Barossa Valley Groundwater Review, 1999

REPORT BOOK 2000/00012

by

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Groundwater Program

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CONTENTS **PAGE**

ABSTRACT		4
INTRODUCTION		4
BACKGROUND		4
HYDROGEOLOGY		5
COMPONENTS OF THE GROUNDWATER BUDGET		6
	Groundwater recharge	7
	Recharge and discharge from streams	7
GROUNDWATER STATUS		7
	Groundwater withdrawals	7
	Water level trends	8
	Salinity trends	10
ISSUES		10
	Demand for additional groundwater development in the Barossa Highlands	10
	Unused water allocation	11
	Leaking wells	11
	Imported water	11
	ASR	12
	Observation network	12
	Licence transfers	12
	Flowing wells	12
CONCLUSIONS		12
SUGGESTED WORK PROGRAM		13
REFERENCES		14
TABLES		
Table 1	The hydrogeology of the Barossa Valley Prescribed Water Area	6
Table 2	The metered extraction volumes for the Barossa Valley over the past five irrigation seasons	7
Table 3	Wells identified with rising salinity in the Barossa Valley Prescribed Water Area	9

FIGURES 15

Fig. 1 Locality *Plan Number (200090–001)* 16
Fig. 2 Hydraulic contours *Plan Number (200090–002)* 17
Fig. 3 Monitored wells *Plan Number (200090–003)* 18
Fig. 4 Water level trends in the upper gravel aquifer *Plan Number (200090–004)* 19
Fig. 5 Water level trends in the fractured rock aquifer *Plan Number (200090–005)* 20
Fig. 6 Fractured rock aquifer hydrographs with declining water levels *Plan Number (200090–006)* 21
Fig. 7 Water level trends in basal aquifer *Plan Number (200090–007)* 22
Fig. 8 Basal aquifer hydrographs *Plan Number (200090–008)* 23
Fig. 9 Water level trends in middle aquifer *Plan Number (200090–009)* 24
Fig. 10 Water level trends in water table aquifer *Plan Number (200090–010)* 25
Fig. 11 Water table hydrographs where MOR010 reflects rainfall and MOR073 exhibits a decline in water level *Plan Number (200090–011)* 26
Fig. 12 Salinity level trends in fractured rock aquifer *Plan Number (200090–012)* 27
Fig. 13 Fractured rock aquifer hydrographs with rising salinity *Plan Number (200090–013)* 28
Fig. 14 Salinity level trends in basal aquifer *Plan Number (200090–014)* 29
Fig. 15 Basal aquifer hydrographs with rising salinity *Plan Number (200090–015)* 30
Fig. 16 Salinity level trends in middle aquifer *Plan Number (200090–016)* 31
Fig. 17 Salinity level trends in upper gravel aquifer *Plan Number (200090–017)* 32
Fig. 18 Example of declining water levels in the Keyneton network *Plan Number (200090–018)* 33
Fig. 19 Licensed irrigation wells *Plan Number (200090–019)* 34

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Robyn Gill

A desktop study was undertaken to review the current status of the groundwater system in the Barossa Valley Prescribed Water Area. With current groundwater withdrawls, water levels are generally stable, except in the Lyndoch Valley region and the Tanunda to Angaston area, where levels are declining annually. Groundwater salinities are stable overall. There is a need to review the water budget and the interaction between the Highland recharge area and the Valley Floor, given the demand for new development in the Highlands. Other issues to be addressed include; the unused water allocation, the impact of the importation of water, an increase in license transfers, the leaking wells, the practice of ASR and a review of the observation network.

INTRODUCTION

Irrigated agriculture in the Barossa Valley region is important to the economy of the region and the State. It has a gross production value excess of $50 million annually (Rust, 1996). With value adding and flow-on effects, the region also contributes around $250 million to the South Australian economy annually (Rust, 1996). Viticulture is the main land use within the area, with irrigated vines covering approximately 2650 ha (Pugh, 1996). Other irrigated crops include lucerne/pasture, starter pasture, orchard crops, vegetables, woodlots, native flowers, cut flowers, along with recreational and industrial uses. Approximately half of the irrigated water is sourced from groundwater while the other half is from surface water; other minor sources come from wastewater, treated sewage effluent and reticulated water.

There is an ongoing demand for additional development, particularly in the Highlands (Flaxman Valley region) which may place stress on the groundwater within the sedimentary aquifers of the Barossa Valley.

This report is a review of the status of the resource and the components of the groundwater budget in order to assess the potential for additional development and identify major problems which need to be addressed.

BACKGROUND

Over the past few decades the increasing expansion of viticulture and other crops requiring irrigation has made restrictions on the use of groundwater necessary.

In the early 1970s the South Australian Department of Mines and Energy (now Primary Industries and Resources South Australia (PIRSA)) began to monitor the effects of groundwater withdrawals from the Valley floor aquifers. This initial study of the Valley's water resources concluded that the amount of groundwater being withdrawn approximately equalled the recharge. During the 1970s and the 1980s there was an increase in irrigation using both groundwater and surface water. It was recognised that without proper management the amount of groundwater withdrawal would soon exceed the amount of recharge, making the system unsustainable.

In 1988 the groundwater resource in the Valley floor was proclaimed under the Water Resources Act (1976). It is thought that the introduction of controls on groundwater withdrawals within the Valley floor has most likely been the catalyst for a significant increase in development of both groundwater and surface water use in the Lyndoch Valley and the surrounding catchment of the North Para River and its tributaries, respectively (Sibenaler, 1991).

In 1990, there was a Moratorium on surface water development throughout the catchment and on groundwater withdrawal from Lyndoch Valley. In 1992, these resources were subsequently Prescribed. For the purpose of more flexibly managing the groundwater resources in specific areas, the prescribed area was subdivided into three zones (Fig. 3).

Zone 1 covering the Valley floor, where no new licences or extensions to existing licences will be approved. All licences to be issued with a volumetric water allocation.

Zone 2 covering the Highlands, where licences will be issued with a water allocation based on an area of irrigation.

Zone 3 where new licences may be issued depending on site conditions and the impact on existing users.

The additional control in turn resulted in more demand for surface water resources in the Greenock area. A Moratorium, restricting the use of surface water in the Greenock Region, has recently been put in place (1999).

HYDROGEOLOGY

The Barossa Valley is situated approximately 60 km north-northeast of Adelaide in a proclaimed wells and watercourses area of the Mount Lofty Ranges (Fig. 1). The Valley proper is an asymmetric sedimentary basin which has a north-south length of approximately 25 km, an average width of 6 to 8 km and is up to 140 m deep (middle and upper sections of Zone 1). It is surrounded and underlain by fractured rock. The Valley contains a complex aquifer system and is bound to the east by a large fault (Stockwell Fault) which separates it from the tectonically elevated Barossa Highlands (Zone 2). The Barossa Highlands are thought to be an important source of recharge to the Valley floor. Other irrigation areas that are connected to the Valley floor in varying degrees are the Southern Barossa (Lyndoch Valley) (lower section of Zone 2) and the Greenock Region, which is just outside Zone 3 of the proclaimed area.

The Barossa Valley contains four sedimentary aquifers of Cainozoic age underlain and surrounded by fractured rock aquifers of the Adelaide Geosyncline. A summary of the major hydrogeological characteristics of these aquifers is shown in Table 1.

The Lyndoch Valley is situated to the south of both the Barossa Valley and the Greenock Region. Groundwater in Lyndoch Valley occurs in gravels and sands, and in the fractured rock which underlies and surrounds these sediments. Both of these aquifers are unconfined and interconnected (Sibenaler, 1991).

In the Greenock Region, groundwater occurs in fractured rock, and apart from a few localised pockets is generally brackish. The amount of groundwater irrigation in the Greenock Region has been estimated as insignificant (Sibenaler, 1991).

In the Valley proper, the lower aquifers and fractured rock generally have salinities that are less than 1500 mg/L, while the upper aquifers tend to be more saline ranging from 1000 to 10 000 mg/L. The complex salinity pattern that exists in the Valley floor aquifers is thought to be due to a number of factors. The main contributing factor is the sedimentary aquifers which form a commonly discontinuous and complexly interlensing system. They often lack an intermediary confining layer, thus allowing the vertical and lateral migration of water. Other factors influencing salinity include: spatial distribution of recharge from percolating rainfall, due to the presence or absence of clays, and mixing of groundwater via throughflow from hard rock aquifers.

To the North of the Valley floor lies a groundwater and surface water divide. North of this divide the groundwater flows in a northerly direction, while to the south the groundwater flows in a southerly direction through the Valley floor (Fig. 2). Within the Jacob, Tanunda and Angaston creeks subcatchments the groundwater flow direction is generally westerly towards the Barossa Valley floor and the Lyndoch Valley region. Groundwater within the Flaxman Valley catchment is expected to flow northerly and hence northwesterly into the Valley floor. The flow within the Valley floor is also strongly influenced by groundwater extraction wells and the volume of discharge to the North Para River (Rust, 1996).

Hydrogeology Unit	Characteristics
Watertable	Situated in the Valley floor, the sediments within the watertable aquifer range from clays to coarse gravels. The gravels are restricted in occurrence and the thickness is from the surface to variable depths. The aquifer is usually associated with creek flood deposits and with the upper sections of alluvial fans abutting the eastern ranges. This unconfined aquifer has salinities in the range of less than 1000 mg/l to greater than 10 000 mg/L, with the lower salinity groundwater generally found near losing streams.
Middle	The middle aquifer is situated below the water table aquifer in the Valley floor. The upper gravels, generally discontinuous clayey or silty gravel, are restricted to the flood plain of the North Para River. The sediments range from less than 0.5 metres to 10 metres in thickness. Salinity ranges from 1600 to 2700 mg/L with well yields varying from 400 to 1200 m^3/day.
Middle Carbonaceous	The middle carbonaceous aquifer is situated below the middle aquifer in the Valley floor. The upper sands of this aquifer have an upper non-carbonaceous and a lower carbonaceous facies. The aquifer varies from 5 to 20 metres in thickness. Well yields vary widely from less than 100 m^3/day to over 1300 m^3/day.
Basal	The quartz sands and gravels of the basal aquifer occupy the deep eastern half of the Valley floor. It generally thins southwards but at its deepest is up to 100 metres thick. The aquifer was little used until recently, but now supplies 50% of irrigation water (Rust, 1996). Salinity ranges from 800 to 1400 mg/L, with yields of 400 to 1000 m^3/day.
Basement	The fractured rock aquifer underlies and surrounds the sedimentary aquifers of the Valley floor and includes the Highlands. The lithology's include schists, phyllites, marbles, quartzites and shales. Weathering of the basement floor is variable. The aquifer supplies 25% of groundwater for irrigation use. The salinity is generally less than 1500 mg/L, although it is highly spatially variable. Well yields vary from less than 100 m^3/day to over 1300 m^3/day. The thickness is undefined.

Table 1 *The hydrogeology of the Barossa Prescribed Water Area.*

The North Para River is the main surface water drainage system of the region with tributaries of Angaston, Tanunda, Jacobs and Lyndoch creeks. The groundwater and surface water resources are hydraulically connected in the region. The North Para River recharges the groundwater system between the eastern foothills and the central area in the proximity of Nuriootpa, as reflected by better quality water in the upper aquifers.

COMPONENTS OF THE GROUNDWATER BUDGET

The most comprehensive review of the groundwater budget for the Barossa Valley was by Cobb (1986). Subsequent reviews by Sibenaler, X. (1991) and Rust, P.P.K. (1996), have provided an overview of monitoring trends as well as examining groundwater pumping withdrawals. However, no detailed analysis of the different components of the waterbudget have been attempted since the report by Cobb in the mid 1980s.

Groundwater is recharged directly via vertical infiltration of rainfall over the valley sediments and the fractured rock aquifers of the highlands, by creek discharge into the shallow aquifers from the North Para River and via lateral throughflow from the fractured rock aquifer of the eastern Highlands. Groundwater discharges the system via pumping withdrawals, evapotranspiration, groundwater discharging into streams (in the southern portion of the Valley) and lateral throughflow in the southern margin of the system.

Increased awareness of the importance of groundwater resources over the last 15 years has resulted in a proliferation of research activities. Improved techniques for estimating the different parameters of the water budget are now available and should now be used to revise and improve the groundwater budget for the Barossa Valley. The most critical parameters that should be investigated as a priority are discussed below.

GROUNDWATER RECHARGE

Valley Floor

Groundwater recharge is the most critical and often the most difficult parameter to estimate. Revised estimates of groundwater recharge to the valley floor can be achieved by chloride mass balance and groundwater hydrography techniques. First order estimates of recharge can be achieved by these two techniques without the additional cost of drilling new wells.

The most accurate method of estimating recharge to sedimentary aquifers is via groundwater dating techniques. Groundwater dating involves using environmental tracers as chronological markers to identify the time that groundwater was recharged. Recharge estimates by this method, although often more accurate, should only be attempted after first order estimates have been made using chloride mass balance and groundwater hydrograph techniques.

Fractured Rock

Estimating groundwater recharge to the fractured rock

Currently there are no reliable methods to measure recharge in fractured rock aquifers. It is however an important component of the groundwater budget and methodologies being developed in the Clare Valley project should eventually be adopted.

Lateral throughflow from the eastern highlands

Based on groundwater elevation contours and salinity, it is considered that a significant component of groundwater recharge to the Valley floor originates as rainfall in the eastern highlands. Rainfall is thought to permeate into the hard rock complex of these hills and, through a series of fractures and faults, makes its way into the aquifers of the Valley. This component of lateral throughflow to the valley is the most difficult component of the water budget to estimate. It requires that the degree of connection at the interface between the sediments and fractured rock be established. As well as this, the location of the capture zone (sourcing the valley sediments) in the eastern Highlands needs to be determined. Calculating volumetric flow rates from the fractured rock Highlands to the sedimentary aquifers would require considerable research over 2–3 years.

RECHARGE AND DISCHARGE FROM STREAMS

The interrelationship between surface water and groundwater in the Barossa Valley is well established. New water and salt balances should be determined as a priority. The current estimates of groundwater inflow and outflow from streams is based on a paucity of data from the late 1970s and is in need of urgent revision. In the early analysis, one gauging station was used and values were averaged over the region. Increased dam development and changes in land use patterns in the Flaxman Valley would inevitably have an impact on the flow and salinity in the North Para River. It has been estimated that the change in land use pattern has resulted in a reduction of groundwater recharge and an increase in the salinity of the recharge water (Rust, 1996).

On the basis of groundwater monitoring results (discussed later) the groundwater resources are showing signs of stress in some locations, where local extraction is greater than recharge to the system. Under the current allocation policy almost 2000 ML of allocated groundwater has not been used. If the total allocation was used then this would place additional stress on the groundwater resources.

GROUNDWATER STATUS

GROUNDWATER WITHDRAWALS

Currently metered irrigators are licensed to extract 5000 ML, from some 236 licensed wells, but usage is significantly less than allocation, particularly in the past two years (Table 2).

Area	Metered Volumes (ML/a)				
	1993/94	1994/95	1995/96	1996/97	1997/98
Valley Floor	3600	4687	3381	2934	2566
Lyndoch Valley	649	883	882	700	786
TOTAL	4249	5570	4263	3634	3352

Table 2 *The metered extraction volumes for the Barossa Valley over the past five irrigation seasons.*

It is important to determine why irrigators are using much less than their groundwater allocation (refer to Issues) as this unused allocation has significant management implications given the occurrence of locations showing signs of over-exploitation.

