.10	mg/L
[161-01]	Nitrate + Nitrite as N	0.007	mg/L
Metals			
[512-21]	Arsenic - Inorganic	0.012	mg/L
[513-21]	Arsenic - Soluble Inorganic	0.008	mg/L
[515-01]	Boron	0.689	mg/L
[525-61]	Cadmium - Total	<0.0005	mg/L
[526-61]	Cadmium - Soluble	<0.0005	mg/L
[530-61]	Chromium - Total	<0.003	mg/L
[531-61]	Chromium - Soluble	<0.003	mg/L
[540-61]	Copper - Total	<0.001	mg/L
[541-61]	Copper - Soluble	<0.001	mg/L
[545-01]	Iron - Total	0.805	mg/L

NOTES
1. The last figure of the result value is a significant figure.
2. Samples are analysed as received.
3. The code shown in [ ] refers to the AWQC analysis code.
4. # - determination of this component not covered by NATA Accreditation.

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A BUSINESS UNIT OF THE SOUTH AUSTRALIAN WATER CORPORATION

FIS-001 Version 1.00 16-Sep-1996

20-NOV-2000

Report No : R029915

Analysis	Component name	Result	Unit
[545-01]	Iron - Soluble	<0.030	mg/L
[550-61]	Lead - Total	<0.0005	mg/L
[551-61]	Lead - Soluble	<0.0005	mg/L
[560-61]	Manganese - Total	0.0138	mg/L
[561-61]	Manganese - Soluble	0.0143	mg/L
[565-61]	Mercury - Total	<0.0005	mg/L
[566-61]	Mercury - Soluble	<0.0005	mg/L
[575-61]	Nickel - Total	0.0009	mg/L
[5[redacted]]	Nickel - Soluble	0.0009	mg/L
[[illegible]61]	Zinc - Total	0.011	mg/L
[[illegible]1]	Zinc - Soluble	0.012	mg/L
Derived Data			
[101-01]	Alkalinity as calcium carbonate	387	mg/L
[200-01]	Langelier Index	0.15	-
[201-01]	Sodium adsorption ratio	11.2	-
[202-01]	Total hardness as CaCO3	432	mg/L
[203-01]	Carbonate hardness as CACO3	337	mg/L
[204-01]	Noncarbonate hardness as CACO3	45	mg/L
[205-01]	Calcium hardness as CACO3	200	mg/L
[206-01]	Magnesium hardness as CACO3	232	mg/L
[207-01]	Free carbon dioxide	41	mg/L
[208-01]	Total chlorides as NACL	1210	mg/L
[209-01]	sodium / total cations ratio	72.0	%
[210-01]	Ion balance	-4.75	%
Pesticides			
[700-01]	Aldrin	<0.05	ug/L
[700-01]	Chlorthal-Dimethyl (Dacthal)	<0.05	ug/L
[[redacted]-01]	Dieldrin	<0.05	ug/L
[[illegible]-01]	Endosulfan 1	<0.05	ug/L
[[illegible]-01]	Endosulfan 2	<0.05	ug/L
[700-01]	Chlorothalonil	<0.05	ug/L
[700-01]	Chlorpyrifos	<0.05	ug/L
[700-01]	4,4-DDD (TDE)	<0.05	ug/L
[700-01]	4,4-DDE	<0.05	ug/L
[700-01]	4,4-DDT	<0.05	ug/L
[800-01]	Simazine	<0.5	ug/L
[700-01]	Endosulfan Sulphate	<0.05	ug/L
[800-01]	Atrazine	<0.5	ug/L
[700-01]	Lindane	<0.05	ug/L
[800-01]	Azinphos-Methyl	<0.5	ug/L
[700-01]	Heptachlor	<0.05	ug/L
[800-01]	Diazinon	<0.5	ug/L
[700-01]	Heptachlor Epoxide	<0.05	ug/L
[800-01]	Fenitrothion	<0.5	ug/L

20-NOV-2000

Report No : R029915

Analysis	Component name	Result	Unit
(700-01)	Trifluralin	<0.10	ug/L
(800-01)	Hexazinone	<0.5	ug/L
(700-01)	Chlordane-a	<0.05	ug/L
(800-01)	Malathion	<0.5	ug/L
(700-01)	Chlordane-g	<0.05	ug/L
(800-01)	Parathion	<0.5	ug/L
(700-01)	Endrin	<0.05	ug/L
(800-01)	Parathion-Methyl	<0.3	ug/L
(700-01)	Methoxychlor	<0.05	ug/L
(800-01)	Prometryne	<0.5	ug/L
(700-01)	Vinclozolin	<0.05	ug/L
Microbiological			
(460-01)	# Heterotrophic Iron Bacteria	<10	/mL
(460-05)	# Heterotrophic Iron Bacteria	Not detected	
(80-07)	Coliforms	0	/100mL
(81-07)	E.coli	0	/100mL

