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AQUIFER STORAGE AND RECOVERY AS A MEANS OF UTILISING IMPORTED WATER IN THE BAROSSA VALLEY

by

Stephen Pugh
Darryl Harvey

Groundwater Program
Sustainable Resources

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SOUTH AUSTRALIA

REPORT BOOK 98/27 **DME 97/674**

AQUIFER STORAGE AND RECOVERY AS A MEANS OF UTILISING IMPORTED WATER IN THE BAROSSA VALLEY

Stephen Pugh and Darryl Harvey

A desktop study to identify the opportunities for aquifer storage and recovery (ASR) in the Barossa Regional aquifer system, with injection water being sourced from the Murray River and supplied through SA Water Corporation infrastructure.

INTRODUCTION

The existing groundwater resources of the region are used for supplementary irrigation of wine grape vines, but are generally more saline than considered desirable for sustained irrigation. With assurance of additional volumes of low salinity water, the viticultural industry can expand its production and reduce potential impacts of saline groundwater.

SA Water, between April and November, has spare pipeline capacity between the Murray River and the Barossa Valley. This spare pipeline capacity can be used to transport low salinity water for use within the Barossa Valley. As the time when spare capacity is available may not necessarily suit irrigation schedules, there is a need to provide temporary storage for the 'imported' water. A method that has been used to provide temporary storage for stormwater and Murray River water, in other regions, has been to inject the available water into the underlying aquifers for storage and later recovery. This process is known as aquifer storage and recovery (ASR).

The purpose of the desktop study is to identify the most appropriate aquifer(s) for ASR trials within the Barossa Valley and surrounding region.

In addition to identifying ASR opportunities, this report provides some understanding of the ASR process, particularly for potential users of this process in the Barossa Valley.

DISCUSSION

There are approximately 2100 wells in the North Para catchment and surrounds, within 500 m[1] of the SA Water distribution network. This area includes about 300 licensed irrigators, many of whom use groundwater as the primary source of irrigation water for wine grape production.

To sustain a strong and economic wine industry, low salinity irrigation water is required for healthy vine growth and to ensure that analysis of wine meets international chemical quality criteria. Currently, many wine grape growers are using marginal quality groundwater to supplement rainfall.

Groundwater salinity varies considerably throughout the region and is often independent of location and depth of water well. To procure additional quantities of a lower salinity water for wine grape irrigation, the community has expressed a strong interest and desire to import low salinity Murray River water. Some deliveries can be made by utilising existing spare capacity in SA Water pipeline infrastructure.

Currently, during the peak usage months of summer, the capacity of the pipeline is generally committed to domestic, urban, livestock and

[1] The decision to limit the study to a corridor of 1000 metre wide is arbitrary only and should not be seen as any form of engineering or geological limit to the potential for ASR.

industrial water in the Mid North region. However, during the cooler months, April to November, available capacity exists in the pipeline to carry water, additional to the needs of traditional and dependent users. Apart from the costs to purchase and transport the water, the greatest obstacle is how to maximise the benefit of the supplementary water supply from the Murray River.

Irrigators will choose different management strategies to maximise the benefits of the low salinity imported water. One of the more common questions is how to store water delivered during the April to November period, for recovery and irrigation during the December to March period.

Aquifer storage and recovery provides an option by which water can be stored for subsequent re-use.

THE AQUIFER STORAGE AND RECOVERY PROCESS

Generally, aquifer storage and recovery (ASR) involves the harvesting of surplus water, from a variety of sources, its temporary storage underground in a suitable aquifer, and subsequent retrieval for re-use in potable, irrigation and industrial applications. ASR is a means of applying a conjunctive water use strategy which utilises an aquifer as the storage medium.

Aquifer storage is a modification of the natural system which has been occurring for millions of years. Natural recharge occurs by infiltration of rainwater through the soil profile, past the vegetation root zone, and down into permeable rocks known as aquifers. Aquifers can store large quantities of water without losses from evaporation and with reduced risk of contamination, both of which are problems associated with all surface storage applications. In addition, surface storage requires valuable land, can incur significant infrastructure capital cost, and carries risks with structural integrity.

The rate of natural recharge to the aquifer system will depend on the amount and incidence of rainfall, the type of soil profile and vegetation, but is in the vicinity of 1–2 mm in areas of low rainfall or densely vegetated areas, and up to 100 mm in high rainfall areas.

Artificial recharge is achieved by injection of surface water, by gravity or pump, through an irrigation or purpose-built well, directly into the aquifer, where it is stored for later re-use. Surface water that can be used for ASR includes urban stormwater, rural streamflow, pipeline supplies or any other suitable source.

Surface water is often of lower salinity than the native groundwater and, when injected into an aquifer, forms a ‘bubble’ or lens of fresh water around the injection well. There is generally some mixing of the two waters at the margins of the ‘bubble’. Lateral movement or migration of groundwater is low, and generally only in the order of a few metres per year, hence the low salinity ‘bubble’ will be retained around the injection well. Aquifers therefore generally provide a stable environment for storage. However, over time, and without regular maintenance injections, the bubble may dissipate and gradually become indiscernible from the native groundwater.

Surface water may contain contaminants such as sediments, heavy metals, nutrients and bacteria. Wetlands and filters are some of the methods that can be used to extract these prior to injection into the aquifer system.

Water from SA Water pipelines in the Barossa Valley has been filtered and will not present these problems and should be able to be injected directly into local aquifers.

History of ASR in South Australia

Although ASR is a relatively new technique, unintentional and indirect ASR has been carried out at Mount Gambier in the South-East of South Australia for over one hundred years. Untreated urban stormwater has been directed into sinkholes and drainage bores within the limestone underlying the city, in close proximity to the Blue Lake which is fed from the same limestone aquifer. Mount Gambier relies on the Lake as its source of potable water.

Deliberate large scale ASR was first carried out in South Australia by irrigators in the Angas–Bremer irrigation area about 25 years ago. In this case, local river water was injected into irrigation bores during winter to replenish the depleted aquifer system, and reduce the salinity of groundwater. The water was then extracted in summer for irrigation purposes.