In terms of the salinity of groundwater extracted, a recent salinity survey indicated that:

- 54% of metered wells representing 55% of the allocation are supplying groundwater with a salinity of less than 1500 mg/L.
- 44% of metered wells representing 44% of the allocation are supplying groundwater with a salinity of 1500 to 3000 mg/L.
- 2% of metered wells representing 1% of the allocation are supplying groundwater with a salinity greater than 3000 mg/L.

WATER LEVEL TRENDS

The PIRSA groundwater monitoring network is spread throughout the Valley and currently consists of 85 wells (Fig. 3). For each well the water level, salinity or both are measured and recorded on a database by the Groundwater Program.

In terms of determining stress to the system, water levels are probably a more effective indicator of stress as they react faster than salinity in a stressed environment.

It has been suggested (Pugh, 1996) that some areas are more adequately monitored than others. For example, the areas between Nuriootpa and Bethany are intensely monitored while the sub-catchments of Jacobs Creek and Rowland Flat areas have very little monitoring (refer to Fig. 3). It is particularly important to increase the number of observation wells where there is the potential for further plantings and irrigation with groundwater.

The current observation network consists of 85 wells; 35 are completed in the fractured rock aquifer; 11 in the basal aquifer; 25 in the middle aquifer; 10 in the upper gravel aquifer and 4 in the water table aquifer.

Of all the aquifers monitored, the fractured rock system shows the highest level of stress, particularly in the Lyndoch Valley sub-region.

Whilst the other aquifers have localised "spots" with declining water levels, their trends are generally small (less than 0.5 m/year). Furthermore, current water levels are generally the same as observed in the 1980s due to the general recovery observed in 1993/94.

Fractured Rock Aquifer

Lyndoch Valley There are 12 fractured rock/upper gravel observation wells in the Lyndoch Valley region, 9 of which have had falling water levels since 1993. The falls in water levels range from 0.1 m/year to 0.8 m/year (Figs. 4 and 5). As shown in Fig. 6, the declining water levels since the very wet 1993 year, are not considered to be associated with rainfall, given that the average rainfall after 1993 is similar or greater than the 1987 to 1993 average. Rather this declining trend appears to be related to the increase in pumping since 1993/94 (Table 2). Furthermore, although accurate groundwater withdrawal volumes are not available pre 1993/94, it is likely that these would have been smaller than the 649 ML mentioned for that year.

Based on the observation well data the current average extraction rate (812 ML/year since 1994) is therefore considered to be greater than the current recharge to the system.

The Valley Floor There is a general small decline in water levels, averaging 0.1 to 0.2 m/year (Fig. 5). However, due to the significant recovery observed in the wet year of 1993, the current water levels are essentially at the same elevation observed some 15 years ago, except in the Tanunda to Angaston area where small but steady declining water levels have been observed.

Highlands There is limited data in this area, but the fractured rock aquifer near Angaston/Penrice is stressed, with water levels declining at rates ranging from 0.2 to 1 m/year.

Basal Aquifer

Water levels have essentially not declined since 1989/91, except in the northern and southern limits with a small declining trend of some 0.1 m/year (Fig. 7).

However, due to the 1993/94 recovery, current water levels are generally similar to those observed in the mid 1980s (Fig. 8), except the southern limits (MOR201).

Middle Aquifers

In the Tanunda area, water levels have been declining steadily (MOR062, MOR064, MOR065, Fig. 9). North of Tanunda, water levels have been declining at a small rate in approximately 50% of the observation wells, but due to the 1993/94 recovery, water levels are currently the same as observed in the 1980s. In the remaining 50% of observation wells, water levels have not changed for the last 6 to 10 years.

Upper Gravels

There are 10 monitoring wells in the Upper Gravel aquifer, 5 of which show steady declining water level trends (Fig. 4). Two of these wells (BRS007 and BRS009) only have water level records from the late 1980s. The water levels in these two wells are stable until the early 1990s, after which there is a steady decline. The remaining three wells have water level records from the mid 1970s and show a gradual overall decline in water levels, with some recovery coinciding with heavy rainfall events.

Water Table Aquifer

The water table aquifer is restricted to only 4 wells, in the northwest corner of the prescribed area (Fig. 10). Water level trends parallel rainfall, except observation well MOR073 at the eastern edge of the Valley, with a steady decline averaging 0.25 m/year since 1993 (Fig. 11). This well is located in an area where the water level in the fractured rock aquifer is declining at a rate of 1 m/year since 1993 (Figs. 10 and 5).

At this point in time no irrigators have raised the issue of falling water levels with PIRSA, although it is unlikely that they would be aware of gradually declining water levels. It is important that irrigators begin to measure their water levels on a regular basis so that a more complete picture can be formed of areas that are under stress. It is also important that irrigators have access to this information to gain some feedback. This could be in the form of a GIS system.

ID	Well Type	Salinity increase per year (EC)	Time Period (Years)	Well Location	Use	Aquifer Type
BLV004	OBS	200	6	North-east of Nuriootpa	INV	Fractured Rock
BRS006	OBS	13.3	18	Lyndoch Valley	IRR	Fractured Rock
BRS014	OBS	16.5	11	Lyndoch Valley	IRR	Fractured Rock
BRS018	OBS	35	7	Lyndoch Valley	IRR	Fractured Rock
MOR151	OBS	36.6	11	North of Rowland Flat	DOM/ IRR	Fractured Rock
MOR163	OBS	18.5	10	North of Tanunda	IRR	Fractured Rock
MOR192	OBS	7.1	14	South-west of Angaston	IRR	Fractured Rock
BRS005	OBS	16.0	20	Rowland Flat	IRR	Basal
MOR100	OBS	87	20	North of Angaston	INV	Basal
MOR155	OBS	12.5	20	South-east of Tanunda	IRR	Basal
MOR204	OBS	40	7	South-east of Tanunda	_	Middle
BRS009	OBS	15	11	Lyndoch Valley	IRR	Upper Gravel

Table 3 *Wells identified with rising salinity in the Barossa Valley Prescribed Water Area*

SALINITY TRENDS

Fractured Rock Aquifer

Of the 27 observation wells regularly monitored, 7 show a rising trend in salinity (Figs. 12 and 13). Four of the wells are located in the Lyndoch Valley. There is no obvious pattern in the location of the remaining three wells in the Valley floor.

Basal Aquifer

Two of the 11 basal aquifer salinity observation wells have an increasing salinity trend (Figs. 14 and 15).

Middle Aquifer

Of the 25 wells monitoring the salinity of the Middle aquifer, only one has an increasing salinity trend (MOR204, 40 mg/L per year over the last 7 years, Fig. 16). A few have lower salinities than when first sampled in the 1970s, but have stabilised than over the last few years. Due to data gaps, it is not known if the variations are due to sampling error (especially non-pumped samples) or due to well leakage.

Upper Gravels Aquifer

The same applies to the Upper Gravels monitoring wells (12), which have all stabilised over the last 10 years, with the exception of BRS009 (Fig. 17).

Observation wells with rising salinity are shown in Table 3.

ISSUES

DEMAND FOR ADDITIONAL GROUNDWATER DEVELOPMENT IN THE BAROSSA HIGHLANDS

The Barossa Highlands region consists of fractured rock in which the groundwater moves through secondary porosity, which is fractures or joints that have been formed by tectonic stresses. The lithology of the region includes shales, marbles, quartzites, phyllites and schists. The salinity and yield of groundwater in the fractured rock aquifers varies widely and can change rapidly over short distances. This significant variability makes it difficult to predict the quantity and quality of groundwater at a particular location and hence the long term sustainability of the groundwater resource. The variability of salinity and yield can be attributed to a number of factors principally; the degree to which the fracture network is interconnected; the rate and spatial variability of groundwater recharge; rock type and the chemical reaction between water and rock. There is very little understanding of fractured rock aquifer systems worldwide.

Currently the groundwater monitoring network in the Highlands is limited to the Penrice and Angaston areas, with two observation bores to the south of Angaston (Fig. 3). There is also no metering of usage on Highland bores, so the exact consumption is unknown. Extension of the network and metering are both recommended in order to maintain a consistent monitoring network and consumption record over the entire North Para Prescribed Water Area, and also to help with approximate recharge estimates. A part of the Keyneton monitoring network overlaps the eastern edge of the North Para Proclaimed Water Area boundary. Salinities have not been recorded, but generally the water levels appear to have a direct relationship with the rainfall up until 1993, after which there appears to be a consistent decrease of water levels in the wells (Fig. 18).

In the Highlands the majority of irrigation occurs within the Angaston Creek subcatchment. Groundwater irrigation represents around 20% of the irrigated area with the remainder coming from farm dams. The distribution of irrigation bores in the Highland subcatchments is illustrated in Fig. 19. Currently groundwater use is mainly in the Flaxman Valley area and extraction is estimated to be in the order of 400 ML/annum. This apparent low utilisation is a reflection of the general restriction on additional development, introduced in 1990, in response to concerns that any additional significant development would impact on the groundwater recharge to the Valley floor aquifers.

To that end, there is a need to gain a better comprehension of two major scientific issues in order to obtain a greater understanding of the hydrogeological processes operating in the Barossa Valley. Firstly, how much recharge occurs in the eastern highlands and secondly how much of this recharge water passes via lateral throughflow to the Valley sediments. A proper understanding of these processes as well as quantitative estimates of volumetric water fluxes, is required for effective management of the region. Currently there are no reliable methods for estimating recharge rates to fractured rock aquifers and as a result there is no reliable way to assess the sustainability of groundwater extraction.

PIRSA has started a preliminary program to address these two major scientific issues. Work completed to date includes drilling of observation bores including a nested piezometer site on the eastern highlands (Morton et. al., 1998). A number of existing observation wells, have been sampled for chemistry and isotope data. The type of data collected so far includes full chemical analysis, stable isotopes of the water molecule (deuterium and oxygen-18) and carbon 14. The chemical data and isotopes within the water molecule can be used to identify the origin as well as the source of water. Carbon 14 can be used to identify the residence time of groundwater, (ie the time since water was isolated from the atmosphere).

Preliminary analysis suggests that the origin of the groundwater is from local rainfall and recharge. The age of groundwater covers a wide spectrum from modern (last few decades) to up to 15 000 years old. The data also indicates a hydraulic connection and recharge via lateral flow from the eastern highlands to groundwater in the valley sediments. Future work will seek to develop a robust conceptual model of the Barossa Valley system including revised volumetric estimates of the water budget.

It should be noted that currently PIRSA is conducting a study on the sustainability of fractured rock in the Clare Valley. The results of this study (eg methodology) can potentially be applied to the Barossa Highlands as the two areas are similar.

The results of these studies should give some indication of whether additional groundwater withdrawal is viable in the Highlands.

UNUSED WATER ALLOCATION

Currently there is a groundwater allocation of 5000 ML in the Barossa region, however, only just over 3000 ML is utilised. There are thought to be several reasons for this under utilisation. Marginal quality can be a problem for some irrigators, either they don’t use their allocation at all, or they mix the groundwater with dam or mains water. Yield can also be a problem with low yields making it physically impossible for irrigators to use the amount of allocated groundwater over the time frame of the irrigation season. Soil and yield can also be a factor, with some irrigators making a management decision on how much water is required.

LEAKING WELLS

Deep, old and poorly completed wells are a potential cause of water quality degradation within the valley. Prior to the implementation of the 1976 Water Resources Act, wells were not required to have a pressure cemented completion. There is the potential for leakage to occur between aquifers when wells are without pressure cementing. During winter there is little difference in hydraulic heads between the aquifers. However, during summer pumping induced reversals in potential pressure gradient allow saline upper groundwaters to gravitate into the fresher exploited aquifers through corroded casing or non-pressure cemented sections of the well.

Several observation wells and privately owned irrigation wells have been identified as either having corroded casing or poor completion. Of the 1227 wells in the Barossa region, 860 were drilled prior to 1976, making it likely that other problem wells will be identified.

IMPORTED WATER

During the off-peak period from April to November, SA Water provides its customers with the opportunity to purchase an extra supply of potable off-peak mains water. Another option that may be available to irrigators in the future is the Barossa Infrastructure Limited (BIL) project. The aim of the BIL project is to import untreated Murray River water to the Barossa for the purpose of irrigation. A group of irrigators have proposed to privately build the infrastructure to import up to 10 GL/annum in the long term.

Some concerns have been raised (Rust, 1996) that the importation of water may cause a possible rise in the water table and dryland salinity/saline stream discharges. There is no doubt that the importation of the volumes considered will have an impact on the water table. The extent of the rise of the water table and associated impacts is currently being investigated by a consultant.

One of the associated impacts will be an increase in saline spring discharges. The need to maintain adequate environmental flows therefore becomes even more important.

ASR

ASR is currently practised at a small scale in the Barossa Valley, essentially to improve groundwater quality.

Previous ASR studies in the Barossa have demonstrated that ASR in the finer grained, less permeable aquifers is not suitable (Pugh and Harvey, 1998). Aquifers that have the least complications with ASR are where bores are completed within the fractured rock aquifer or the more highly permeable basal or upper gravel aquifers (Pugh and Harvey, 1998).

The practise of ASR to improve groundwater quality, could be useful in areas such as the Greenock Region where water is currently considered too saline for vine irrigation. Since groundwater in this region has not been well documented, close monitoring on the long term effects of ASR to the region should be carried out.

OBSERVATION NETWORK

There is a need to extend the Highlands observation network to cover not only the Penrice and Angaston area, but the rest of the Highlands zone. The importance of this is to assess the quality and quantity of the entire region, giving a consistent coverage.

Currently there are only 4 observation bores in the water table aquifer. With the future introduction of imported water, it is important that this network is extended so that any rise in the water table and possible salinisation problems can be quickly identified and appropriately managed.

LICENCE TRANSFERS

It is anticipated that the level of transfer applications will increase significantly with the possible implementation of the BIL project. There is therefore a need to better define water usage by aquifer type and distribution. In conjunction with the observation network it will be possible to better define zones where transfers in may increase the level of aquifer stress.

FLOWING WELLS

Numerous wells in the Rowland Flat region are flowing during the non irrigation season; it is very unlikely that this water would be returned to the groundwater system in its entirety, with the majority probably lost to evaporation. These wells should be capped or backfilled.

CONCLUSIONS

In parts of the Valley floor groundwater levels are continuing to decline. This is particularly the case in the Lyndoch area. Salinities in the Barossa region appear to be static with the exception of a few wells.

The unused groundwater allocation has the potential to significantly exacerbate the level of aquifer stress. If the extra water were to be auctioned, which is a possibility, then serious consideration should be given as to where the extra allocation of water will go.

The practise of ASR could possibly open up areas for development where the groundwater has traditionally been too saline to use.

Whilst the issue of recharge from the highlands directly into the Valley floor, and the extent to which this could be affected by additional development, is important, it will require significant resourcing to be quantitatively investigated.

