Eco Management Services Pty Ltd

Barossa Infrastructure Limited

Barossa Pipeline Project

Report on

Environmental Effects of Increasing the volume of Imported Water to 10 Gigalitres

Eco Management Services Pty Ltd

Barossa Infrastructure Limited

Barossa Pipeline Project

Report on

Environmental Effects of Increasing the volume of Imported Water to 10 Gigalitres

.

Prepared by:

Eco Management Services Pty Ltd

June 2015

4 Corella Street, Nuriootpa, SA 5355

TEL: 0408 816 431 EMAIL: pmanning@ecomanagementservices.com.au

CONTENTS

SUMMARY

Barossa Infrastructure Limited (BIL) imports Warren Reservoir-River Murray water into the Barossa Valley for supplementary viticulture irrigation. Currently, approximately 8,000 ML is being used. This also includes approximately 300 ML of reclaimed water from the Nurioopta Waste Water Treatment Plant, in the Gomersal area. Eventually, BIL intends to increase the volume transferred to approximately 10.000 ML and requires an examination of the potential environmental effects of the transfer volume increase and the use of the reclaimed water. This report examines the potential environmental effects of the proposed increase in volume and is an addendum to the earlier EMS (2000) report. In summary, it is concluded that:

- The BIL water contributes to the sustainability of the Barossa as a wine producing area of high quality, by providing:
  - Additional good quality water (low salinity) to meet the demand of the Barossa wine industry, in particular:
    - Enable existing supplies of high salinity irrigation water to be replaced or mixed with low salinity water, which is important for quality.
    - Supplementing additional limited supplies, enabling new plantings, including in areas where groundwater is too saline for use.
    - Providing a reliable water supply to sustain production in times of climate variability (drought) and change.
- From a horticultural perspective the continued use of BIL water is also sustainable. It will be applied at a low rate of approximately 100 mm per year, which is about 20-25% of the requirement for vines. Even with this low rate, ongoing management of irrigation is required to ensure there are no issues with soil salinity, waterlogging or excess water moving below the root zone. There are a number of important drivers which will ensure its efficient use, and are:
  - The need to provide a quality product, including for overseas markets, and:

        - A strong negative correlation between salinity and quality, therefore involving careful salinity management.
        - A strong negative correlation between yield and quality, therefore requiring management of application rates.
    - The high cost of BIL water.

  In addition:

    - BIL customers are required to prepare irrigation management plans, which takes into account location, soils, use of cover crops, mulch etc. BIL is currently upgrading its technology to enable real time monitoring with web based flowmeters, weather information and soil moisture readings.

- For the existing BIL water use and proposed increase to 10,000 ML, it is very unlikely that there will be any change in the regional water table, apart from naturally occurring seasonal variation. This is supported by data from the 14 monitoring wells established in 2001 to monitor the water table and salinity. Variations observed, due to rainfall patterns, are the same as those occurring regionally, irrespective of soil types.
- Monitoring indicates that no perched water tables have developed. With the proposed increase the risk continues to be very low, because of the low application rate of the BIL water of 100 mm/year, irrigation in summer usually starting in December, and with efficient management resulting in very little water moving past the root zone.

Assuming a conservative 50% replacement of saline irrigation water (average 1,500 mg/L TDS) in the Barossa Valley Floor and Lyndoch Valley, but all new water in the Greenock Creek and Gomersal Creek Catchments, there is a net average annual reduction in load to the surface of approximately 522 tonnes per year. There is however a salt load redistribution with a large decrease in the average annual load on the Barossa Valley Floor and Lyndoch Valley of 2,034 tonnes per year, but an increase in the Greenock Catchment of 1,512 tonnes per year. For the purpose of this assessment this assumes 5,400 ML used in the Greenock Creek Catchment, 2,200 ML in the Barossa Valley Floor and 1,400 ML in the Lyndoch Valley. The large reduction in the Barossa Valley Floor and Lyndoch Valley is particularly significant as these areas have the most soils with high risks of salinization and water logging.There should be no adverse effects on any remnant terrestrial vegetation.

The reduction in salt load will benefit aquatic ecosystems in the North Para River and tributaries where salinity has increased in the study area, particularly improving water quality in refugia pools. There may be a small increase in the longer-term in watercourses in the Greenock Creek Catchment, but which are already saline. Below the confluence of Greenock Creek there is the net average decrease of 520 tonnes per year.

In addition to the DEWNR monitoring network for ground and surface water, monitoring should continue, with periodic data review and reporting at:

- The 14 wells established for BIL monitoring.
- New gauging station on Greenock Creek (salinity).

At this stage no additional sites are considered necessary.

1.0 INTRODUCTION

Barossa Infrastructure Limited (BIL) imports Warren Reservoir-River Murray water into the Barossa Valley for supplementary viticulture irrigation. It will also drought proof viticulture enabling sustainable production from year to year which is essential to maintain market share.

An Environmental Assessment of the project was undertaken by Eco Management Services Pty Ltd in 2000 (EMS, 2000). For the assessment it was predicted that the transfer amount would be 7,000 ML per year by 2006/07. The study area is shown on Figure 1.

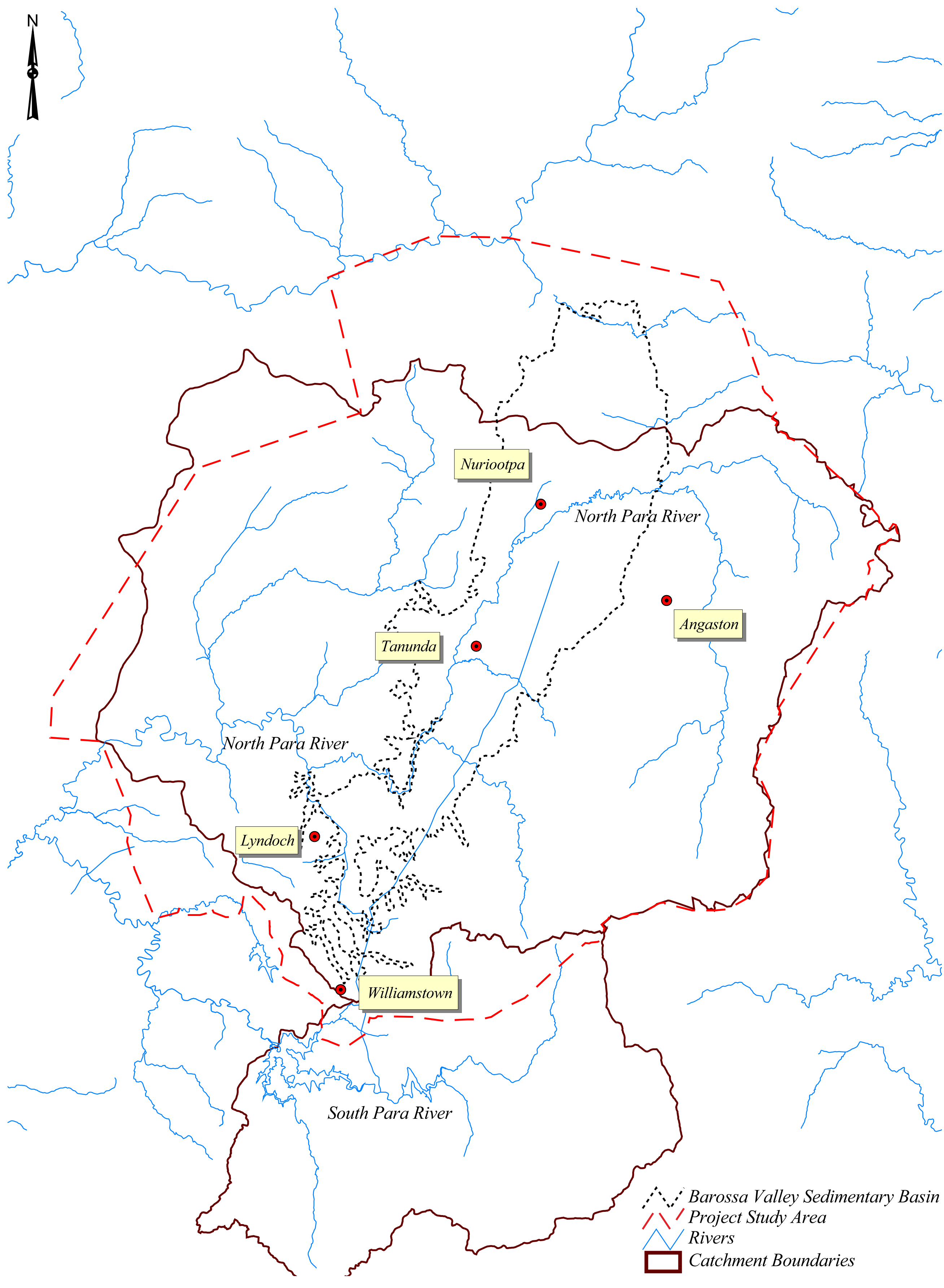
Currently, approximately 8,000 ML is being used. This also includes approximately 300 ML of reclaimed water from the Nurioopta Waste Water Treatment Plant, in the Gomersal area. Eventually, BIL intends to transfer approximately 10,000 ML and requires an examination of the potential environmental effects of the transfer volume increase and the use of the reclaimed water. This report examines the potential environmental effects of the proposed increase in volume and is an addendum to the earlier EMS (2000) report.

2.0 PROJECT OBJECTIVES

The Barossa Pipeline Project began because of the relatively high salinity of much of the groundwater for irrigation and the need to drought proof the viticulture industry. Many growers have had to use this groundwater, which is problematic because of a negative correlation between yield and quality with increasing salinity. Supplies of good quality water have become limited, including from groundwater and surface water. The imported BIL water now provides a reliable source of good quality water in sufficient quantity. It also enables the further development of the industry where the salinity is too high for use and where surface supplies are unreliable.

3.0 KEY ISSUES

The key environmental issues examined are:



ECO Management Services

Drawing prepared by ID&A Pty Ltd for Barossa Infrastructure Limited. ID&A Drawing No. 5500512 - D036

Figure 1
Project Study Area

- The potential for the use of BIL water to result in a rise in regional water tables.

- Changes in the salt load entering surface drainage as base flow.

- The potential for any adverse effects on ecosystems (remnant terrestrial vegetation and water dependent ecosystems) because of the creation of perched water tables, and any changes in salinity.

- Irrigation sustainability and the potential for soil degradation due to the impact of irrigation water with high salinity water.

4.0 SUSTAINABLE IRRIGATION

The use of BIL water will be sustainable in the long term, in maintaining the production of quality grapes and wines, without a deteriorating soil condition. How this is assured is outlined below.

4.1 Soils, Soil Salinity, Waterlogging and Perched Water Tables

A detailed examination of soils was undertaken in the previous EMS (2000) assessment, to identify areas with the potential for water logging, soil salinization or the creation of perched water tables close to the soil surface, which could impact on yield and quality. The assessment used very detailed CSIRO Barossa soil surveys completed in the 1950's and PIRSA soil association maps to extend the soil mapping at the margins, particularly on the western side of the study area. This data was grouped and simplified to ten major soil types appropriate for the purpose of developing management profiles in relation to the use of imported water. This simplified soil map is shown on Figure 2. Each was given a rating related to the level of irrigation management required to prevent water moving below the root zone, i.e. their potential for the development of perched water tables and/or salinity problems as

a result of the application of excess water. In the development of an overall salinity management plan for the North and South Para Rivers by Rural Solutions (Evans et al 2003), soil attribute maps including Salinity induced by Watertable, Susceptibility to Waterlogging and Salinity Risk Areas were produced and the soil map in Figure 2 and the management ratings are generally consistent with the attribute maps. Soil salinization through rising water tables is a risk in some areas, notably the Barossa Valley Floor from Nuriootpa to Lyndoch. Secondary salinity from the mining of deeper more saline waters with salt being brought to the surface adds to the risk, but the replacement of the more saline groundwater with alternative low salinity water for irrigation will reduce risks, if properly managed (Evans et al, 2003).

The rating of the soil units in Figure 2 according to the level of management required to prevent water moving below the root zone, is as follows:

Soil Unit		**Management Level**
1.	Sandy and loamy red-brown earth	2
2.	Skeletal soils	1
3.	Clayey red-brown earth	1
4.	Terra rossa soils	1
5.	Dark brown cracking clays	1
6.	Sand-over-clay soils	9
7.	Sand-over-clay and transitional red-brown earths	8
8.	Yellow podsolic soils	5
9.	Red podsolic soils	4
10.	Alluvial soils	10

Rating 1 = low level of management needed

Rating 10 = high level of management needed

It was determined that there are three soil associations which have the potential for the creation of perched water tables, which are:

The sand-over-clay group (Unit 6)

Management Rating 9

Very poor drainage and the fact that these soils frequently occur on flat ground together with a shallow topsoil, make these soils the most difficult of all to irrigate efficiently. Perched water tables and salt problems already exist in the Kalimna, Ebenezer, Vine Vale, Rowland Flat and Lyndoch area on both sides of the River under this soil unit.

Sand-over-clay and transitional red-brown earth group (Unit 7)

Management Rating 8

Many of these soils occur on the western rim of the Valley and in mid to high slope positions and may themselves escape the potential problems of poor drainage and/or overwatering. However, on lower slopes, flat land or landlocked situations there is a significant potential for perched water tables to develop. Some of this area falls into the 'potential new areas for development' category and hence the need for adequate management of irrigation systems.

Alluvial soils (Unit 10)

Management Rating 10

Due to their proximity to the drainage system and topographic position in the land system a high level of management is needed. The lateral movement of excess water from irrigated sites above often contributes to perched water tables in these locations in addition to overuse of water on the site. There are already perched water tables established under many of these soils in the Nuriootpa, Rowland Flat and Lyndoch districts and some of the shallow groundwaters have a salinity level of 3500-4000 mg/L of total soluble salts. Where a perched water table rises to within two metres of the surface the agricultural potential of these otherwise very fertile soils will be considerably reduced.

The salinity of groundwater is shown on Figure 3 and the general depth to watertable in Figure 4. The three soil associations (Units 6, 7 and 10) that are considered to require careful irrigation management are also shown on Figure 5, along with the zones where the regional water table occurs at a depth less than 5 metres below ground.

4.2 Irrigation Management

There are a number of factors in the use and management of the BIL water which ensure its effective use, and that it is not used excessively, which results in a low risk of potential adverse environmental effects. These are summarised as follows:

There is a strong negative correlation between yield and quality, especially with red grapes and premium prices are only paid for quality standards attained. Excessive water use would impact on quality and BIL water is only applied at the rate of 100 mm, which is a relatively small part of the annual viticulture requirement of 400-450 mm, In addition excess water may cause waterlogging, which would also result in adverse effects on crop yield and quality.

There is a strong negative correlation between salinity and quality, therefore requiring careful irrigation management.

Irrigation is in the summer, usually starting in December. Because of the low average application rate of 100 mm, it is very unlikely that irrigation water will move significantly below the root zone. This is ensured by the preparation and application of Irrigation Management Plans (see below). This minimises any potential for any runoff to watercourses.

The relatively high cost of BIL water would encourage efficient use.

All BIL applicants are required to prepare an Irrigation Management Plan (IMP). All new and larger plantings have IMPs. It is important to note that BIL has the power to disconnect customers who are causing environmental problems. The plans should ensure, or identify:

- Water application in a controlled way, i.e. a water meter is the simplest and most basic measurement device.
- That soil types have been taken into account, as indicated above, particularly in those higher risk soil types.
- An appropriate method of application – drippers, under vine sprinklers.
- The correct rate of water used on a per Ha basis.
- Alternate crops and under vine mulching.
- Source of the water, including bores, dams, mains.
- Water quality (TDS mg/L) and whether or not the supplies are mixed in order to achieve a quality standard (<1,500 mg/L).
- Whether or not BIL water will replace existing supplies that are salty or used to facilitate "new" plantings.
- Method of storage of water – well recharge, dams, lined or not.
- Growers are required to employ some form of moisture monitoring device to assist them determine when to start watering and thereafter, when to most effectively use their limited supplies to maximum economic advantage. In this regard BIL are upgrading their technology to enable site monitoring with web based flowmeters, weather information and soil moisture readings.
- When and how water applied – growth stage, frequency, amount, on advice from wine industry viticulturist.
- The location of the vineyard – Section, Hundred.

As discussed in EMS (2000), the process should also provide for feedback on specific management requirements for the locality of which the landowner may not necessarily have been aware, e.g. potential for perched water table/salinity problems to develop. Individual water users are required to monitor their own irrigation systems whether they happen to be in an area of high level of management or not. One or two growers with less efficient watering will not affect the regional hydrological system but they may cause problems for their closest neighbours in more sensitive areas. Hence all clients of the BIL scheme are made fully aware of their responsibilities from the outset and these responsibilities have been documented in their agreements as conditions for use of the water.

It is a condition of BIL's contract with its customers that they may not take, store or use water supplied by BIL unless the customer has all necessary licences, permits or approvals, and the use of the water is lawful and in accordance with the customer's approved irrigation management plan. To that extent, BIL will co-operate with the relevant authorities to ensure that the customer's obligations are complied with or, failing reasonable attempts to do so, BIL may suspend the delivery of water to the customer.

5.0 POTENTIAL ENVIRONMENTAL EFFECTS

5.1 Irrigation and the Regional Water Tables

With regards the proposed 10,000 ML, and the points made in the detailed EMS (2000) assessment:

Some of this will:

- replace existing groundwater use,
- be mixed with current groundwater use to improve the salinity of the applied water,
- substitute for lack of runoff into dams, and
- be for new irrigation ventures.

Winter rainfall may penetrate from 2.5 to 3.5 metres in average to above average seasons. It varies between drought and wet periods, e.g. at the Nuriootpa Viticulture Research Station the average depth of winter penetration over a nine year period was 2.9 metres, varying from 0 metres in a drought to nearly 6 metres in one of the wettest years on record. Summer rainfall can be discounted completely as it is lost by evapotranspiration.

Although most irrigation will occur in summer, poor management in the form of overwatering may still allow some seepage past the root zone. Depending on the soil type and the soil moisture level existing at the end of winter, this could lead to increased accession to the water table. It could also cause waterlogging in some areas,

which would impact on the plants (Evans et al, 2003). Depths to the water table in the study area are given in Figure 4. This shows areas where the regional water table lies at a depth of less than 5 metres below ground level which is considered the upper limit to which effects could be felt under normal circumstances. It was estimated that with 80% irrigation efficiency only 20 mm of irrigation water could migrate past the root zone. Assuming a porosity of 30%, if this water reached the water table, it would result in a rise of approximately 60 mm, in the area of irrigation. Importantly, after cessation of irrigation such a rise under the irrigation block would dissipate by lateral flow.

If irrigation over the summer months is efficient, i.e. no water escapes past the root zone, the evapotranspiration component of the water budget will increase to compensate for the imported water. Under these conditions there will be no net increase in vertical seepage to the regional water table.

With the increase from approximately 8,000 ML currently used, to 10,000 ML as proposed, application rates will remain the same, up to 100 mm. Although uncertain as to the exact extent, on the Barossa Valley Floor and Lyndoch areas, much of the imported water will replace groundwater.

.

Overall, there is very unlikely to be any change in regional water tables, apart from naturally occurring seasonal variation. This is supported by water level observations since 2001 in 14 new observation wells, constructed in the areas with soil types considered the most sensitive to irrigation (Watersearch, 2014, refer Appendix 1). The results from the new wells, combined with those of additional longer term monitoring, shows the annual fluctuations in the water table brought about by variations in rainfall recharge rates and evapotranspiration. It also shows longer term upward and downward trends in the average water table elevation. The trends seen in the 14 monitoring wells are the same as those seen regionally, irrespective of the soil type.

In terms of the water budget for the whole valley floor sedimentary sequence, it was also noted that the reduction in groundwater extraction will cause some modifications viz:

- the average elevation of the deeper aquifers pressure surface will increase whilst the magnitude of the annual fluctuations will decrease;
- downward seepage from the water table, upward seepage from the underlying hard rocks and lateral seepage from the eastern hard rocks will decrease in magnitude; and
- lateral seepage to the hard rocks in the west will increase and possibly some small increase in the base flow to the North Para River.

5.2 Irrigation and Salt Load Reduction

Based on monitoring data for 2014, the average salinity of imported water is approximately 280 mg/L, refer Appendix 2. The typical groundwater used for irrigation is 1,500 mg/L, as much of the Barossa area is underlain by saline groundwater, refer Figure 3. For every megalitre of imported water substituting for groundwater with an average salinity of 1,500 mg/L, a net reduction of 1.19 tonnes of salt per year reaching the land surface is achieved.

In the previous EMS (2000) assessment for the initial 5,000 ML imported, approximately 1800 ML was for the Barossa Valley Floor, 530 ML for the Lyndoch Valley and the balance to the Greenoch Creek Region (actually 3,100 ML applied for). For this update of the previous assessment, it is assumed that for the 10,000 ML the volumes for each of the three areas will double. Because of the uncertainty as to the full extent of replacement water, the exact degree of salt reduction is also uncertain. Therefore, it is also conservatively assumed that for the Barossa Valley Floor and Lyndoch Valley only 50% replaces groundwater, and all of the water used in the Greenock Creek area is for new irrigation and additional water with no replacement. Comments on salt accession on the land surface the Valley floor, the Lyndoch Valley and the Greenock Creek region are summarised below.

(a) Barossa Valley Floor

If overall, approximately 3,600 are used, with 50% replacement, this would result in an overall reduction in salt load at the surface of approximately 1,320 tonnes per annum. Because of the product quality issues, referred to in the

Introduction, it is more likely that there will be a higher percentage replacement of the saline groundwater than less.

Lyndoch Valley

Similarly, if approximately 1,400 ML is used, with a 50% replacement, there will be a 714 tonnes/annum reduction.

Greenock Creek Region

In this area groundwater is too saline for irrigation and is everywhere greater than 2,000 mg/L TDS and commonly greater than 3,000 mg/L TDS, refer Figure 3. Consequently, all imported water will be used for new vineyards or to ‘drought proof’ a property relying on surface runoff into dams for subsequent irrigation. If approximately 5,400 ML is used in this area, with a salinity of average 280 mg/L, there will be an increase in the salt load of around 1,512 tonnes per year.