Comments:

Job :1062432 Analysis :560-61
Mn soluble > Mn total is within acceptable analytical uncertainty

Job :1062432 Analysis :605-61
Zn soluble > Zn total is within acceptable analytical uncertainty

Job :1062432 Analysis :158-05
D>TOC but within experimental error

Job :1062432 Analysis :460-05
Microscopical examination of the sample did not detect iron associated microorganisms

Approved Signatory for Inorganic Chemistry

Approved Signatory for Microbiology

Approved Signatory for Organic Chemistry

Appendix B Activities Schedule

Frequency	Activity	Elements covered
Monthly	• Water quality sampling as per water quality monitoring plan (Appendix C), send samples to laboratory and collate sample results into a database.	2, 3, 4, 5
	• Record monthly injection and recovery totals.	4
	• Download SCADA data and compile for annual report. Investigate any deviations from set points and record in the Incident Log including results of investigations. Report to EPA in accordance with licence conditions.	4, 6, 10
	• Visual inspection of all facilities, Confirm irrigation exposure minimisation requirements are being met at all irrigation areas. Confirm signage is still current in all stormwater irrigation points and ASR well heads where stormwater can be harvested for irrigation. Observations to be recorded in the Facility Log. Schedule immediate maintenance when required.	4
	• Inspection of wetland flora health and irrigation area's plant health. Record observations in the Environment Log. Arrange weed and vermin control in basins as required.	4
	• Visual inspection of gross pollutant traps. Notify City Infrastucture if out-of-schedule cleaning is required.	4
	• Backwash ASR wells in accordance with operational guidelines.	4
	• Respond to any customer complaints or inquiries in accordance with the Customer Service Charter.	8
Quarterly	• Report to the Salisbury Water Advisory Board - summary of business activities including volumes stored and recovered and any significant operational, maintenance or customer related issues.	6, 8
	• Report to ESCOSA.	6
6 -Monthly	• Calibration of all flow meters and water quality probes. Record results in the Calibration Log.	6
	• Meet with SA Water - Water Quality Reference Group.	10
Annually	• Review Council's commitment to use of harvested stormwater. Document in the Alternative Water Use – Management Plan and have endorsed through the annual budget endorsement process.	1
	• Review new land use via the Development Approval process in each of the stormwater catchments and update individual ASR scheme risk assessments, as required.	2
	• Removal of sediments and waste from the wetland basins with disposal via approved methods e.g. composting or landfill.	4
	• Review of Calibration Log for all meters and sensors.	4
	• Review of Facility Log.	4
	• Review of Environment Log and submit Irrigation Management Plan (IMP) reports if required.	4
	• Review of Incident Log.	4
	• Review of Customer Complaints Log.	4
	• Review the Facility Log, site security and maintenance programs.	4
	• Review of recovery efficiency of each ASR scheme.	4
	• Review staff training and schedule training for all employees as part of the Position Description Review (PDR) process and training plan budget submission.	7
	• Ensure 4 yearly cross-connection audits have been carried out on all domestic customers.	5

Frequency	Activity	Elements covered
	• All performance records including deviations as recorded in the Manager's Quarterly Reports to the Advisory Board, are to be consolidated into the annual Business Unit report to Council. Council papers are made publically available via the Council website.	8, 10
	• Communicate with the larger community and stakeholders via council website with updates on water quality and risk management activities for the year.	8
	• Undertake regular community education on the need to protect stormwater quality.	8
	• Submit EPA Annual Report with discussion on all exceedances and water quality criteria.	10, 11
	• Review of EPA Annual report by SA EPA with referral to Department of Health and Ageing , when appropriate.	11, 12
	• Update Alternative Water Use – Mangement Plan based on all of the above activities with sign off by the Salisbury Water Business Advisory Board.	12
5-Yearly	• Perform long term evaluation of annual compiled results and compliance conditions.	12
	• Audit against all elements of this Activity Schedule.	11

Activities undertaken in this schedule are to be performed in accordance with the Salisbury Water Operations Manual.