SUGGESTED WORK PROGRAM

Activity	Milestones	Priority
Establish monitoring network for fractured rock aquifer	• Check suitability of existing wells. • Survey wells to obtain reference elevations. • Monitor four times a year for water level and salinity. • Establish management policies so that irrigation wells in the fractured rock aquifer are metered, and all water levels and salinities are monitored.	High
Groundwater Budget -Stream Water and Salt Balance	• Review suitability of existing gauging stations for monitoring water salinity and stream discharges. • Install additional gauging stations if required. • Establish Chloride rainfall monitoring stations in the Barossa Proclaimed Water Area (3–4 years).	High
Groundwater Budget - Groundwater Recharge	• Establish Chloride rainfall monitoring station (2–3 years). • Desktop study of vertical recharge using hydrographs • Adopt methodologies from the Clare Valley LWRRDC project and develop a research proposal to estimate recharge using a hydrochemical approach, in fractured rock.	High Medium Medium
Groundwater Budget - Fractured Rock	• Establish Chloride rainfall monitoring station (2–3 years).	High Medium
Lateral throughflow from fractured rock sediments	• Develop research proposal.	Medium
Assess the unused water allocation potential impact.	• Cross-index well I.D. with water Licence • Confirm water salinities • Consult well owners	High
Assess the impact of leaking wells	• Review salinity data and identify potential leaking wells. • Field investigation of identified potential leaking wells.	Medium
Establish a Spatial Distribution of Metered Usage	• Categorise irrigation bores by aquifer type (sedimentary and fractured rock). • Cross-index well identification with allocation Licences.	High

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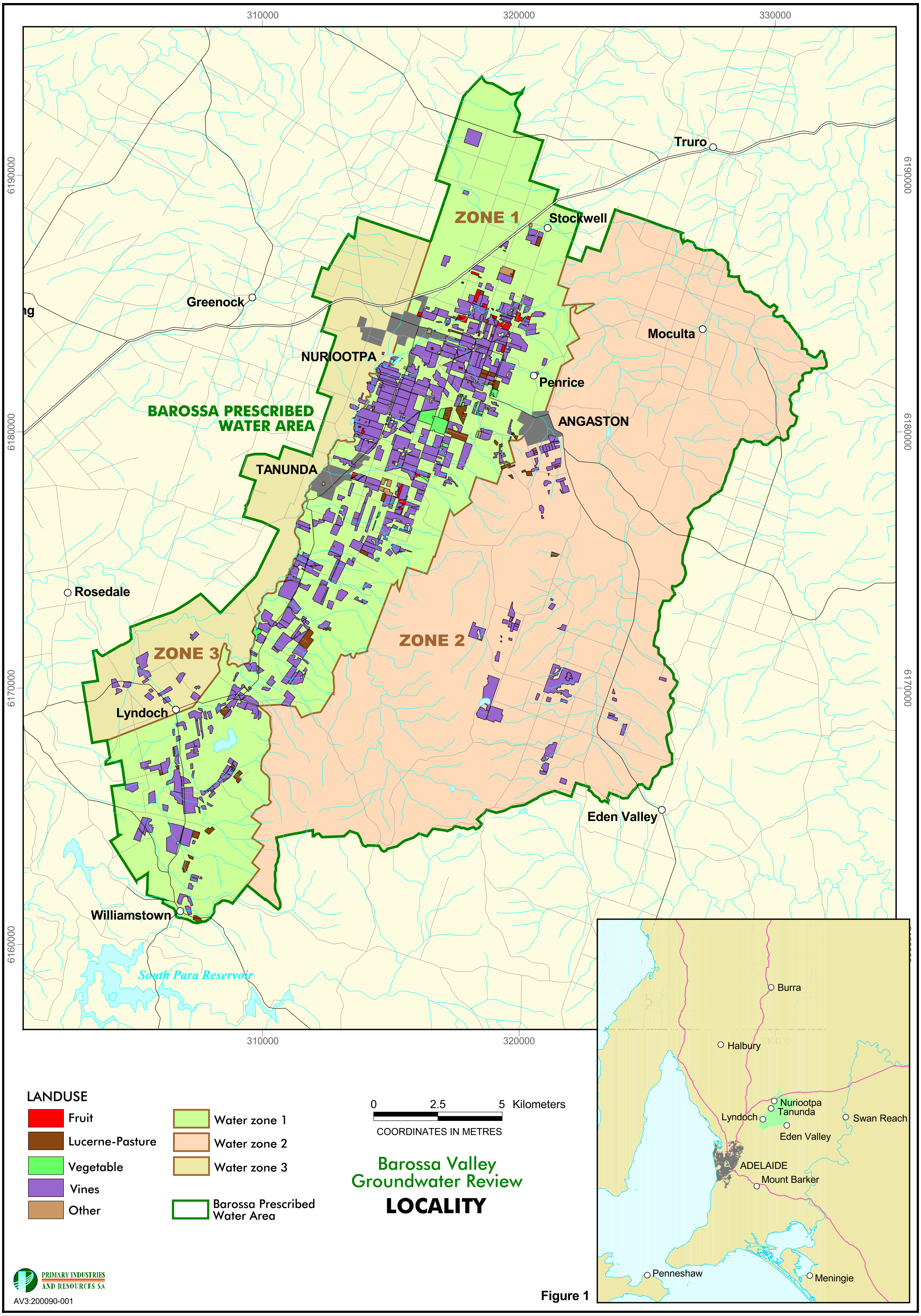
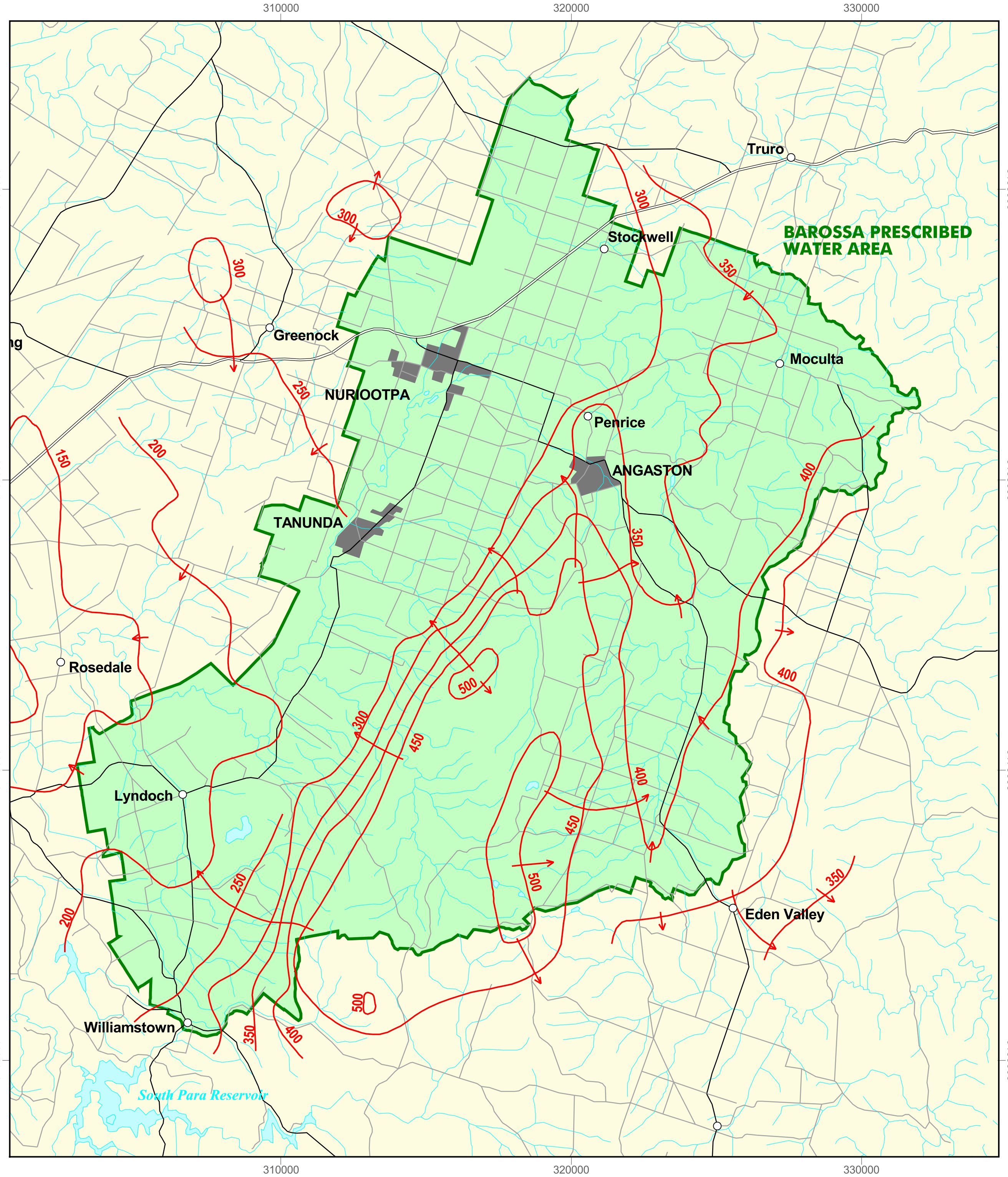
Figures


310000
320000
330000
6190000
6180000
6170000
6160000
Truro
ZONE 1
Stockwell
Greenock
Moculta
NURIOOTPA
Penrice
BAROSSA PRESCRIBED WATER AREA
ANGASTON
TANUNDA
Rosedale
ZONE 2
ZONE 3
Lyndoch
Eden Valley
Williamstown
South Para Reservoir
Burra
Halbury
Nuriootpa
Tanunda
Lyndoch
Swan Reach
Eden Valley
ADELAIDE
Mount Barker
Penneshaw
Meningie
LANDUSE
Fruit
Lucerne-Pasture
Vegetable
Vines
Other
Water zone 1
Water zone 2
Water zone 3
Barossa Prescribed Water Area
0
2.5
5
Kilometers
COORDINATES IN METRES
Barossa Valley Groundwater Review
LOCALITY
PRIMARY INDUSTRIES AND RESOURCES SA
AV3:200090-001
Figure 1