The Gomersal area currently receives 1,864 ML, which includes 306.9 ML of reclaimed water from the Nuriooootpa WWTP. With an average TDS of about 750 mg/L (data from Seed Consulting Services, 2014), this would be an additional 230 tonnes per year.

The results of salinity sampling in the 14 monitoring wells are equivocal with some showing little variation between sampling while others vary significantly. Some wells have shown a slow upward trend since monitoring began. For the regional network, DEWNR (2013) comment that for the water table aquifer there is an overall increase in salinity levels in 2013 compared to 2012.

Overall, in terms of the North Para River catchment the main effect on the salt budget is the redistribution of the salt accessions to the land surface. With the conservative 50% replacement of groundwater use for the Barossa Valley floor and Lyndoch Valley, the area where the 12 of the 14 monitoring wells are located, then these two areas would show a reduction of salt accession for the historical range of groundwater

use of 2,034 tonnes per year. There will be a net increase in the Greenock Creek region of 1,512 tonnes per year. So overall there is likely to be a net reduction in salt accession to the surface soil. This is significant as it is the salt in irrigation water that eventually reaches the watertable and through lateral flow discharges to watercourses. It is to be noted, however, that rates of groundwater movement are slow, with 1 metre/annum being indicative. Consequently, the effects of salt load changes make take a long time to be observed and will also be dependent on local site factors, such as the distance of irrigation areas from watercourses. To assist in gaining some perspective on this, flow and seasonally adjusted data from continuous monitoring for the North Para River at Yaldara indicates a mean salt load 0f 5,640 tonnes per year (Evans et al, 2003)

5.3 Terrestrial and Aquatic Ecosystems

The previous EMS (2000) assessment concluded that with importation of up to 7,000 ML, as previously proposed there was little risk of perched water tables or salinity affecting remnant terrestrial native vegetation or salinity affecting native vegetation or aquatic fauna in the watercourses. The current proposed increase to 10,000, presents no increased risk as discussed below.

5.3.1 Remnant Terrestrial Vegetation

Remnant terrestrial native vegetation should not be affected as a consequence of:

- Perched water tables if they occur are also very unlikely within the top 0.3 to 0.5 metres of the soil. Irrigation will mainly occur in the summer when the soil moisture is already low and only sufficient used to make up for evaporation. Irrigation management which aims to provide sufficient for the vines to produce quality fruit, effectively ensures that water does not move below the root zone of the vines. Consequently, excess water from irrigation sufficient to create waterlogging is very unlikely. The watertable is at least 5 metres below most of the area of the three soil associations, described above, refer Figure 5. Also native vegetation is generally shallow rooted, with the majority of roots

generally found in the top 0.3-2 metres of soil, with most within the top 0.5 metres.

- As mentioned above, any effects would be below irrigation areas, and not native vegetation, dispersing by lateral flow when irrigation ceases. Also, as discussed in EMS (2000), remnant patches within the Sand - over - clay Association and Sand - over - clay with transitional red brown earth Association, are on hilltops or on raised sloping ground, where groundwater is unlikely to accumulate beneath, but dissipate by lateral flow. Riverine vegetation, including on the Alluvial soils, River red gum (Eucalyptus camaldulensis) and Blue gum (E. leucoxylon) are tolerant of seasonal waterlogging.

- As pointed out earlier, the remnant vegetation blocks are upslope or on hilltops. Salt in irrigation water on the surface reaches the watertable due to leaching with winter rains. On the Barossa Valley Floor and Lyndoch Valley, with the current proposal there will be a net reduction in salt accession of approximately 2,034 tonnes per annum, which would further reduce any potential risk.

- In the Greenock Creek Catchment, assuming the 5,400 ML the salt load of approximately 1,512 tonnes per annum is additional. However, because of the depth of the water table, low application rates in summer with lateral dispersion at the end of irrigation and irrigation only occurring in the vineyards, it is still very unlikely that any adjacent vegetation could be affected. In this area the majority of soils are Sand& loamy Red Brown Earth and Brown Earth (refer Figure 2), which do not form perched water tables. Where there are Sand-over-clay and transitional red-brown earth there are remnant vegetation (*Eucalyptus fasicularis* and *E.obliqua*), As mentioned above, these remnant blocks are also on hilltops or at least on raised sloping ground where ground water is unlikely to accumulate beneath but to travel away from the native vegetation. As a result salt will be removed laterally in a discharge to the watercourses. Also, the remnant native vegetation species

occurring are generally tolerant of salinity, especially the dominant tree species which have a moderate to high tolerance.

5.3.2 Riparian and Aquatic Flora and Fauna

With the importation of the 10,000 ML and a conservative 50% replacement of groundwater use there will be a net reduction in the man-made portion of the salt accession to the surface, of approximately 522 tonnes per annum within the Barossa region. There will be a redistribution of the salt accession, with an increase in the Greenock Creek Catchment (Greenock and Salt Creek), but a large reduction in the Barossa Valley Floor and Lyndoch Valley (Tanunda Creek, Jacobs Creek and Lyndoch Creek). There would be a net reduction in the salt load to the North Para River downstream.

All of the watercourses in the region have been modified since European settlement, including physical impacts on channels, loss of riparian habitat, feral fauna species, weed infestation and flow modification. Even so, many still retain natural attributes and still support diverse aquatic communities and can be rehabilitated. It is therefore important that there is no further deterioration and where possible existing impacts reduced.

In response to the normal seasonal pattern of rainfall, these watercourses are ephemeral, having a naturally pronounced seasonal pattern of flow, which also varies from year to year. In the drier periods, along the length of the North Para River (5^{th} order stream) flows are reduced with the river becoming a series of pools with small base flows. Below Nurioopta the North Para River is a discharge zone and low base flows are maintained by groundwater discharge. The pattern is similar in the larger tributaries, including Tanunda, Lyndoch and Jacobs Creeks (4^{th} order streams), but flows can be a trickle or no flows in the smaller 3^{rd}, 2^{nd} and 1^{st} order streams. These pools are important refugia for aquatic fauna and flora, and some would be a water source for birds, mammals and reptiles during dry periods, including droughts. Base flows help in maintain these pools and the hyporheic habitat. Flow modification has occurred largely as a result of farm dams, causing a delay in the onset of flows at the beginning of the wet season by 1-2 months, which affects habitat connectivity

between pools and causing a decline in water quality in the pools. (AMLRNRMB 2009)

These watercourses experience seasonal high salinities (in summer – low flow) as a result of natural saline groundwater discharge. As mentioned above, below Nuriootpa the North Para River is a discharge zone, with salinity increasing with distance downstream. In the North Para River at Yaldara, which drains approximately 71% of the 527 km^2 Barossa PWRA catchment, for the salinity monitoring record since 1994 64% <2,500 mg/L TDS, 21% <1.000 mg/L, 35% was between 2,500-4,000 mg/L and 1% >4,000 mg/L (DEWNR 2014). Further upstream at Penrice which drains approximately 22% of the Barossa PWRA there is a lower salinity, with 98% of the total record being <2,500 mg/L TDS, 20% being <1,000 mg/L and only 2% being >2,500 mg/L. The watercourses in the Greenock Creek Catchment have saline base flows, due to the saline groundwater, which is greater than 2,000 mg/L and in areas greater than 3000 mg/L. EPA (2013a) recorded salinities of 2,755- 4498 mg/L (at Roenfeldt Road). Salt Creek had a salinity reading of 6,700 in October 2001 (Evans et al, 2003). In comparison Tanunda Creek near Bethany was 584 mg/L (EPA 2011a). Concentrations would be higher in the lower reaches. Jacobs Creek, for example, was 859-2,627 mg/L near the confluence with the North Para (EPA 2013b), but lower upstream with 429-530 mg/L at the Kaiser GS (EPA 2013c).

Ecosystem Condition Reports are prepared by the EPA for watercourses, which take into account flow characteristics (natural or modified), riparian habitat condition including aquatic macrophytes, aquatic macroinvertebrate diversity including the presence of rare, sensitive and flow dependent species, and water quality. In all of the watercourses there are varying degrees of disturbance of the riparian habitat and bank and bed disturbance. While in many reaches of the watercourses there is still a canopy of the River red gum, the understorey is dominated by introduced weeds. In this assessment of the proposed increase in BIL water of greatest interest is water quality because of salinity and the aquatic fauna and flora.

Greenock Creek (at Roenfeldt Road) was assessed by EPA (2013a) as being in poor condition as a consequence of the limited extent of canopy species, poor condition of understorey vegetation being mostly weeds and damage to banks. The

macroinvertebrate diversity was also low (21 species in total, but with 16 in spring and 12 in Autunm). They are tolerant and widespread with no rare, sensitive or flow dependent species. The high salinity was also a factor. In contrast, although modified from their former natural condition, most locations in the North Para and other tributaries, including Tanunda, Jacobs and Lyndoch Creeks, are in better condition with a more diverse aquatic community as well as some rare, sensitive or flow dependent species, although along the length of the watercourses some locations were more degraded than others and are assessed as poor. In the North Para River, for example, at Rowland Flat there are 48 species of macroinvertebrates and it is classified as fair (EPA 2011b) and 4kms NW of Angaston it is classified as fair with 51 species (EPA 2011c). There were some rare, sensitive or flow dependent species among the more widespread ones. On the river at the Penrice gauging station it is classified as fair with a moderate diversity of 25 species but with low sensitive species, the Mayflies *Ataalophlebis australis* and *Thraulophlebia inconspicua* (EPA 2011d). It also had a rich macrophyte community. Further upstream in the Flaxman Valley, 4.5 km NW of Eden Valley the river is assessed as poor with 25 species (EPA 2011e) and at Mt Mackenzie it is also poor with 27 species (EPA 2013d). They are all tolerant and widespread and there are no rare, sensitive or flow dependent species. Also the general habitat is more degraded than downstream.

As indicated above, the threats to the aquatic ecosystem include the increased periods of no flow between the refugia pools and a deterioration of water quality (Vanlaahoven and van der Wielen 1999, quoted in AMLRNRMB 2009). Below Nuriootpa base flows to the pools during dry periods is from groundwater discharge which are saline. The mining of deeper saline groundwater for irrigation has increased the salt load to the water table and into the baseflows. With increased periods of no flow, as a result of evaporation, salinity in the pools would increase. This would be exacerbated by increased salt loads. With climate change effects in South Australia are expected to include: more hot and very hot days, increased evaporation, reductions in average annual rainfall, and an increase in the frequency and severity of droughts (Harding et al 2015). This will certainly place further stress on the aquatic ecosystem if no remedial action is taken. The use of additional BIL water has a beneficial effect on the watercourses and aquatic ecosystems in the overall reduction in one potential stressor, which is the reduction in the anthropogenic salt accession to the surface, of

approximately 522 tonnes per annum. Importantly the reductions will occur in the Barossa Valley Floor and Lyndoch Valley where there remains a reasonably diverse aquatic community. There will be an increase in the salt load to watercourses in the Greenock Creek Catchment. However, below the confluence of this catchment and the North Para River, there is still a net reduction in the annual average salt load, helping to maintain the quality of the important refugia pools.

6.0 USE OF RECLAIMED WATER

In the Gomersal area, reclaimed water from the Nuriootpa WWTP has been used for irrigation since 2010 and was approved by SA Health in 2009. However, it is only a small proportion of irrigation water and is used to boost the volumes of available irrigation water. It is not used in addition to the BIL water and the low application rate of 100 mm remains the same. Imported water for irrigation is still predominantly BIL water. Similarly for imported water generally, for reclaimed water sustainable use, it should not:

- Cause a rise in the underground water table elevation sufficient to detrimentally affect ecosystems
- Adversely affect the natural flow of water or the quality of surface water, underground water or water in a watercourse or lake
- Adversely affect the productive capacity of the land by causing salinity, sodicity, waterlogging, perched water tables or other such impacts.
- Adversely affect water dependent ecosystems.

As described in previous sections, because of the low average application rate it is very unlikely with efficient irrigation management that irrigation water will move much at all below the root zone. As already described, irrigation will not result in any damage to adjacent ecosystems, terrestrial or aquatic. A condition of approval is that the reclaimed water is applied by drip irrigation. As it is applied in the summer there is virtually no risk of runoff. This would also prevent any export of nutrients to any watercourse. Another condition of approval is that the scheme is periodically audited, including the analysis of soils where the reclaimed water is used, to ensure that there is no soil degradation. Results of an audit have been separately reported (Seed Consulting Services, 2014) and to date indicate no impact.

7.0 MONITORING AND REPORTING

Strategic regional monitoring is being undertaken to provide:

- An early warning of any adverse effects.
- An opportunity for corrective action to be taken.

This is outlined below in relation to groundwater (water table) and surface waters.

At this stage, as discussed below, it is not considered necessary to change the current surface water salinity monitoring.

Water Table Monitoring

Groundwater monitoring is intended to determine if irrigation whether by groundwater or imported water, is having a detrimental effect, and will address:

- Fluctuations in the regional water table elevation and its salinity.
- Creation of perched water tables.

Fourteen new water table monitoring wells were established in 2001, of which seven are in the areas of soil associations 6, 7 and 10 where the water table is nominally shallower than 5 metres (Figure 5). As discussed above, these are the areas where, if poor management practices are followed, increased accessions to the water table may result in a rising water table. The sites were selected in conjunction with DEWNR and are incorporated into their existing network. Of the DEWNR previous 85 well monitoring network (throughout the catchment) only 4 monitored the water table (Gill, 2000).

Monitoring data is periodically reviewed and reported. The most recent was in 2014 (Watersearch, 2014) and is included in Appendix 1. At this stage no additional monitoring locations are considered necessary.

Surface Flow Salinity Monitoring

Salinity monitoring is undertaken by the DEWNR at locations within the study area, on the North Para at Yaldara, Penrice and on the Tanunda Creek at Bethany. Data from grab samples is also available at other locations. In the Greenock Creek Catchment, there was no flow or long term salinity data to enable a quantitative assessment to confirm the effects of the new irrigation. To provide for future monitoring a gauge station has been constructed on Greenock Creek, although data is not yet available.

At this stage no additional permanent stations are recommended. It is recommended that the data continues to be reviewed and reported.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of monitoring and the above discussion, it is concluded that:
The BIL water contributes to the sustainability of the Barossa as a wine producing area of high quality, by providing:

- Additional good quality water (low salinity) to meet the demand of the Barossa wine industry, in particular:
- Enable existing supplies of high salinity irrigation water to be replaced or mixed with low salinity water, which is important for quality.
- Supplementing additional limited supplies, enabling new plantings, including in areas where groundwater is too saline for use.
- Providing a reliable water supply to sustain production in times of climate variability (drought) and change.

From a horticultural perspective the continued use of BIL water is also sustainable. It will be applied at a low rate of approximately 100 mm per year, which is about 20-25% of the requirement for vines. Even with this low rate, ongoing management of irrigation is required to ensure there are no issues with soil salinity, waterlogging or

excess water moving below the root zone. There are a number of important drivers which will ensure its efficient use, and are:

- The need to provide a quality product, including for overseas markets, and:
- A strong negative correlation between salinity and quality, therefore involving careful salinity management.
- A strong negative correlation between yield and quality, therefore requiring management of application rates.
- The high cost of BIL water.

In addition:

- BIL customers are required to prepare irrigation management plans, which takes into account location, soils, use of cover crops, mulch etc. BIL is currently upgrading its technology to enable real time monitoring with web based flowmeters, weather information and soil moisture readings.

For the existing BIL water use and proposed increase to 10,000 ML, it is very unlikely that there will be any change in the regional water table, apart from naturally occurring seasonal variation. This is supported by data from the 14 monitoring wells established in 2001 to monitor the water table and salinity. Variations observed, due to rainfall patterns, are the same as those occurring regionally, irrespective of soil types.

Monitoring indicates that no perched water tables have developed. With the proposed increase the risk continues to be very low, because of the low application rate of the BIL water of 100 mm/year, irrigation in summer usually starting in December, and with efficient management resulting in very little water moving past the root zone.
Assuming a conservative 50% replacement of saline irrigation water (average 1,500 mg/L TDS) in the Barossa Valley Floor and Lyndoch Valley, but all new water in the Greenock Creek and Gomersal Creek Catchments, there is a net average annual reduction in load to the surface of approximately 522 tonnes per year. There is, however, a redistribution with a large decrease in the average annual load on the Barossa Valley Floor and Lyndoch Valley of 2,034 tonnes per year, but an increase in

the Greenock Catchment of 1,512 tonnes/year. For the purpose of this assessment this assumes 5,400 ML used in the Greenock Creek Catchment, 2,200 ML in the Barossa Valley Floor and 1,400 ML in the Lyndoch Valley. The large reduction in the Barossa Valley Floor and Lyndoch Valley is particularly significant as these areas have the most soils with high risks of salinization and water logging. There should be no adverse effects on any remnant terrestrial vegetation.

The reduction in salt load will benefit aquatic ecosystems in the North Para River and tributaries where salinity has increased in the study area, particularly improving water quality in refugia pools. There may be a small increase in the longer-term in watercourses in the Greenock Creek Catchment, but which are already saline. Below the confluence of Greenock Creek there is the net average decrease of 520 tonnes per year.

In addition to the DEWNR monitoring network for ground and surface water, monitoring should continue, with periodic data review and reporting at:

- The 14 wells established for BIL monitoring.
- New gauging station on Greenock Creek (salinity).

At this stage no additional sites are considered necessary.

REFERENCES

AMLRNRM (2009) Water Allocation Plan, Barossa Prescribed Water Resources Area. 2009. Adelaide Mount Lofty Ranges Natural Resource Management Board, March 2009

DEWNR (2014), Barossa Water Resources Area, Surface Water Status Report 2010-11, Government of South Australia, through Department of Environment, Water and Natural Resources.

EMS (2000), Barossa Pipeline Project, Environmental Assessment, Prep for Barossa Infrastructure Limited, Eco Management Services Pty Ltd, November 2000

EPA (2011a) Aquatic Ecosystem Condition Report
Tanunda Creek near Bethany, Environment Protection Authority 2011

EPA (2011b) Aquatic Ecosystem Condition Report

North Para River, Rowland Flat, Environment Protection Authority 2011

EPA (2011c) Aquatic Ecosystem Condition Report
North Para River 4kms NW Angaston, Environment Protection Authority 2011

EPA (2011d) Aquatic Ecosystem Condition Report
North Para River downstream of Penrice GS, Environment Protection Authority 2011

EPA (2011e) Aquatic Ecosystem Condition Report
North Para River 4.5 kms NW from Eden Valley, Environment Protection Authority 2011

EPA (2013a) Aquatic Ecosystem Condition Report
Greenock Creek, Roenfeldt Road, Environment Protection Authority 2013

EPA (2013b) Aquatic Ecosystem Condition Report
Jacobs Creek near confluence with North Para River, Environment Protection Authority 2013

EPA (2013c) Aquatic Ecosystem Condition Report
Jacobs Creek, Kaiser GS, Environment Protection Authority 2013

EPA (2013d) Aquatic Ecosystem Condition Report
North Para River, Mt McKenzie GS, Environment Protection Authority 2013

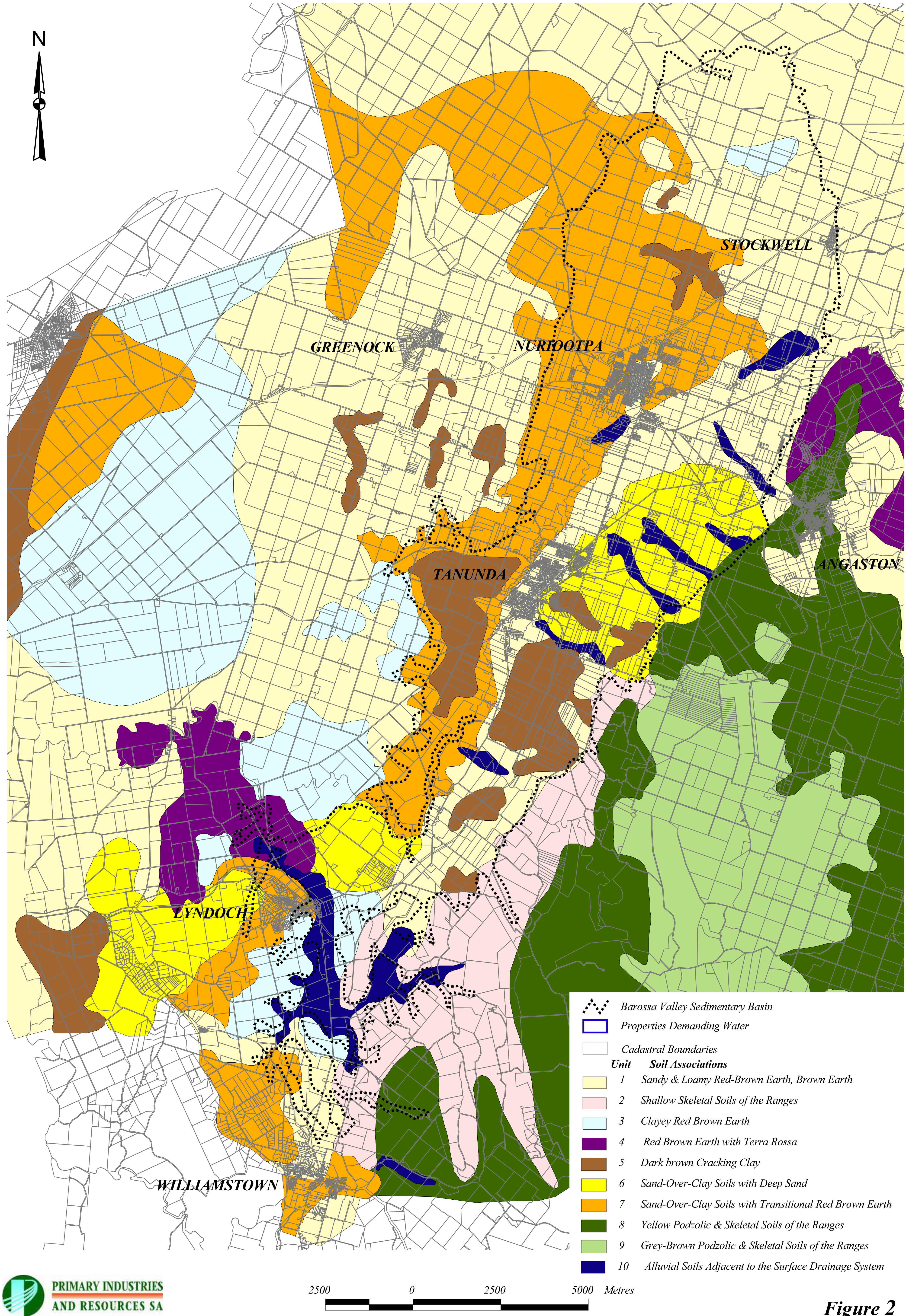
Evans, Terry, Craig Liddicoat, Chris Henschke and Trevor Dooley (2003), North and South Para Catchments, Rural Solutions SA, March 2003

Gill, R. 2000. Barossa Valley Review, 1999 Primary Industries and Resources Report Book 2000/00012.