Appendix C Water Quality Monitoring Schedule

Legend

CoS Water Business Unit	
CoS Asset Services	
Water Data Services	
DEWNR	
Water Watch	
SA Water/Allwater	
Discontinued	

Monitoring undertaken in this schedule is to be performed in accordance with the Salisbury Water Operations Manual.

Location ID	Sample Location		Testing Frequency	Sampling Parameters
ASR Water Monitoring				
	All ASR wetlands	Outlet - Injection	Weekly (during injection season)	Weekly Chem / Phys sampling using YSI Sonde
8586	The Paddocks Wetlands	Outlet - Injection	Every 12.5 ML Injected	Suite A-0 ML & Langelier Index, then Suite D-12.5ML, Suite G-25ML, Suite D-37.5ML & Suite D-50ML
9551	The Paddocks ASR	Extraction line	Every 15 ML Extracted	Suite F-15 ML & Langelier Index, then Suite D-30ML & Suite D 45ML
8590	Kaurna Park Wetlands	Outlet - Injection	Every 50 ML Injected	Suite A-0ML & Langelier Index, then Suite G - 50, Suite G-100, Suite G-150 & Suite G-200 ML
9550	Kaurna Park ASR - Well 1	Extraction line	Every 50 ML Extracted	All Suite F - 50 & Langelier Index, then Suite D-100 & Suite D-150ML
95502	Kaurna Park ASR - Well2	Extraction line	Every 50 ML Extracted	All Suite F - 50 & Langelier Index, then Suite D-100 & Suite D-150ML
8605	Greenfields Wetlands (Stage 1)	Outlet - Injection	Every 50 ML Injected	Suite A-0ML & Langelier Index, then Suite G +Boron - 50, Suite G-100, Suite G-150 & Suite G-200 ML
95631	Pooraka Triangle Wetlands	Outlet - Injection	Every 25 ML Injected	Suite A-0 ML & Langelier Index, then Suite G- 25, Suite G-50, Suite G-75 & Suite G-100ML
95634	Pooraka Triangle ASR	Extraction line	Every 15 ML Extracted	Suite F-15ML then Suite D- 30 & Suite D-45 ML
9553	Parafield Cleansing Reed Bed	Outlet - Injection	Every 100 ML Injected / this includes a total from the 2 wells at Parafield and the 6 at ASTR.	Suite A-0 ML then Suite D-100 ML, Suite G-200 ML Suite D-300ML & Suite G-400ML.
9541	Parafield ASR Well 1	Extraction line	Every 50 ML Extracted	Suite F-50 ML & Langelier Index, then Suite D-150 ML & Suite D-300ML
9542	Parafield ASR Well 2	Extraction line	Every 50 ML Extracted	Suite F-50 ML & Langelier Index, then Suite D-150 ML & Suite D-3000ML
9561	Observation Well - Parafield		End of the Month- Feb, Jul & Nov	Suite F - Feb, thereafter Suite - C July & Nov
	All other Bores at Parafield : PWPS-1 (20743), PWPS-2 (20943) OWPS1-LPWF (20741) OWPS1-LPWF (20742) OWPS1-Q1 (20739) OWPS1-R2 (21116) OWPS1-R3 (21118), PWT 1 (21114) PWT 2 (21115), PWT 3 (21117)		June / July	EC & level
14026	Mixing Tank at Greenfields	Stoemwater inlet line	Weekly	*E. coli*
	Mawson Lakes	Soil Analysis near obbs bore GW14 & GW15	Annually in September	
Groundwater Monitoring				
	Ed Parks	Observation wells	Jan, April, July & Oct	Water depth, and EC
	Mawson Lakes	Observation wells	Jan, April, July & Oct	Water depth and EC
	Springbank Waters	Observation wells	Jan, April, July & Oct	Water depth and EC
	Main North Rd Detention Basin	Observation wells	Jan, April, July & Oct	Water depth and EC