250 Hydraulic contours (m AHD)

Groundwater flow direction

Barossa Prescribed Water Area

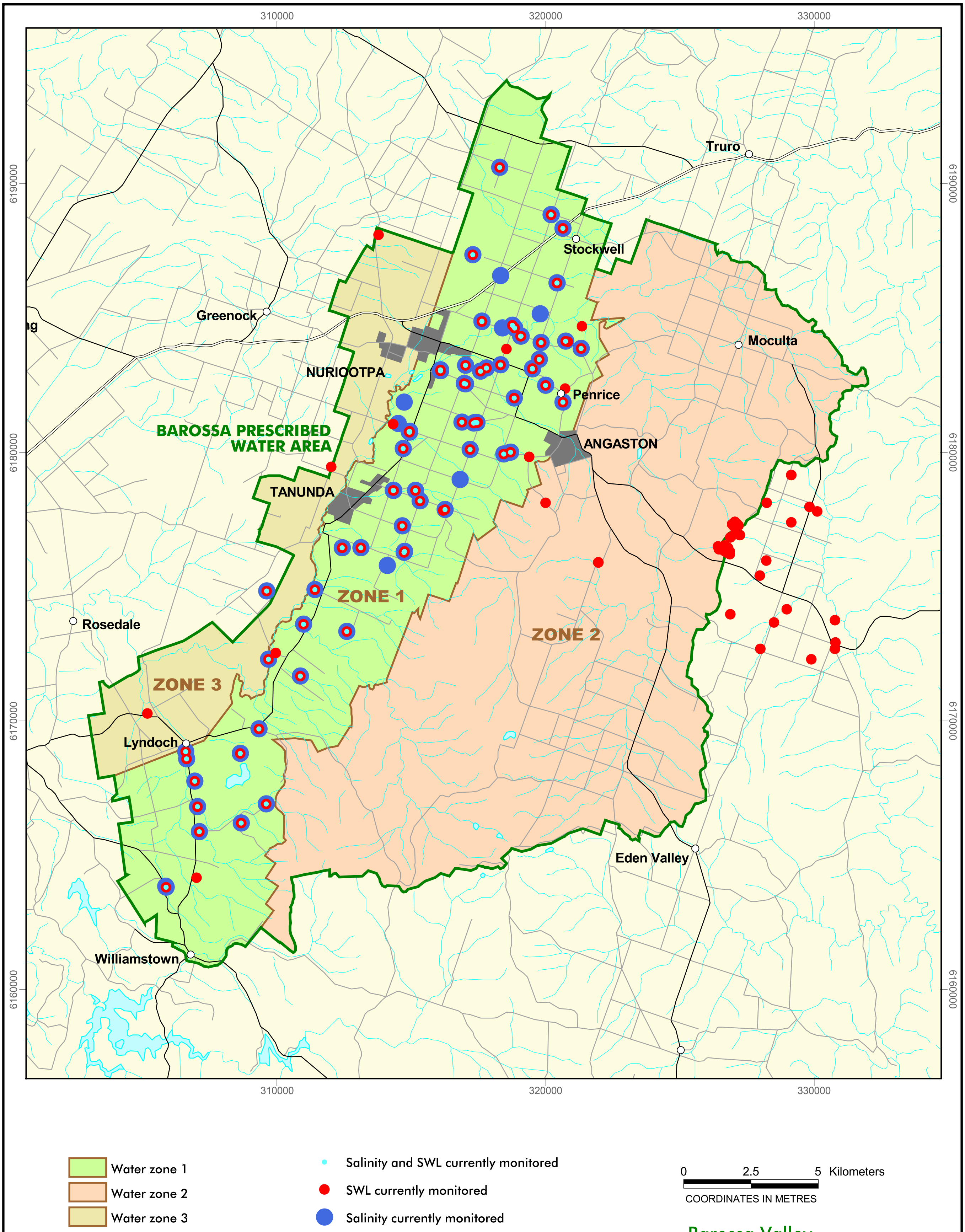
Barossa Valley
Groundwater Review

HYDRAULIC CONTOURS

PRIMARY INDUSTRIES AND RESOURCES SA

AV3:200090-002

Figure 2



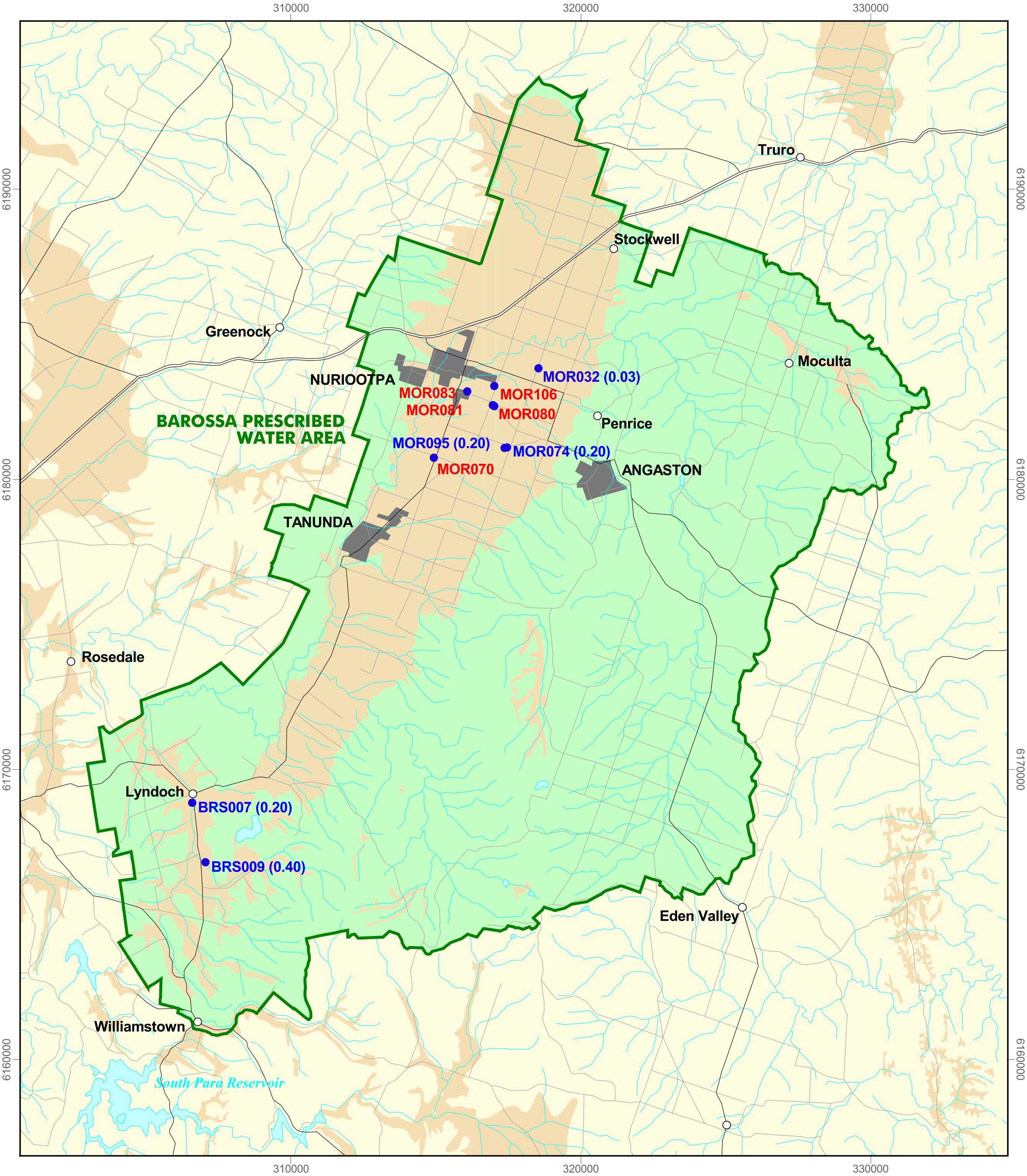
Barossa Valley
Groundwater Review

MONITORED WELLS

PRIMARY INDUSTRIES AND RESOURCES SA

AV3:200090-003

Figure 3



MOR032 (0.03) ● Average m/year decline

MOR081 ● Stable water level

Quaternary sediments

Barossa Prescribed Water Area

0 2.5 5 Kilometers

COORDINATES IN METRES

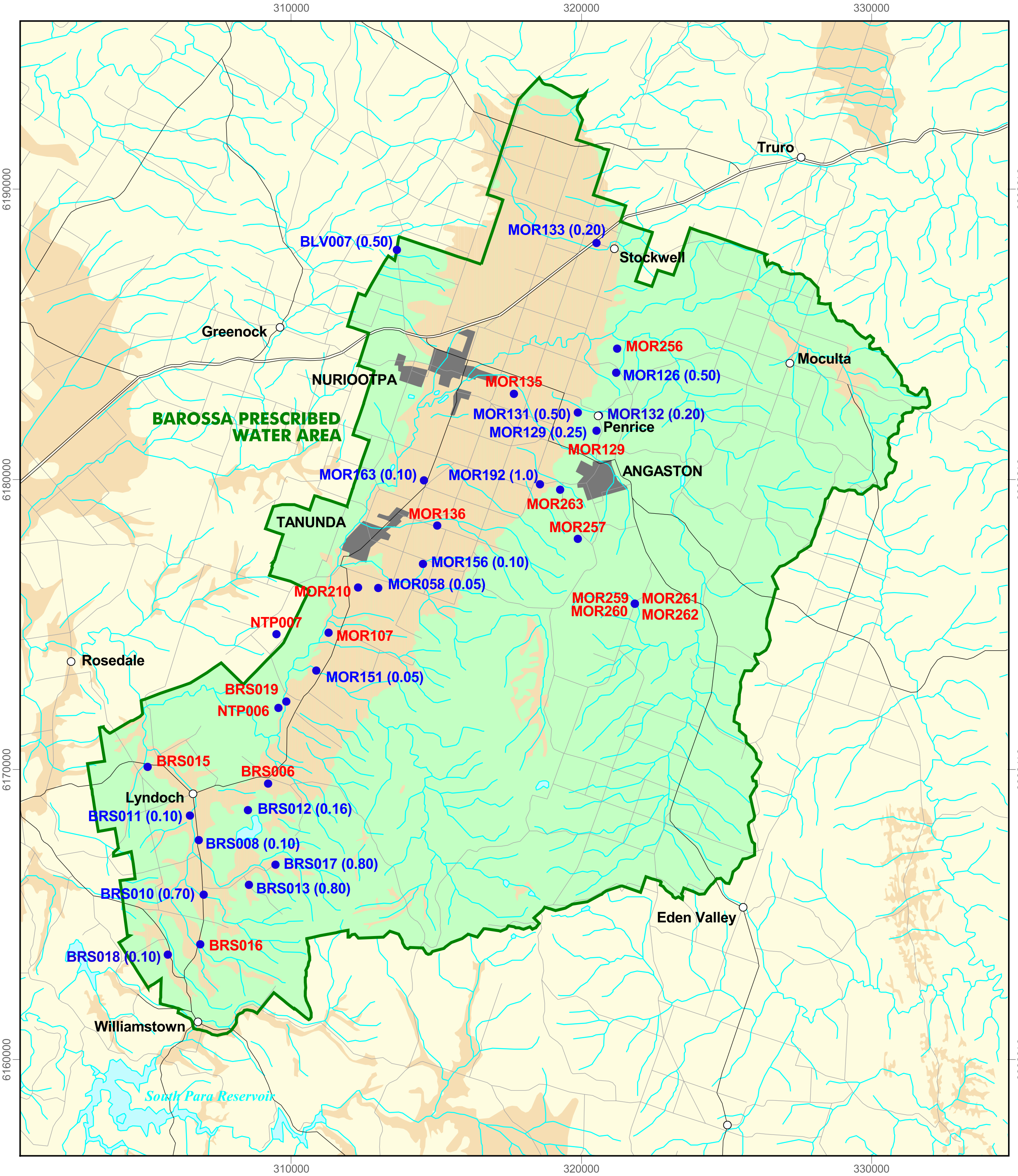
Barossa Valley
Groundwater Review

WATER LEVEL TRENDS IN UPPER GRAVEL AQUIFER

PRIMARY INDUSTRIES AND RESOURCES SA

AV3:200090-004

Figure 4



MOR135 (0.03) ● Average m/year decline

BRS016 ● Stable water level

Quaternary sediments

Barossa Prescribed Water Area

0 2.5 5 Kilometers

COORDINATES IN METRES

Barossa Valley
Groundwater Review

WATER LEVEL TRENDS IN FRACTURED ROCK AQUIFER

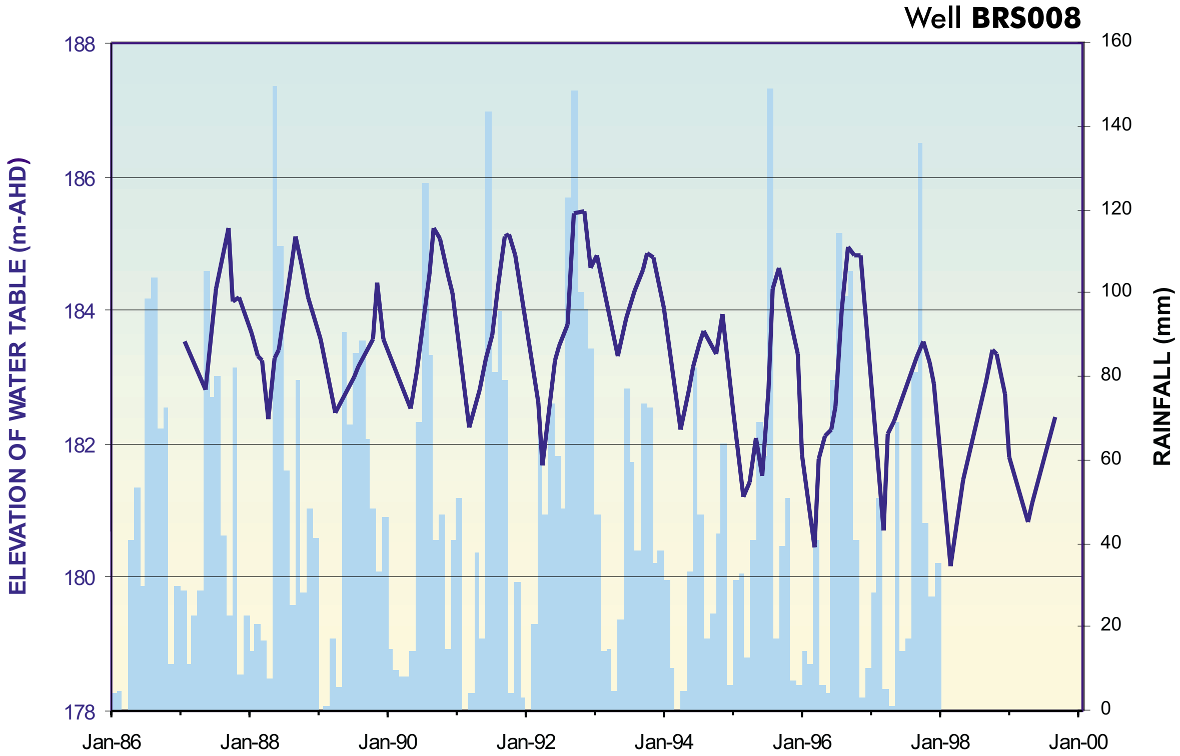
PRIMARY INDUSTRIES AND RESOURCES SA

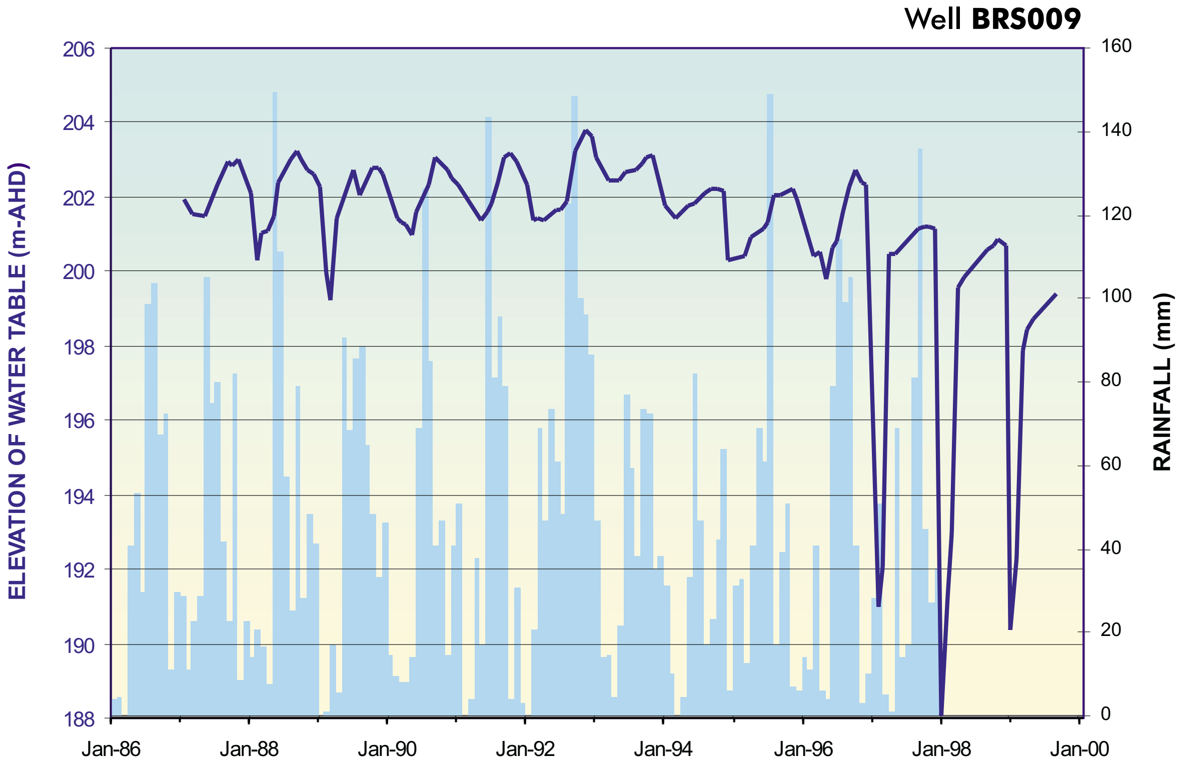