Harding, C, Deane, D. Green, G and Kretschmer, P. 2015, Impacts of Climate Change on Water Resources in South Australia/ Phase 4 Volume 2 – Predicting the impact of climate change to groundwater dependent ecosystems: an application of a risk framework to a case study in the South East NRM region – Middlepoint Swamp. DEWNR Technical Report 2015/01, Government of South Australia, through Department of Environment, Water and Natural Resources.

Seed Consulting Services (2014) Gomersal Recycled Water Reuse Scheme. Produced for Barossa Infrastructure Limited, September 2014

Watersearch (2014) Groundwater (Water Table) Monitoring 2014, Prepared by Watersearch Pty Ltd for Barossa Infrastructure Limited, December 2014.



PRIMARY INDUSTRIES AND RESOURCES SA

Cadastral information provided by the Resource Information Group, DEH
Drawing prepared by ID&A Pty Ltd for Barossa Infrastructure Limited. ID&A Drawing No. 5500512 - D031

Figure 2
Summarised Soil Associations

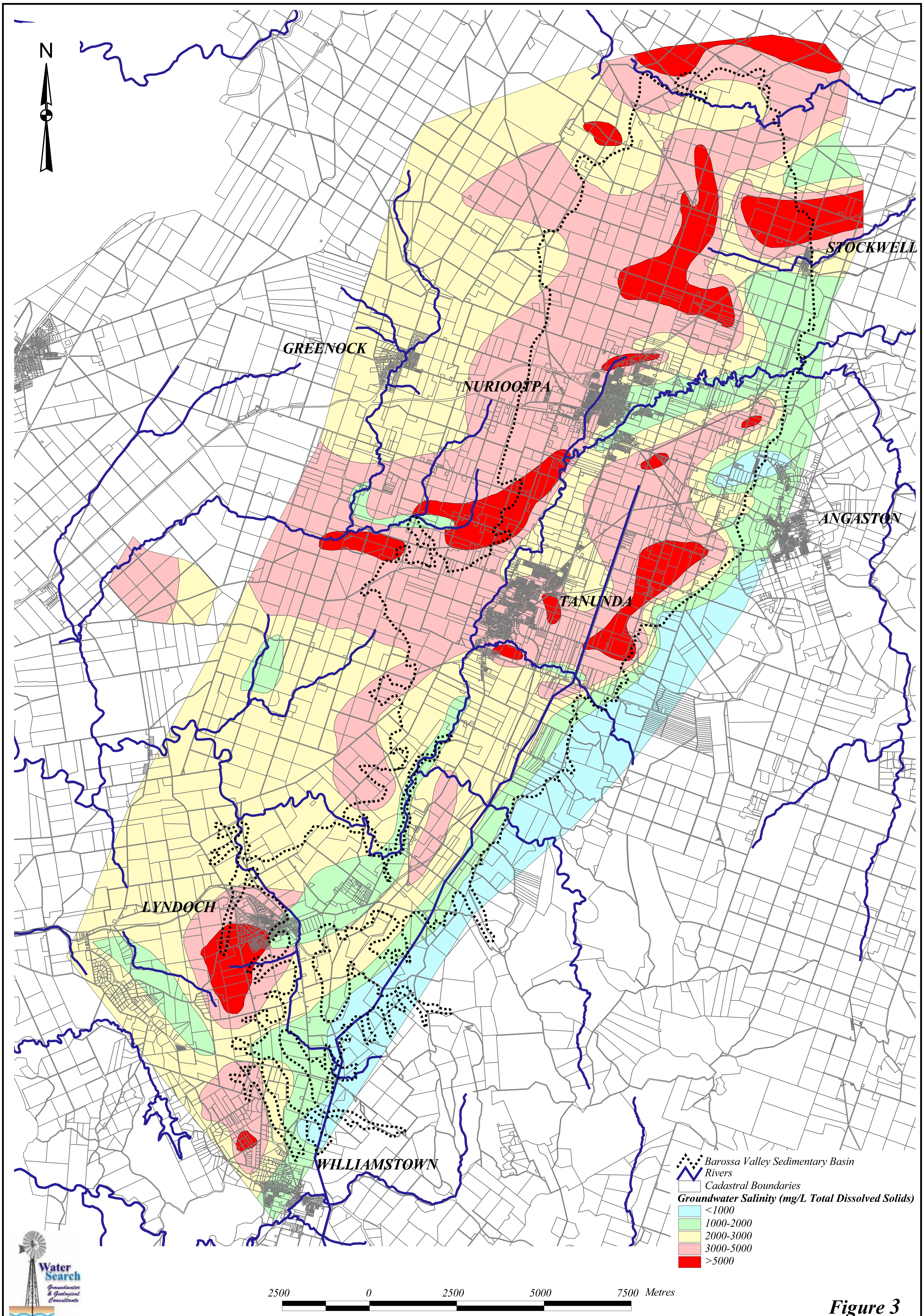


Figure 3
Watertable Salinity Zones

Cadastral information provided by the Resource Information Group, DEH
Drawing prepared by ID&A Pty Ltd for Barossa Infrastructure Limited. ID&A Drawing No. 5500512 - D038

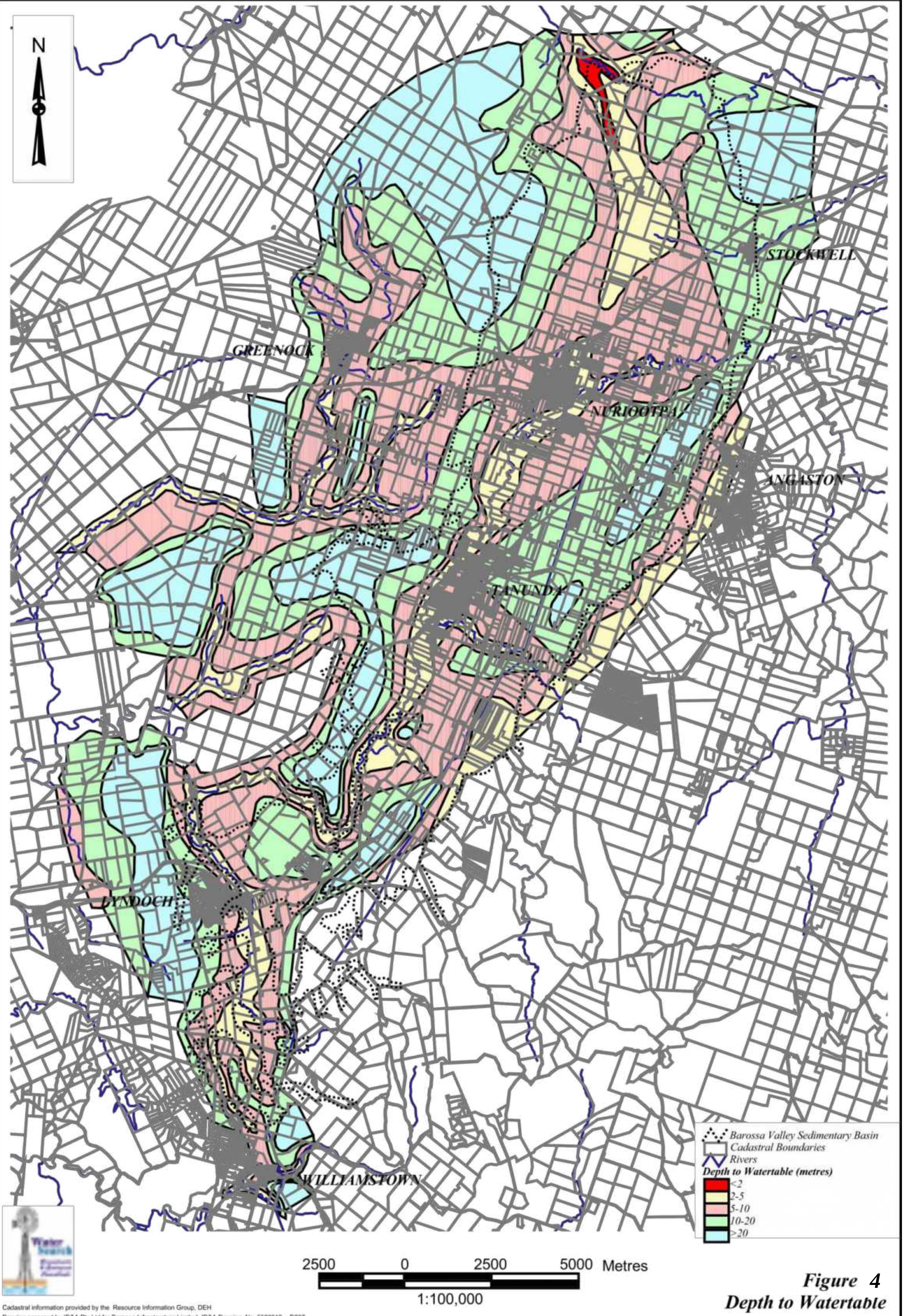
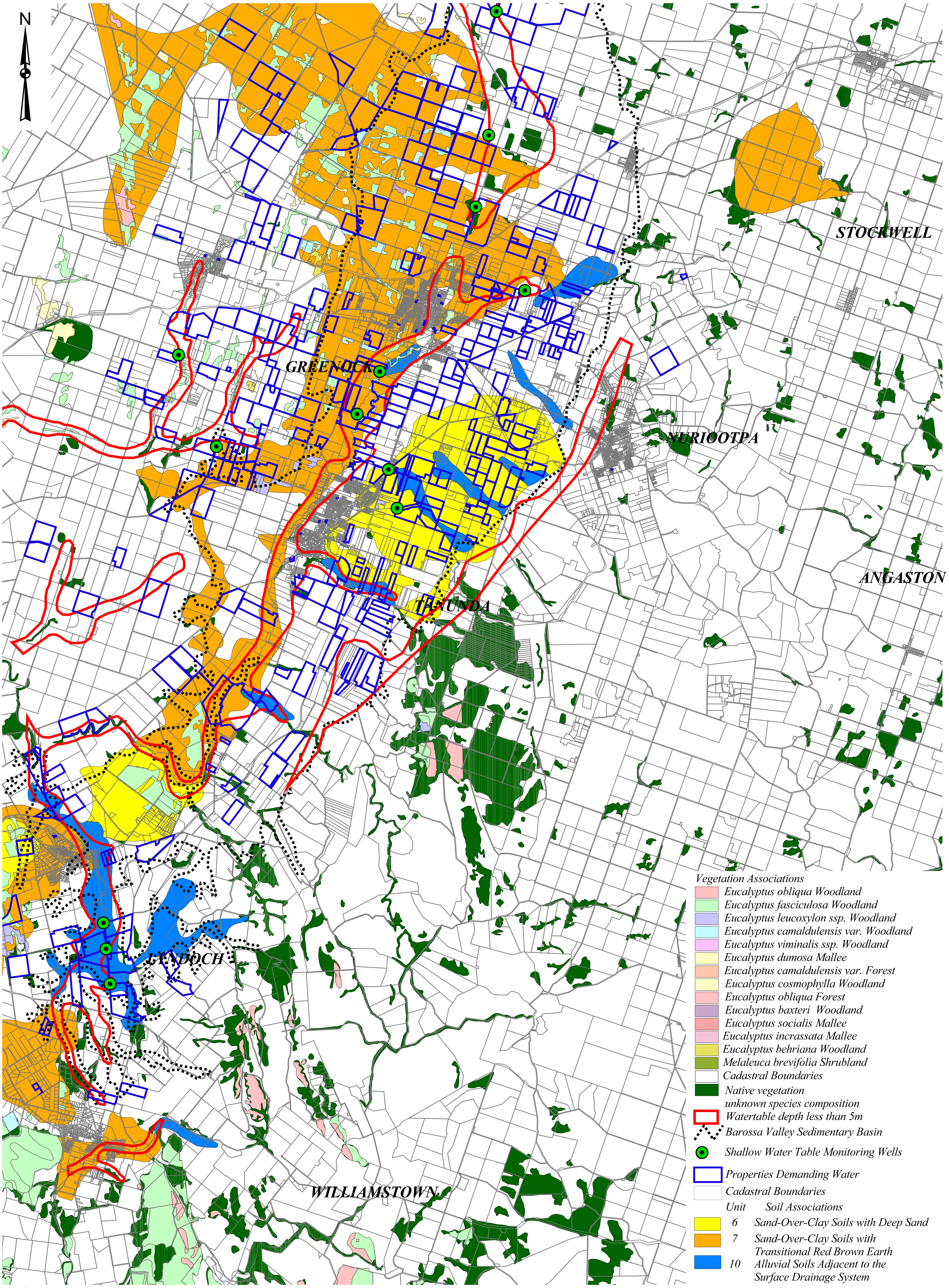


Figure 4
Depth to Watertable

Cadastral information provided by the Resource Information Group, DEH
Drawing prepared by ID&A Pty Ltd for Barossa Infrastructure Limited. ID&A Drawing No. 5500512 - D037



2500 0 2500 5000 Metres

1:100,000

Water Search
Groundwater & Geological Consultants

PRIMARY INDUSTRIES AND RESOURCES SA

Figure 5
Priority Irrigation Management Areas:
Watertable depth less than 5m and sensitive soil associations

Cadastral information provided by the Resource Information Group, DEH
Drawing prepared by ID&A Pty Ltd for Barossa Infrastructure Limited. ID&A Drawing No. 5500512 - D023

APPENDIX 1

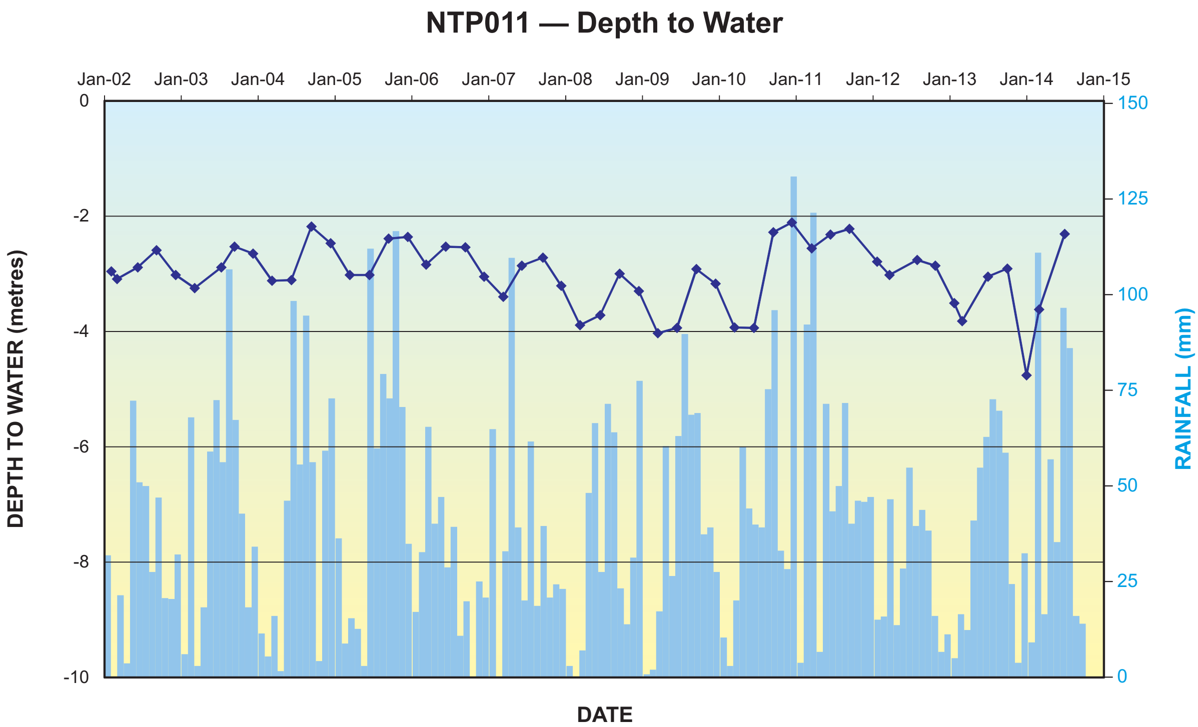
Groundwater (Water Table) Monitoring 2014,

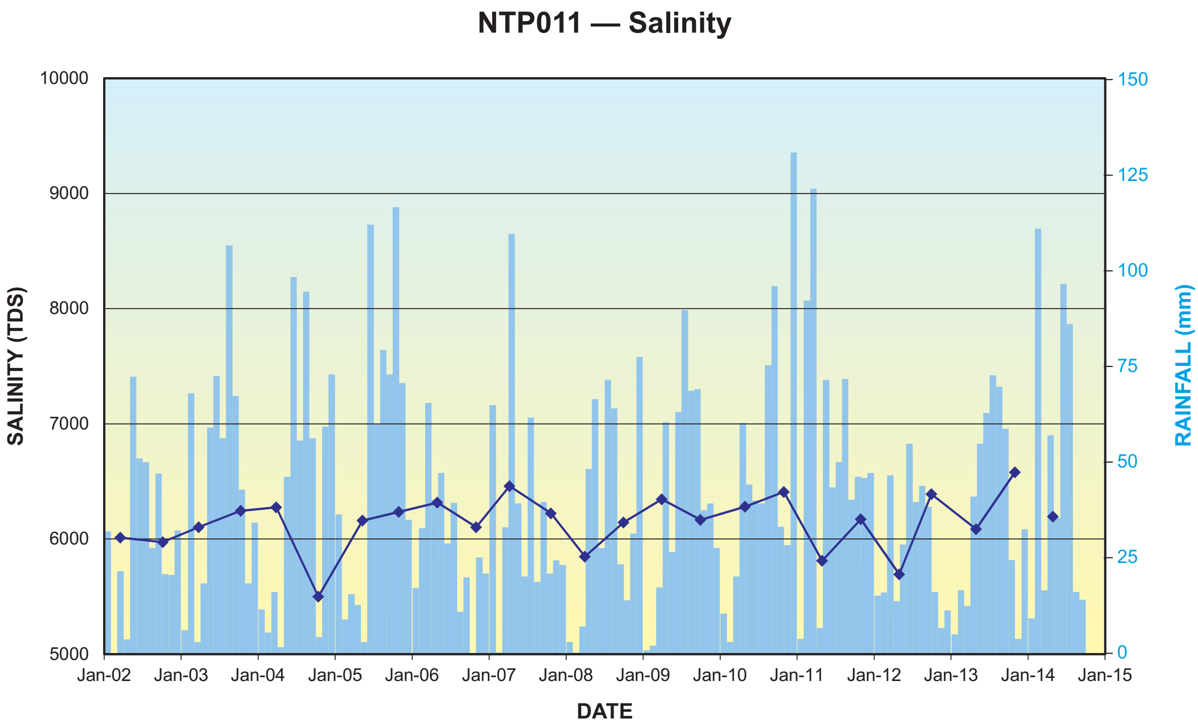
Report prepared by Watersearch Pty Ltd for Barossa Infrastructure Limited, December 2014.

Groundwater (Water Table) Monitoring 2014
Barossa Valley
Barossa Infrastructure Ltd

Report Bk. 2014/22
December 2014

Water Search Pty. Ltd.
Box 191
Angaston 5353
Ph./Fax. 08 85642362





Rainfall data is for Nuriootpa

WATER SEARCH *Groundwater & Geological Consultants*

Figure 8

BAROSSA INFRASTRUCTURE LTD

Observation Well — NTP011

DEPTH TO WATER AND SALINITY GRAPHS - 2014

686-3414

CONTENTS **PAGE**

FIGURES

1. Introduction

Barossa Infrastructure Ltd (BIL) transfer Warren Reservoir - River Murray water into the greater Barossa Valley region for supplementary viticulture irrigation.
Prior to its implementation an environmental assessment of the project was undertaken by Eco Management Services Pty Ltd (2000).
Their report recognised that of the ten general soil classifications identified three were considered to have the potential to develop rising water tables if over irrigation resulted in greater accession to the water table.
The assessment report proposed the drilling of 14 shallow monitoring wells in these soil formations and this was undertaken in October 2001 and documented in Water Search Pty Ltd (2001).
This report documents the monitoring results to date and includes some longer term monitoring results for comparison purposes.

2. Groundwater Resources

Three major aquifers exist in the area, two sedimentary aquifers (upper and lower) that occur in the valley proper and a fractured rock aquifer that lies to the east and west of and underlies these sedimentary aquifers.
In terms of annual groundwater extraction all three aquifers show the same pattern ie a decrease in an extraction from 2003/04 to 2005/06, an increase for the following two years followed by a decrease until 2010/11 to increase to 2012/13 (for the upper aquifer its extraction doubled over the latter period). Increases in extraction generally correspond to periods of lower rainfall which also results in lower recharge to the water table. The combination of these factors is reflected in the monitoring of the water table elevations.

3. Monitoring Network

Within the constraints of the geographical extent of the three soil classifications of concern drilling sites were also controlled by

* the need to drill on road verges to allow for all year and on-going access
* the location of overhead and underground services and
* input from and approval by officers of the then Department for Water Resources (DWR)

All wells were drilled using solid-flight augers to several metres below the water table or if not recognised to a maximum depth of 15 metres. Upon completion of the drilling programme each wellhead reference point was survey levelled to AHD to allow for the wells to be incorporated into the now DEWNR regional network.
Figure 1 shows the well locations along with additional DEWNR shallow aquifer monitoring wells documented in this report.

4. Monitoring Results

The environment assessment report proposed that water levels and salinity be monitored initially on a monthly basis and subject to review each year.
After the initial water level reading in February 2002 the Department has been measuring water levels on an approximate three monthly basis and sampling the wells about every six

months (end of summer, end of winter). All data are stored in a computer database alongside each wells unique monitoring well code, a sequential numbering system based on the Hundred in which the well resides (Figure 1).