Location ID	Sample Location		Testing Frequency	Sampling Parameters
Ornamental Water Monitoring				
8588	Lake Windemere	Outlet	Fortnightly over Summer	Fortnightly visual inspections for Algae over the summer months
8592	DSTO	Outlet		
8594	Walpole Road Wetlands	Outlet Pond		
8598	Montague Farm	Pond before culvert on Main Nth Rd		
9544	Gulfview Heights Lake	Pond		
	Railway Wetlands	TBA		
9562	Pine Lakes Ornamental Lake	Pond		
9570	Springbank Waters	near footbridge		
9563	Pooraka Triangle ornamental	Pond		
Community Bores				
	All Community Bores	Under Hutch from Bore Head works	Over Summer	Salinity - EC
95461	Happy Home Bore	Under Hutch from Bore Head works	Annually in March	Suite E
95462	Hausler Bore			Suite E
95463	Underdown Park Bore			Suite E
95478	Andrew Smith Drive Bore			Suite E
95465	Salisbury Ovals Bore			Suite E
95466	Salisbury North Oval Bore			Suite E
95467	Salisbury Downs Oval Bore			Suite E
95468	Pitman Park Bore			Suite E
95469	Carisbrooke Park Bore			Suite E
95470	Salisbury Golf Course			Suite E
95471	Wildwood Drive Reserve Bore			Suite E
95472	Reg Growth Reserve Bore			Suite E
95473	Yalumba Drive Oval Bore			Suite E
95475	Lake Windamere Bore			Suite E
95477	Adams Oval Bore			Suite E
95479	Edinburgh Parks South	From truck filling spot	Annually in March	Suite G
Ambient Monitoring				
	Parafield Cleansing Reed Bed	Reedbed	Quarterly (Jan, Apr, July, Oct)	Plant Health
	Greenfields Wetlands (Stage 1)	Outlet	Fortnightly	EC, and Water Level
8607	Greenfields Stage 3 (Connector)	Inlet	May, Oct, Jan	Suite G
8608	Greenfields Stage 3 (Connector)	Outlet	May, Oct, Jan	Suite G
	Greenfields Stage 3 (Connector)	Inlet	Fortnightly	EC, and WL & Turb
	Greenfields Stage 3 (Connector)	Outlet	Fortnightly	EC, and WL & Turb
	Greenfields Wetlands (Stage 2)	Inlet	Fortnightly	EC, and Water Level
9584	Uni SA Wetlands	One Sample	October	Suite G
	Wetland Surveys	Main Water body	Fortnightly	Visual to determine if algal blooms are present - particually blue green algae.

Location ID	Sample Location		Testing Frequency	Sampling Parameters
Mawson Lakes				
	Sir Douglas Mawson - Main Lake Shearwater Lake Smaller lakes - The Bridges and Cascades		Fortnightly over Summer - Visual inspections Monthly - use of the YSI sonde	Fortnightly Visual inspections for Algal blooms over the summer months Monthly testing with the YSI sonde for Salinity, Dissolved Oxygen, pH and Turbidity.
	Mawson Lakes	Various Waterways Refer to monitoring sheet	Quarterly (Jan, Apr, July, Oct)	EC
Waterway / Catchment Monitoring				
	Dry Creek EPA Monitoring Station (Outfall Station at Greenfields)	Fortnightly Visits	Ongoing Flow based	Flow monitoring and fortnightly visits to sample Total N, P, nitrate & nitrite, Iron, Zinc, Lead, Copper, Total Dissolved Solids, Conductivity & Suspended Solids, pH & Turbidity.
	Little Para EPA Monitoirng Station (Outfall Station - Globe Derby)	Fortnightly Visits	Ongoing Flow based	
	Summers Road EPA Monitoring Station (Outfall Station)	Fortnightly Visits	Ongoing Flow based	
	Little Para EPA Monitoirng Station (Upstream of Little Para Fault -	Fortnightly Visits	Ongoing Flow based	
	EP Catchment - Bellchambers Rd	Monthly Visits	Ongoing Flow based	Flow monitoring and regular inspections to take 5 grabs samples - Suite F from each composite sampler. 1 at start of season, 3 at winter rain events, 1 at summer rain event
	EP Catchment - Helps Rd Drain	Monthly Visits	Ongoing Flow based	
	EP Catchment - Commercial Rd	Monthly Visits	Ongoing Flow based	
	Adams Creek / Edin Parks	Waterway	Monthly	EC
	Greenfields (cavan catchment)		Monthly	E.coli
86092	Dry Creek	Before Mawon Lakes (Technology Park)	This form of monitoring which was carried out seasonally has been discontinued	Suite E
	Dry Creek	After Mawson Lakes	This form of monitoring which was carried out seasonally has been discontinued	Suite E
Biological Monitoring				
	COS Wetlands- Kaurna Park, Parafield Reed Bed, Paddocks		Spring	Samples collected and analysed for macroinvertebrates in Spring
	Little Para River upstream from the Old Spot Hotel		Autum and Spring	Samples collected and analysed for macroinvertebrates in Spring and Autumn. Chemical analysis of water taken at the same time - use the YSI sonde.
	Dry Creek Walkleys Heights behind Yatala Jail			
	Helps Road Drain			
	Little Para River		Initial Survey then follow up every 5 years.	Flora and Fauna surveys of Waterways to determine water dependant ecosystems requirements and current health.
	Dry Creek			
	Helps Road Drain			
	Little Para River		Monthly field salinity surveys using the YSI sonde during injection season upstream & downstream of constructed	Salinity surveys along sections of a creek near constructed wetlands to determine marked salinity changes.
	Dry Creek			
	Helps Road Drain			
	Marine area adjoining Barker Inlet		Initial Survey then follow up every 5 years.	Collect and assess orthorectified digital photography ever 5 years
	Little Para River			
	Dry Creek			
	Helps Road Drain			