In recent years, trials by the Groundwater Program of Primary Industried and Resources SA (formerly

Mines and Energy Resources SA, MESA), in collaboration with other partners, have examined ASR applications in the metropolitan area at Andrews Farm, The Paddocks Wetlands, Greenfields Wetlands, Regent Gardens, Scotch College and Mawson Lakes, and with SA Water at Clayton on Lake Alexandrina.

The performance of wetlands for reducing pollutants in an ASR scheme for urban water resource development was first investigated at The Paddocks. Since then, ASR schemes designed specifically to capture urban stormwater and hold it in specially constructed wetlands have been established at Andrews Farm and Regent Gardens.

Andrews Farm

A detention basin is used to provide temporary storage of the urban runoff and settle the sediment in the water prior to injection into the confined [2] aquifer. Results indicate that the confined aquifer is capable of storing injected water and the brackish native groundwater has been significantly modified to a level suitable for irrigation.

The Paddocks

The Paddocks was developed with the long-term goal of conjunctive wetland treatment and ASR of stormwater using a confined limestone aquifer. Injection at this site was under pressure due to the low permeability of the aquifer. 75 ML of stormwater were injected during winter 1996, and a recovery trial produced an equivalent amount of irrigation-quality water.

Clayton

At Clayton, on the western shore of Lake Alexandrina, town water supply has traditionally been pumped from the lake. In recent summers, however, this supply has been under threat from toxic algal blooms caused by high nutrient loads in the Murray River. An ASR project is being undertaken to inject potable water from the lake into a highly permeable, unconfined [3] limestone aquifer which has a salinity similar to sea water. This unique situation required the development of a buffer or sacrificial water-mixing zone around the lens of potable water. Testing has now confirmed that a potable water lens can be successfully created, and the project has established an alternative safe potable town water supply for use during periods of risk.

Willunga Basin Irrigation Area

In the Willunga Basin, aquifer injection testing has been undertaken as a result of interest shown in ASR by irrigators and the local council, and as part of the catchment water resource management. Three sites have been tested: 'Gemtree' ' near McLaren Flat, 'Priest's' on the north western edge of McLaren Vale, and 'Aldinga Scrub'.

Enhancing South Australia's water resources

ASR can be used as an option to provide temporary storage for water collected from local surface systems, or imported via pipelines.

ASR has the potential to enhance the State's water resources and relieve the pressure on traditional sources. In the broader sense, opportunities exist to rethink traditional water management and distribution policies, and to provide cost-effective and innovative alternatives to current methods of water supply and stormwater management. In irrigation areas, surplus winter water can be harvested for summer re-use.

ASR has the greatest potential in those regions which are approaching full development of existing water resources, have degraded or low quality groundwater, but have a surplus of suitable quality alternative water resources available out of season, from pipeline supplies or stormwater systems.

EXPECTATIONS OF WATER RECOVERY

As mentioned in the previous section, during the injection process, a mixing zone is created and acts as a buffer between the native groundwater and the injected bubble of water. As additional water is

[2] A *confined aquifer* : is an aquifer that is 'confined' between confining layers, or aquitards. When released into a well, the groundwater will rise above the height of the aquifer

[3] *unconfined aquifer* : an aquifer where the groundwater has a free water table, ie., it is not confined under pressure.

injected, the core of the bubble grows and the buffer zone extends. During the recovery process the initial water has a quality similar to that of the injected water, and as the buffer zone contracts around the extraction point, the salinity will increase. Generally, as the extraction volume approaches the injection volume, the quality of extracted water will begin to approach that of the native groundwater.

The amount of water recovered, with a salinity lower than the native groundwater, when expressed as a percentage of the volume injected, is referred to as the ***recovery efficiency.*** The recovery efficiency will depend upon the maximum acceptable salinity and a number of hydrogeological factors that will vary from site to site. The data in the figure 7 relates to 'The Paddocks' site. 'The Paddocks' characteristics should not be interpreted as reflecting what may occur in the Barossa Valley, but is to be taken as an indication only of what results have been recorded with a well-managed ASR [4] site.

Environmental impact on individual properties, the region, and the groundwater system are important considerations, and should be carefully assessed by an experienced consultant prior to the implementation of ASR.

There may be a potential for some local shallow water tables to rise, causing land degradation. This could occur if aggregated recovery of water is considerably less than the injection volume, and/or poor irrigation management occurs. It will be necessary for proponents of ASR to consider the long term impacts of aquifer storage, the subsequent recovery and irrigation management strategies.

ASR IN THE BAROSSA VALLEY

Safe and efficient storage of the 'off peak' water may provide the greatest challenge to irrigation managers to maximise the benefits of the additional water for the least economic and environmental cost.

It is believed that aquifer storage and recovery is an effective and optimum strategy that utilises SA Water pipeline water to reduce salinity of native groundwater, and hence, the useable sustainable yield. The imported water can then be used to irrigate existing or additional plantings which is an individual choice for the land managers.

From previous aquifer recharge trials in the Barossa sediments, it is not considered appropriate, at this stage, to undertake recharge into the finer grained, less-permeable aquifers of the region. The least problems with ASR are expected in wells completed within the fractured rock aquifer or the more highly permeable basal or upper gravel aquifers.

Whilst Murray River potable water delivered in SA Water pipelines is considered to be of high quality, it should be recognised that there exists a risk, albeit minor, for a detrimental reaction in the mixing of injected Murray water and native groundwater. The reactions may be both physical and chemical. A physical reaction could occur with the release of dissolved gas caused by temperature variation and chemical reactions could occur between disinfecting chemicals in the potable water and the aquifer and native groundwater.

It is considered that existing infrastructure of existing suitable irrigation wells, but with minor modifications, will enable injection in the same well that is equipped with an extraction irrigation pump.

Groundwater in the Barossa Valley generally lies either within the sedimentary aquifer system or the underlying/surrounding fractured rock aquifer. The sediments are generally fluvial (riverine) deposits, of layered interfingering lenses of clays, carbonaceous sands, sands and gravels. They have been deposited along stream lines, lagoons and oxbow lakes, with sediments derived as a result of upstream erosion and *in situ* decomposition of organic matter.

These sedimentary sequences have been classified into five broad layers. Water table, upper gravels, carbonaceous sands, non-carbonaceous sands, and basal gravels. They do not all occur through the valley, and are variable in thickness at each site.