4.1 Belvidere Plains

Figures 2 to 4 show the water level hydrographs and salinity fluctuations for the three monitoring wells BLV8, 9 and 10 in the Hundred of Belvidere north of the Sturt Highway. The plots also show the monthly rainfalls recorded at Nuriootpa by the Bureau of Meteorology. Whilst there are some differences the water level hydrographs show a similar pattern of a slowly rising water table until early 2006 followed by a general decline until the 2010 and 2011 winters when water levels consistently rose to again decline from the spring of 2011 to date reflecting the rainfall and hence recharge rates either side of that date and changes in the upper aquifer extraction volumes. Superimposed on these average trends are the annual water table fluctuations reflecting the changing balance between winter rainfall recharge and summer evapotranspiration. As the typical depth to water in BLV8 and BLV9 is 2 metres deeper than in BLV10 annual fluctuations are more subdued.

To try and obtain representative water samples for salinity testing each well is pumped using 12V submersible pumps until at least two well volumes are removed.
The northernmost of the three wells BLV9 (Figure 3) has the lowest salinity and the least fluctuation over the sampled period. It showed a slow rise until mid 2006 (parallel to the slow average rise in the water table) followed by a levelling off to again trend upwards from the winter of 2009. BLV8, the well with the highest salinity, has also shown the greatest fluctuation (Figure 2) and BLV10 is intermediate between the two (Figure 4). The latter two wells do not appear to show any significant trends.
Whilst it is difficult to be definitive about the reasons for fluctuations of such magnitude causes could include remobilization of stored salts in the unsaturated zone under variable recharge conditions, salinity stratification below the water table dominating sampling protocols etc.

4.2 West of North Para River

The water level hydrographs for the four water table monitoring wells show relatively small annual cycles of a rise and fall in the water table superimposed on a relatively stable or an overall rising trend prior to 2006 followed by a slight downward trend after that (Figures 5 to 8).
This is the same as seen in the Belvidere Plains monitoring wells and is a reflection of the amount and intensity of the annual rainfall and hence recharge to the water table.
This area is underlain by the fractured rock aquifer and because of salinity constraints is not extensively exploited for irrigation.
Again the wetter 2010 and 2011 winters resulted in a greater amount of rainfall recharge and hence a rise in the water table over late winter - early spring and this is seen in all four monitoring wells to again decline over 2012 and rise over 2013 and 2014. Despite some fluctuations the water table salinity in NTP8 (Figure 5) varied in a relatively narrow band until early 2008 but has shown a slow increase since then.
NTP9 fluctuates more than the other wells which may be related to the existence of the North Para River to the east of it. The salinity in NTP10 decreased from its drilling date till early

2008 then stabilized at around 7000 mg/L until late 2010 to again show a downward trend followed by a 'plateauing'. Similarly NTP11 fluctuates around 6000 mg/L.

4.3 Central Valley Floor

Figures 9 to 13 show water table hydrographs for long-term (non-BIL) monitoring wells incorporated in the regional network. The graph for MOR212 (Figure 12) shows the strong relationship between the amount and intensity of incipient rainfall and the corresponding fluctuation in the water table elevation eg 1992 - 1993, 1996, 2005 and 2010/11.
Figure 9 (MOR10) also shows the long-term cycles experienced by the water table over the past fifty-two years.
Such cycles urge caution in ascribing short-term trends (<10 years) to a cause other than rainfall recharge rates and/or variable groundwater extraction.
The late hydrograph for MOR84 in Nuriootpa (Figure 10) should be discounted as it became subject to surface water running into its casing (and reflected in the salinity graph).
Apart from this well long term water table salinities have shown a rise then a fall (MOR204, Figure 11), a slow fall (MOR213, Figure 12) or a significant rise (MOR213, Figure 13, corner of Menge and Magnolia Roads).

The water table hydrograph for MOR273 (Figure 14) northeast of Nuriootpa shows the same features as seen in the Belvidere Plains and Hundred of Nuriootpa monitoring wells ie an upward trending water table till 2006 followed by an overall downward trend with a rise over the 2009 to 2012 winters. Its salinity graph shows wide fluctuations probably related to the nearby North Para River.
MOR274 at Kroemers Crossing shows the ubiquitous rising water table trend till 2006 followed by a slow downward trend with a rise over the 2010/2011 winters followed by a flattening then slow decline.
Well MOR272 has been vandalized.

4.4 Lyndoch Valley

Figure 16 shows the long-term trends in the water table fluctuations experienced in the Lyndoch Valley (BRS9, Figure 1). Whilst it is a problematic monitoring well being influenced by pumping and recharging of fresh water the overall observed trends are on a par with those seen to the north in the Valley proper.

The water level hydrograph for BRS22 (Figure 17) and BRS25 (Figure 19) show the same pattern as seen in the other water table monitoring wells ie a rising or reasonably stable average water table elevation followed by an overall decline till early 2009 followed by upward trends brought about by enhance winter rainfall recharge to again fall over 2012 as extraction from the upper aquifer increased.
Both wells have also shown a small increase in salinity since sampling commenced but now appears to be stabilizing in BRS25 and falling in BRS22 (Figure 17).

Data for BRS24 (Figure 18) is sporadic but no comment existed in the database as to why it is not read or sampled on a regular basis.

5. Conclusions and Recommendations

The water level hydrographs for the dedicated BIL monitoring wells generally show a similar pattern of a rising or relatively stable average water table elevation from 2002 until 2006 followed by a downward trend till 2009 with subsequent rises brought about by two to three years of enhanced winter recharge with a general decline over 2012. The same is seen in other regional monitoring wells and appears to be correlated solely to the trend in the rainfall pattern and hence recharge rates and the parallel variation in the extracted volumes from the upper aquifer. The longer term (non-BIL) monitoring wells show that over the past few decades the water table in the Barossa Valley has gone through extended periods of rising and falling average levels related to the long term trends in the rainfall patterns.
Trends in salinities are harder to define as the sampling methodology itself can influence the results let alone the immediate hydrogeology surrounding the monitoring well.
Some wells show small variations between sampling runs whilst others vary significantly.
Some wells show a slow increase since monitoring began to continue to do so or to plateau over the past few years whilst one indicated an average downward trend.
It is important that monitoring continues expecially as weather patterns appear to be changing.
It is recommended that a further review of the collected data be undertaken at the end of 2016.

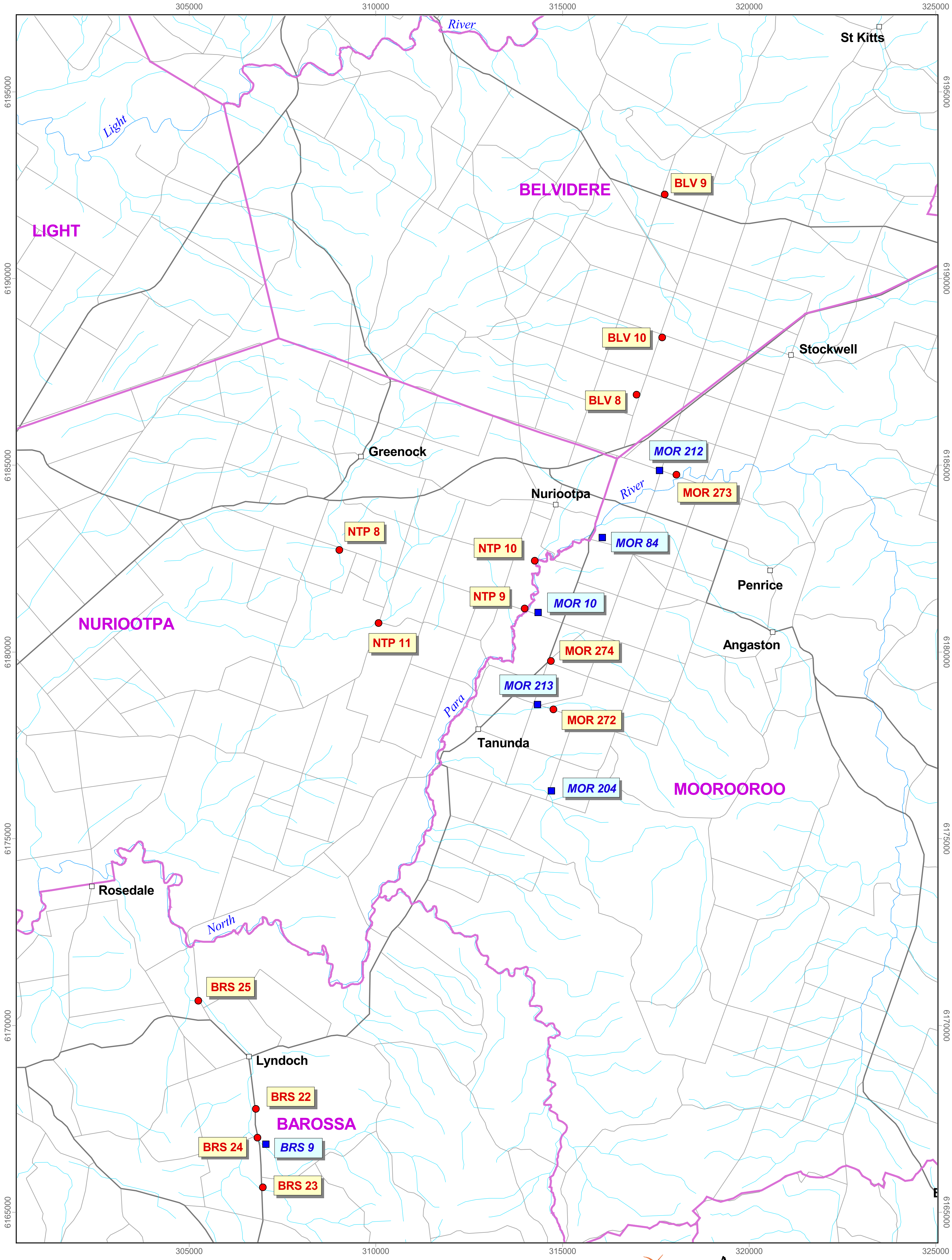
5. Acknowledgements

Acknowledgement is given to the Bureau of Meteorology for supplying monthly rainfall data for Nuriootpa, Tanunda and Lyndoch and to DEWNR for making the database available.

6. References

ECO Management Services Pty Ltd 2000.
Barossa Pipeline Project Environmental Assessment.
Barossa Infrastructure Limited.

Water Search Pty Ltd 2001.
Monitoring Wells Drilling Barossa Valley, Barossa Infrastructure Limited - Report Bk 2001/22.



Water Search
Groundwater & Geological Consultants
654-3223

BLV 9 Water table monitoring well and number
BLV 9 DWLBC monitoring well and number
Hundred boundary
River
Creek
Highway / main road
Main road
Minor road / track

GDA

N

0 2 4 6 8 Kilometers

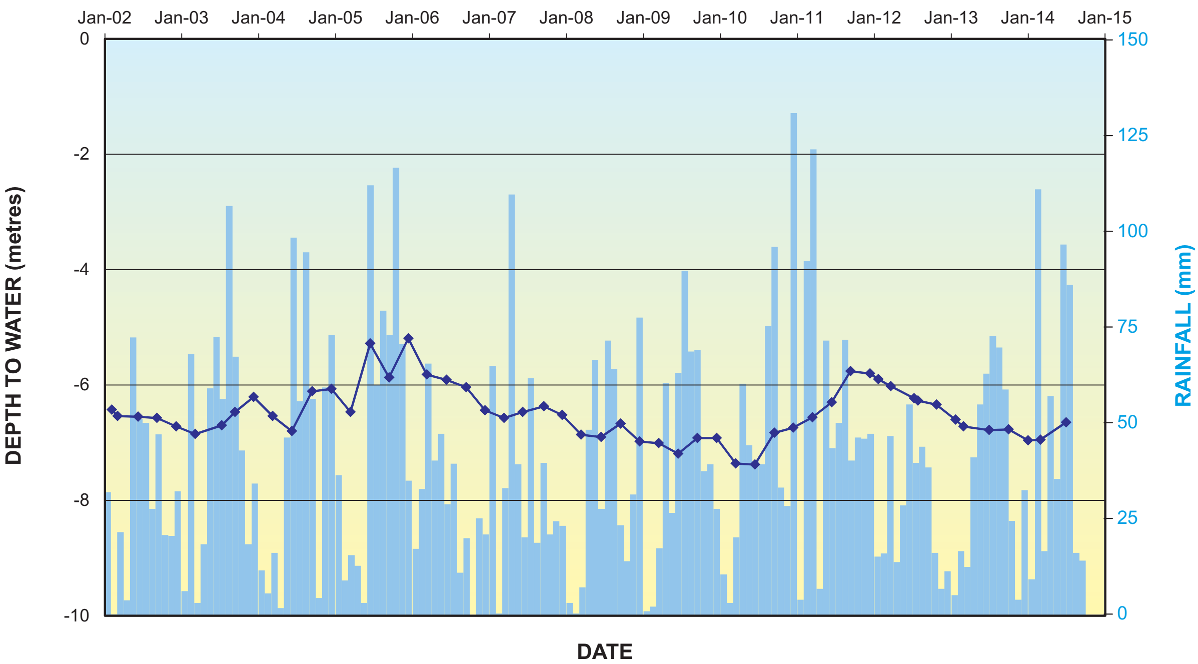
DATUM GDA 94 - MAP PROJECTION MGA ZONE 54

Barossa Infrastructure Limited

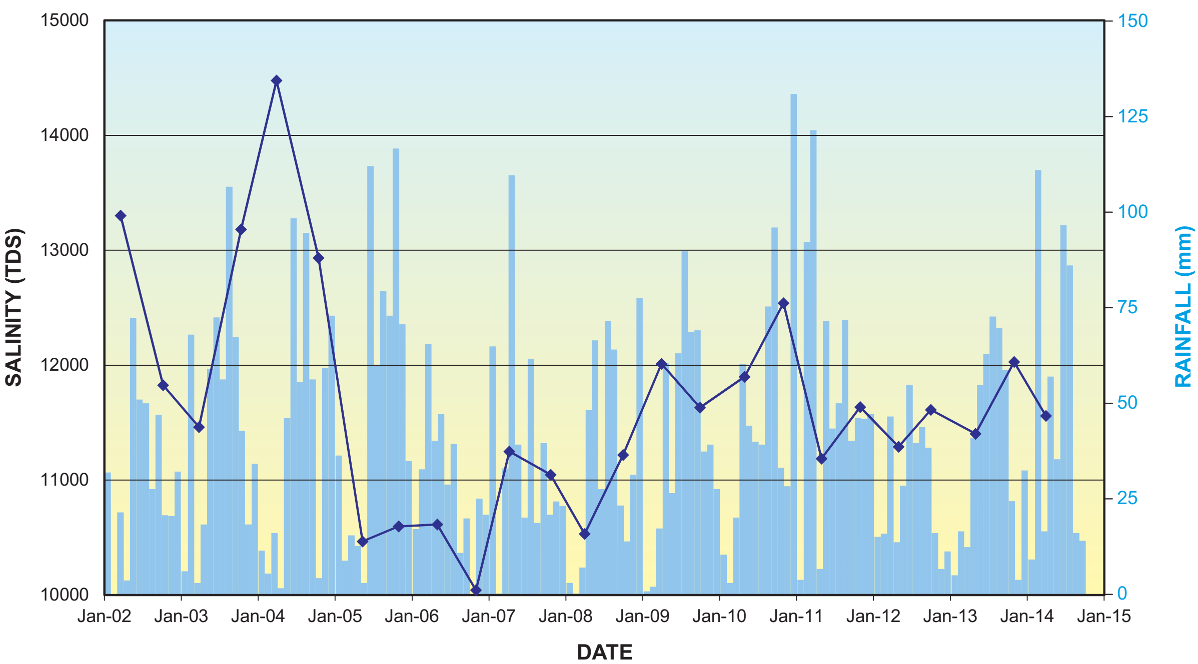
WATER TABLE MONITORING WELL LOCATION PLAN