Appendix D Parafield Wetland Removal Efficiencies

Parafield wetland system pre-treatment performance (holding storage and cleansing reed bed combined 22/08 – 15/09/06, Page *et al*. 2008).

Parameter	Holding storage inlet*	Cleansing reed bed outlet*	Corrected for chloride RE**	RE** (log_{10})
Physical Characteristics				
True Colour (HU)	51	52	0.27	0.14
Conductivity (µS/cm)	247	293	-0.03	-0.01
Suspended Solids (mg/L)	3.5	1.3	0.74	0.59
TDS (mg/L)	130	191	-0.02	-0.01
Turbidity (NTU)	4.5	2.9	0.53	0.33
Major Ions (mg/L)				
Alkalinity	67.5	86.6	0.08	0.04
Bicarbonate	125	105	0.39	0.21
Sulphate	23.0	9.9	0.69	0.51
Chloride	24.0	34.5	0.00	0.00
Fluoride	0.35	0.21	0.57	0.37
Calcium	37.9	26.9	0.49	0.29
Magnesium	17.1	6.3	0.74	0.59
Potassium	6.8	5.4	0.43	0.24
Sodium	22.3	21.0	0.08	0.04
Microbiological (n/100mL)				
Coliforms	3.5×10^5	2.3×10^3	0.99	2.00
E. coli	2.4×10^2	2.3×10^1	0.93	1.15
Enterococci	7.0×10^2	6×10^0	0.99	2.00
Nutrients (mg/L)				
Ammonia	0.07	0.02	0.84	0.80
Nitrogen (t)	0.91	0.45	0.65	0.46
Organic Nitrogen	0.90	0.48	0.64	0.44
BOD (t)	3.7	1.2	0.77	0.64
COD (t)	82.7	42.4	0.63	0.43
Organic Carbon (d)	15.7	7.9	0.64	0.44
Organic Carbon (t)	16.8	8.6	0.63	0.43
UV_{254} absorbance	0.51	0.32	0.55	0.35
Phosphorous (t)	0.13	0.04	0.76	0.62
Sulphur (t)	7.5	3.3	0.68	0.49
Metals (mg/L)				
Aluminium (t)	0.18	0.17	0.31	0.16
Iron (d)	0.09	0.33	-1.71	-0.43
Iron (t)	0.3	0.55	-0.32	-0.12
Lead (t)	0.003	<0.0005	0.86	0.85
Manganese (d)	0.01	0.02	-0.49	-0.17
Manganese (t)	0.043	0.042	0.29	0.15
Zinc (t)	0.10	0.03	0.81	0.72

(d) dissolved, (t) total

* Volume averaged mean concentrations, n = 7

** RE (removal efficiency) corrected for chloride

Appendix E Mawson Lakes Irrigation Management Plan

Extracts of key sections of the Irrigation Management Plan for the Mawson Lakes Reclaimed Water Scheme (Hydro-Plan Pty. Ltd., 2004) are presented here. References to figures, tables and appendices correspond to numbering within the original document; only selected items are shown here.