Licensed groundwater irrigators within the prescribed area between Nuriootpa and Penrice generally use the upper gravels aquifer as a source of irrigation water. The deeper basal sand aquifer is commonly used in the eastern portion of the valley.

[4] It should be noted that the aquifer at 'The Paddocks' site is a confined limestone aquifer. The Barossa aquifers are likely to be unconfined fractured rock or basal sediments. 'The Paddocks' has been used as an example because it is a well-documented field study.

The fractured rock aquifer underlies and surrounds the valley sediments. This aquifer is used for irrigation by approximately one third of the licensed groundwater irrigators of the Valley. (Figure 4).

All sedimentary aquifers within the Barossa Valley and the underlying fractured rock aquifer have some potential to be injected from the existing pipeline network.

The injection rate has a general relationship to the sustainable rates of extraction from the aquifer. Water will be available from SA Water pipelines at approximate flows of 0.75 litre /sec for a 20mm meter and 1 litre/sec for 25mm meter. These rates should be compatible for aquifer injection into most irrigation wells in the Barossa Valley.

POTENTIAL SUITABLE AREAS FOR ASR

The attached maps (Figs. 1-6) were developed using a Geographical Information System, with a base map displaying all wells within a 500 m distance of existing SA Water pipelines, and licensed irrigation wells completed within fractured rock and colour coded for salinity. From these coverages, the most appropriate potential sites for ASR have been indicated.

POTENTIAL NEW LANDS FOR IRRIGATION

Pipeline infrastructure exists in the Greenock-Freeling areas. The groundwater in the region is primarily within fractured rock aquifers and quality is generally brackish to saline. In its present condition it is generally unsuitable for irrigation of vines, however if the native groundwater can be supplemented with low salinity water, the salinity may be lowered sufficiently for irrigation of vines. The groundwater in the region has not been well documented, and therefore careful, and site specific investigation and assessments may be required.

BAROSSA VALLEY MANAGEMENT ISSUE

It should be noted that the current local water resource management policy only allows for 80% recovery of local sourced injected volume. However, 100% recovery of imported water volume is permissible.

GETTING STARTED

Where to undertake ASR.

The suitability of any well for ASR is reliant on a number of factors which will determine the simplicity or complexity of the system required. Foremost is the geology of the proposed area. The proximity to existing SA Water infrastructure can determine capital cost and available flows of injection water.

The structure of a well is important to ensure integrity for its life and performance as an injection well.

All wells are identified by a unique Unit Number, and when a prospective well is identified, an irrigator can request the basic construction information from the Groundwater Program of PIRSA. Available details should include:

- internal diameter of casing and casing type
- well depth
- depth to water
- the date when the last water sample was obtained for salinity testing

GROUNDWATER SAMPLING

To obtain a representative groundwater sample from an irrigation well, for salinity analysis:

- Pump the well for 15 to 20 minutes prior to taking the sample.
- Fill a clean 0.5 to 1 litre plastic or glass bottle and empty twice, then retain the third sample for testing.
- Seal the container for later analysis or assess salinity on the spot.
- Measure the salinity (mg/L) or electrical conductivity (µS/cm) and the temperature of the water. If facilities to test the sample are not available, the local Landcare Group, school or winery laboratory may be able to assist. South Australian NATA certified water quality

analytical laboratories are listed at the end of this report.

ASSESSMENTS AND CONSIDERATIONS

Prior to undertaking ASR with SA Water resources, an assessment of the well condition, groundwater salinity and extent to which the salinity of groundwater is to be reduced has to be considered.

In addition, the volume of water to be recharged has to be considered, and in particular, its singular and aggregated impact on local aquifer recharge.

Land salinisation may occur as a consequence of prolonged artificial recharge in conjunction with natural recharge, particularly if natural recharge is well above average. A consequence of greater than average rainfall (eg 1992), and or, significantly reduced extraction volumes of groundwater, is water table rise. In some areas this can lead to salts being mobilised, rising to the surface causing soil salinisation.

MONITORING

Depth to groundwater in the recharge well should be monitored at least bi-monthly. It may be undertaken by irrigators, their appointed contractor, or communally organised contractor. The assessment of water level monitoring should initially be undertaken with an experienced groundwater consultant. This will give land managers a better understanding of the short and long term impacts on the local aquifer caused by other local extractions or recharge.

Subsequent assessment of monitoring data can be done by land managers in consultation with an appropriate consultant or experienced person.

Where recharge is being practiced in areas of shallow groundwater (less than 5 m), regular monitoring and assessment of water levels should be undertaken. This may necessitate specifically drilled monitoring wells.

The reason for additional monitoring of shallow watertable areas, is to record the impact of individual and communal local recharge, or extraction, on the local watertable.

If long term (over 3 years) water level monitoring indicates that watertable levels are rising, recharge of individual wells, or those within the affected area may have to be reassessed. The result of unchecked watertable rise may be water logging, or increased salt input, affecting grape vines (low yield and poor quality grape juice) and subsequent salinisation of land. These outcomes may be irreparable.

The volumes, rates of injection and salinity of water being injected should be regularly monitored and recorded. This will assist with the management of recharge and the groundwater system.

Extracted water volumes, rates and salinity will also be required to gauge the effectiveness of recharge on the irrigation water quality, and assist in the financial benefit assessment of recharging with pipeline water.

Monitoring results for each recharge well should be compiled and a copy of the data sent to PIRSA Groundwater Program, PO Box 2355 Adelaide 5001. This will enable the State to monitor the locations and impacts of ASR. The catchment water management board may require a copy of details to assist in local water resource management.

RECOMMENDATIONS:

Prior to implementation of ASR, it is recommended that a hydrogeological investigation of the local aquifer system and well is undertaken and a report compiled for the proponent. This should include identification of the well and aquifer being used for recharge, the strata and watertable details, volume of water to be injected to the system and monitoring of injected and extracted water, with salinity monitoring to gauge benefit of ASR at the site.

If separate wells are used for recharge and extraction, the interconnection of aquifer between them should be established.