AV3:200090-005

Figure 5

HARD ROCK AQUIFER

Elevation grid interval 2 metres





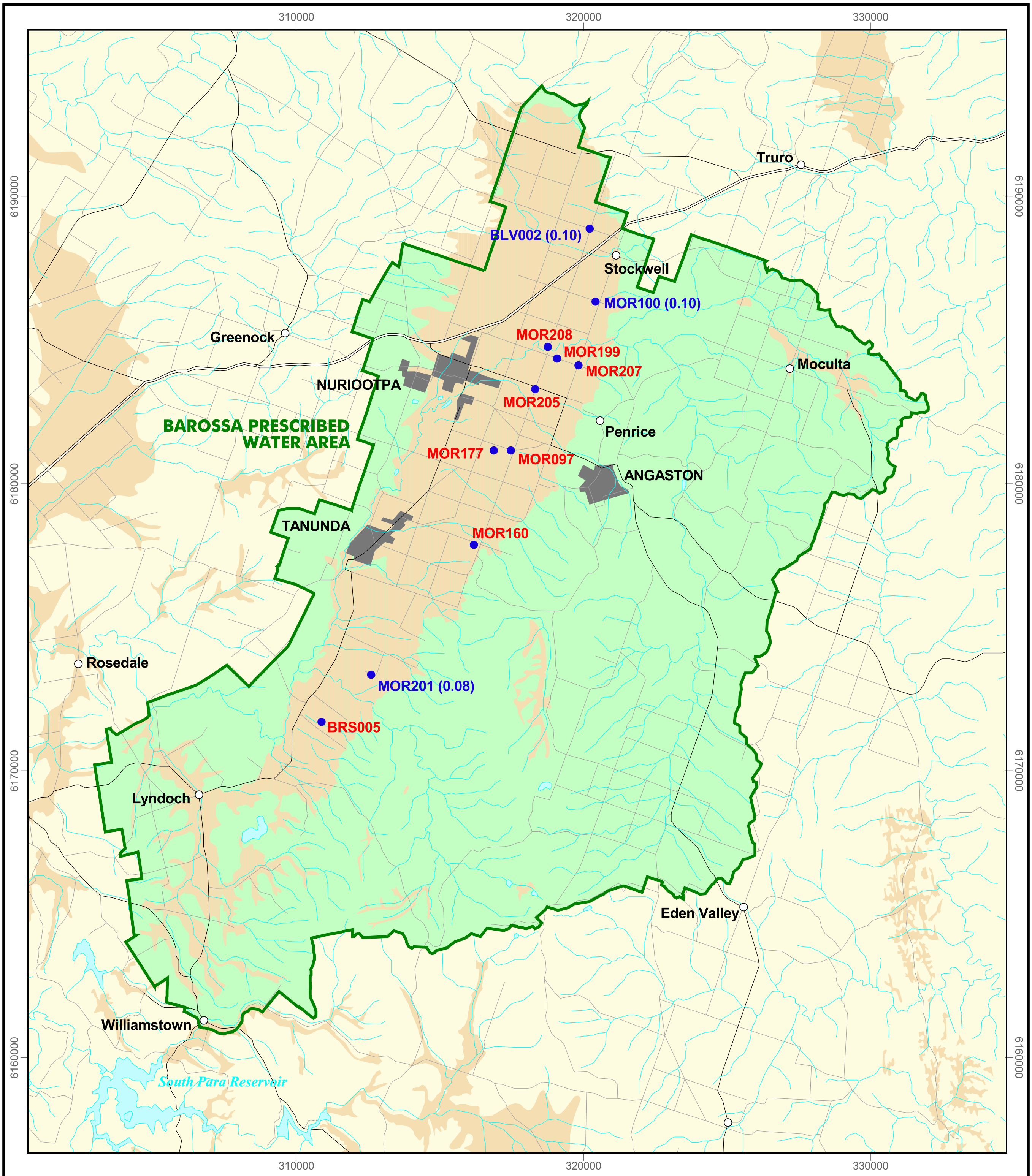
Barossa Valley Groundwater Review

Monitored wells BRS008 and BRS009

FRACTURED ROCK AQUIFER HYDROGRAPHS WITH DECLINING WATER LEVELS

CD:200090_006.CDR

Figure 6



MOR100 (0.10) ● Average m/year decline

MOR205 ● Stable water level

Quaternary sediments

Barossa Prescribed Water Area

0 2.5 5 Kilometers

COORDINATES IN METRES

Barossa Valley
Groundwater Review

WATER LEVEL TRENDS IN BASAL AQUIFER

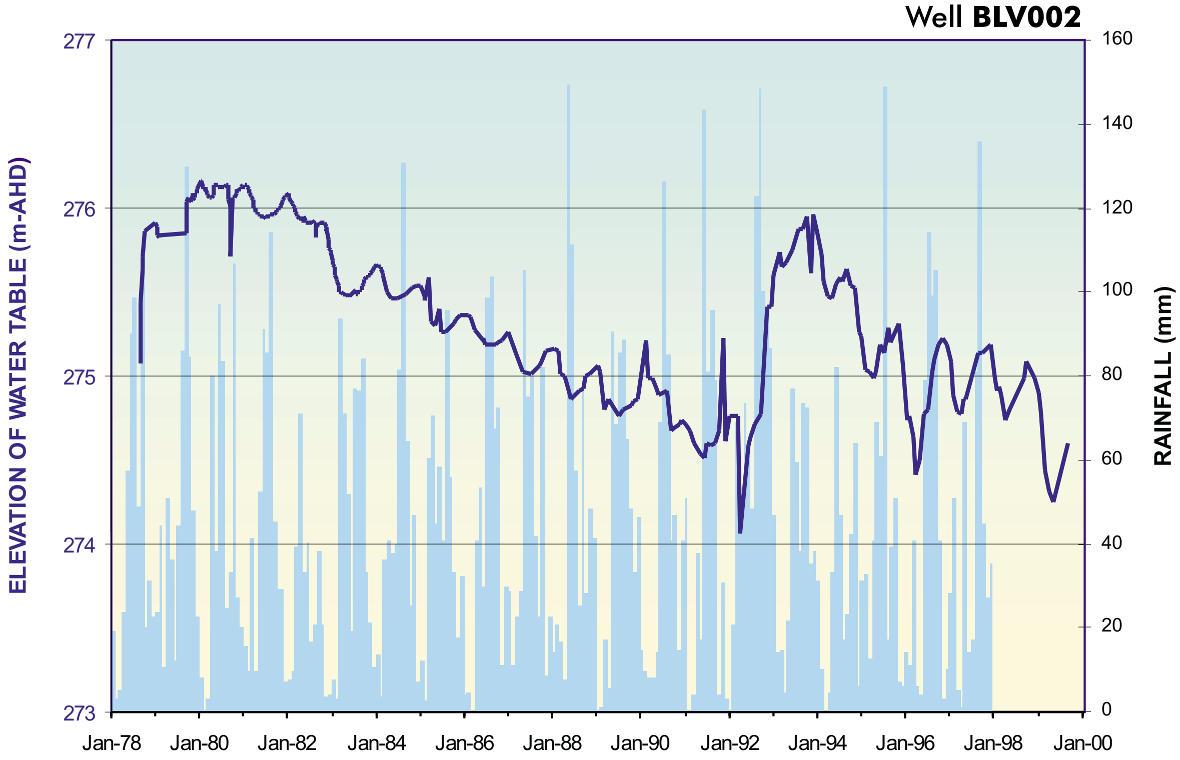
PRIMARY INDUSTRIES AND RESOURCES SA

AV3:200090-007

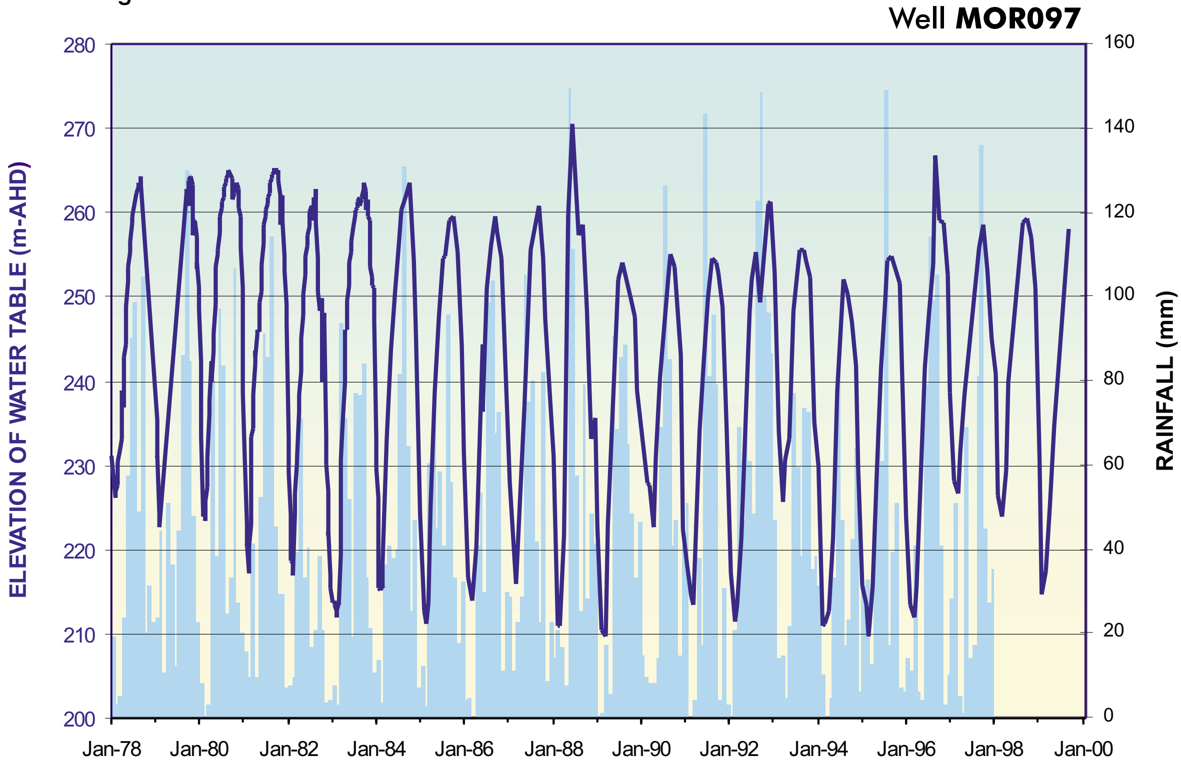
Figure 7

BASAL AQUIFER

Elevation grid interval **1** metre



Elevation grid interval **10** metres



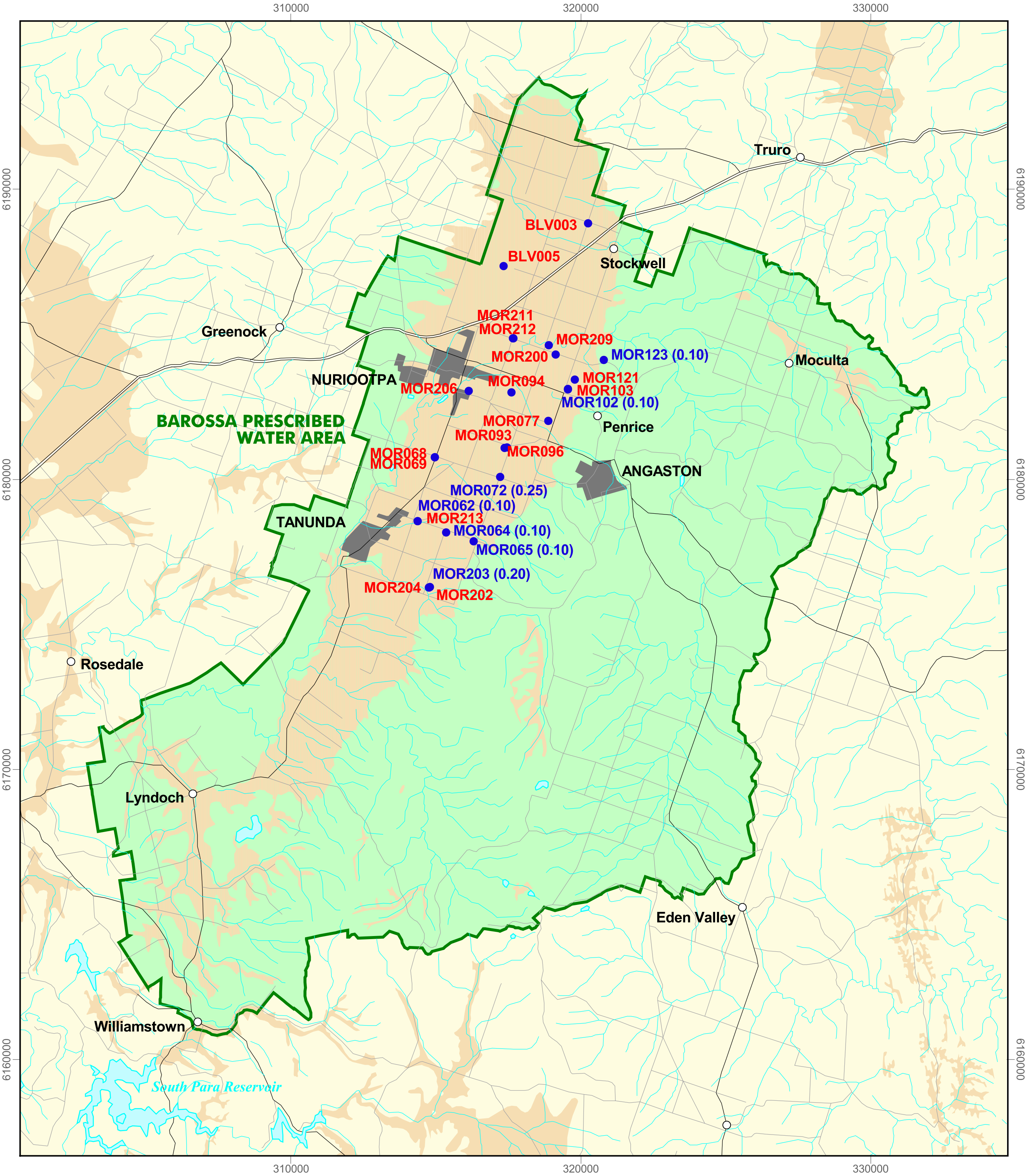
Barossa Valley Groundwater Review

Monitored wells BLV002 and MOR097

BASAL AQUIFER HYDROGRAPHS

CD:200090_008.CDR

Figure 8



MOR062 (0.10) ● Average m/year decline

MOR203 ● Stable water level

Quaternary sediments

Barossa Prescribed Water Area

0 2.5 5 Kilometers

COORDINATES IN METRES