2. INTRODUCTION

2.1. Background

Hydro-Plan has been engaged by the Mawson Lakes Joint Venture ("MLJV") to prepare an Irrigation Management Plan ("IMP") for the Mawson Lakes area. An IMP is required by the EPA because reclaimed water from Bolivar will soon be delivered through the existing Reclaimed Water Scheme ("RWS"), in place of potable water which has been used during the establishment years at Mawson Lakes. The scope of the current IMP cycle is represented in the diagram below:

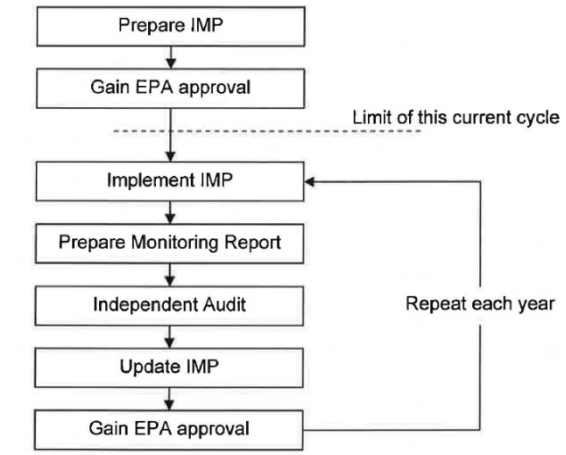

Figure 1 Current position in the IMP process

2.2. Development status

The Mawson Lakes site is still under development so this IMP is based on a combination of existing and proposed irrigation sites. By the year 2010 there will be approximately 10,000 residents living in 4,000 homes surrounded by 30% open space, around 74 ha of which will be irrigated. Since 1999 when construction first started, parks and landscaped areas have been developed and irrigated with potable water through the reclaimed water scheme. Currently 16 ha have been completed so a good baseline exists for comparing irrigation with and without reclaimed water. Due to the development status, it is not possible to define exactly where each irrigation site and each pipe will be, but there is a well defined breakdown which is sufficient for the purposes of this IMP.

2.3. Stakeholders

Mawson Lakes is a new Eco-Development being constructed 12km north of Adelaide. The development will provide for approximately 10,000 residents by the year 2010 and is being managed by the Mawson Lakes Joint Venture, a partnership between the SA Government (Land Management Corporation (LMC)) and the Delfin Lend Lease Consortium, with support from the University of SA and City of Salisbury. The RWS is part of this development and it will supply over 50% of household water (for toilet flushing, garden watering and potentially car washing) and 100% of public space irrigation. SA Water will own and operate the RWS following completion of the handover process from MLJV. It is anticipated that this will be complete by June 30, 2004. The Mawson Lakes Water Cycle Management Team was established to manage the provision of reclaimed water to the

Mawson Lakes development. This team includes the Mawson Lakes Joint Venture, the City of Salisbury, and the South Australian Water Corporation (SA Water).

2.4. Objectives of the RWS and the IMP

The primary objective of both the RWS and the IMP is sustainable use of reclaimed water. Prior to preparing this IMP, much effort had already been expended by the MLJV towards sustainable use of reclaimed water. In an increasingly environmentally conscious marketplace, it makes good commercial sense for the MLJV to distance itself from a 'wet & green' image associated with many residential developments. A successfully implemented IMP will be a useful reward and endorsement of the MLJV efforts. The following features of the RWS are well aligned with objectives of an IMP:

- Water will be Class A standard (many re-use schemes have lower standard and therefore more stringent management requirements)
- Commercial and domestic re-use systems have already been created according to safe practices (consumer education, appropriate signage, lilac colour pipes and fittings)
- Bulk water blends will limit salinity to 900 mg/L on average (many re-use schemes have higher and un-capped salinity, thus requiring more stringent management)
- A task force comprising representatives from Northern Adelaide and Barossa Catchment Water Management Board ("NABCWMB"), The Botanic Gardens of Adelaide, The Mawson Lakes Joint Venture and The City of Salisbury has developed significant knowledge about sustainable plant-soil-water relationships in the local environment
- Residents have been made aware of the benefits of conserving water (less water, less potential for harmful effects)
- Residents have been made aware of the benefits of re-using water and are therefore generally eager to contribute to environmentally sustainable practices (the culture for sustainable re-use is already established)

2.5. Compliance requirements

Department of Human Services and Environment Protection Agency express their regulatory requirements through the Reclaimed Water Guidelines. Chapter 10 of the guidelines refers to Irrigation Management Plans and section 10.3 refers to inclusion of DHS approval for the irrigation system using reclaimed water. This requirement arises from the Public and Environmental (Waste Control) Regulations of the Public and Environmental Health Act 1987.