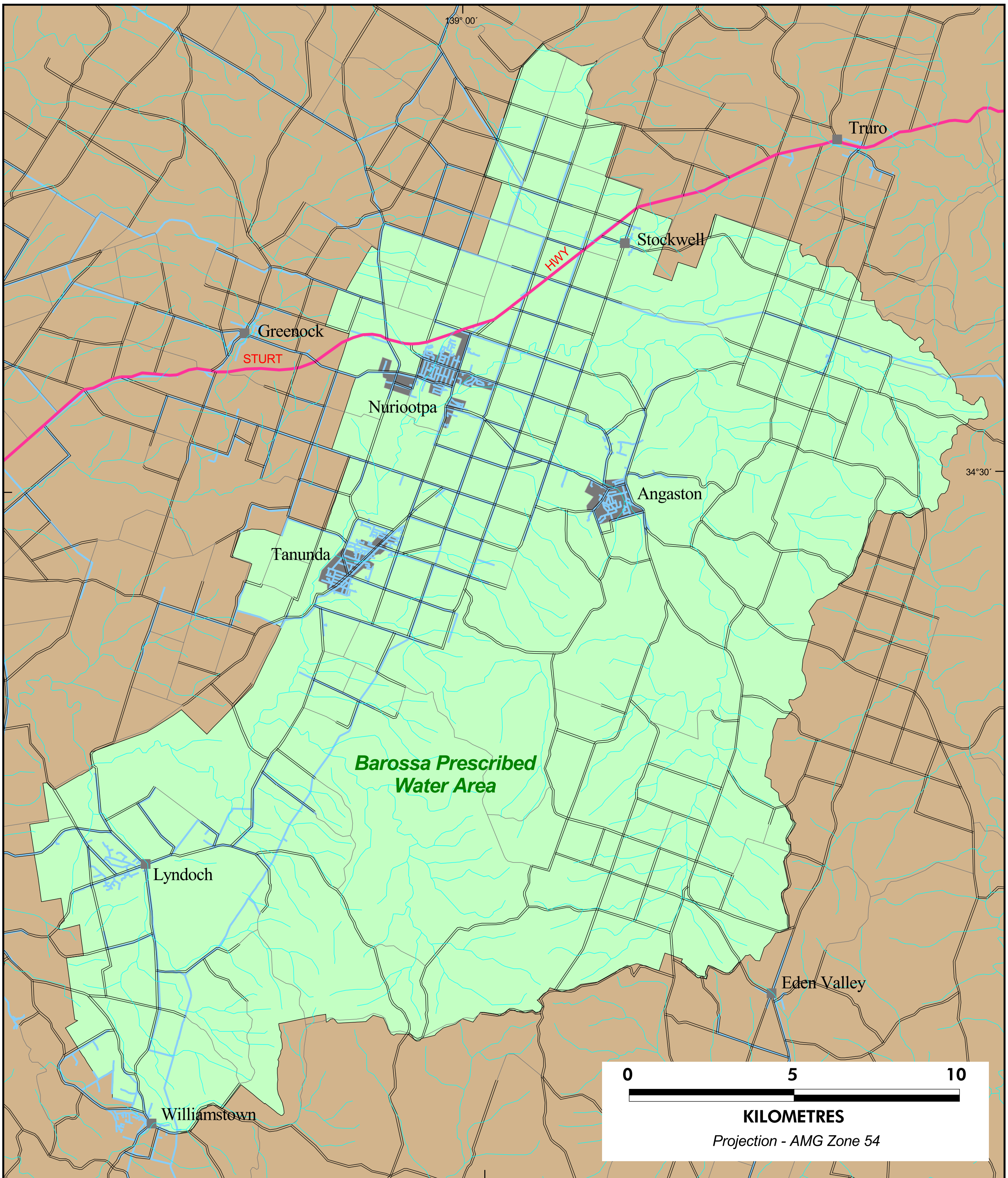
Observation wells completed into the shallow water table should be monitored for water levels with bi-annual data reports being compiled. If water levels are less than 5 metres, a report should be submitted to the catchment water management board.

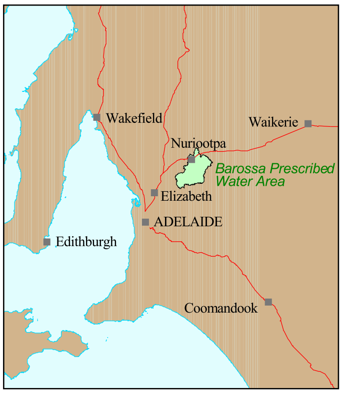
Well construction for new injection/production wells can be advised by a consultant or Groundwater Program of PIRSA.

REFERENCES

MESA, Oct 1997. *Aquifer Storage and Recovery; directions for water resource* management

Howles, S.R., Gerges, N.Z. and Dennis, K., 1997. The Paddocks Wetland, Salisbury Council, Aquifer Storage and Recovery. *South Australia. Department of Primary Industries and Resources. Report Book,* 98/1