Figure 1

BLV008 — Depth to Water



BLV008 — Salinity



Rainfall data is for Nuriootpa

WATER SEARCH Groundwater & Geological Consultants

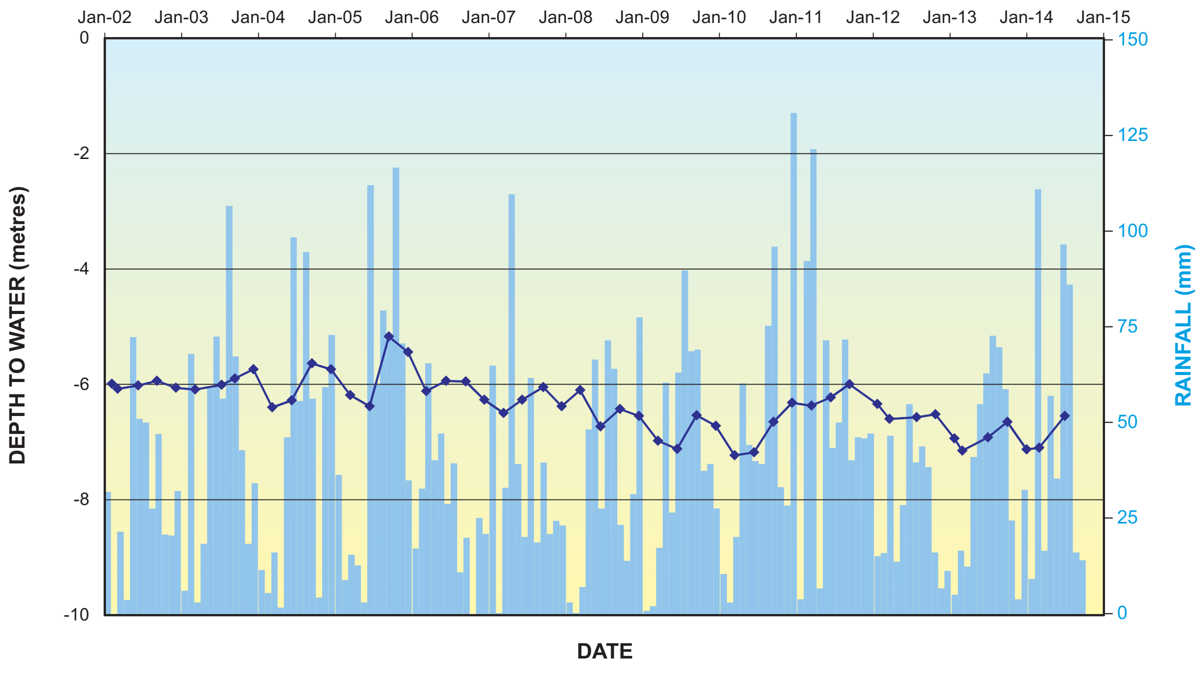
Figure 2

BARROSSA INFRASTRUCTURE LTD

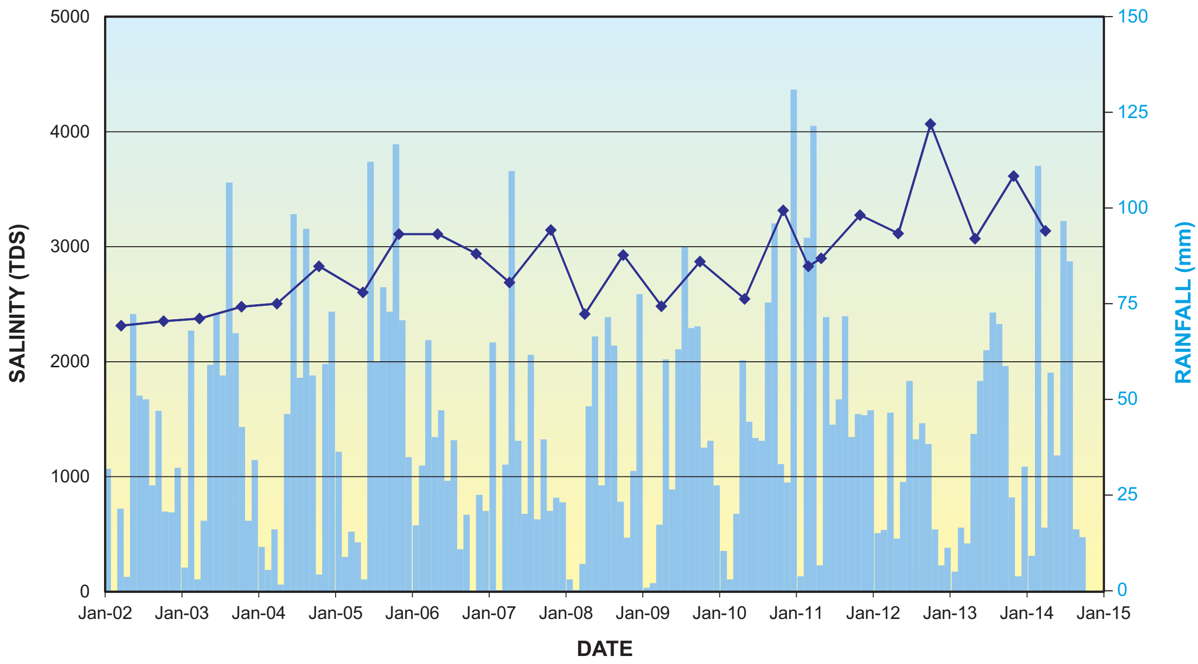
Observation Well — BLV008

DEPTH TO WATER AND SALINITY GRAPHS - 2014

BLV009 — Depth to Water



BLV009 — Salinity



Rainfall data is for Nuriootpa

WATER SEARCH *Groundwater & Geological Consultants*

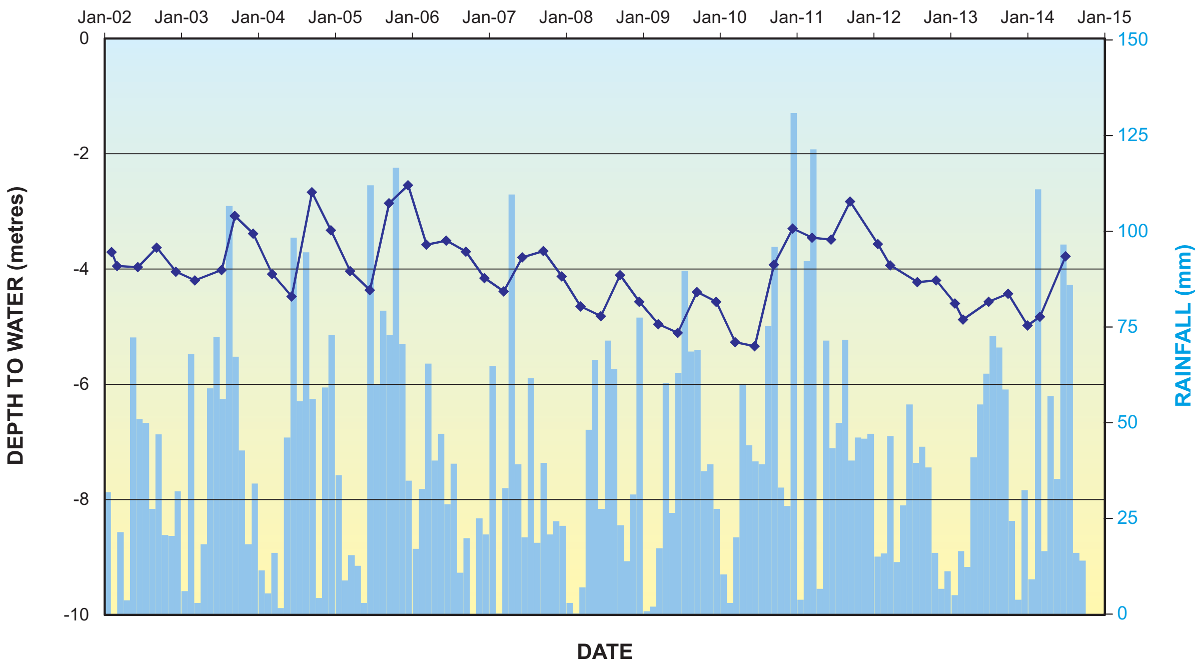
Figure 3

BAROSSA INFRASTRUCTURE LTD

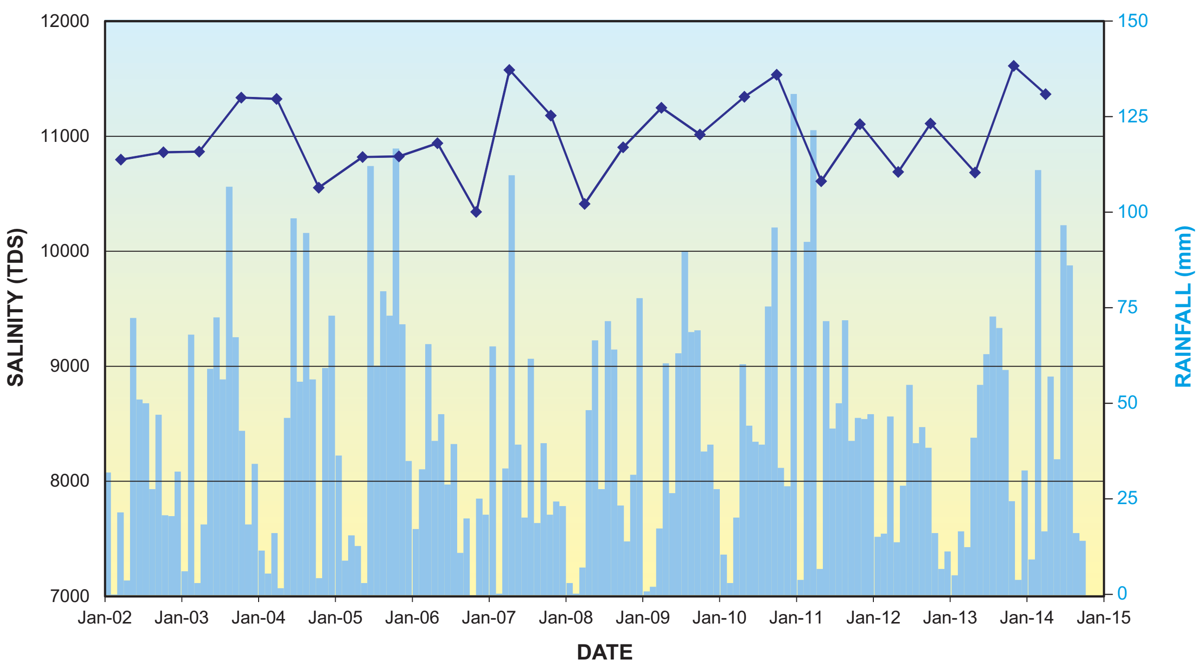
Observation Well — BLV009

DEPTH TO WATER AND SALINITY GRAPHS - 2014

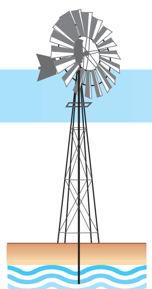
BLV010 — Depth to Water



BLV010 — Salinity



Rainfall data is for Nuriootpa



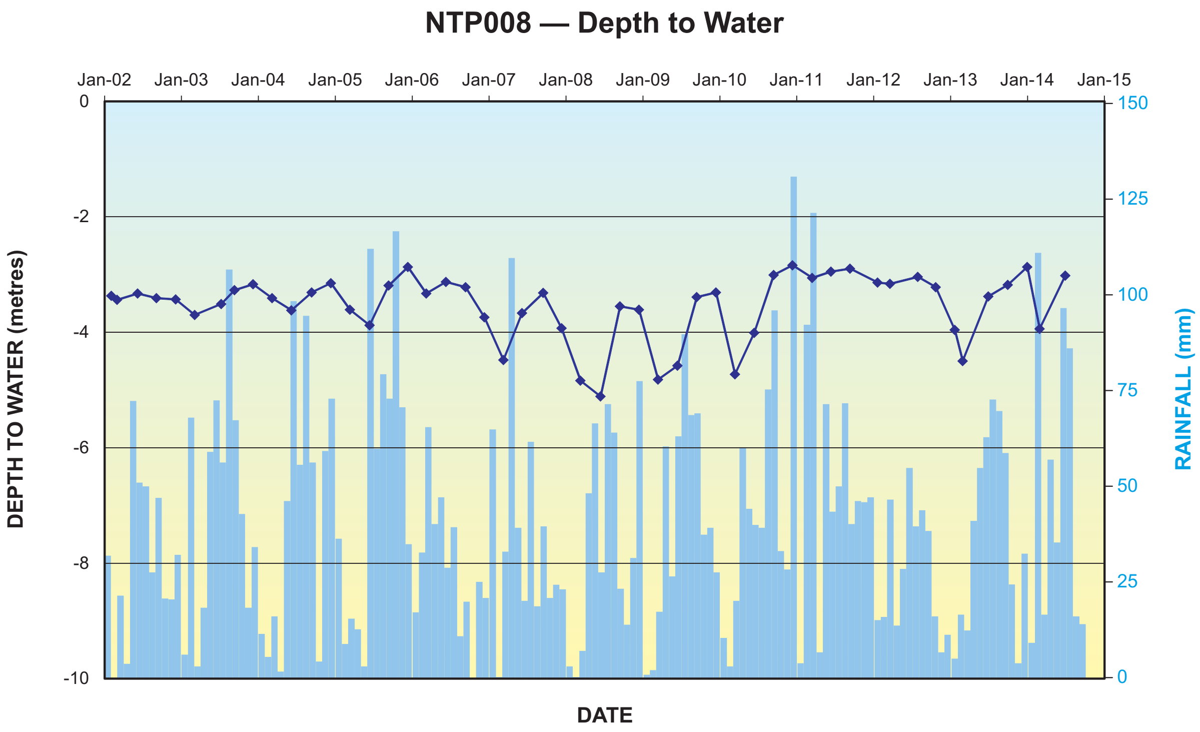
WATER SEARCH *Groundwater & Geological Consultants*

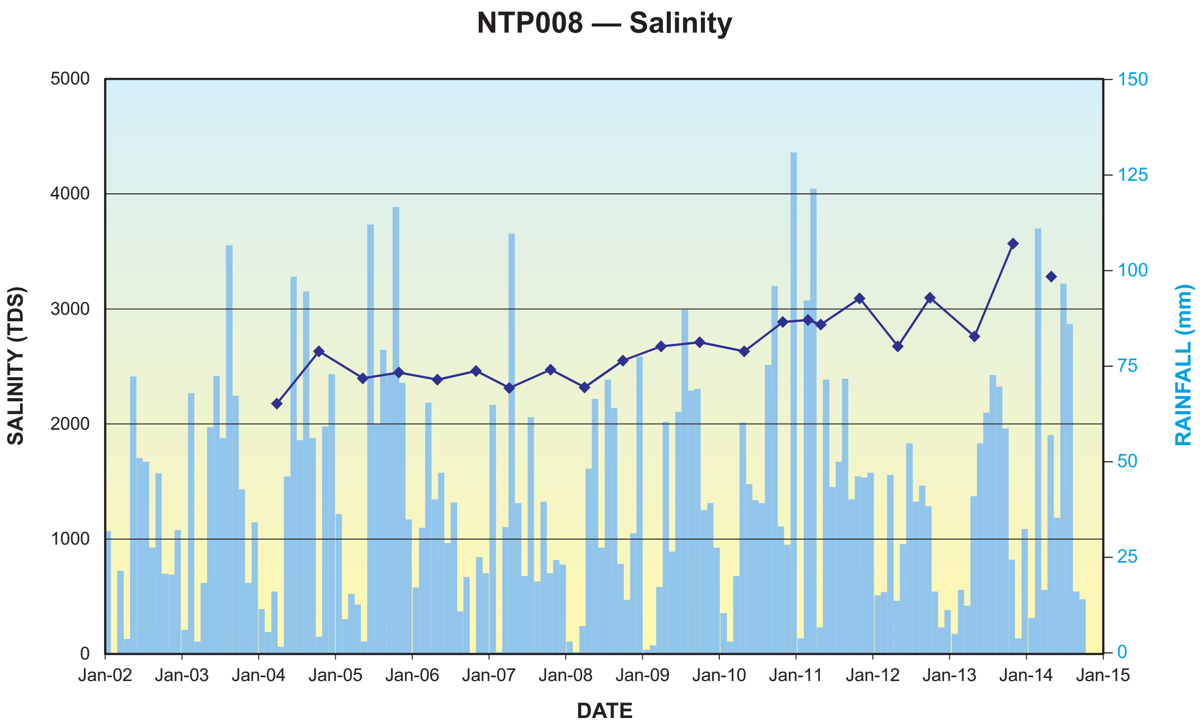
Figure 4

BAROSSA INFRASTRUCTURE LTD

Observation Well — BLV010

DEPTH TO WATER AND SALINITY GRAPHS - 2014





Rainfall data is for Nuriootpa

WATER SEARCH *Groundwater & Geological Consultants*

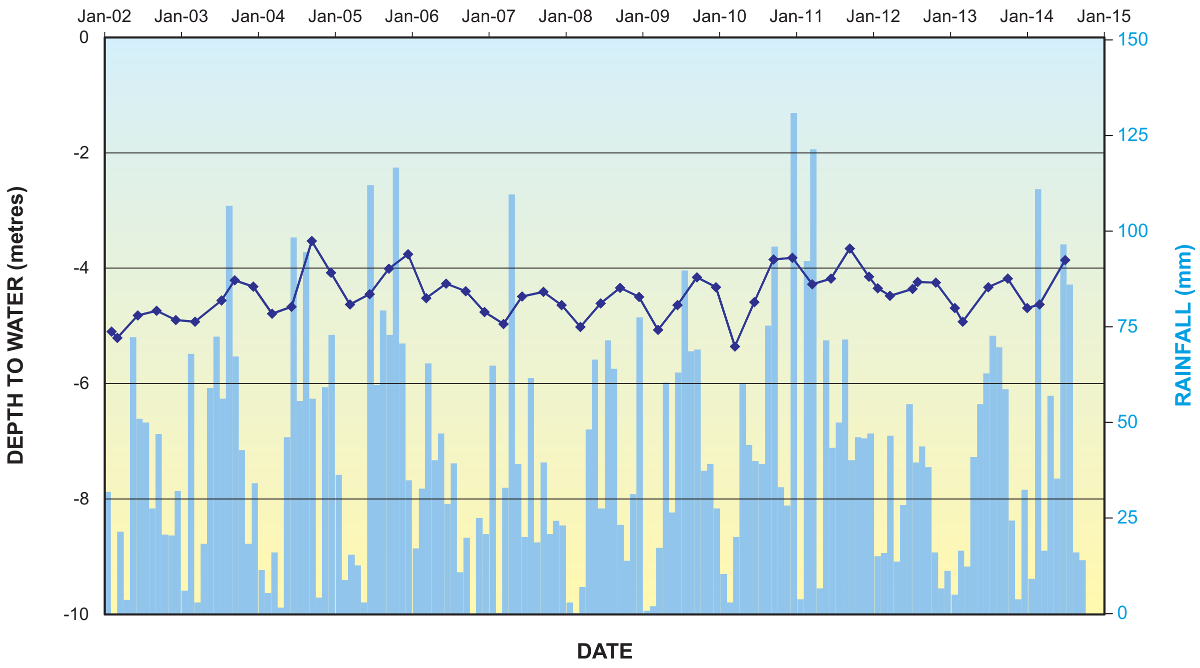
Figure 5

BAROSSA INFRASTRUCTURE LTD

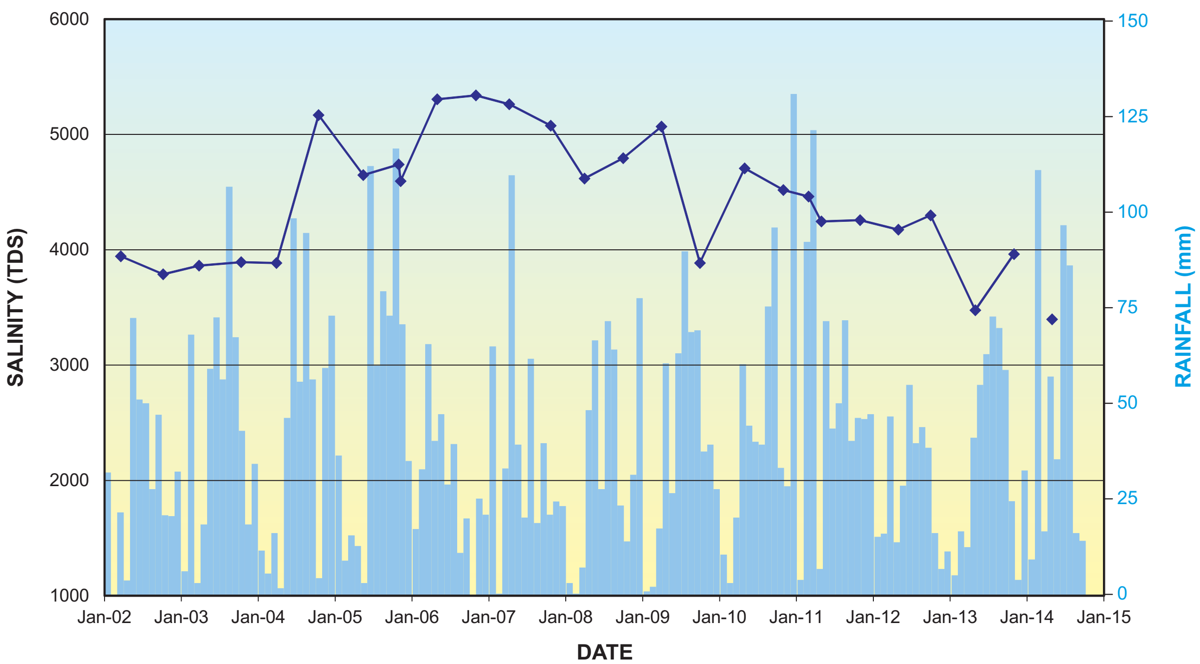
Observation Well — NTP008

DEPTH TO WATER AND SALINITY GRAPHS - 2014

NTP009 — Depth to Water



NTP009 — Salinity



Rainfall data is for Nuriootpa

WATER SEARCH *Groundwater & Geological Consultants*

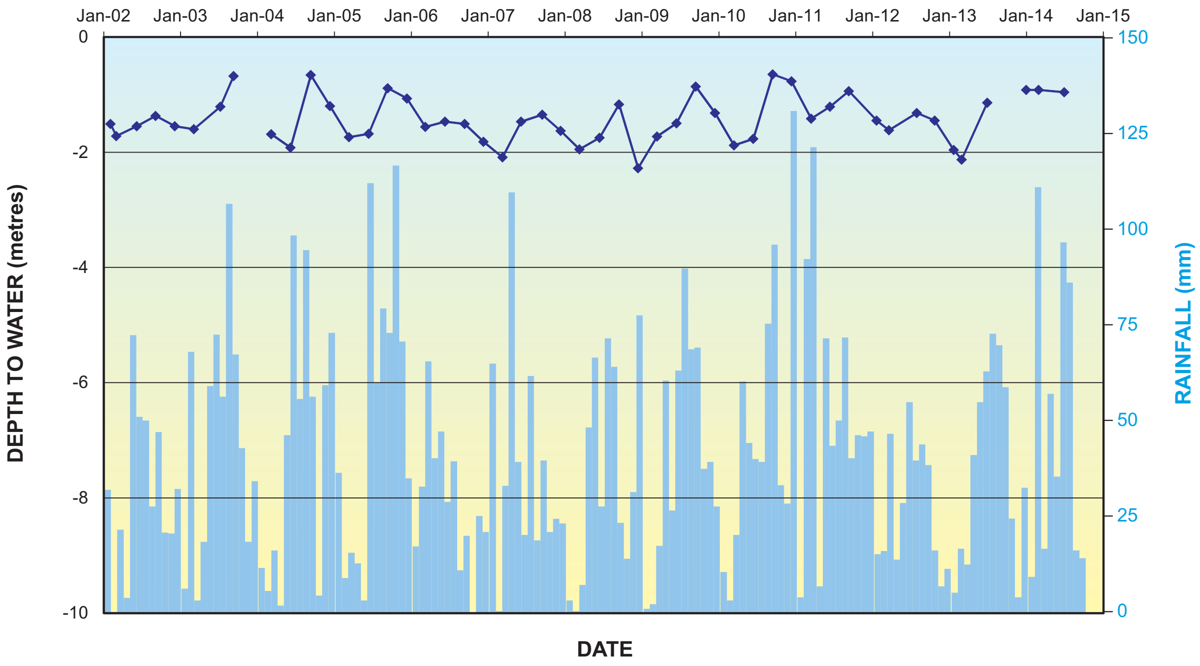
Figure 6

BAROSSA INFRASTRUCTURE LTD

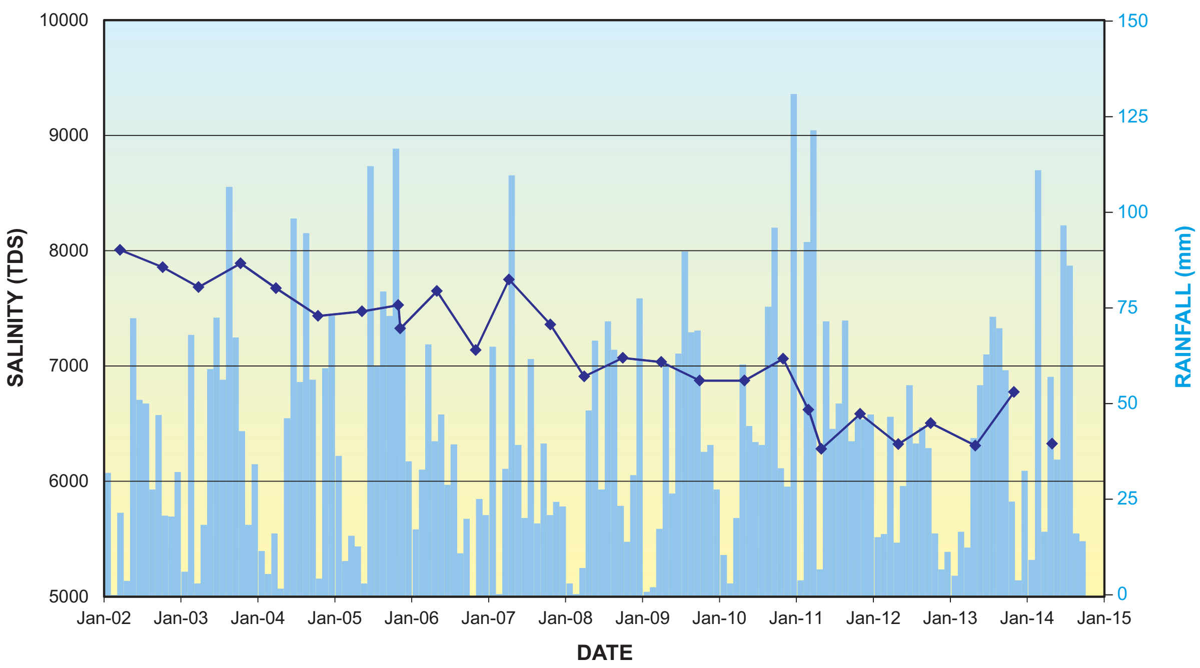
Observation Well — NTP009

DEPTH TO WATER AND SALINITY GRAPHS - 2014

NTP010 — Depth to Water



NTP010 — Salinity



Rainfall data is for Nuriootpa

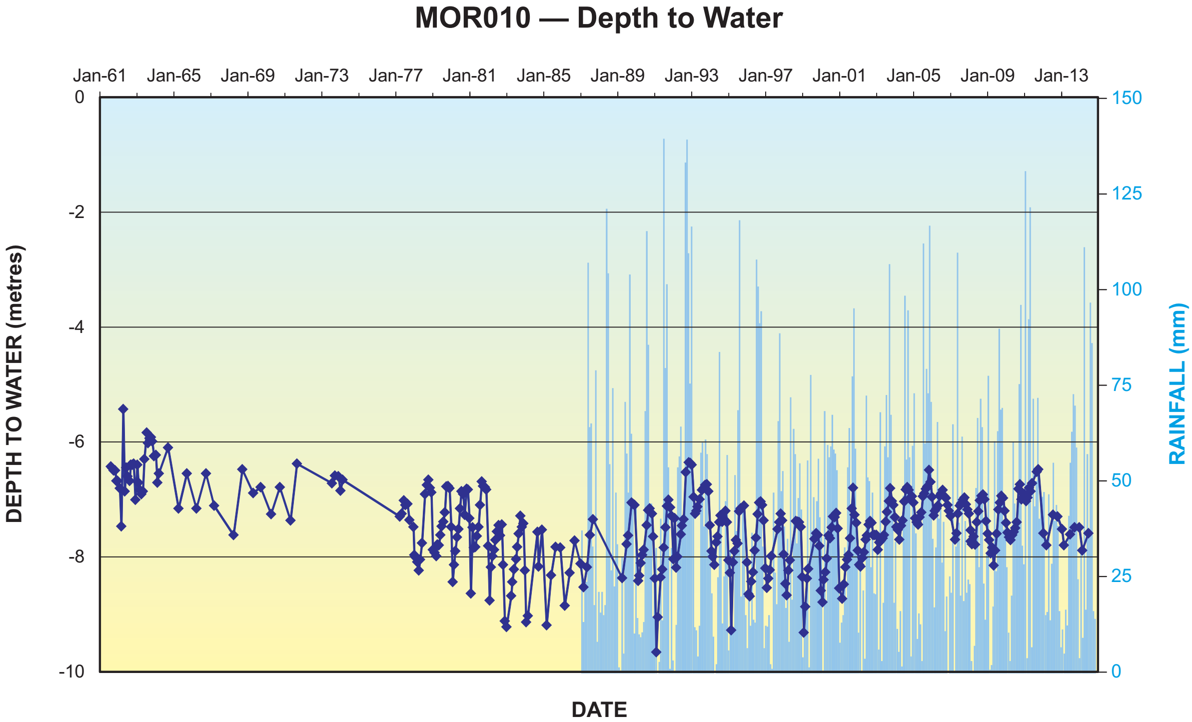
WATER SEARCH *Groundwater & Geological Consultants*