SA Water advised 9 June 2004 that subsequent to discussions between SA Water, DHS and EPA, SA Water will separate the DHS and EPA approvals. Therefore the auditing and contingency plans relating to health risks are not included in this IMP.

3. SITE DESCRIPTION

3.2. Physical

3.2.1. Limits of Sites using Reclaimed water

The location of the RWS is shown in Figure 7. A recent aerial photo of the site is given in Figure 26 Appendix A showing the site limits for use of reclaimed water. The Mawson Lakes site is the sole destination of reclaimed water under this scheme.

The areas occupied by University of South Australia, Technology Park and Endeavour College are included in the Mawson Lakes site because it is intended that the RWS will supply water to these areas within a few years. However, these areas are specifically excluded from the scope of the current IMP. The IMP will be revised and submitted to the EPA for approval prior to extension of the RWS.

The corridor containing the pipes which transport bulk water to the Mawson Lakes area is included in the IMP only to the extent that maintenance activities may affect the environment. No irrigation or re-use will be conducted along the pipeline corridor however small quantities may be discharged during maintenance. The conceptual design for the bulk water supply follows a sewer main so the conceptual design includes connection points for discharge to sewer during maintenance activities.

4. IRRIGATION SYSTEM DESCRIPTION

4.2. Sources & Bulk Supplies

4.2.2. Parafield

Although the reclaimed stormwater system ~ill ordinarily supply 25% of the RWS demand (20.8 L/s), it will be capable of delivering at least 75% of the maximum daily flow (62.4 L/s) so that it can replaced the Bolivar supply if it fails. The design capacity of the Parafield system is therefore 300% above the max ~mum flow anticipated.

It is assumed that the quality of reclaimed stormwater to be supplied is 'equivalent for Class A reuse applications' and TDS will generally be less than 200mg/L, but may reach a maximum of 300mg/L.

The CoS will provide variable-speed pumps from the stormwater ASR wells I wetlands at Parafield, with interface to Mawson Lakes RWS, such that sufficient stormwater can be called upon and supplied. Where this fails, the potable water backup supply to the missing tank or network will be utilised to service Mawson Lakes. Water quality is summarised as follows:

- Class A
- Salinity average 200, max 300 mg/L
- BOD < 20 mg/L
- Turbidity (mean) s 2 NTU
- Faecal Coliforms (median) ≤ 10 organisms per 100 mL
- Pathogens < 1 organism per 50 L

Approximately 2.8 kilometres of 225 mm PN 12 PVC-M rising main will transfer reclaimed stormwater from the CoS pump station outlet pipe located at Parafield, to the tank at Greenfields. The proposed route is shown on Figure 16.

4.3 Distribution to sites

4.3.5. Services to Public Open Space

Services to irrigation systems on public open space also utilise double check backflow prevention devices. Water meters and backflow preventers have only recently been installed in preparation for changeover to non-potable water. The meters and backflow prevention devices are housed in a lockable metal cabinet to minimise inference.

6. MONITORING

6.1. Objectives

Monitoring is a key component of a successful IMP. It will enable the operators to identify potential problems so they can take corrective actions. Monitoring of water tables, water use and water quality will form the primary elements. The objective is to build an understanding of the fate of water, salt and nutrients. The majority of the monitoring effort will be expended in reading water meters and estimating hydraulic loading (ML/ha/a) so that excessive applications can be identified and corrected.

The first monitoring period will establish a benchmark against which 'post-irrigation' effects can be reported. As irrigation has already occurred (with potable water) at Mawson Lakes, consider benchmarking against irrigation at typical sites in the surrounding environment (e.g. City of Salisbury sites) so that effects of irrigation with Mawson Lakes area can be separated from regional effects of urbanisation.

6.2. RWS Water Quality

6.2.2. Parafield

Data will be collected by CoS under prior agreement for ASR. Additional data in relation to water quality may be required. This will be determined by SA Water.

6.4. RWS meter readings

6.4.2. Public Open Space

Record the annual volume per RWS site. Determine hydraulic loading using an estimate of area irrigated by the irrigation system. Cross-check to irrigation scheduling records. On at least two representative sites, monitor the weekly irrigation schedule in terms of frequency and depth of water applied.

6.6. Control site

Install a potable water connection for the irrigation at Windermere Reserve at the same location as GW17. Commission a soil analysis report prior to beginning of the irrigation in the 2004-05 season. Monitor water use in the same manner as the RWS. Maintain the reserve with the same treatments as other reserves.