SA Water pipelines
Creeks
Highway
Main road
Secondary road
Minor road

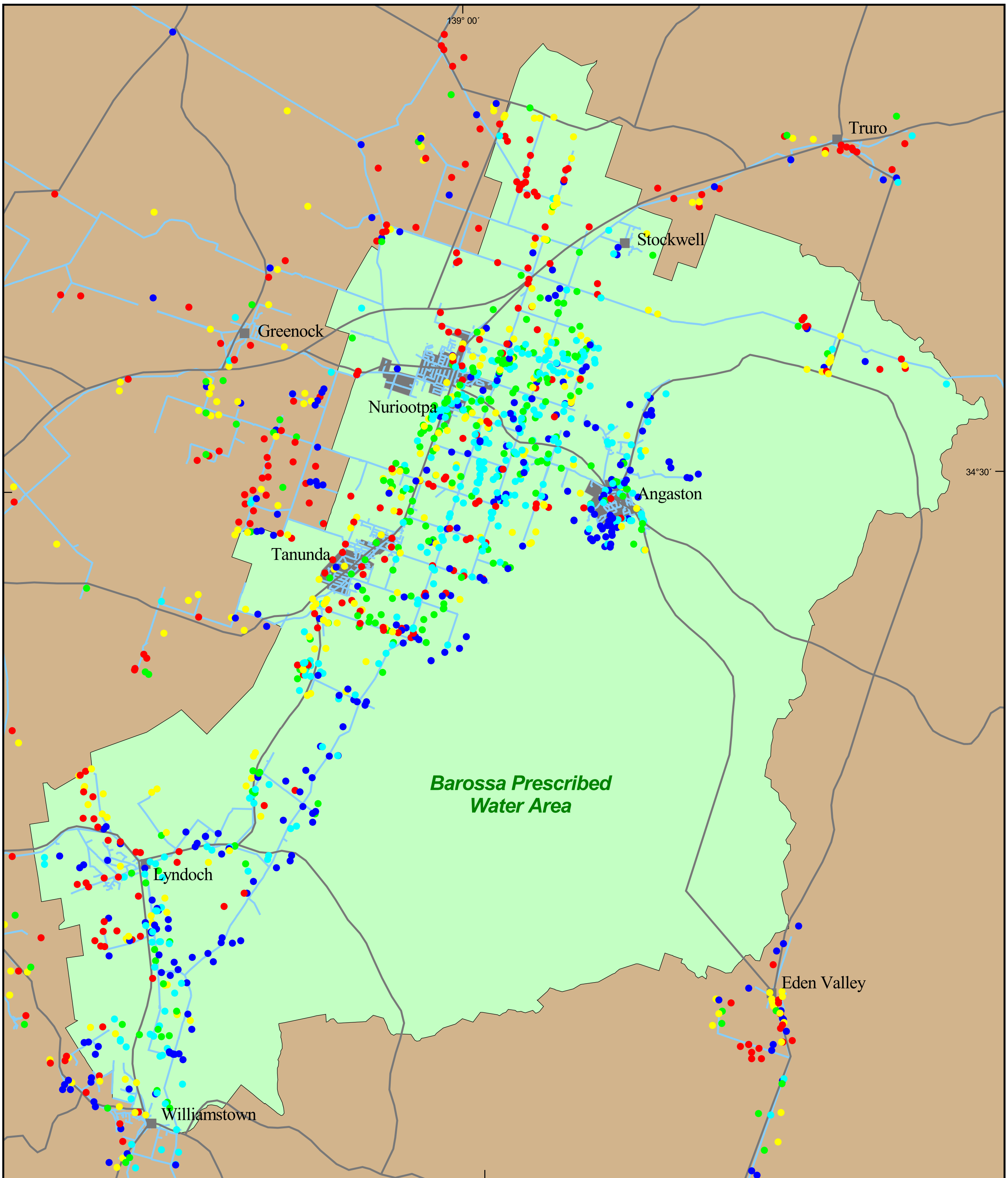
Aquifer Storage and Recovery – Barossa Valley

INFRASTRUCTURE OF THE BAROSSA PRESCRIBED WATER AREA

Figure 1

AV3:101309SP:101309SP.APR

98-1124



Water Well Salinity (mg/L)

- 1 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 3000
- 3001 - 30000

SA Water pipelines

0 5 10

KILOMETRES

Projection - AMG Zone 54

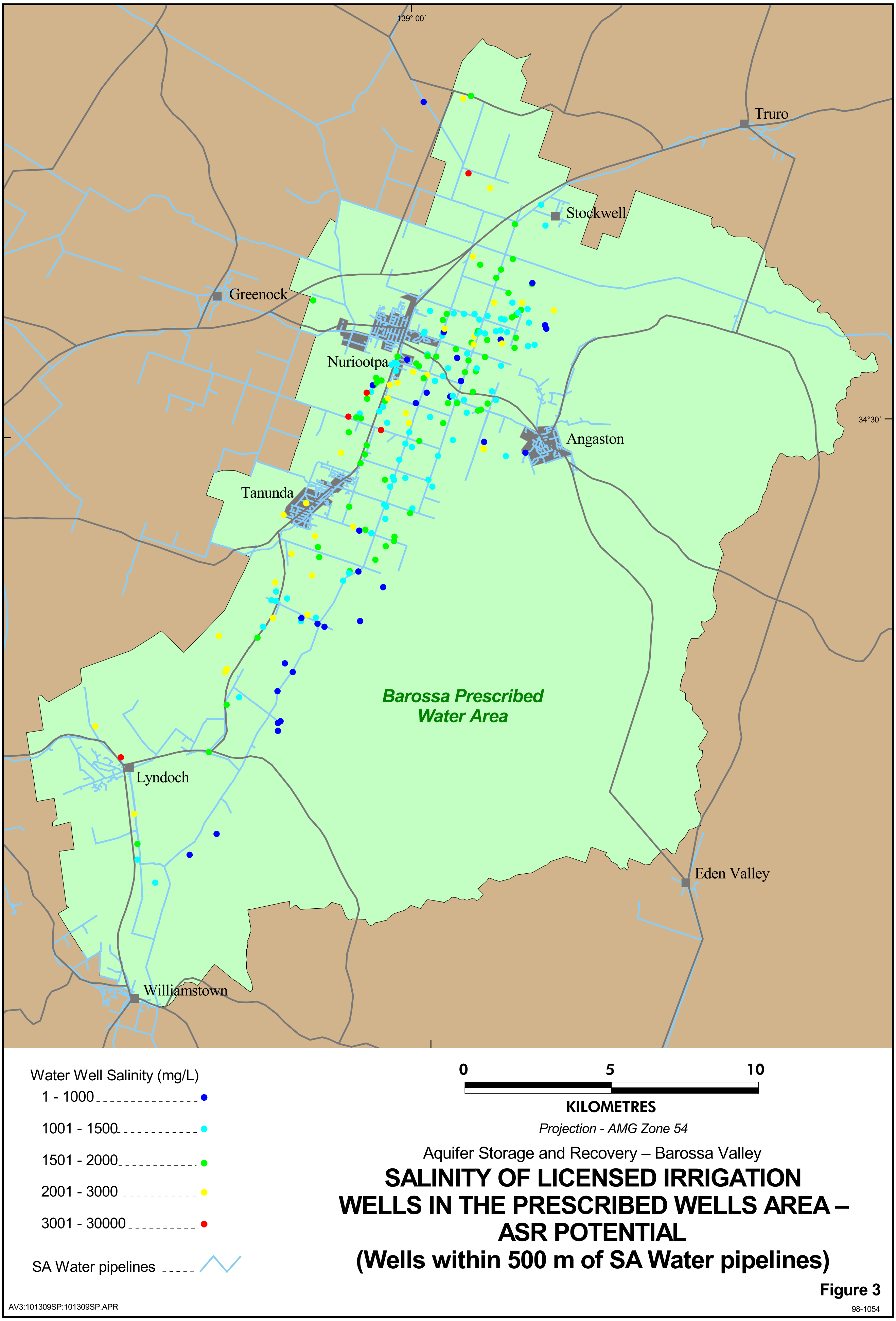
Aquifer Storage and Recovery – Barossa Valley