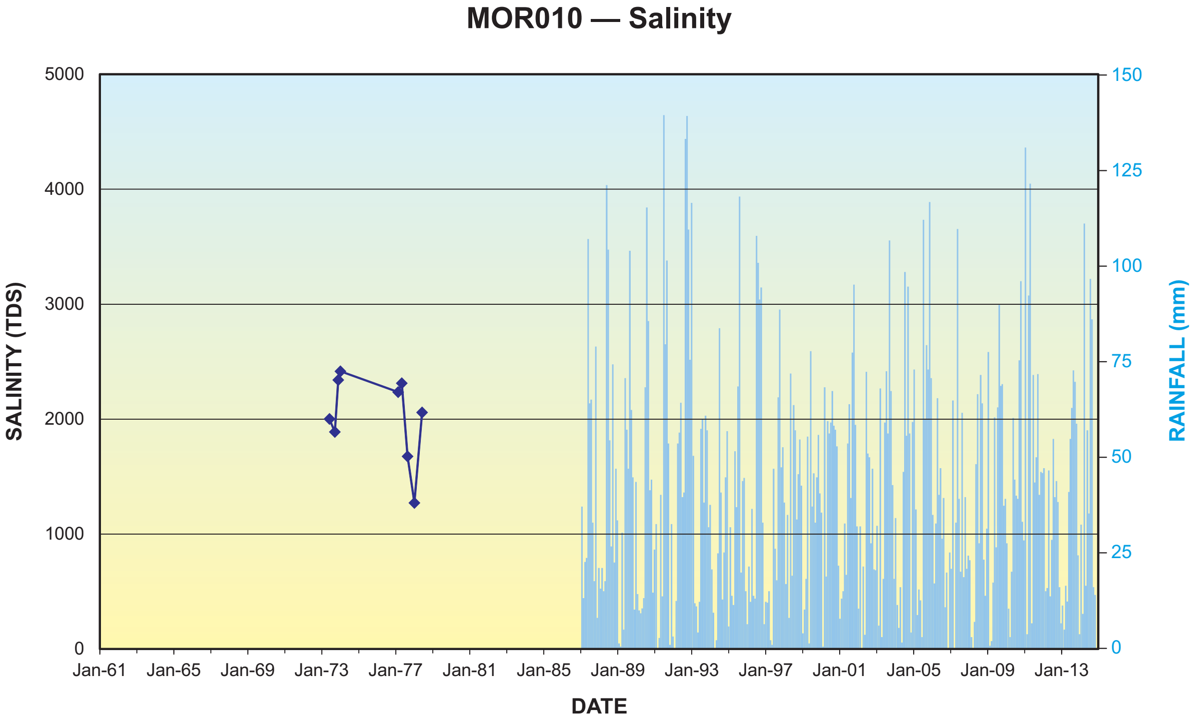
Figure 7

BAROSSA INFRASTRUCTURE LTD

Observation Well — NTP010

DEPTH TO WATER AND SALINITY GRAPHS - 2014





Rainfall data is for Nuriootpa

WATER SEARCH Groundwater & Geological Consultants

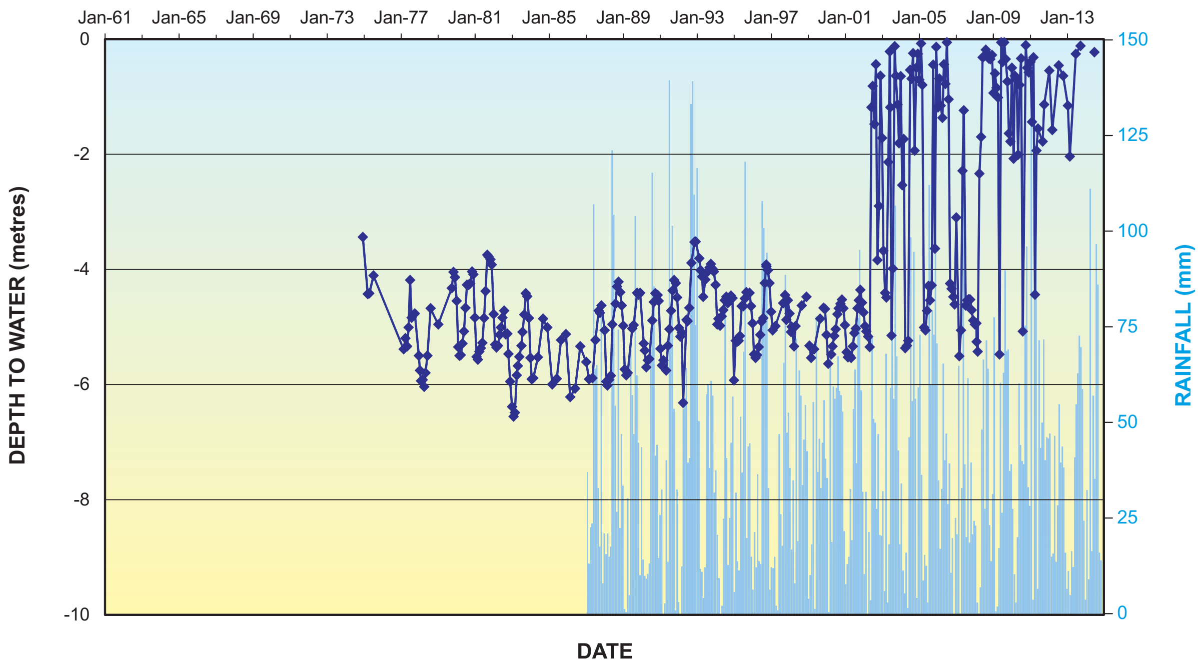
Figure 9

BAROSSA INFRASTRUCTURE LTD

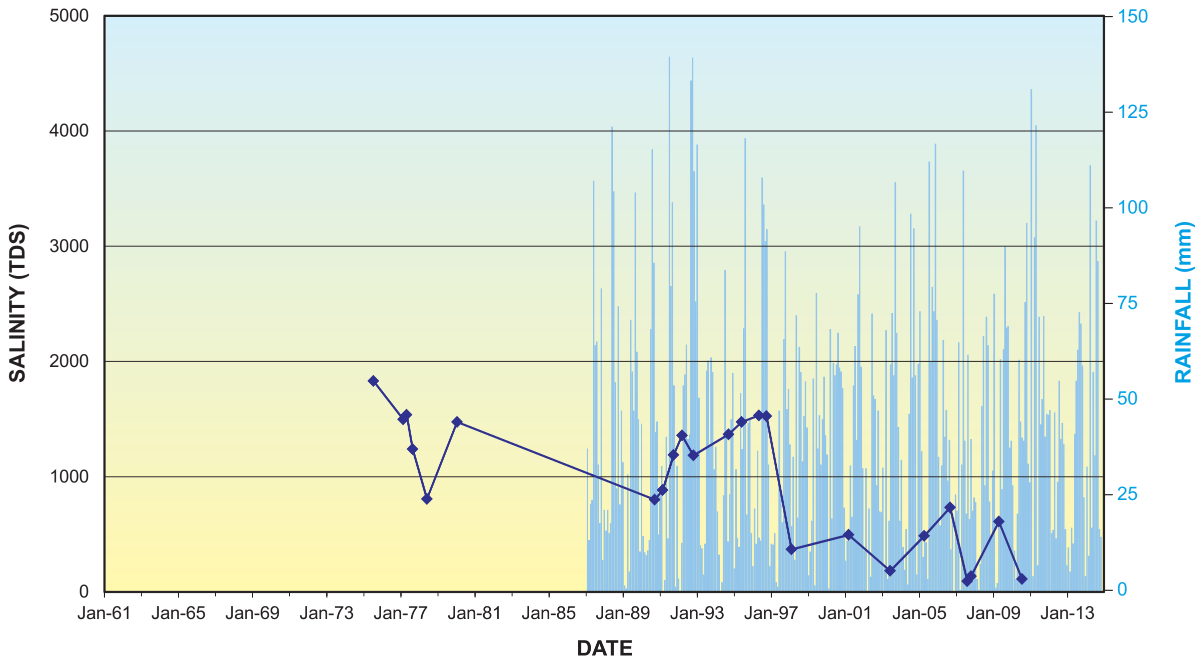
Observation Well — MOR010

DEPTH TO WATER AND SALINITY GRAPHS - 2014

MOR084 — Depth to Water



MOR084 — Salinity



Rainfall data is for Nuriootpa

WATER SEARCH *Groundwater & Geological Consultants*

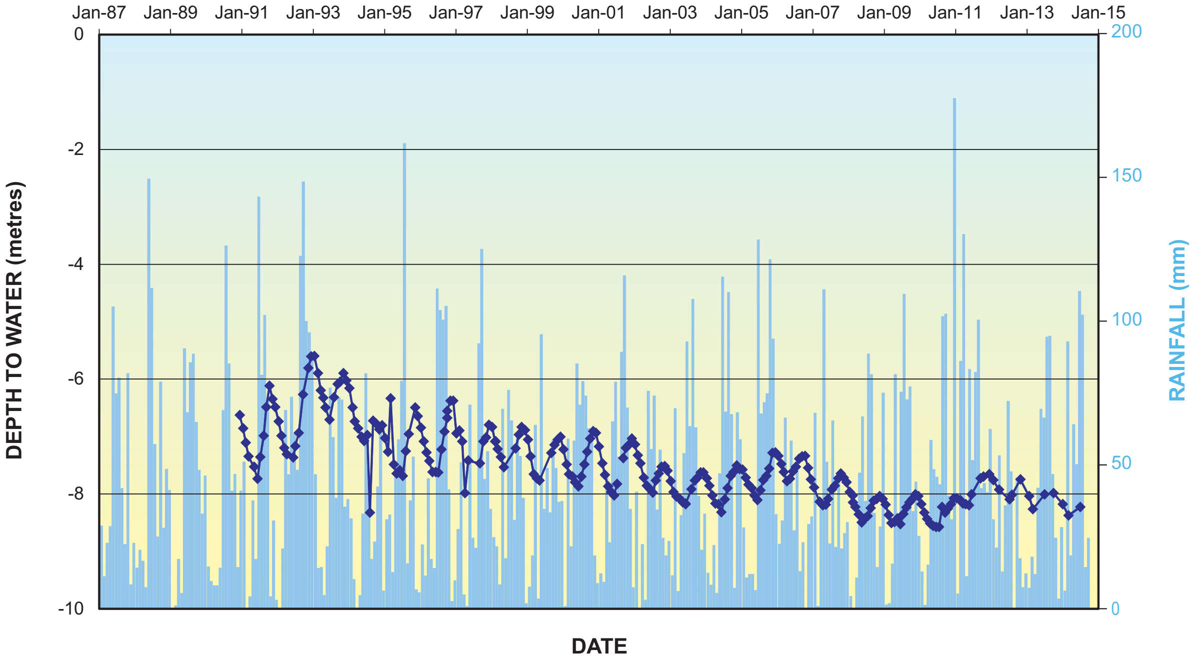
Figure 10

BAROSSA INFRASTRUCTURE LTD

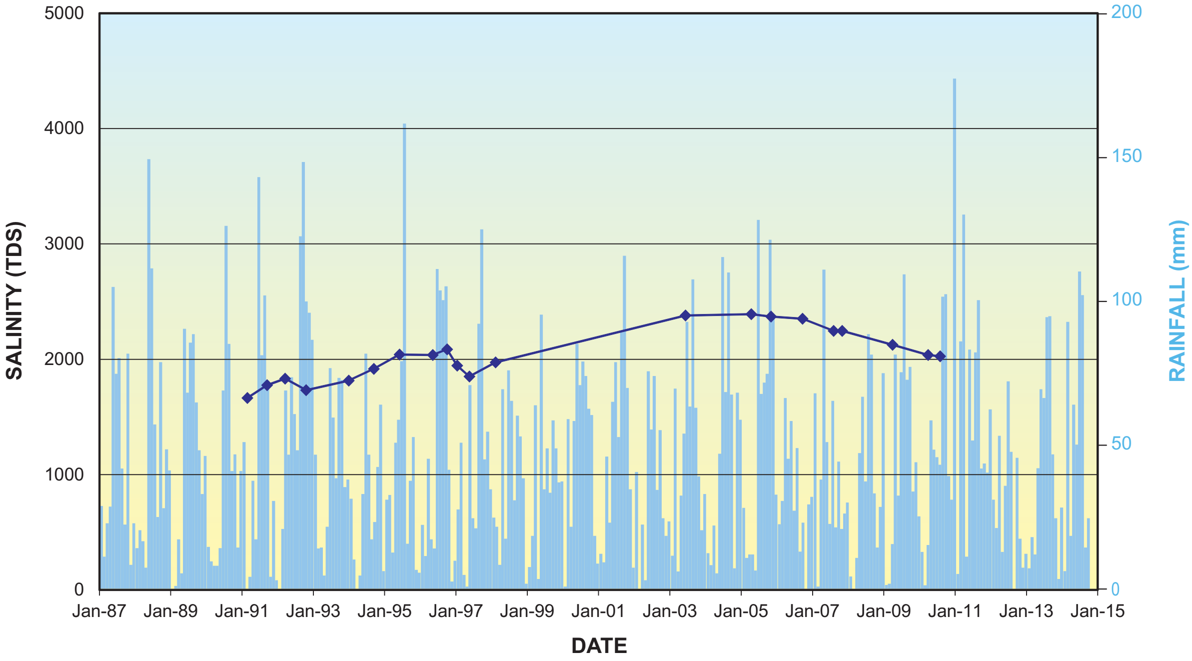
Observation Well — MOR084

DEPTH TO WATER AND SALINITY GRAPHS - 2014

MOR204 — Depth to Water



MOR204 — Salinity



Rainfall data is for Tanunda

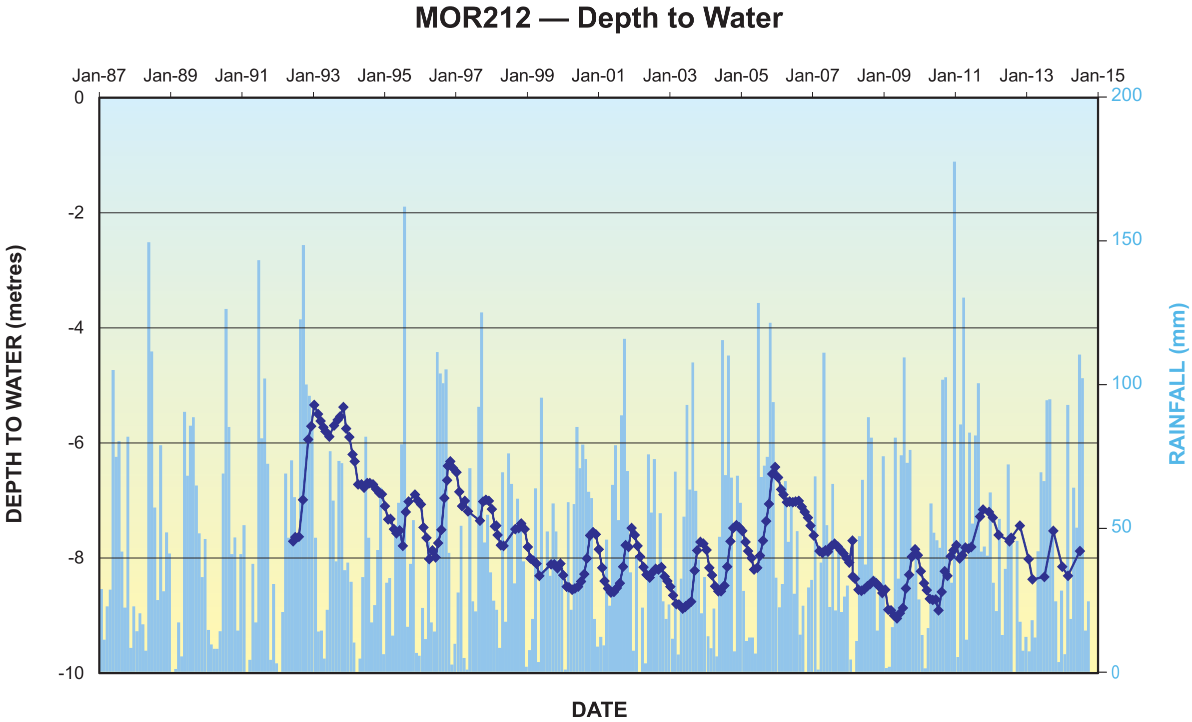
WATER SEARCH *Groundwater & Geological Consultants*