6. 7. Shallow Aquifers

6.7.1. Perched Water Table

Continue to monitor GW1 on GW17 a monthly basis for 18 months. Depending on other objectives, consider reducing the number of readings for wells adjacent the wetland. If not already done, take samples for BOD, SS, DO, nitrogen and phosphorous before irrigation with reclaimed water commences. Resume monitoring some of the wells installed in 1999 west of the railway. Monitor level and EC monthly. Observe signs of groundwater flows through gravel packing around sewer and stormwater pipes, and signs of high water table levels where up welling and unidirectional flow may be occurring. Encourage the University of SA and Technology Park to install and monitor wells.

6.7.2. Quaternary Aquifers

Conduct a literature review of the relationship between the Q1 aquifer and the perched water table. Collate relevant data.

6.8. Tertiary aquifers

Utilise monitoring data from existing observation well YAT130. Monitor trends. Refer Figure 24 and Figure 25.

6.9. Surface waters

Monitor Dry Creek flow and water quality (EC, pH, Turbidity) at the entrance and exit from the Mawson Lakes site. Compare to other sites already monitored upstream and downstream.

6.10. Soils

6.10.1. Benchmarking

Commission soil reports in new reserves. Commission soil reports where existing irrigated parks and observation wells coincide at Shearwater Reserve (GW15) and Trinity Reserve (GW14) to establish a baseline impact of irrigation with potable water prior to irrigation with reclaimed water.

6.10.2. Revisit benchmarks

After 3 years, revisit 10% of the soil analyses conducted to observe changes.

6.11.1rrigation Systems

Conduct irrigation audits on 20% of the reserves to record precipitation rates and distribution uniformity.

Improve estimates of irrigation water demand. Continue to monitor soil moisture levels and to use regulated deficit irrigation scheduling.

6.12. Landscape plantings

Procedures are already in place to directly monitor success of landscaping strategies. The primary methods are visual inspection and feedback from residents. To create another indicator which is more sensitive than usual, six trees will be planted at a location where water table has been identified (thus far) to be the highest. This location is 80m south-east of GW15 and recognisable as a low point on the cross-section of Figure 23. The trees will be selected from those varieties known to be sensitive to high groundwater and high salinity. These trees will also be monitoring impact of the RWS on water quality in the PWT.

7. CONTINGENCY PLANS

7.2. Excessive public open space use

If water use in public open space is excessive (average over 6 ML/ha/a), environmental harm could occur through elevated water tables, excess nutrients and salinity. If irrigation systems are no longer used, retain the irrigation system for several years to monitor whether salts rise to the surface by capillary action. If salts do appear, the irrigation system should be turned on to leach salts from the root zone. This will help maintain vegetative cover to protect against erosion of silts to watercourses.

7.3. Perched Water Table

If "hot spot" areas develop, 1 to 3 wells should also be completed in the Q1 aquifer and at least one nest of piezometers, with completion in the PWT, Q1 and Q2 aquifers. The Q1 well should be completed with at least 100 mm casing to allow a well discharge test to be carried out. Data from the water levels and response to pumping would provide a better understanding of the interaction between the systems, particularly between the PWT and Q1. This data would be required to improve the reliability of the groundwater modelling flagged in section 5.5 above.

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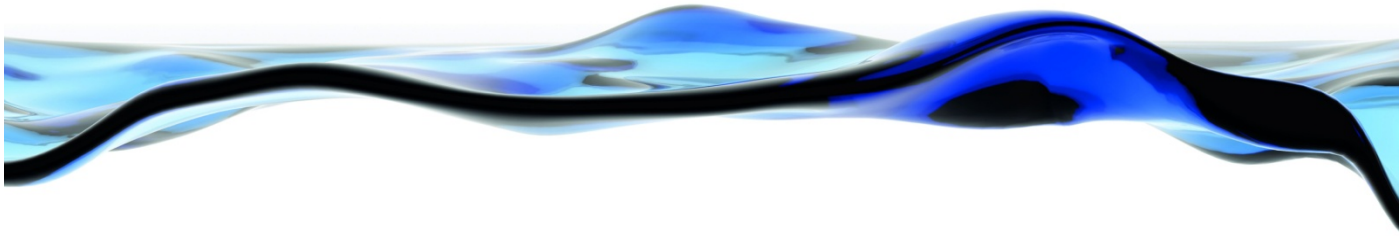

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