SALINITY OF WELLS WITHIN 500 m OF SA WATER PIPELINES

Figure 2

AV3:101309SP:101309SP.APR

98-1053



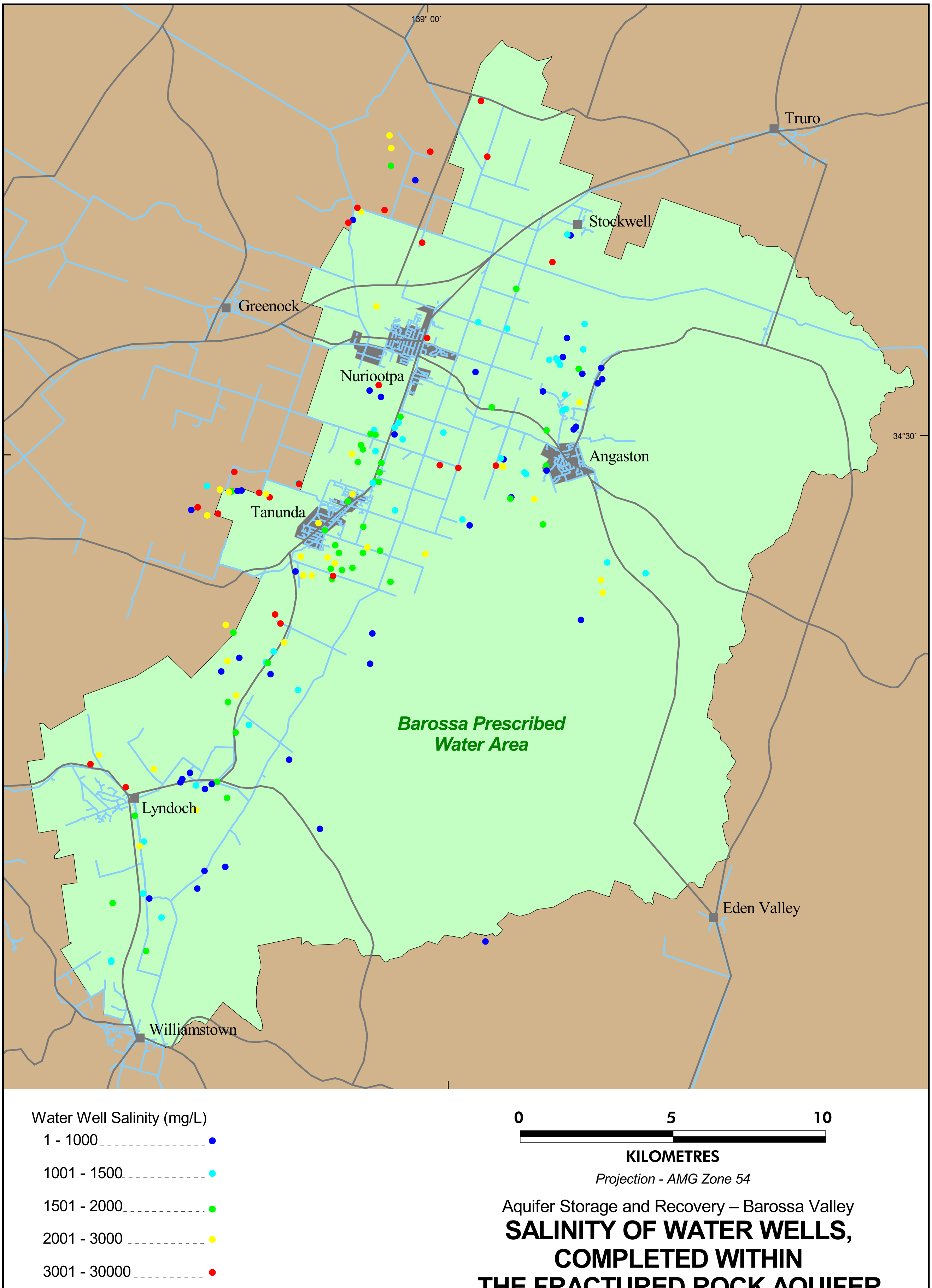
Aquifer Storage and Recovery – Barossa Valley

SALINITY OF LICENSED IRRIGATION WELLS IN THE PRESCRIBED WELLS AREA – ASR POTENTIAL (Wells within 500 m of SA Water pipelines)