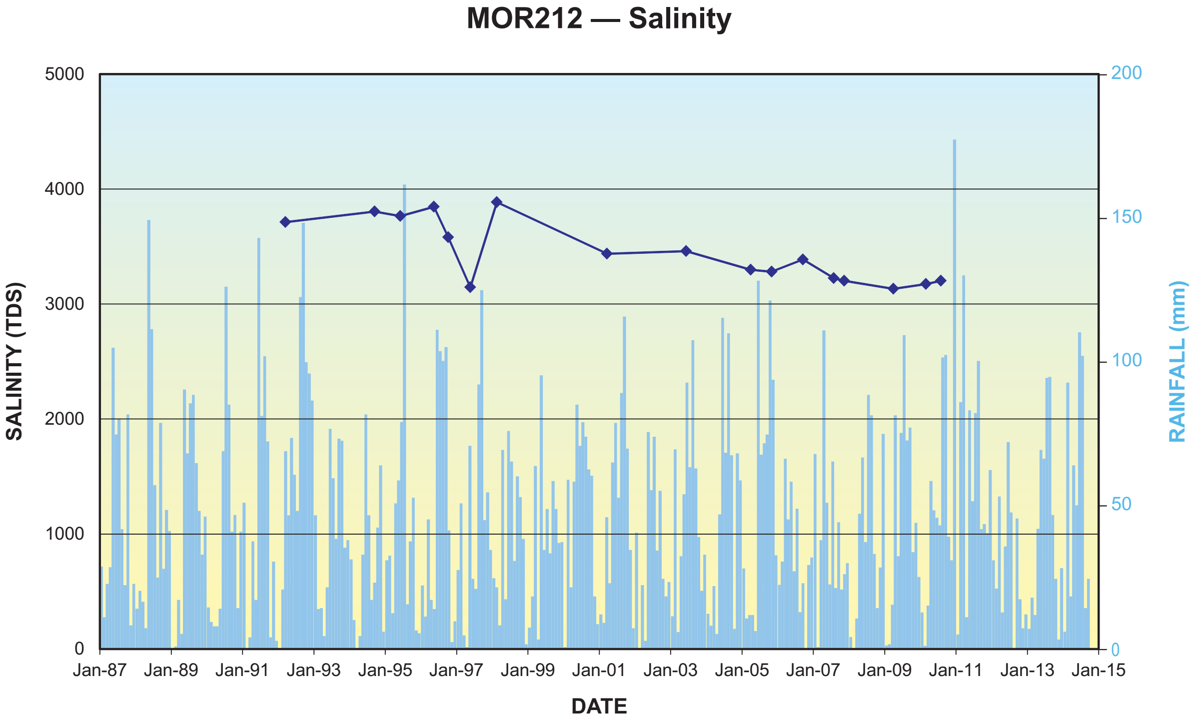
Figure 11

BAROSSA INFRASTRUCTURE LTD

Observation Well — MOR204

DEPTH TO WATER AND SALINITY GRAPHS - 2014





Rainfall data is for Nuriootpa

WATER SEARCH Groundwater & Geological Consultants

Figure 12

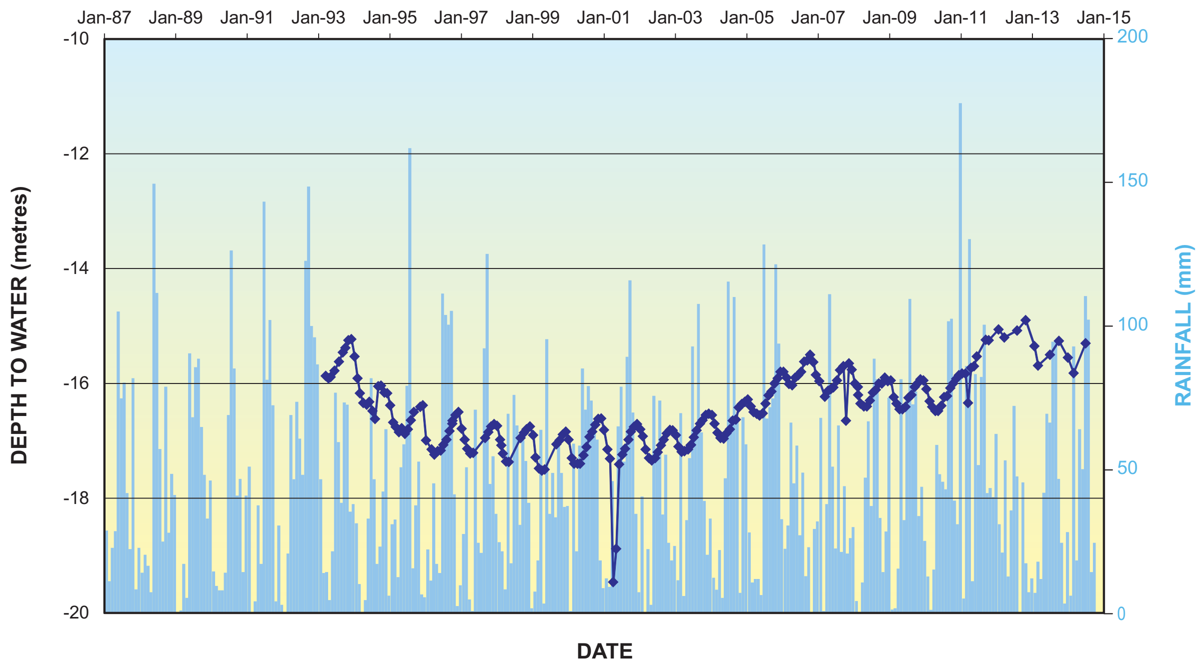
BAROSSA INFRASTRUCTURE LTD

Observation Well — MOR212

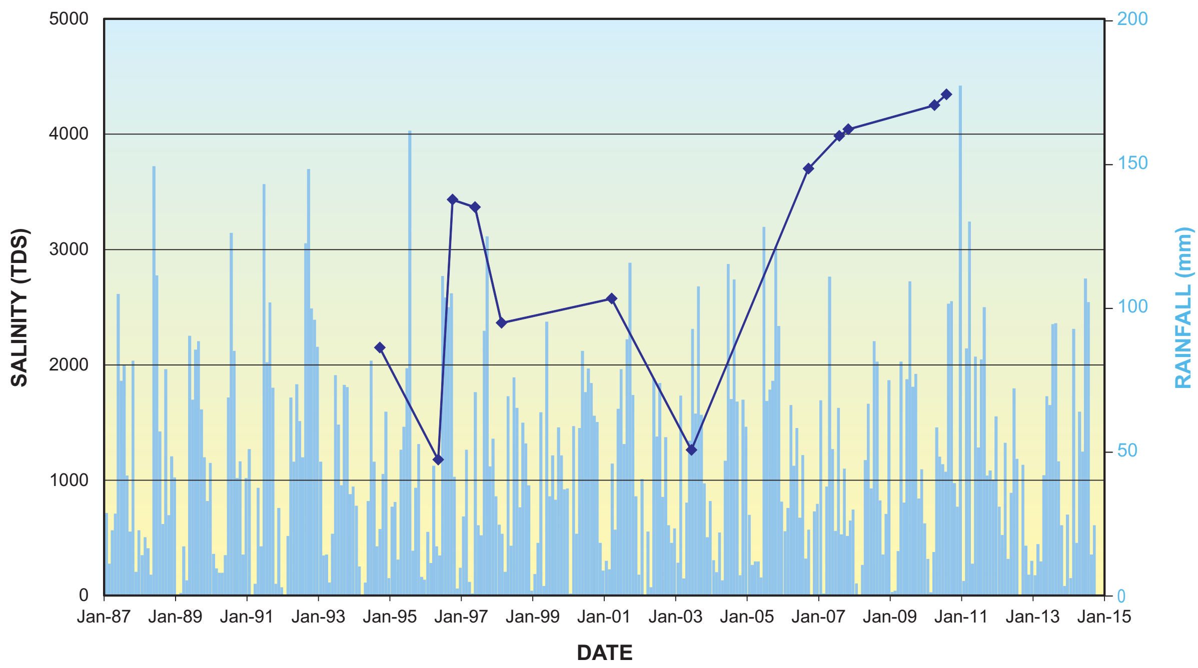
DEPTH TO WATER AND SALINITY GRAPHS - 2014

686-3418

MOR213 — Depth to Water



MOR213 — Salinity



Rainfall data is for Tanunda

WATER SEARCH *Groundwater & Geological Consultants*

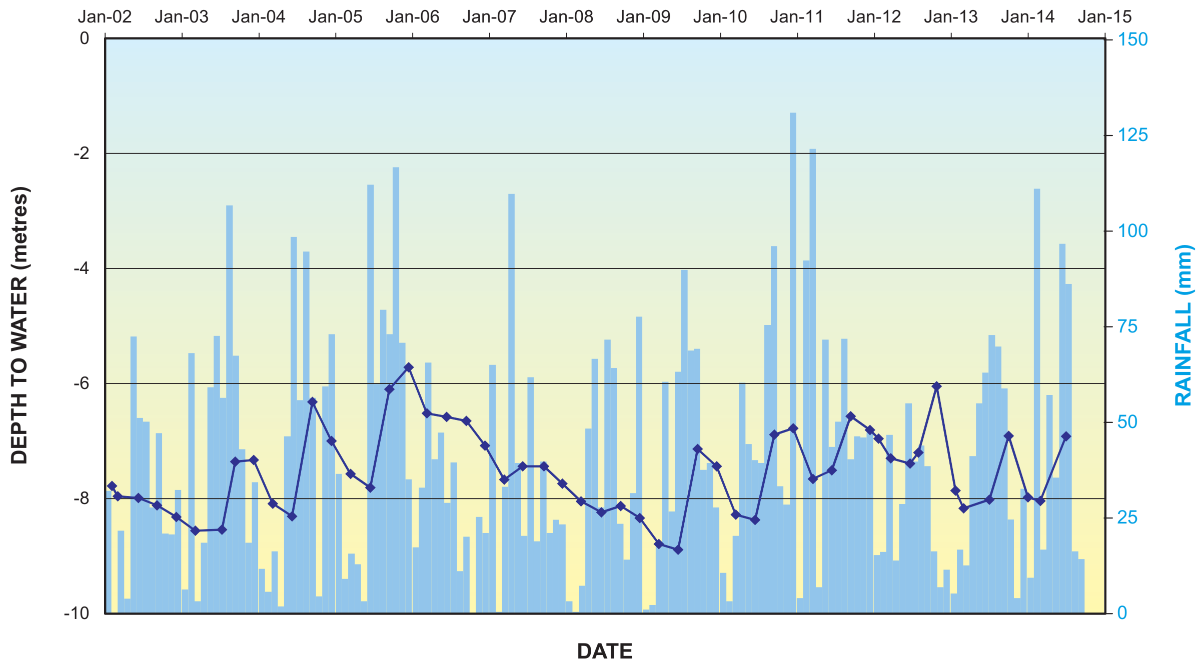
Figure 13

BAROSSA INFRASTRUCTURE LTD

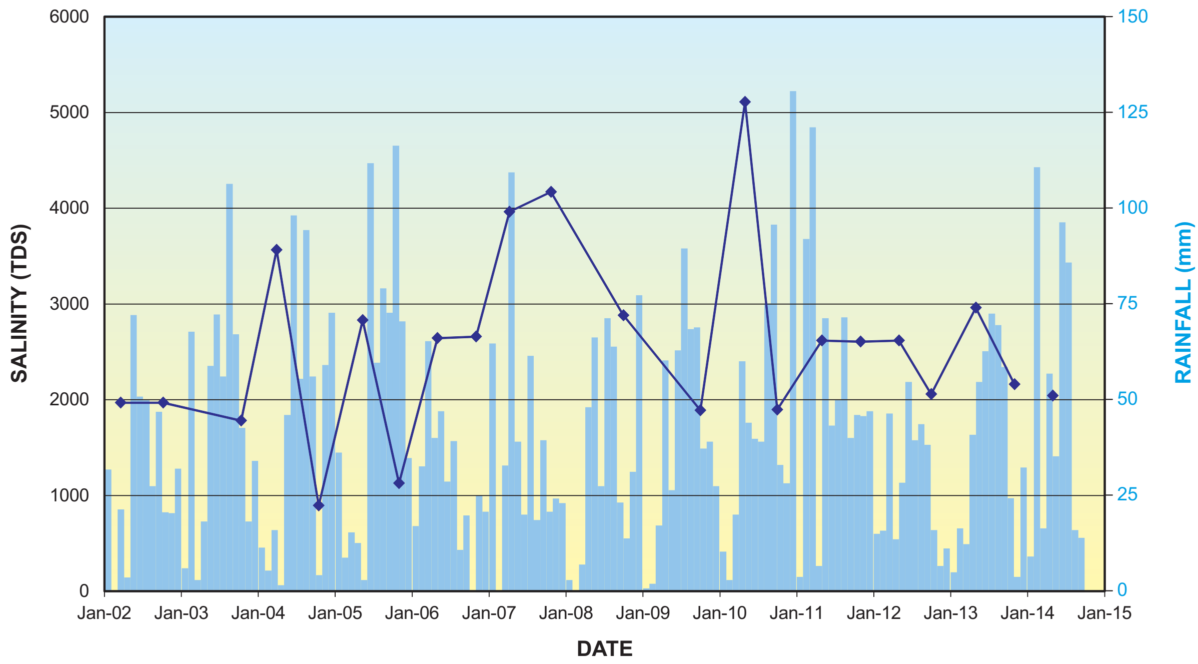
Observation Well — MOR213

DEPTH TO WATER AND SALINITY GRAPHS - 2014

MOR273 — Depth to Water



MOR273 — Salinity



Rainfall data is for Nuriootpa

WATER SEARCH *Groundwater & Geological Consultants*

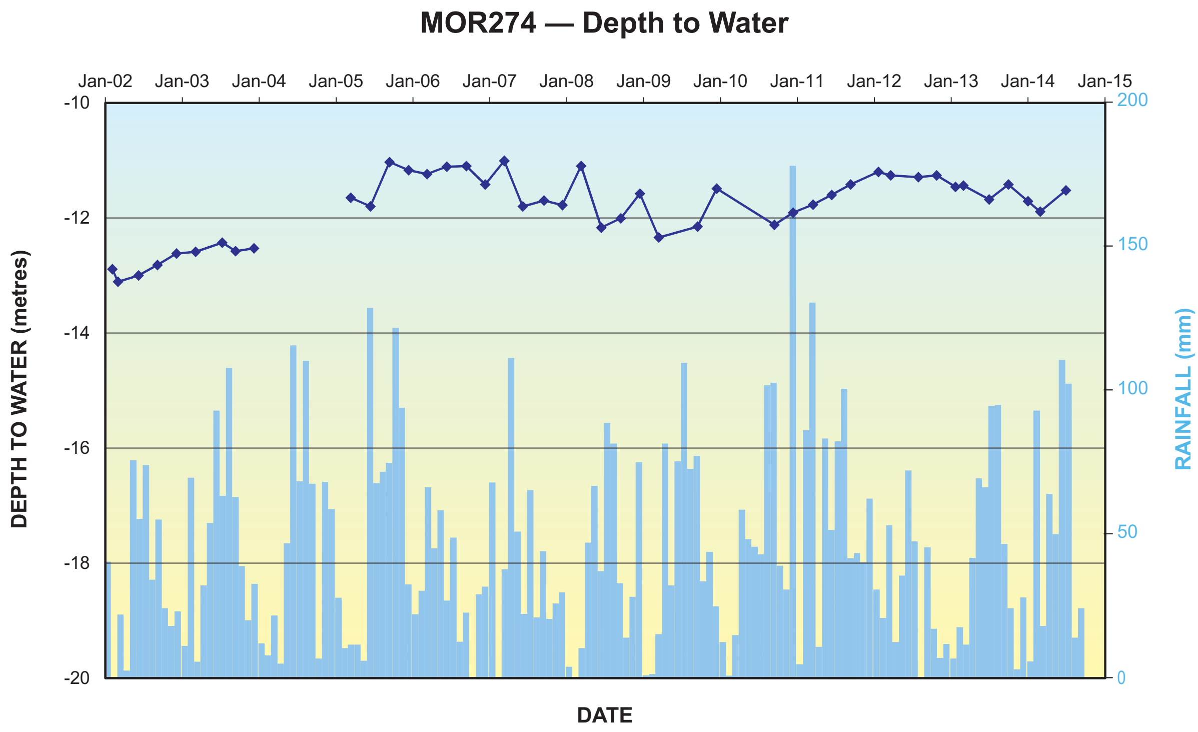
Figure 14

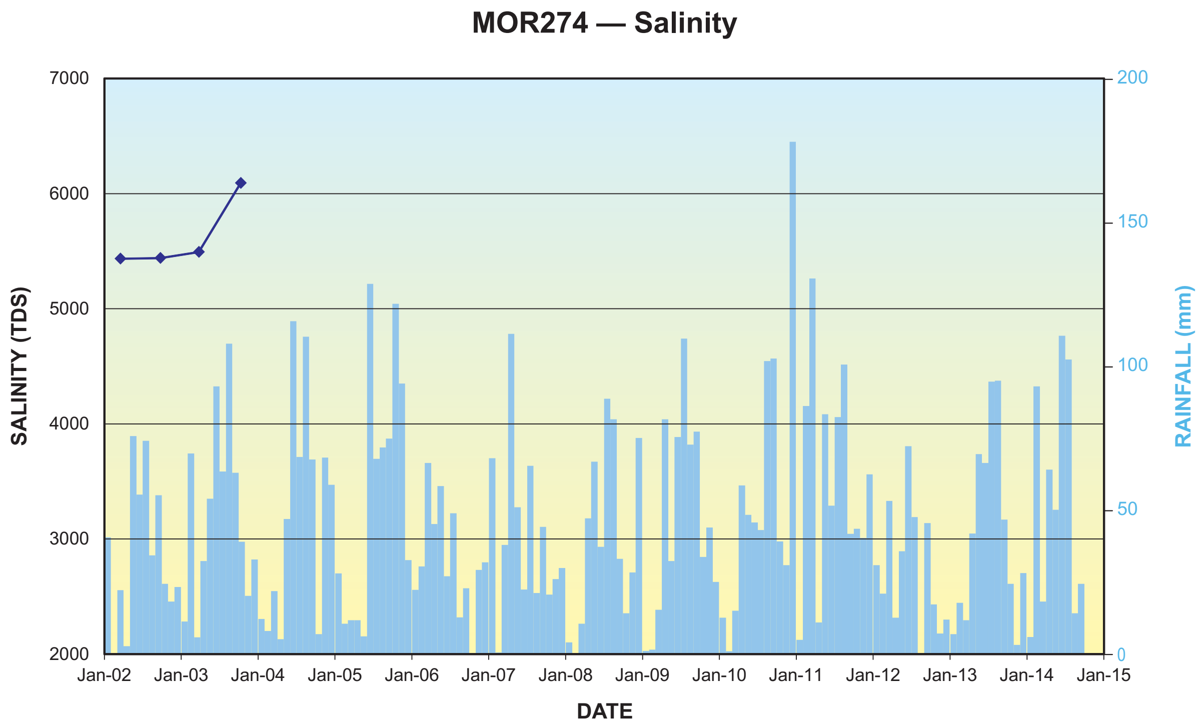
BAROSSA INFRASTRUCTURE LTD

Observation Well — MOR273

DEPTH TO WATER AND SALINITY GRAPHS - 2014

686-3420





Rainfall data is for Tanunda

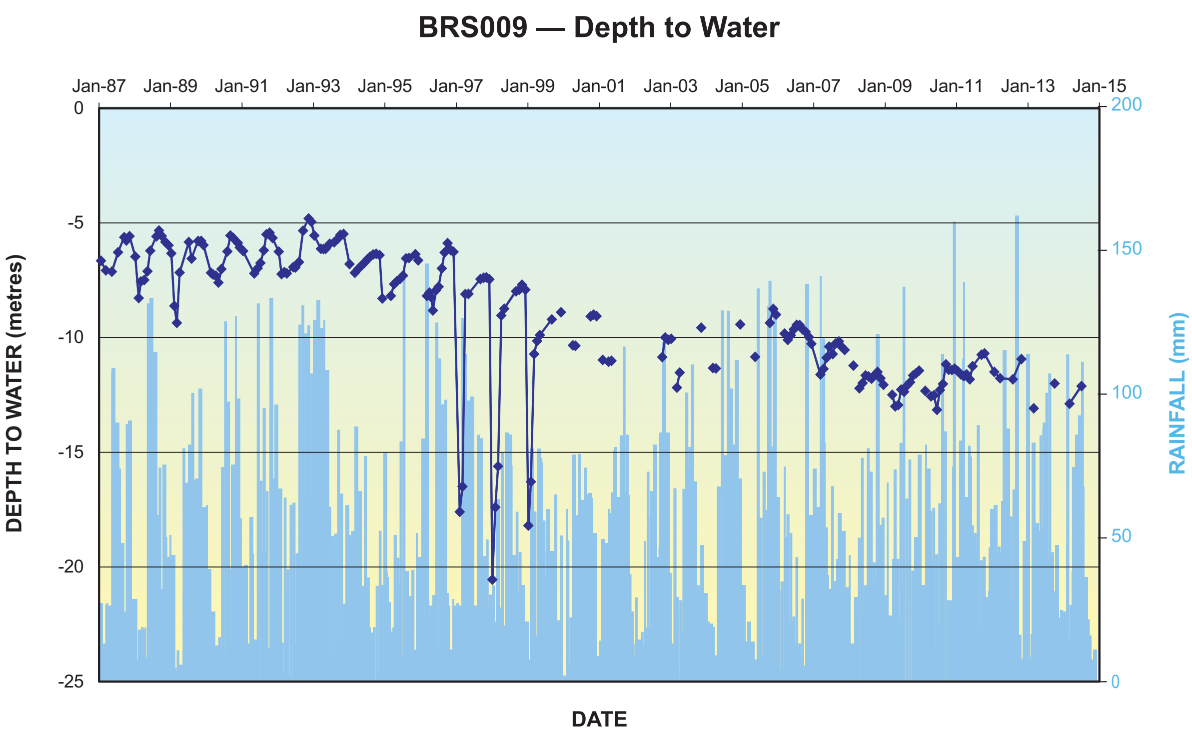
WATER SEARCH *Groundwater & Geological Consultants*