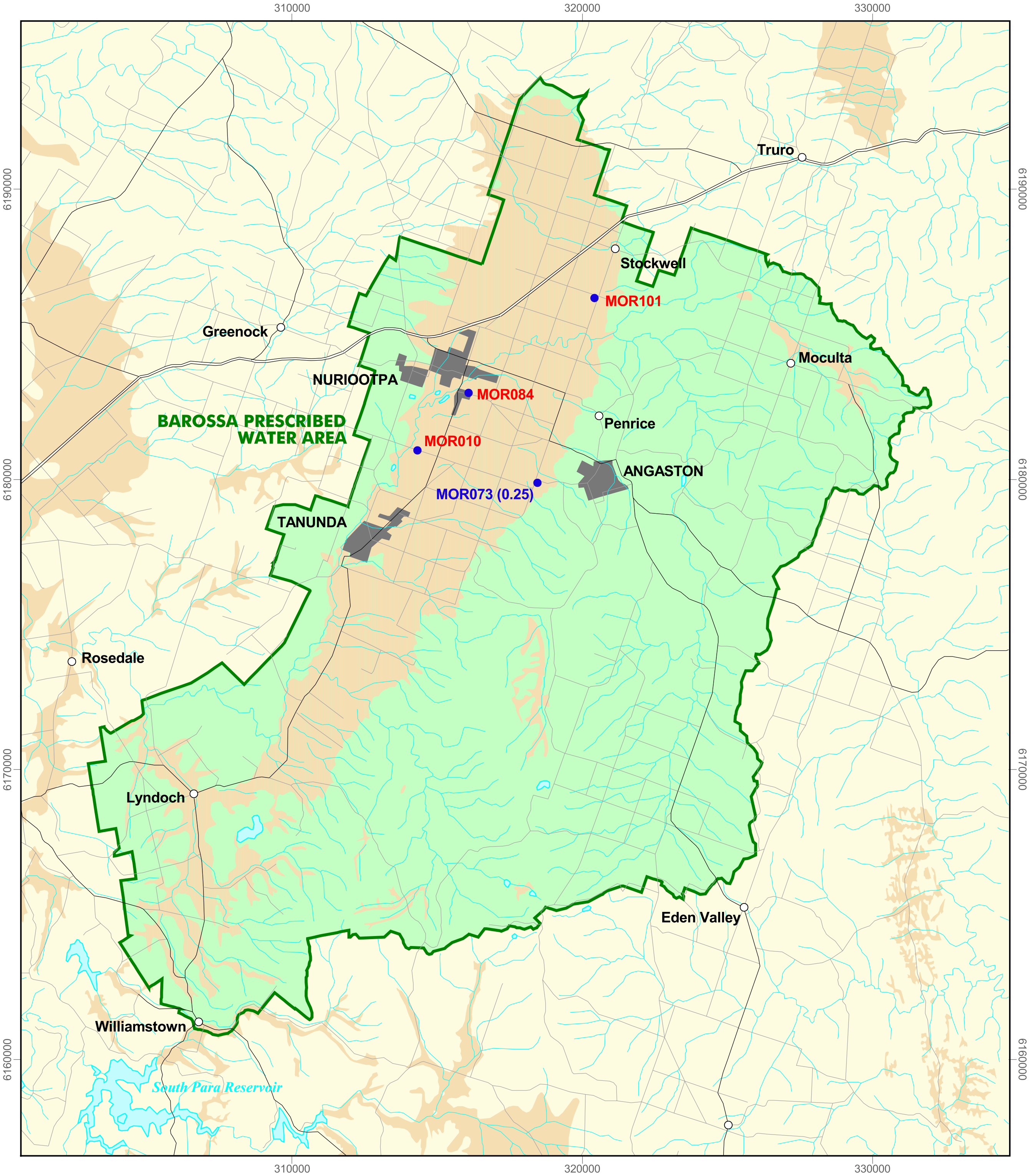
Barossa Valley
Groundwater Review

WATER LEVEL TRENDS IN MIDDLE AQUIFER

PRIMARY INDUSTRIES AND RESOURCES SA

AV3:200090-009

Figure 9



MOR073 (0.25) ● Average m/year decline

MOR010 ● Stable water level

Quaternary sediments

Barossa Prescribed Water Area

0 2.5 5 Kilometers

COORDINATES IN METRES

Barossa Valley
Groundwater Review

WATER LEVEL TRENDS IN WATER TABLE AQUIFER

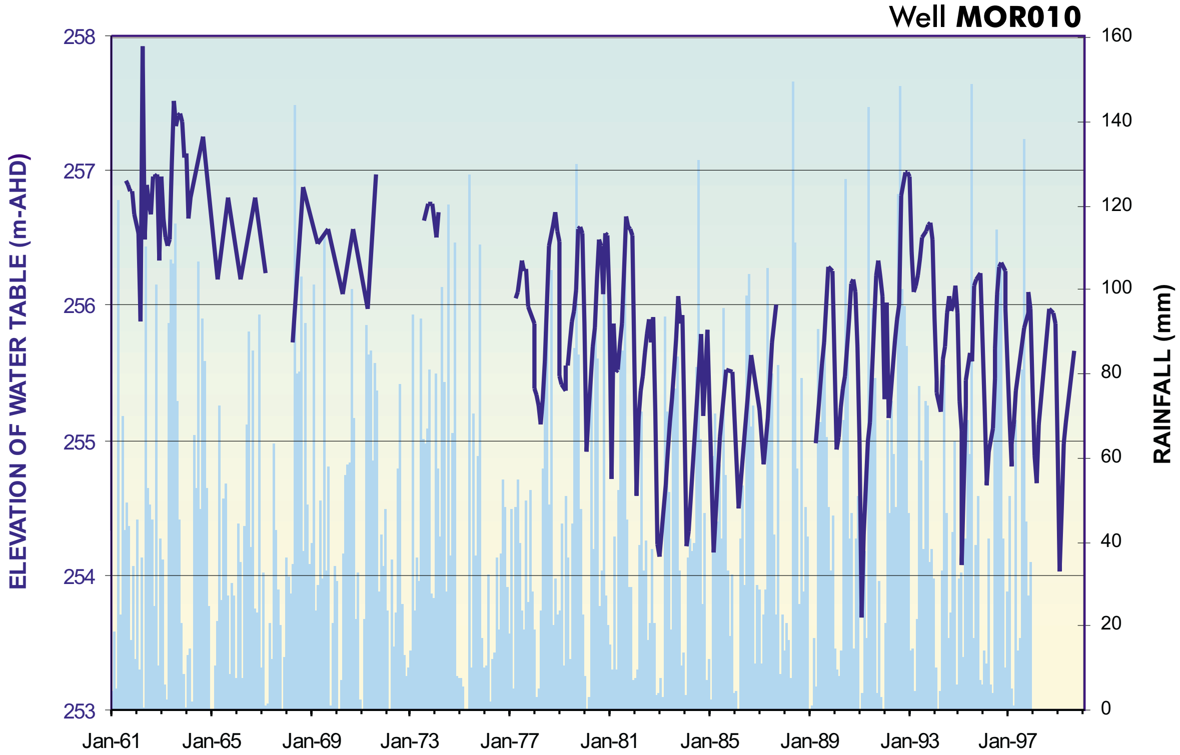
PRIMARY INDUSTRIES AND RESOURCES SA

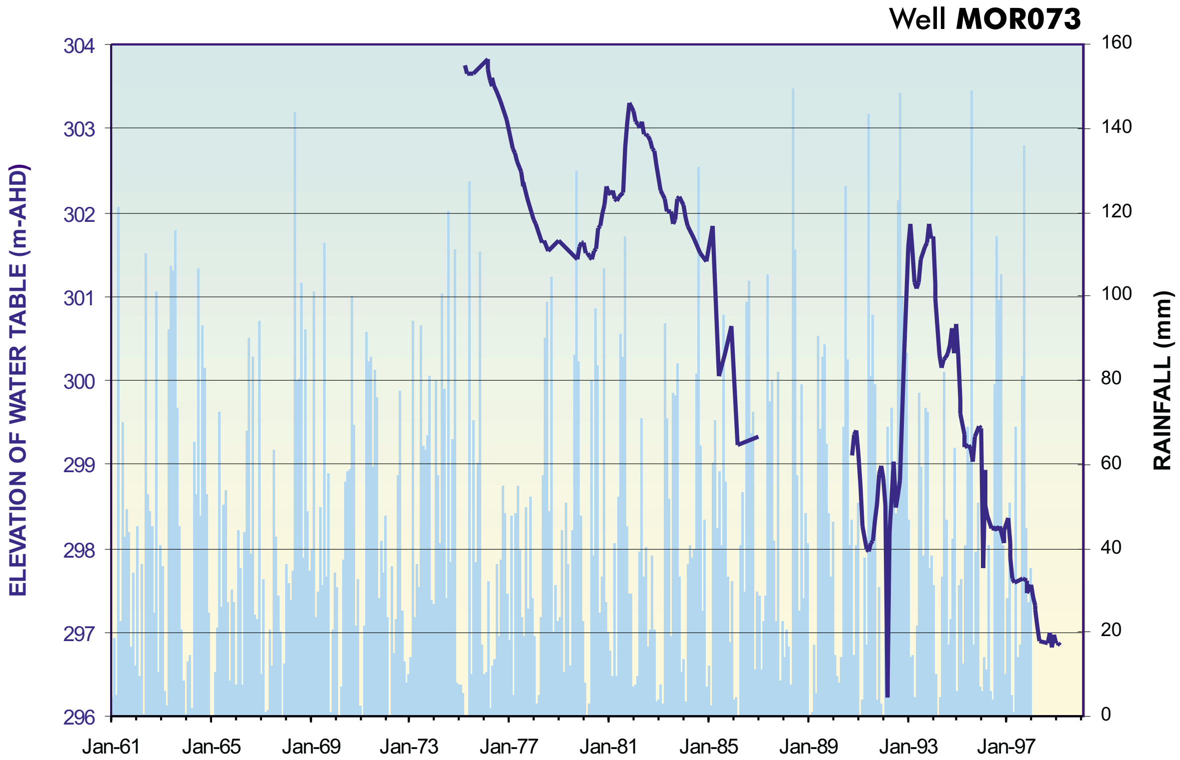
AV3:200090-010

Figure 10

WATER TABLE AQUIFER

Elevation grid interval **1** metre





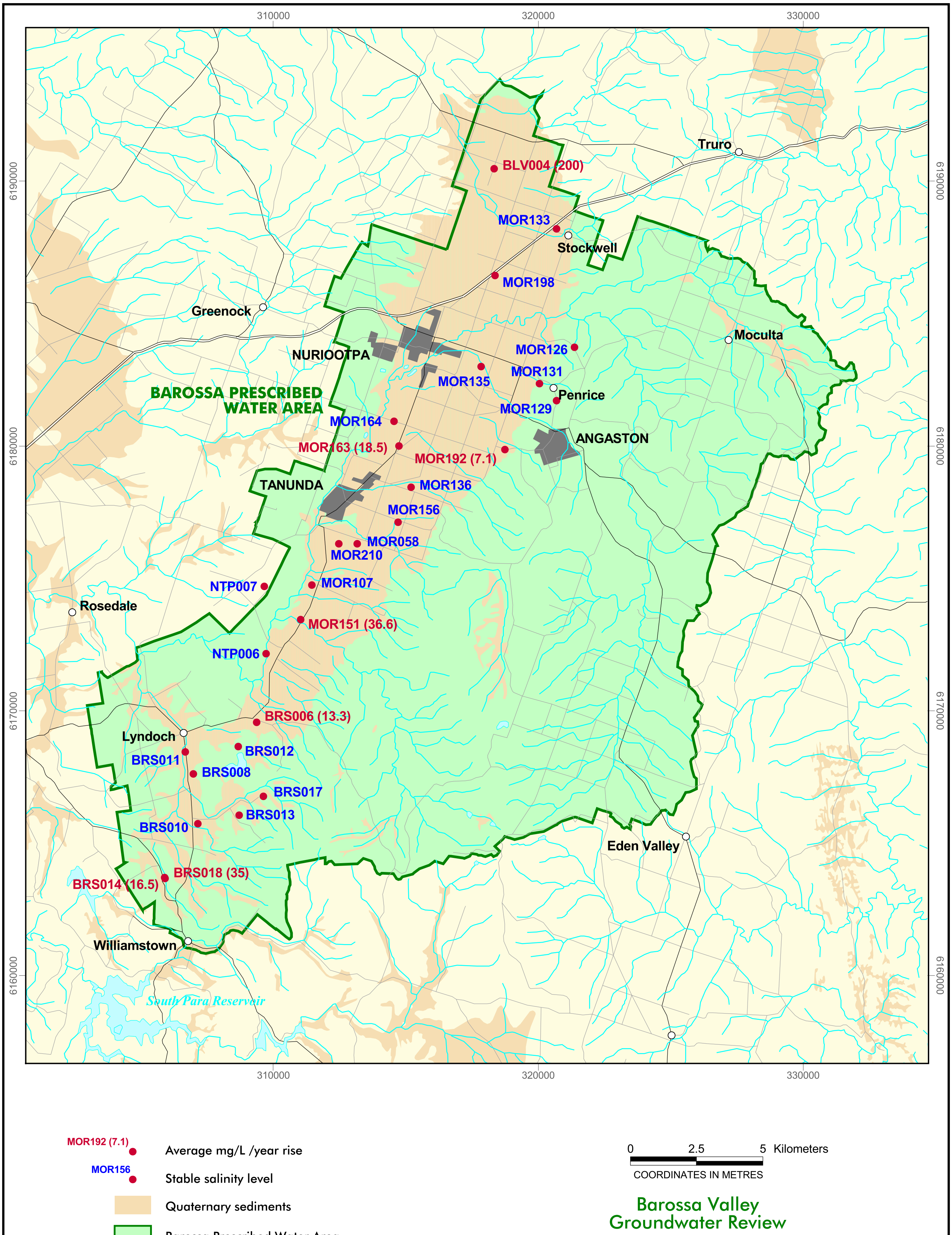
Barossa Valley Groundwater Review

Monitored wells MOR010 and MOR073

WATER TABLE AQUIFER HYDROGRAPHS WHERE MOR010 REFLECTS RAINFALL and MOR073 EXHIBITS A DECLINE IN WATER LEVEL

CD:200090_011.CDR

Figure 11



Barossa Valley
Groundwater Review

SALINITY LEVEL TRENDS IN FRACTURED ROCK AQUIFER

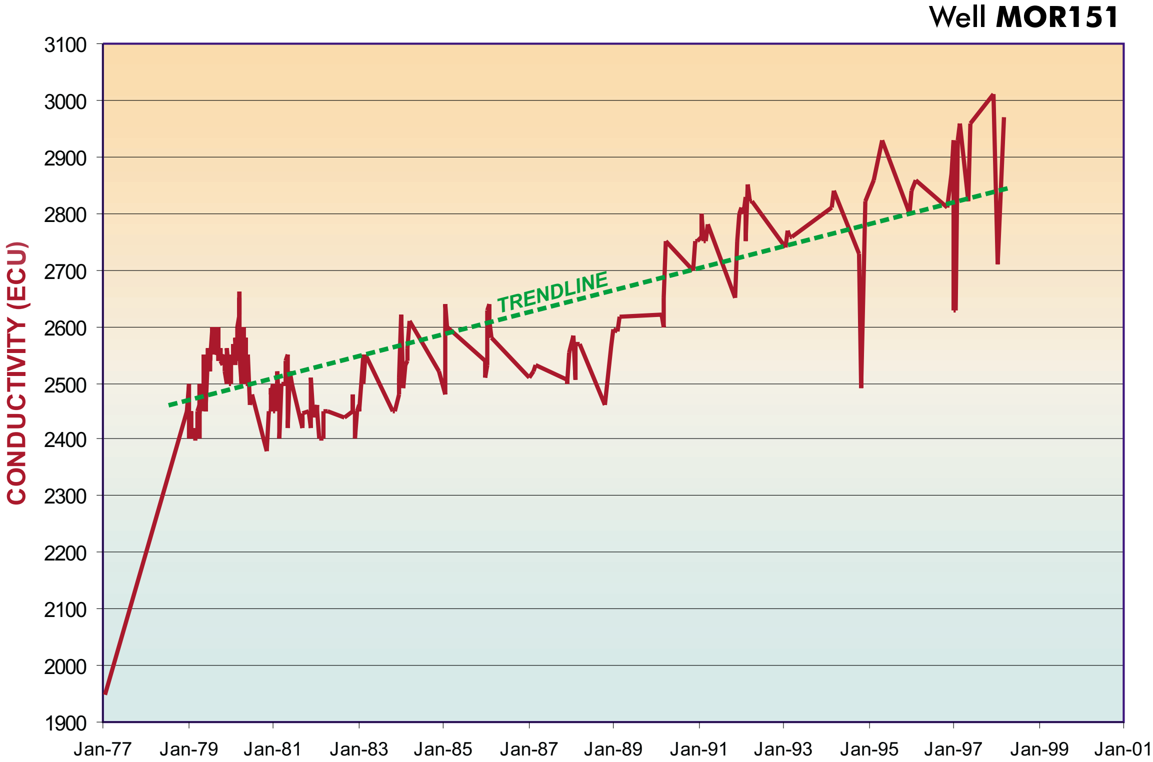
PRIMARY INDUSTRIES AND RESOURCES SA

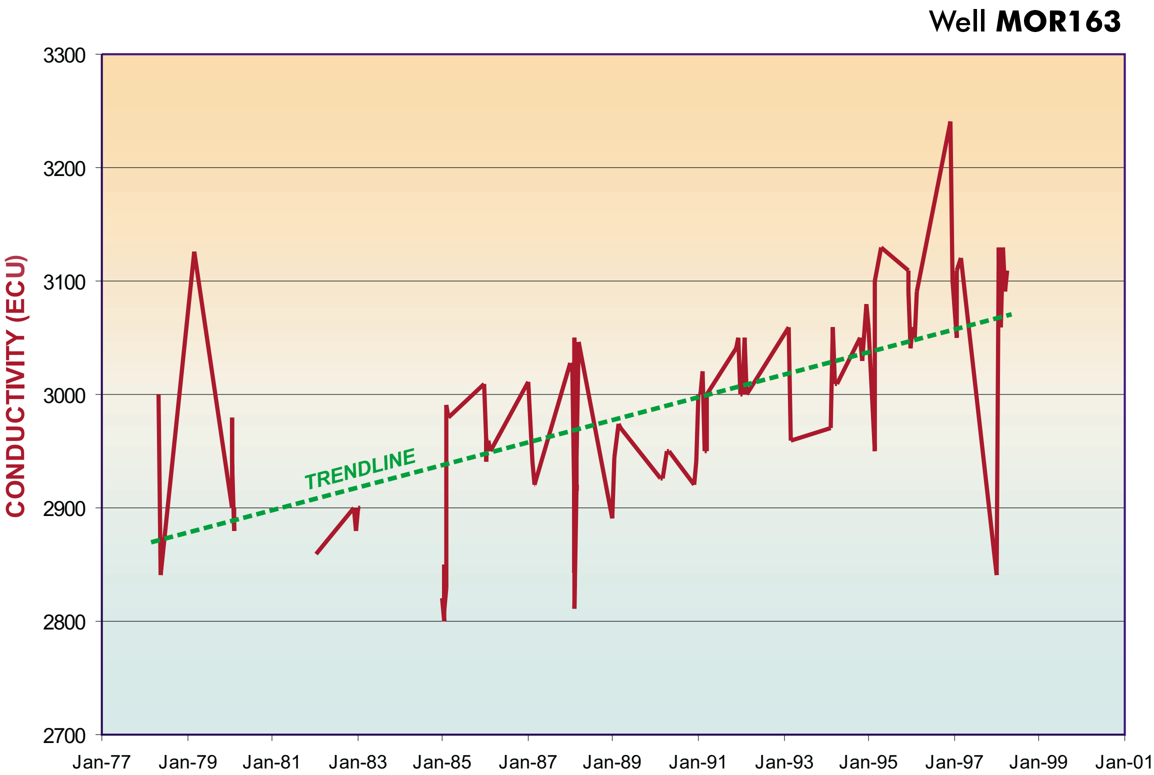
AV3:200090-012

