BARROSSA INFRASTRUCTURE LIMITED

BAROSSA PIPELINE PROJECT

ENVIRONMENTAL ASSESSMENT

Eco Management Services Pty Ltd
October 2001

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ENVIRONMENTAL ASSESSMENT

prepared for

Barossa Infrastructure Ltd

by

Eco Management Services Pty Ltd

in association with

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and
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SUMMARY

An environmental assessment has been undertaken of the proposal by Barossa Infrastructure Ltd (BIL) to transfer 7000 ML/annum of Warren Reservoir-River Murray Water for supplementary viticulture irrigation. It is predicted that the transfer will amount to 5000 ML/a in 2001/02, and up to 7000 ML/a by 2006/07. It is also predicted that most of the growth in the water transferred will be directed to the Gomersal-Rosedale-Sheoak Log area.

(i) Key Issues Addressed

The key issues that have been addressed are:

- The potential for the use of BIL water to result in a rise in regional water tables.
- The effects on the salt budget and the potential for increases in the salt load entering surface drainage as base flow.
- The potential for the creation of perched water tables, with adverse effects on plant growth and for migration off-site.
- The effects of any changes in salinity and chlorine residuals on ecosystems and the implications of interbasin transfer of water.

(ii) Summary of Findings

The findings of the investigations undertaken to date, in relation to these issues are as follows:

(1) Water Budget and Effects on Regional Water Tables

Poor management in the form of excessive overwatering may allow seepage past the root zone, and depending on the soil type this could lead to increased accession to the regional water table. However, with efficient irrigation management, with little or no water escaping past the root zone, then the evapotranspiration component of the water budget will increase to compensate for the imported water.

It is unlikely with the low application rate proposed (70-100 mm) in summer, that there will be any significant net increase in vertical seepage to the water table. Consequently there will be no change in regional water tables, apart from the naturally occurring seasonal variations. This investigation has assumed a 100mm application rate, which is at the upper end of the range.

(2) The Effects on the Salt Budget

The imported Warren Reservoir-River Murray water has a predicted TDS range of 93mg/L to 568 mg/L with an average of 304 mg/L. Assuming an upper limit of 568 mg/L TDS, it is almost one third of the average salinity of groundwater currently used for irrigation. At the average TDS of 304 mg/L it is one fifth of the average salinity of groundwater used for irrigation.

Salt in irrigation water will eventually reach the regional water table as a result of above average winter rainfall recharge, and eventually discharges in base flows in the catchment streams, in the same way as the natural saline groundwater currently discharges. Most of the North Para system below Nuriootpa is a groundwater discharge zone.

The effects of the BIL water are variable from area to area depending on whether the imported water is for new irrigation, and the extent to which it will be replacement of current saline groundwater usage. Comments on the Barossa Valley floor, Lyndoch Valley and Greenock Creek areas are as follows:

(a) Barossa Valley Floor

Approximately 1800 ML of the initial 5000 ML will be used in this area. It is unclear at this stage as to the exact extent this will be replacement water. However, for applications in the Vine Vale-Bethany area (areas with soil types with the potential for perched water tables), approximately 66% will be replacement water. Consequently there will be a net reduction in salt load. Each megalitre of groundwater replaced by imported water results in an average reduction of one tonne of salt reaching the land surface. It is likely that only a relatively small proportion of the future water importation would be used in this area.

(b) Lyndoch Valley Area

Approximately 530 ML of the initial 5000 ML has been applied for (Rosedale-Lyndoch Valley). For that part of the valley with a soil type where a perched water table can occur, approximately 52% will be replacement water. Consequently there will also be a net reduction salt load. It is also unlikely that significant future increases will occur in this area.

(c) Greenock Creek Area

Approximately 3100 ML of the initial 5000 ML has been applied for. Little groundwater is used in this area and the BIL water will provide a reliable good quality supply in dry periods. It is in this area that the majority of future increases in importation of water can be expected. The salt in the irrigation water will eventually be removed in local creek base flows, as does the natural saline groundwater. There may be a relatively small increase in salinity levels in the base flows.

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. Assuming a conservative 50% replacement of groundwater use for the Barossa Valley floor and Lyndoch Valley then, as indicated above, these two areas would show a reduction of salt accession for the historical range of groundwater use. There will be a net increase in the Greenock Creek region.

It is important to bear in mind the rate of groundwater flow at the water table. For the current gradient on the water table under the central valley floor these velocities are of

the order of one metre per year. In areas of higher material permeability higher velocities will result and conversely lower velocities with lower permeability materials. However, considering the nature of the materials in the upper water table zone in most of the catchment the above is an acceptable indicative value.

(3) Potential for Perched Water Tables

Based on detailed CSIRO soil data, ten general soil classifications were identified for the study area. Of these three were identified as having the potential for developing a perched water table, if excessive water is applied during irrigation. These soils are the sand over clay group, sand over clay and transitional red-brown earth group and the alluvial soils. These mostly occur in the Barossa Valley floor.

Because of the low average application rate of 100mm, it is very unlikely with efficient irrigation management that irrigation water will move significantly below the root zone. This is the most important management objective. Excess water may cause waterlogging, which may result in adverse effects on vegetation and crop yield and quality. <u>This in fact is a powerful management incentive for growers</u>.

There is no area which cannot be effectively managed. All BIL customers will be required to prepare irrigation management plans and annual returns.

(4) Effects on Ecosystems

An examination has been made of the potential effects on remnant native vegetation in the region and aquatic faunal communities.