Figure 3

AV3:101309SP:101309SP.APR

98-1054



Aquifer Storage and Recovery – Barossa Valley

SALINITY OF WATER WELLS, COMPLETED WITHIN THE FRACTURED ROCK AQUIFER OF THE BAROSSA VALLEY

Figure 4

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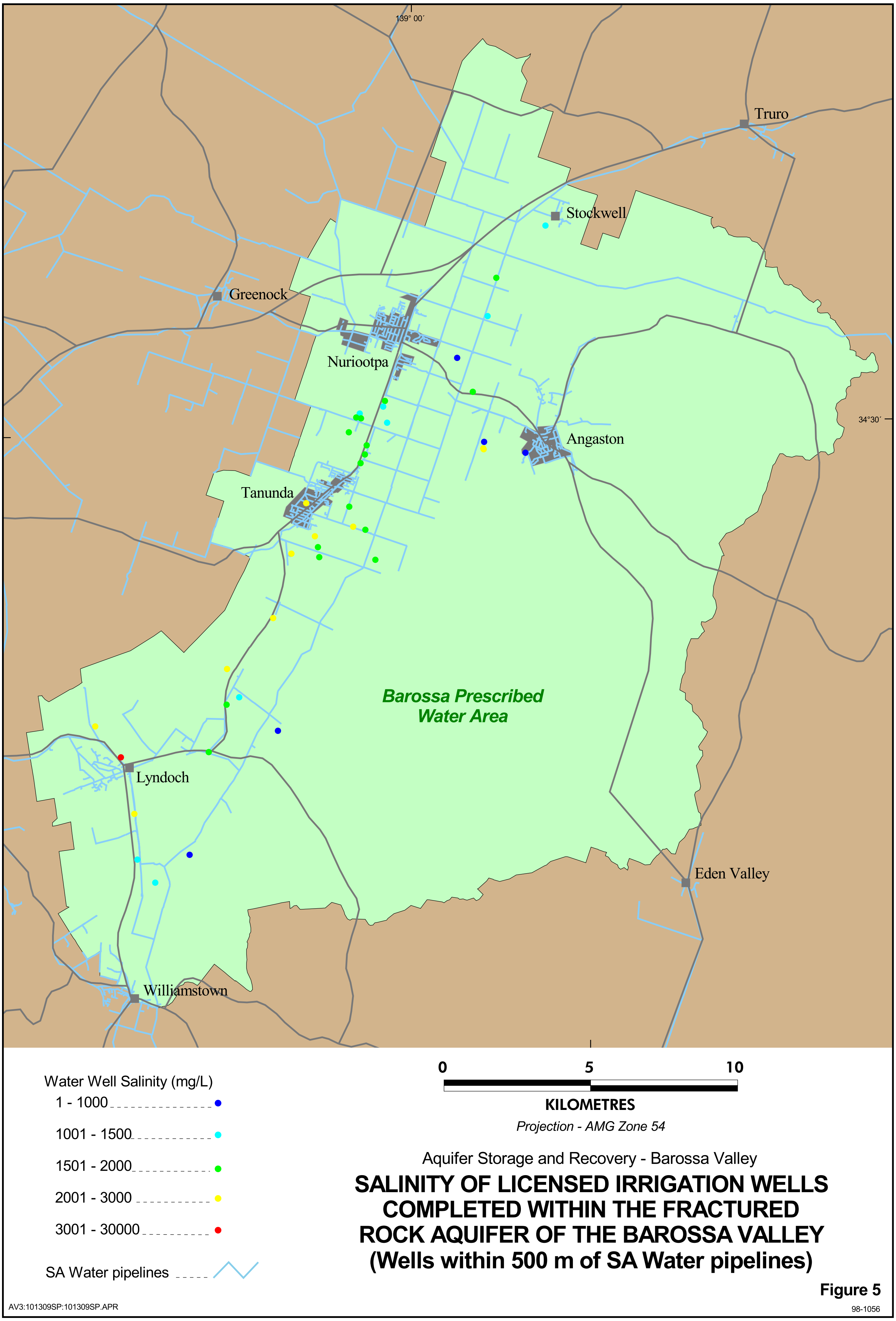
98-1055



Projection - AMG Zone 54

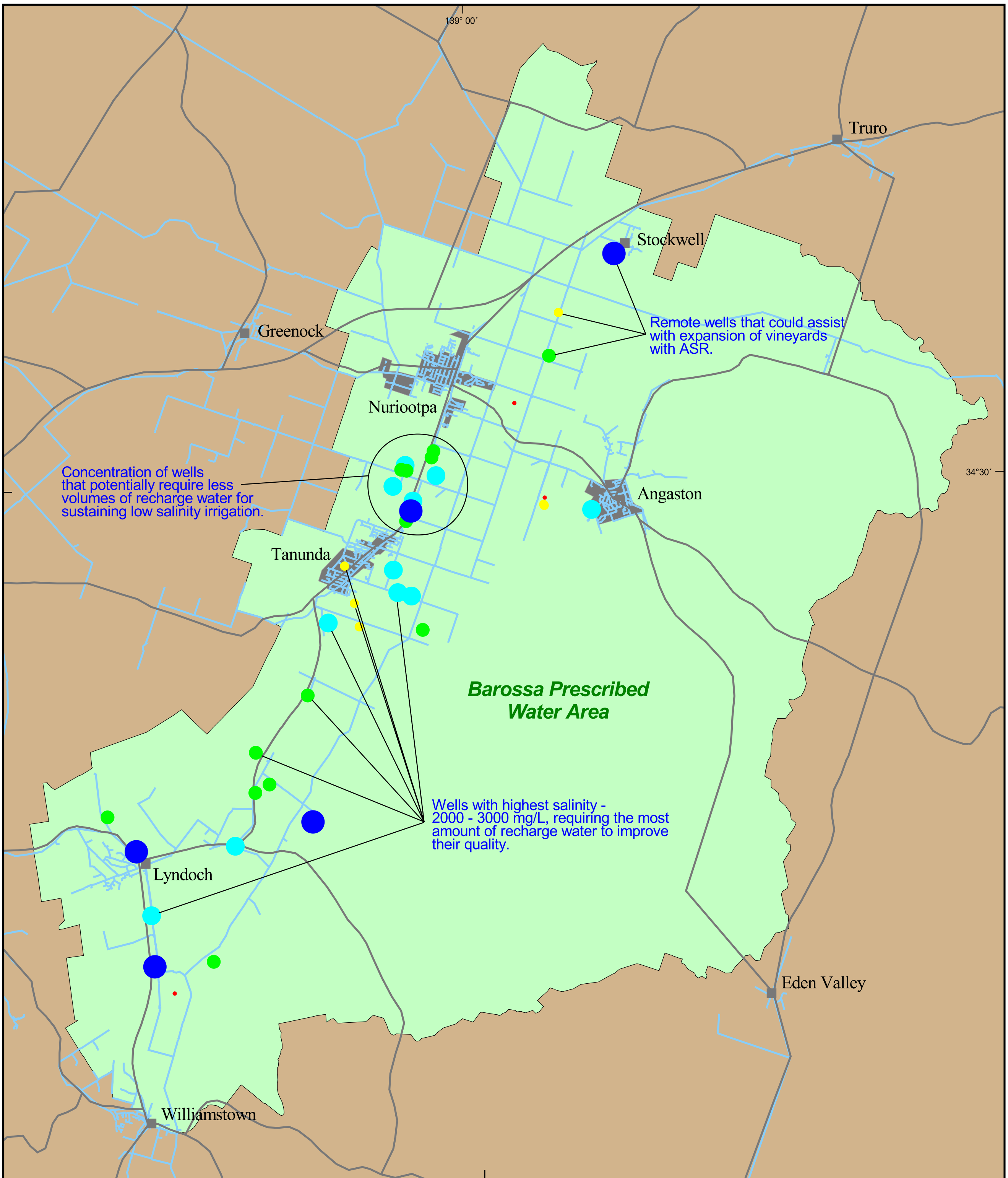
Aquifer Storage and Recovery - Barossa Valley