Figure 12

FRACTURED ROCK AQUIFER

Conductivity grid interval **100** ECU units





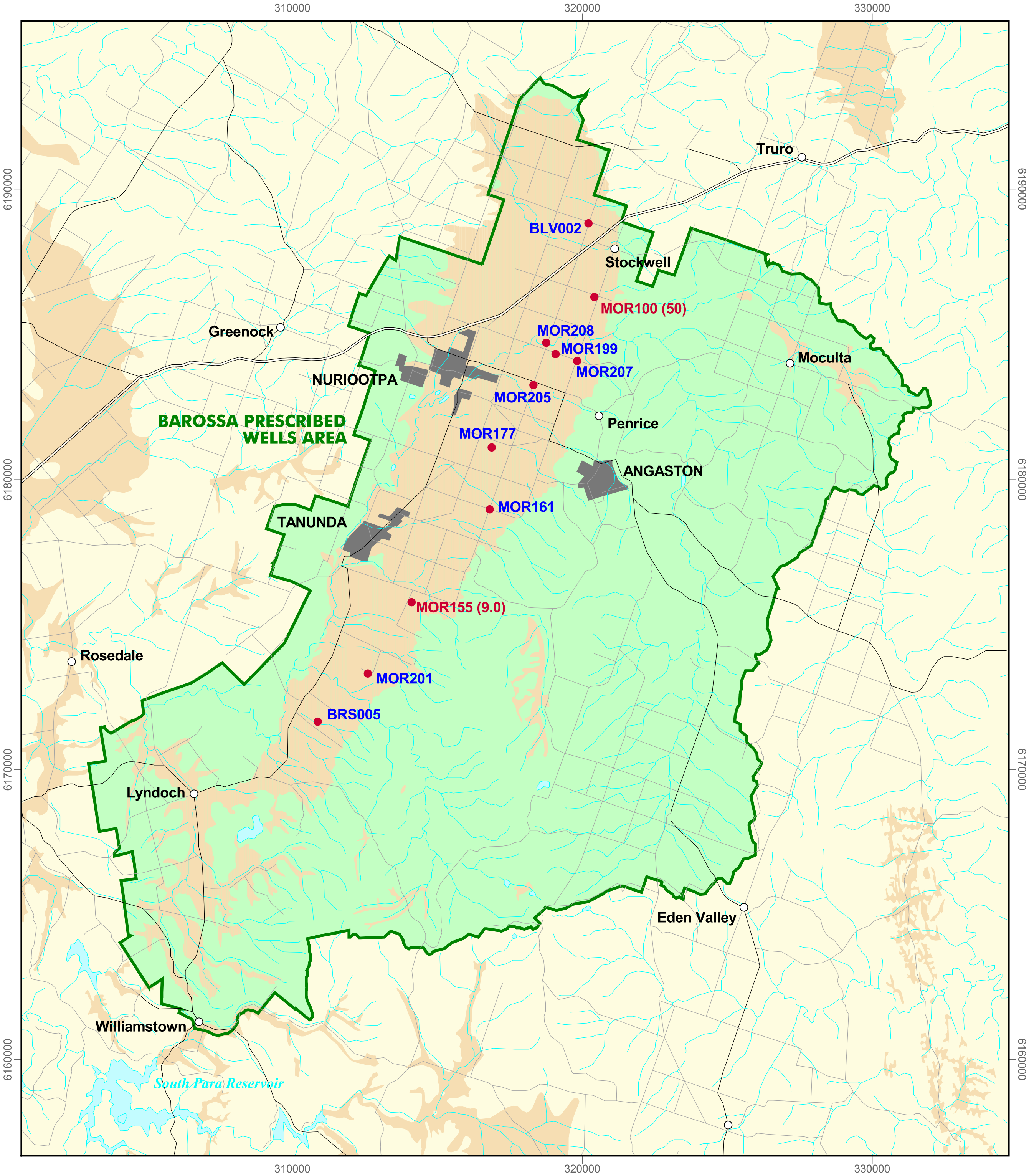
Barossa Valley Groundwater Review

Monitored wells MOR151 and MOR163

FRACTURED ROCK AQUIFER HYDROGRAPHS WITH RISING SALINITY

CD:200090_013.CDR

Figure 13



MOR201 (0) ● Average mg/L /year rise

MOR208 ● Stable salinity level

Quaternary sediments

Barossa Prescribed Water Area

0 2.5 5 Kilometers

COORDINATES IN METRES

Barossa Valley
Groundwater Review

SALINITY LEVEL TRENDS IN BASAL AQUIFER

PRIMARY INDUSTRIES AND RESOURCES SA

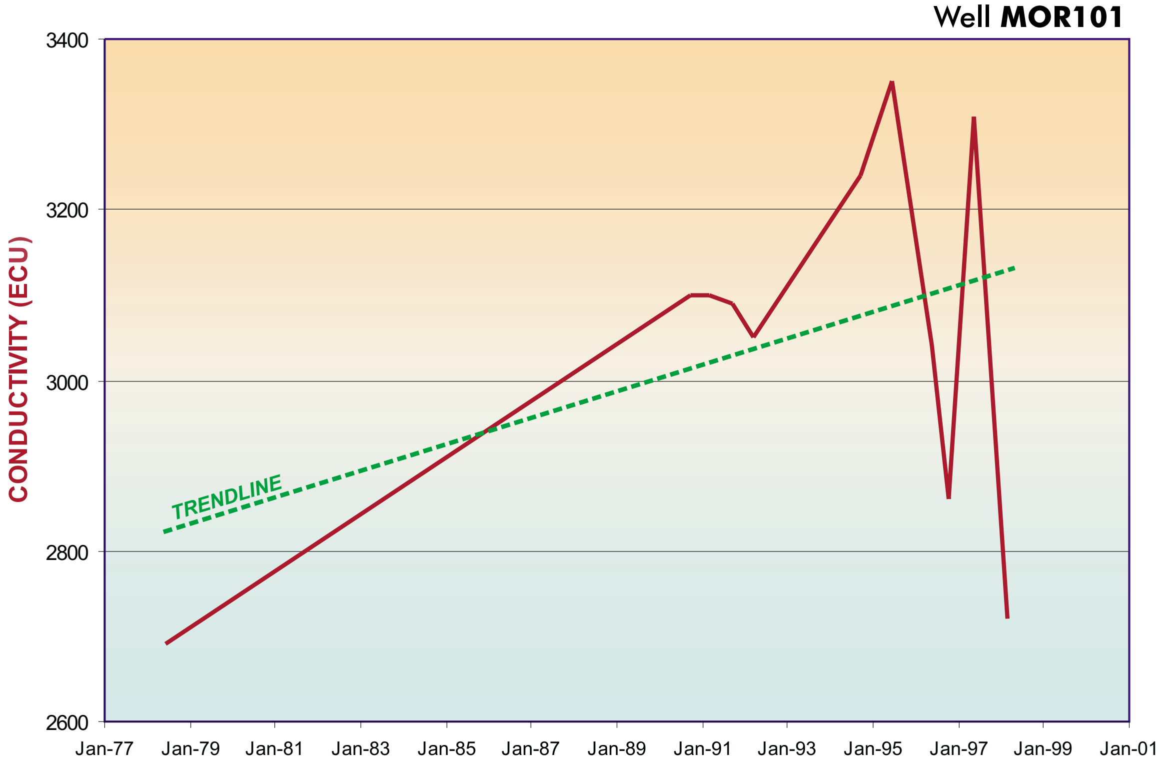
AV3:200090-014

Figure 14

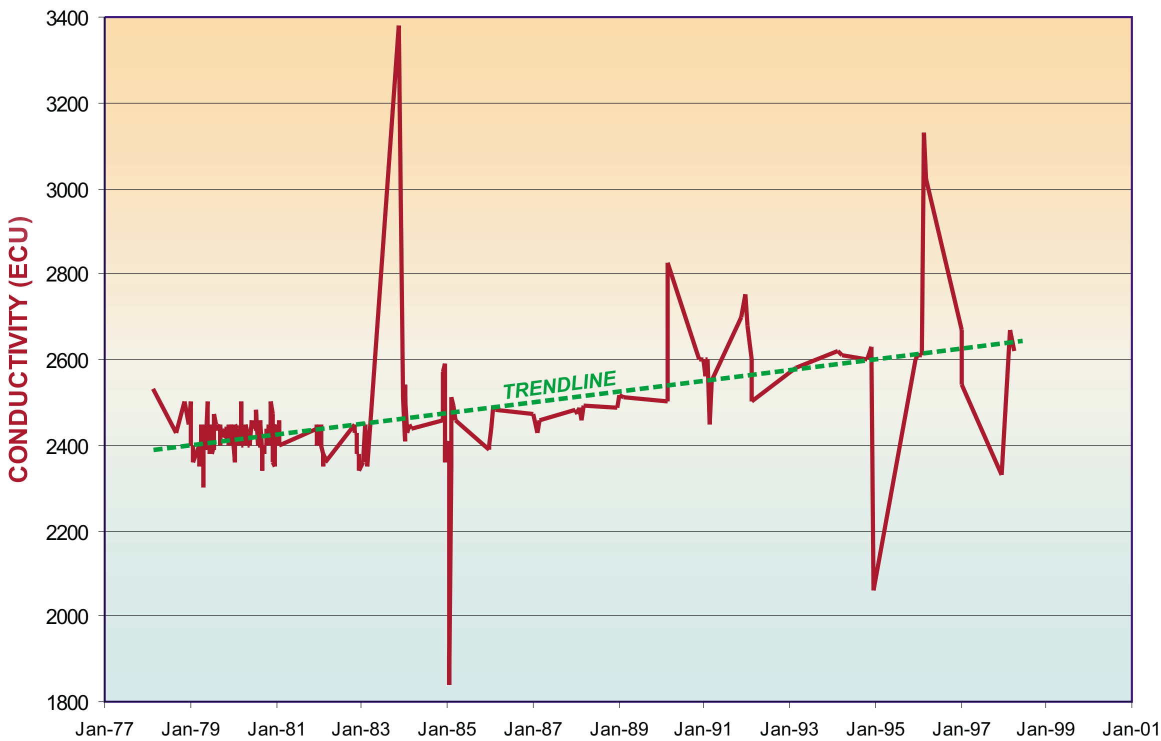
BASAL AQUIFER

Conductivity grid interval **200** ECU units

Well **MOR101**



Well **MOR155**



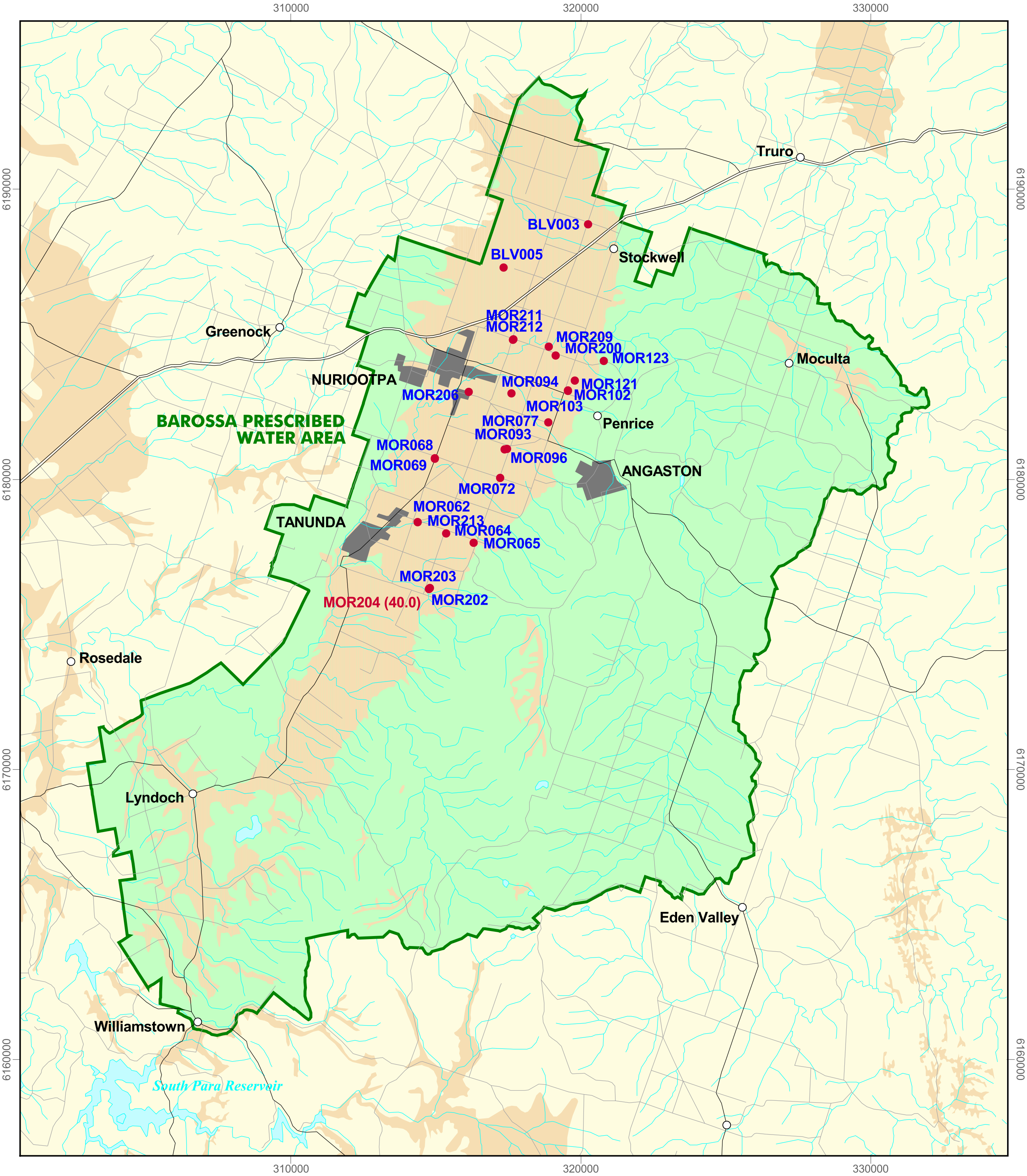
Barossa Valley Groundwater Review

Monitored wells MOR101 and MOR155

BASAL AQUIFER HYDROGRAPHS WITH RISING SALINITY

CD:200090_015.CDR

Figure 15



MOR062 (0) Average mg/L /year rise

MOR072 Stable salinity level

Quaternary sediments

Barossa Prescribed Water Area

0 2.5 5 Kilometers