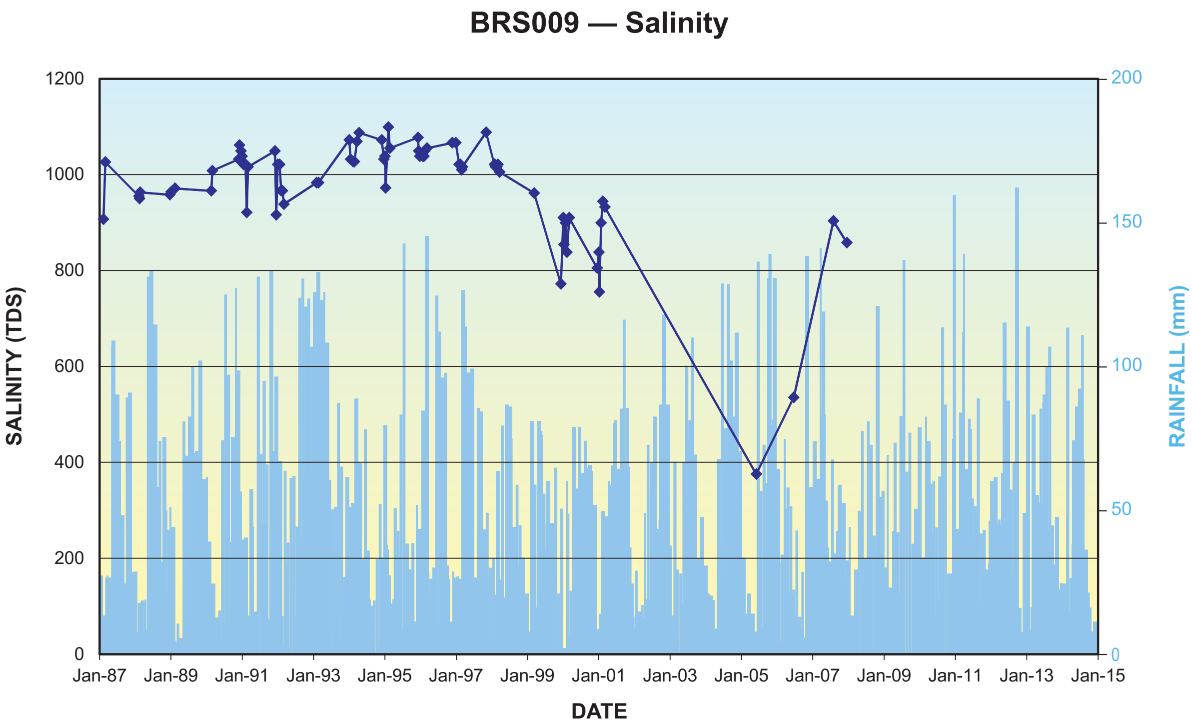
Figure 15

BAROSSA INFRASTRUCTURE LTD

Observation Well — MOR274

DEPTH TO WATER AND SALINITY GRAPHS - 2014





Rainfall data is for Lyndoch

WATER SEARCH *Groundwater & Geological Consultants*

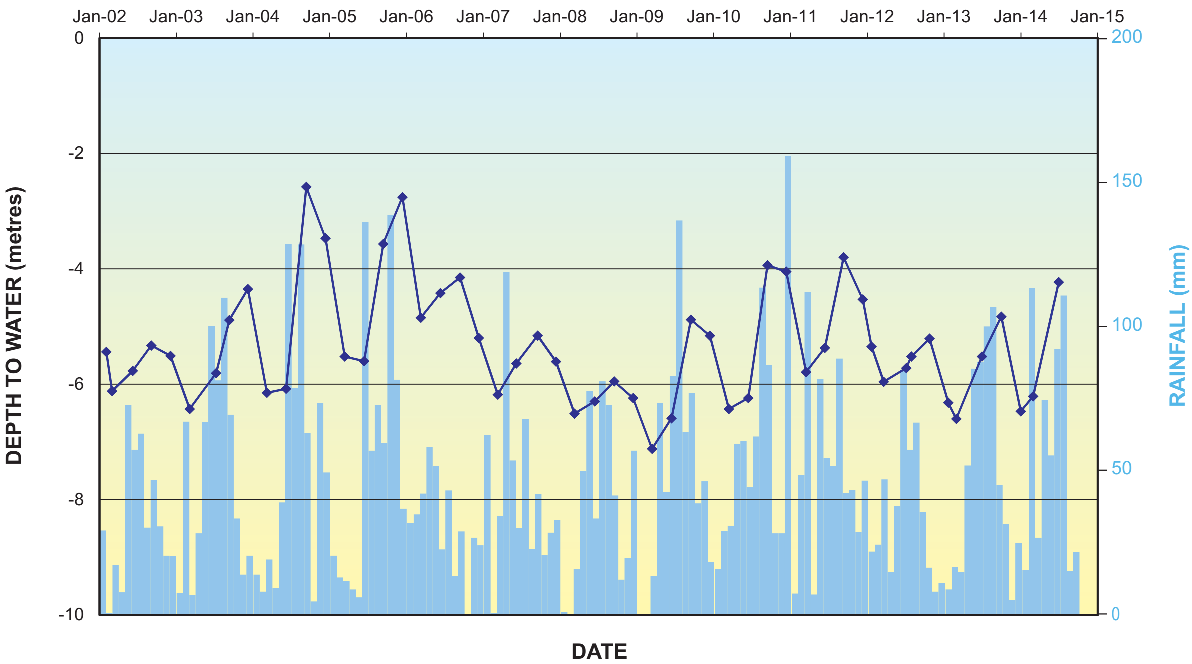
Figure 16

BAROSSA INFRASTRUCTURE LTD

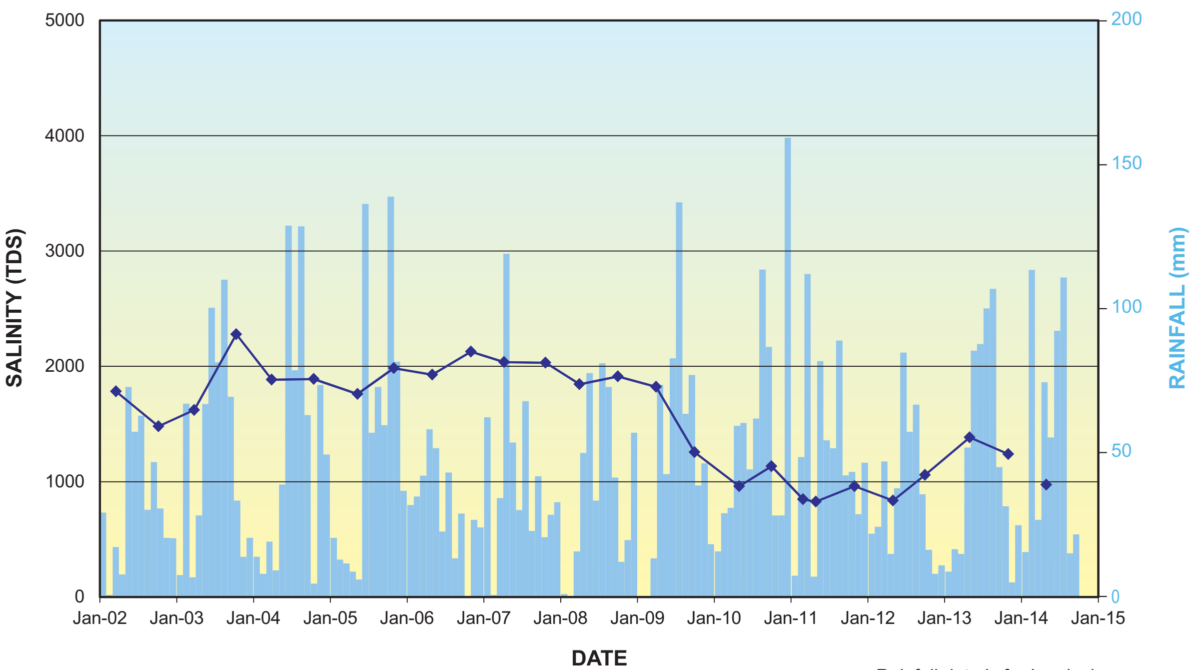
Observation Well — BRS009

DEPTH TO WATER AND SALINITY GRAPHS - 2014

BRS022 — Depth to Water



BRS022 — Salinity



Rainfall data is for Lyndoch

WATER SEARCH *Groundwater & Geological Consultants*

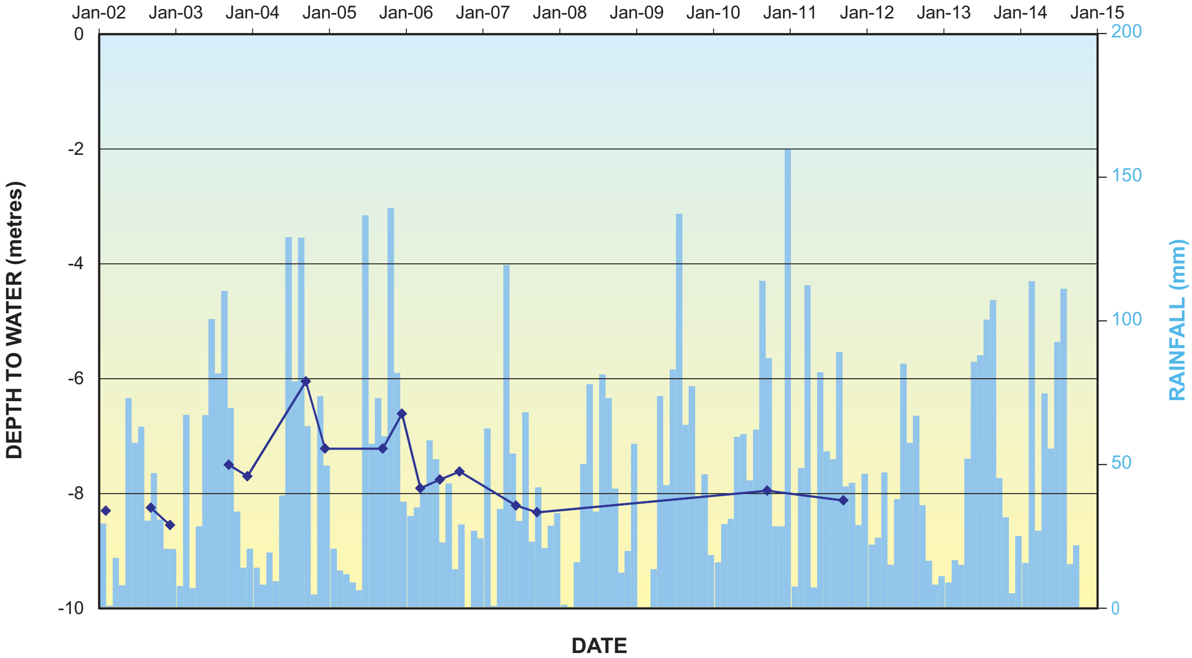
Figure 17

BAROSSA INFRASTRUCTURE LTD

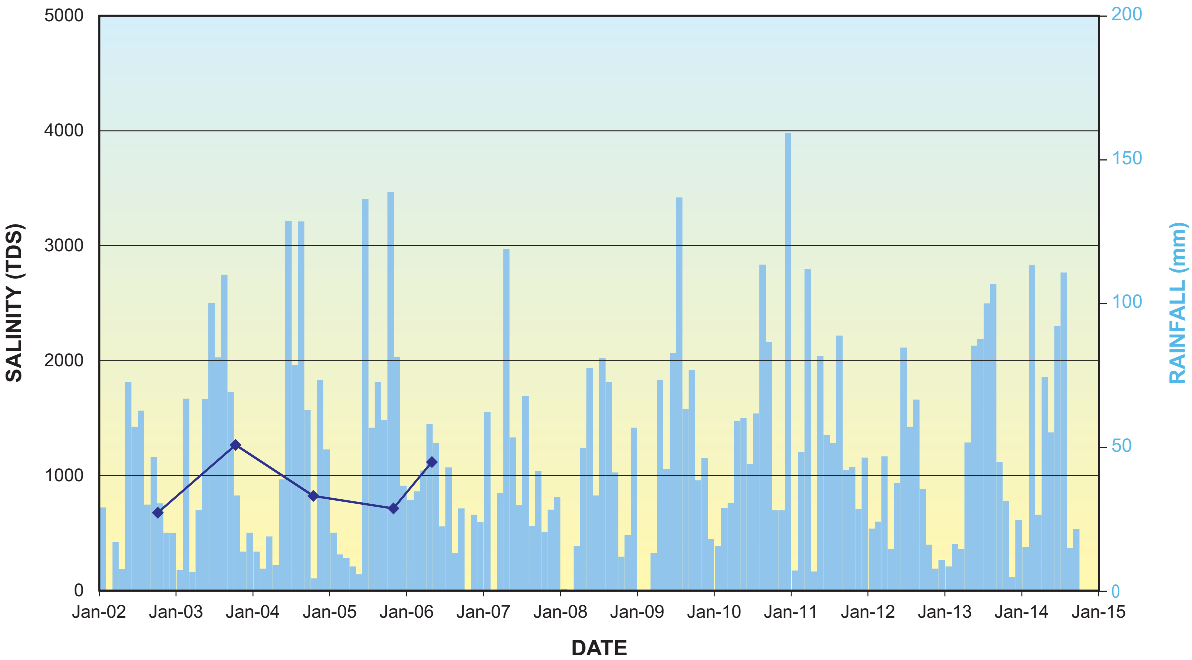
Observation Well — BRS022

DEPTH TO WATER AND SALINITY GRAPHS - 2014

BRS024 — Depth to Water



BRS024 — Salinity



Rainfall data is for Lyndoch

WATER SEARCH *Groundwater & Geological Consultants*

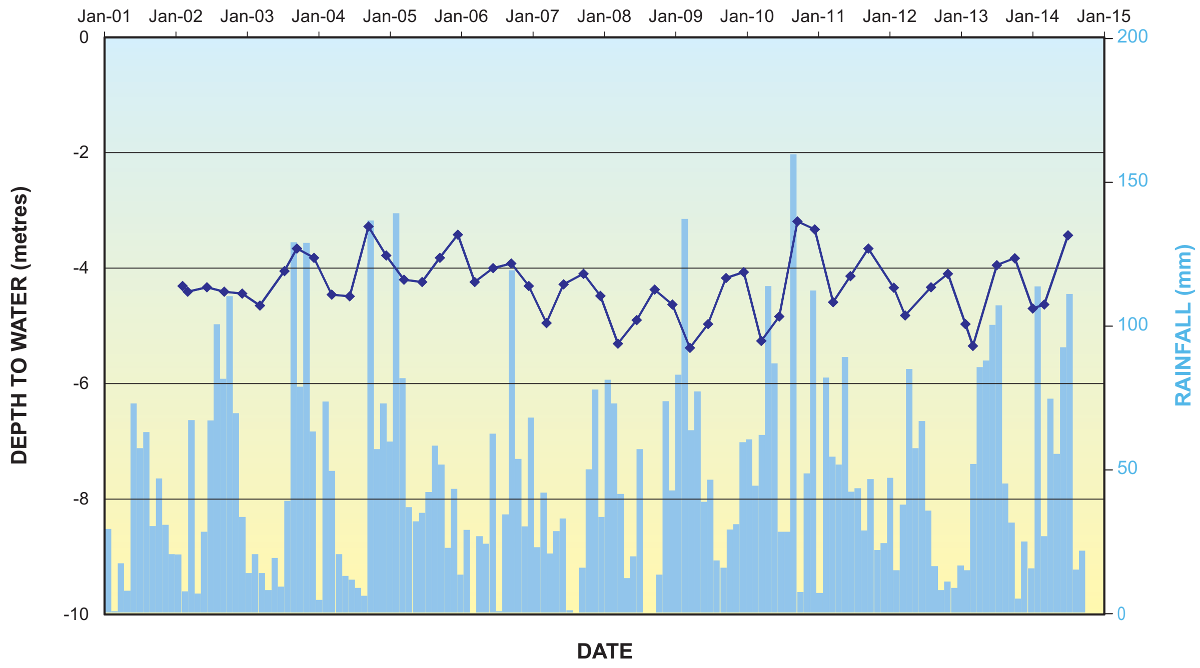
Figure 18

BAROSSA INFRASTRUCTURE LTD

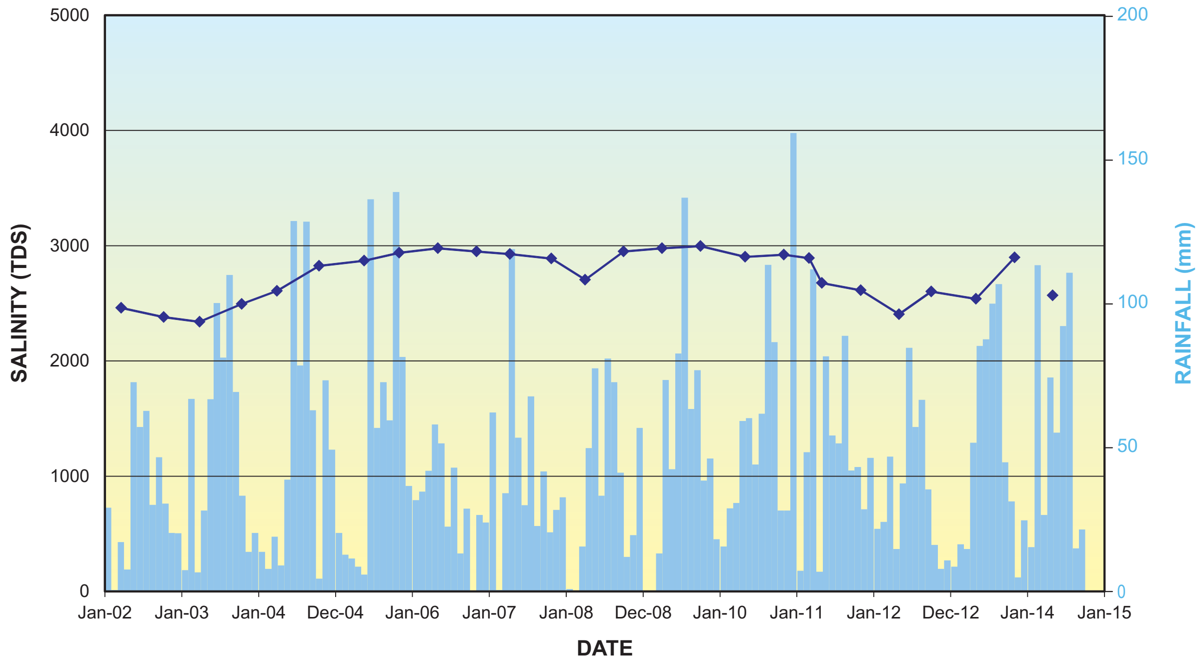
Observation Well — BRS024

DEPTH TO WATER AND SALINITY GRAPHS - 2014

BRS025 — Depth to Water



BRS025 — Salinity



Rainfall data is for Lyndoch

WATER SEARCH *Groundwater & Geological Consultants*

Figure 19

BAROSSA INFRASTRUCTURE LTD

Observation Well — BRS025

DEPTH TO WATER AND SALINITY GRAPHS - 2014

APPENDIX 2

Reclaimed water quality

Reclaimed Water Quality Data, January 2011-January 2015

Test	Jan-11	Mar-11	May-11	Nov-11	Jan-12	Mar-12	May-12	Oct-12	Jan-13	Mar-13	Apr-13	May-13	Jul-13	Aug-13	Oct-13	Dec-13	Feb-14	May-14	Nov-14	Jan-15	Units
Coliforms		91	130	290	1100	260	37	21	2000	290	190	0	1	0	24	150	1400	>2400			/100ml
Coliforms – Presumptive		91	130	290	1100	260	37	21	2000	290	190	0	1	0	24	150	1400	>2400			/100ml
E.coli		0	0	3	1	1	0	3	1	4	2	0	0	0	7	3	1	0	1	2	/100ml
E.coli/F Coliforms – Presumptive	200	0	0	5	1	1	0	3	1	4	2	0	0	0	7	3	2	0	1	2	/100ml
Faecal Coliforms	2	0	0	5	1	1	0	3	1	4	2	0	0	0	7	3	2	0	1	2	/100ml
Arsenic - Total	0.0009	0.0012	0.0011	0.0008	0.0011	0.0013	0.0011	0.0007	0.0014	0.0014	0.0006	0.0008	0.0006		0.0013	0.0013	0.0015	0.0012	0.0007	0.002	mg/L
Boron - Soluble	0.035	0.034	0.029	0.029	0.023	0.033	0.02	0.031	0.032	0.037	0.045	0.079	0.047		0.033	0.025	0.031	0.03	<0.02	0.04	mg/L
Cadmium – Total	<.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0003	mg/L
Calcium	10.9	12.8	14.6	17.8	20.5	19	19.1	17.3	17.6	19.2	19	20.7			14	13.8	13.6	15	11.8	10.9	mg/L
Chromium – Total	0.0034	0.0021	0.0028	0.0019	0.0017	0.0044	0.0013	0.002	0.0036	0.0031	0.0018	<0.0001			0.0022	0.0021	0.003	0.0032	0.0018	0.0031	mg/L
Iron - Total	3.804	3.127	3.669	2.303	2.791	4.654	2.073	1.644	3.361	3.026	1.839	0.0401	0.0026		1.685	2.325	3.351	3.087	1.707	3.763	mg/L
Lead – Total	0.0028	0.0028	0.0039	0.0029	0.0031	0.0028	0.0018	0.0034	0.0022	0.0028	0.0022	0.0004	0.0003		0.0014	0.0021	0.0037	0.0024	0.0027	0.0024	mg/L
Magnesium	10	10	0.04	16.7	17.7	15.9	13.9	14.1	13.8	11.4	12.1	10.8			12	11.2	10.2	10.3	9.5	8.95	mg/L
Manganese - Total	0.0877	0.0624	0.0303	0.0577	0.0658	0.0512	0.0243	0.0357	0.0479	0.0929	0.0411	0.0003	0.0015		0.0431	0.0403	0.0465	0.0383	0.058	0.0559	mg/L
Potassium	3.21	3.56	3.57	3.99	4.06	4.82	6.24	4.32	4.99	5.45	6.08	6.69			3.35	3.8	4	4.25	3.52	3.14	mg/L
Sodium Absorbtion Ratio																				2.69	
Sodium	51.4	51.8	59.6	90.6	97.8	78.1	68.6	74.4	68.4	57.1	59.1	60.7			71.3	65.3	57.2	59.4	56.7	49.5	mg/L
Sulphate	13.5	12.9	15	19.5	19.8	18.6	16.8	17.7	17.1	16.2	18	38.4	42.2	48.9	18	16.8	15	16.2	14.4	14.1	mg/L
Total Hardness as $CaCO_3$																			69	64	mg/L
Zinc – Total	0.0084	0.0059	0.0124	0.0133	0.0064	0.0071	0.0051	0.0342	0.0055	0.0067	0.0122	0.0061	0.0039		0.0079	0.0085	0.014	0.0078	0.0134	0.0152	mg/L
Ammonia as N	0.01	0.017	0.006	0.016	0.006	0.022	0.018	0.017	0.008	0.028	0.015	0.494	0.32	0.27							mg/L
Chloride	101	105	115	170	189	141	128	150	121	89	86	66	88	113	124	111	90	96	100	90	mg/L
Nitrate + Nitrite as N	0.313	0.312	0.28	0.193	0.225	0.2	0.271	0.145	0.036	0.176	0.166	0.086		0.66	0.2	0.212		0.319	0.216		mg/L
Nitrate as Nitrogen													1.03	0.05	1.54	1.37	0.091	1.03	1.42	0.176	mg/L
Total Nitrogen													0.192	0.006			1.27			1.37	mg/L
Phosphorus – Total	0.126	0.139	0.125	0.099	0.11	0.106	0.099	0.037	0.304	0.129	0.1	0.015	0.014		0.077	0.09	0.138	0.111	0.108	0.033	mg/L
Atrazine															<.5				<0.5		μg/L
Azinphos-methyl															<.5				<0.5		μg/L
Diazinon															<.5				<0.5		μg/L
Fenitrothion															<.5				<0.5		μg/L
Hexazinone															<.5				<0.5		μg/L
Malathion															<.5				<0.5		μg/L
Parathion															<.5				<0.5		μg/L
Parathion Methyl															<.5				<0.3		μg/L
Prometryne															<.5				<0.5		μg/L

Simazine															<.5				<0.5		µg/L
Trihalomethanes	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	10									µg/L
Alkalinity as calcium carbonate	32	39	42	47	50	66	70	60	67	91	95	102			47		54	63			mg/L
Alkalinity as bicarbonate	39	48	51	58	61	80	85	73	82	112	116	124	108	99	57		66	77			mg/L
Conductivity	422	432	483	705	746	634	589	640	554	490	505	495			535	498	431	449	437	423	µScm
Total Dissolved Solids ppm	230	240	270	390	410	350	320	350	300	270	280	270	320	350	290	270	240	250	240	230	mg/L
pH	7.2	7.4	7.4	7.1	7.5	7.5	7.8	7.7	7.8	7.3	7.9	8.2	8.3	8.3	7.3	7.4	7.7	7.5		7.5	
Turbidity	37	39	30	25	33	64	49	22	41	63	47	1.2	0.14	0.2	20	31	58	55	31	52	NTU

Test	**Jan-11**	**Mar-11**	**May-11**	**Nov-11**	**Jan-12**	**Mar-12**	**May-12**	**Oct-12**	**Jan-13**	**Mar-13**	**Apr-13**	**May-13**	**Jul-13**	**Aug-13**	**Oct-13**	**Dec-13**	**Feb-14**	**May-14**	**Nov-14**	**Jan-15**	**Units**
Total Dissolved Solids ppm	230	240	270	390	410	350	320	350	300	270	280	270	320	350	290	270	240	250	240	230	mg/L
pH	7.2	7.4	7.4	7.1	7.5	7.5	7.8	7.7	7.8	7.3	7.9	8.2	8.3	8.3	7.3	7.4	7.7	7.5	7.5	7.5	