SALINITY OF LICENSED IRRIGATION WELLS COMPLETED WITHIN THE FRACTURED ROCK AQUIFER OF THE BAROSSA VALLEY (Wells within 500 m of SA Water pipelines)

Figure 5

AV3:101309SP:101309SP.APR

98-1056



Water Well Supply (L/s)

- 0.1 - 2
- 2.1 - 5
- 5.1 - 10
- 10.1 - 20
- 20.1 - 38

SA Water pipelines

0 5 10

KILOMETRES

Projection - AMG Zone 54

Aquifer Storage and Recovery – Barossa Valley

YIELD OF LICENSED IRRIGATION WELLS, COMPLETED WITHIN THE FRACTURED ROCK AQUIFER SYSTEM

Figure 6

AV3:101309SP:101309SP.APR

98-1057

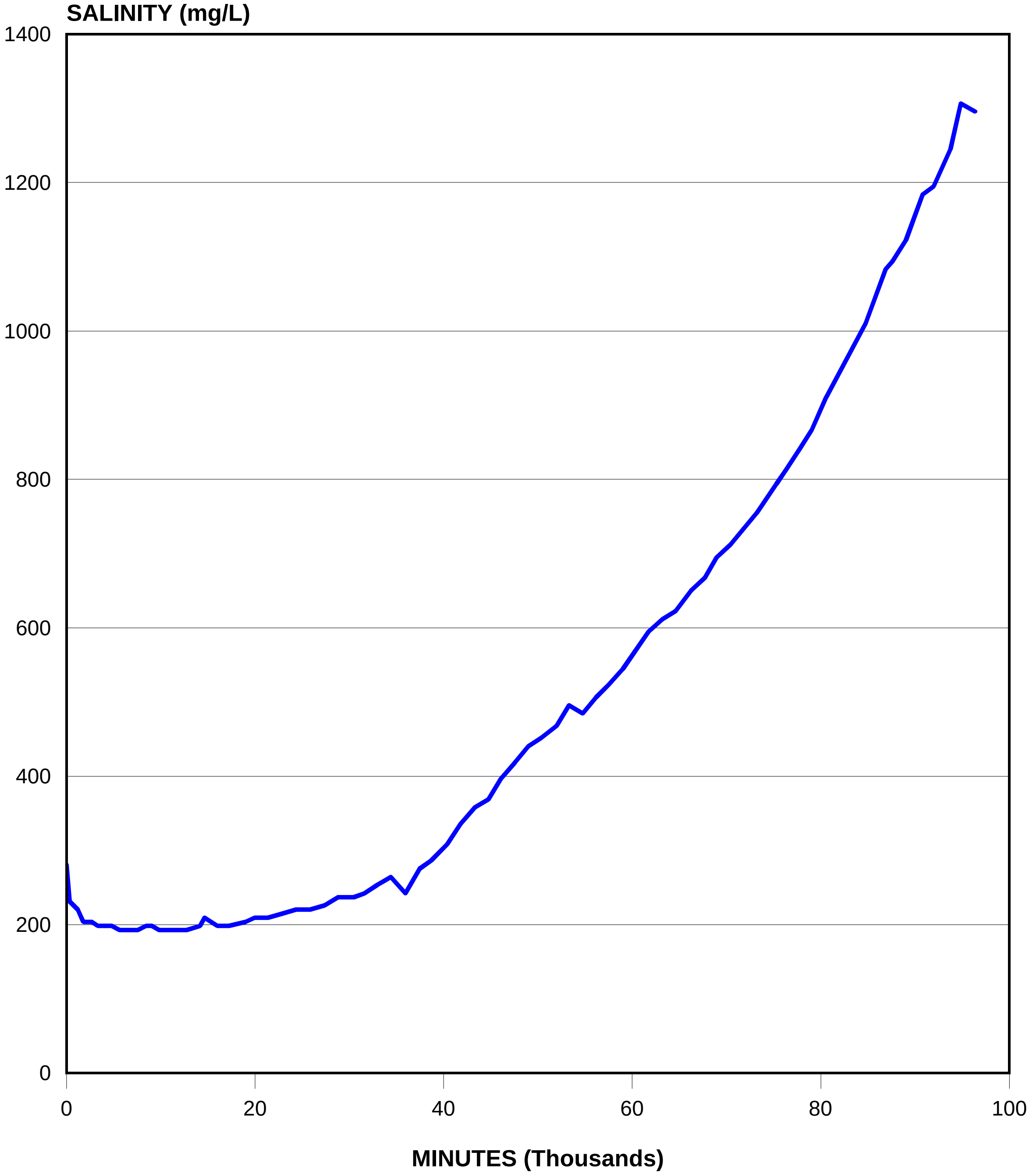
INDEXX:	1097
PROJECT:	"THE PADDOCKS"
Start Date:	14th Jan. 1997
Start Time:	10:45
Test type:	RECOVERY EFFICIENCY
Volume_ML	76.0

NOTES:

Discharge following injection of 75 ML and residence period of 98 days.
Probe damages and water level data not considered to be accurate.

Initial salinity 1860 mg/L

Recovery efficiency of 76 ML
wrt injected water ~ 40%
wrt drinking water (1 800 EC) ~ 90%
wrt irrigation water (3 000 EC ~ 100%+



Aquifer Storage and Recovery - Barossa Valley

RECOVERY EFFICIENCY OF "THE PADDOCKS"

Figure 7

HG : 101309.PRS

98-1058