COORDINATES IN METRES

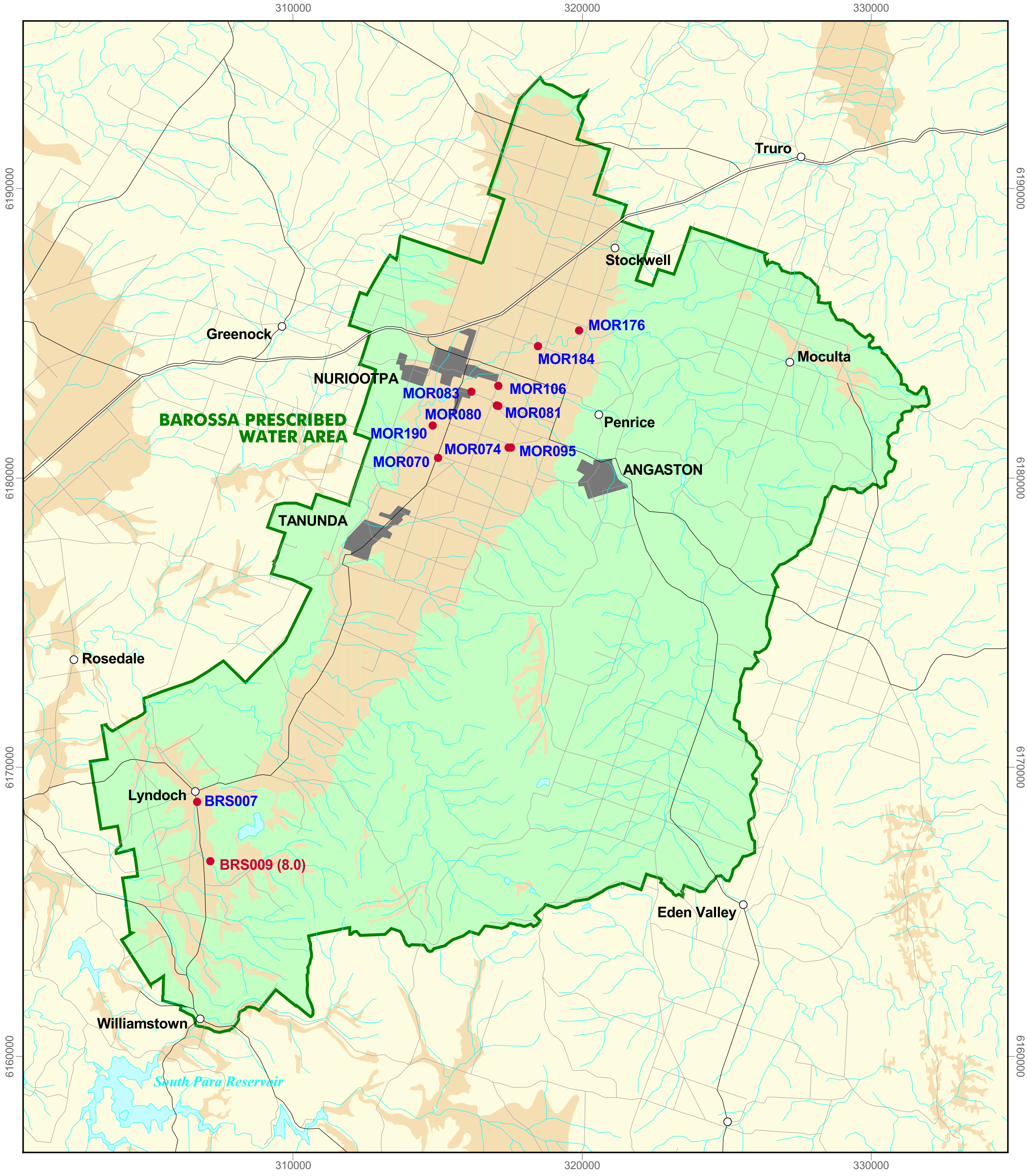
Barossa Valley
Groundwater Review

SALINITY LEVEL TRENDS IN MIDDLE AQUIFER

PRIMARY INDUSTRIES AND RESOURCES SA

AV3:200090-016

Figure 16



BRS009 (8.0) ● Average mg/L /year rise

BRS007 ● Stable salinity level

Quaternary sediments

Barossa Prescribed Water Area

0 2.5 5 Kilometers

COORDINATES IN METRES

Barossa Valley
Groundwater Review

SALINITY LEVEL TRENDS IN UPPER GRAVEL AQUIFER

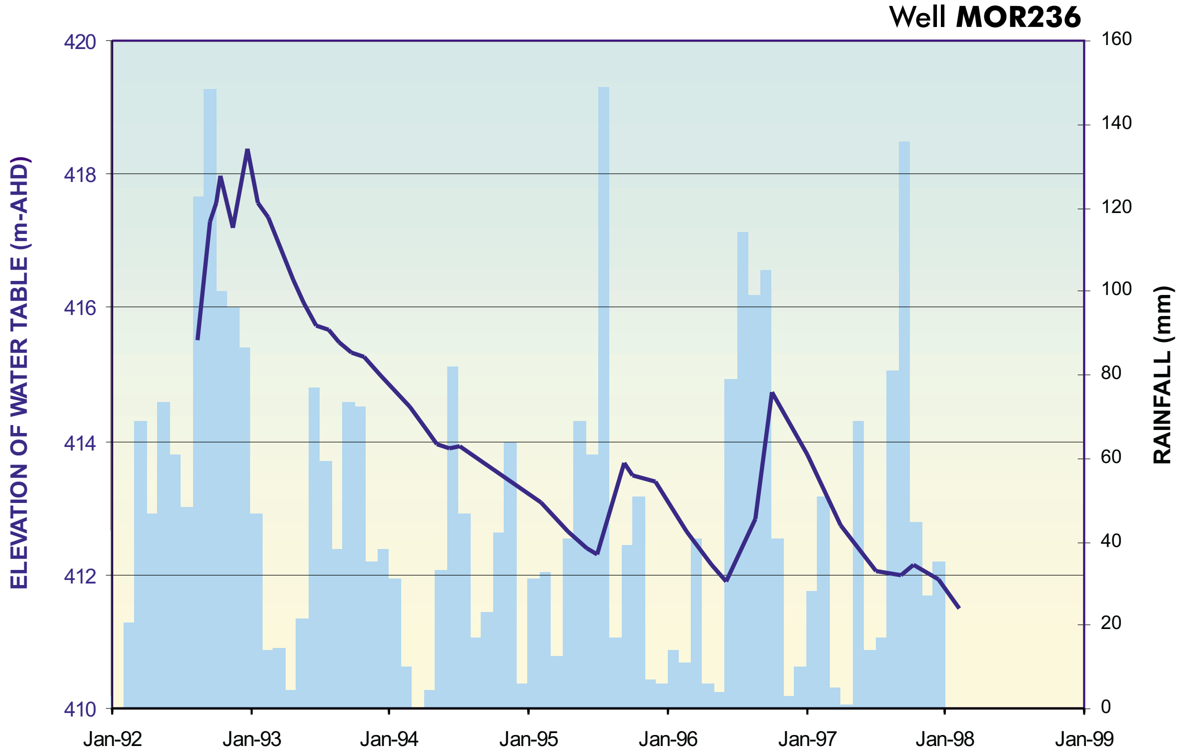
PRIMARY INDUSTRIES AND RESOURCES SA

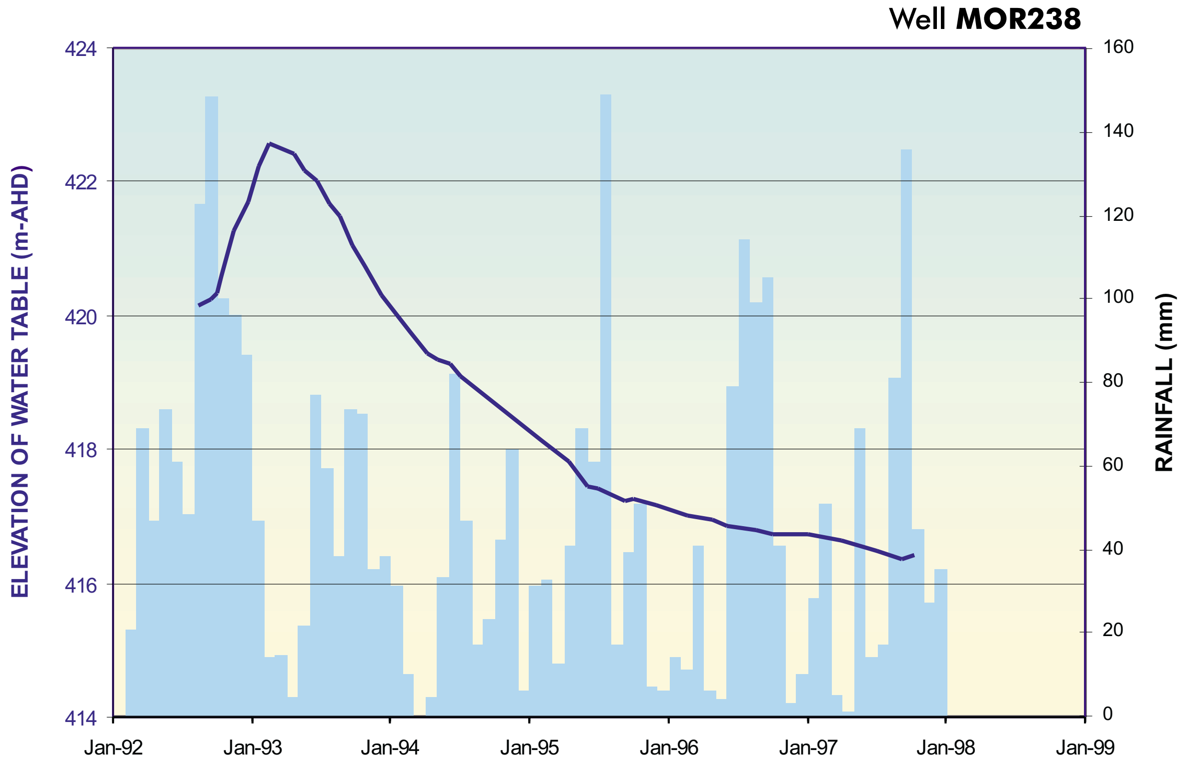
AV3:200090-017

Figure 17

KEYNETON NETWORK

Elevation grid interval **2** metres





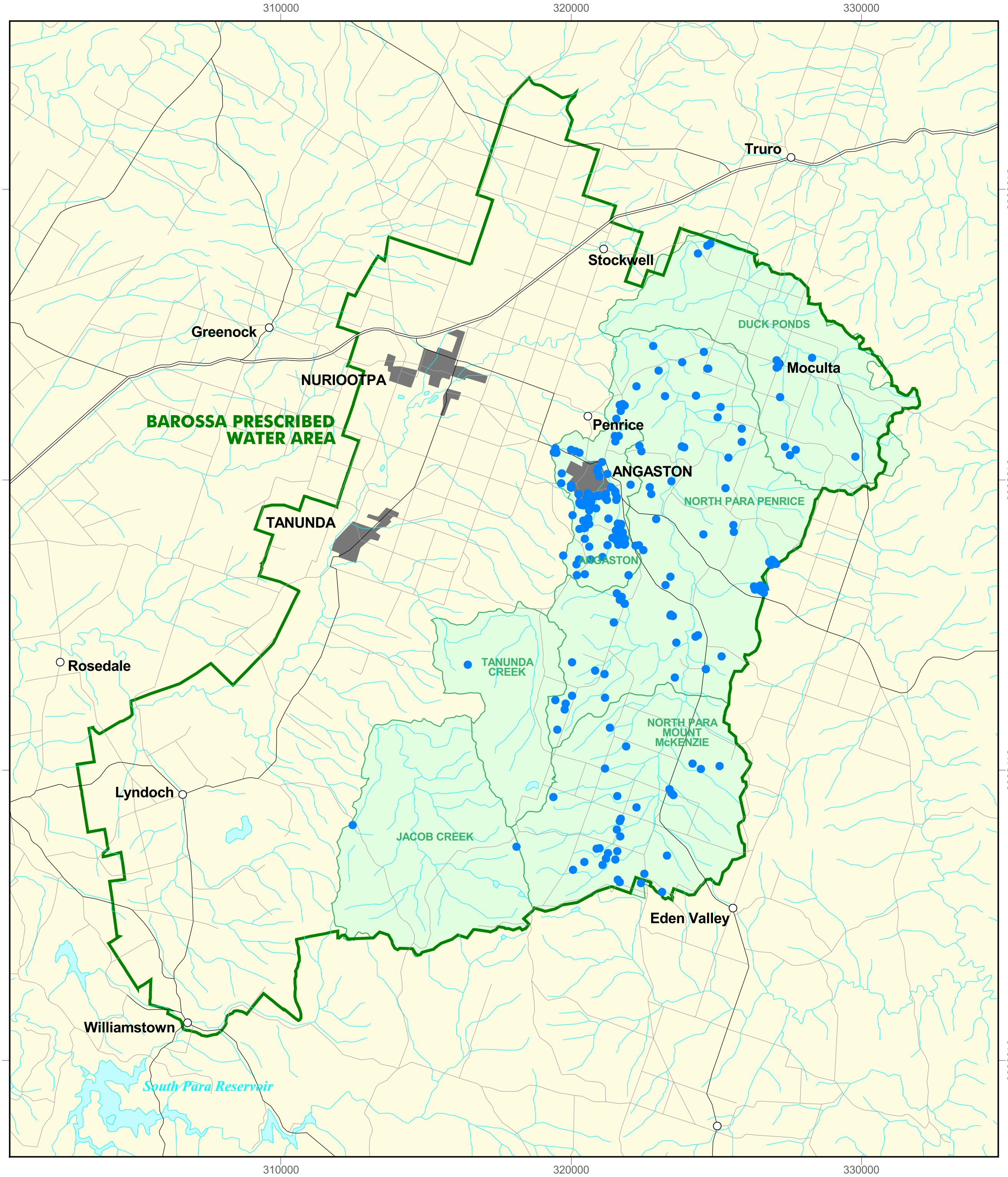
Barossa Valley Groundwater Review

Monitored wells MOR236 and MOR 238

EXAMPLES OF DECLINING WATER LEVELS IN THE KEYNETON NETWORK

CD:200090_018.CDR

Figure 18



Licensed irrigation well

Subcatchment area

Barossa Prescribed Water Area

0 2.5 5 Kilometers

COORDINATES IN METRES

Barossa Valley Groundwater Review

LICENSED IRRIGATION WELLS

PRIMARY INDUSTRIES AND RESOURCES SA

AV3:200090-017

Figure 19