It is concluded that:

(a) Native Vegetation

There will be no effects on remnant native vegetation, as a result of the following:

- If perched water tables do occur, they would be below irrigation areas and not native vegetation, most of which is well removed from irrigation areas, on ridge tops, or upslope. In any case, sufficient unsaturated topsoil would exist above any perched water table for native plants to survive.
- The remnant native vegetation species present are generally tolerant of salinity, especially the dominant tree species which have a moderate to high tolerance.
- Existing native watercourse vegetation:
  - is tolerant to even greater salinity levels, in excess of 5000mg/L, than those currently occurring in the watercourses, and
  - is adapted to seasonal waterlogging and drying out.

Lateral movement of soil water is so slow that it is unlikely to reach adjacent native vegetation before it evaporates.

(b) Aquatic Fauna

There will be no adverse impacts on aquatic fauna in the watercourses. These watercourses experience seasonal high salinities (summer – low flow) as a result of natural saline groundwater discharge. In the Barossa Valley floor and Lyndoch Valley areas the partial replacement of saline water will reduce salt loads. In the Greenock Creek area where there are new irrigation areas, there may in the very long term be an increase in salinity in the small ephemeral watercourses. Again this is very long term and is likely to be a minor variation compared to the naturally occurring range.

Because of the intention to continue to use the Warren Reservoir and irrigate directly, chlorine residuals in River Murray piped water are not an issue for aquatic ecosystems. For the same reason, there is unlikely to be an increased risk of species transfer from the River Murray to the North Para system.

(iii) Monitoring

A network of 14 shallow monitoring wells have been located in the soil associations which have the potential for perched water table formation. These wells have been drilled and completed.

These will provide a strategic early warning of any potential problem developing, providing the opportunity for corrective action to be taken to prevent any adverse effects.

It is proposed that initially these be monitored monthly (water level and salinity). The frequency of ongoing monitoring would be reviewed each year.

Depending upon the specific locations of future requests for imported water, additional monitoring wells may be required. This should be regularly reviewed.

(iv) Corrective Action

In the event that monitoring indicates a problem developing, corrective action will be taken. The selection of appropriate corrective actions will depend on the nature and extent, if any, of adverse effects. Actions could include the need to reduce the quantum or rate of water transported to one or a group of customers, to require one or a group of customers to better manage their irrigation, or to require one or a group of customers to implement groundwater drainage works. The evidence and information gathered to date indicate that adverse effects can be prevented by efficient irrigation management and this is where effort will be focussed.

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.

(v) Recommendations

As indicated above, with efficient irrigation, particularly with the low application rates, potential adverse effects can be minimised or avoided. To ensure that this remains the case, it is recommended that:

(a) The irrigation management plans that will be prepared by BIL customers, be reviewed by the appropriate water management authority.

It is proposed that each of the customers be required to monitor their own activities and provide annual returns. It is also proposed that customers use a soil moisture monitoring device, which can be quite simple and relatively inexpensive.

(b) Monitoring of the network of shallow wells established by BIL be undertaken by the Department for Water Resources, as part of their broader monitoring within the valley.

(c) A new surface monitoring site be established within the Greenock Creek catchment area.

(d) That the water management authorities liaise with BIL via its Board to determine the need and implementation strategy for any changes to monitoring or water use to ensure long term sustainability.

1.0 INTRODUCTION

Barossa Infrastructure Limited (BIL) propose to import 7000 ML of Warren Reservoir-River Murray water into the Barossa Valley for supplementary viticulture irrigation. It is predicted that the transfer will amount to approximately 5000 ML/a in 2001/02 and up to 7000 ML/a by 2006/07. Existing water supplies have been identified as inadequate to sustain market position in the wine industry. This is due to either inferior quality, i.e. using saline groundwater, or the annual variation in surface water volume.

It is important to appreciate that currently many growers are using relatively high salinity groundwater for irrigation and there is a negative correlation between both yield and quality with increasing salinities. It is obviously desirable that a low salinity water resource be available on a reliable basis. In addition the mining of deep aquifer saline groundwater also leads to the importation of salt to the surface soils. It is also obviously desirable that as far as practical this saline water be replaced with low salinity water to achieve a net reduction in salt load.

BIL has been formed by the Barossa growers to provide a reliable and quality supplementary irrigation system. Overall, a major objective of the project is to provide a water supply which can replace the existing saline groundwater, and when applied in environmentally and viticulturally appropriate quantities can also help to sustain yields and quality through dry periods.

As part of the development of the project, BIL through Arup Stokes the Engineering Designer, have commissioned Eco Management Services Pty Ltd in collaboration with Water Search Pty Ltd and PIRSA to undertake an environmental assessment of the project, addressing key issues outlined in Section 3.2 below.

This report summarises the results of the investigations undertaken.

2.0 BRIEF DESCRIPTION OF THE PROJECT

The delivery of River Murray water involves the following key structural elements:

(a) The use of existing SA Water Infrastructure, including:

- The Mannum/Adelaide Pipeline
- The Warren transfer main between the Mannum/Adelaide pipeline and the Warren Reservoir.
- The Warren Reservoir for storage.
- A section of the Warren trunk main from the Warren Reservoir into the Barossa Valley.

(b) Construction of the Barossa Supplementary Water Infrastructure, which will reticulate water throughout the valley for delivery to BIL customers at specified pressure and flow rates.

BIL's agreement with SA Water requires that all of the subject water be sourced from the River Murray by way of irrigation water rights held by BIL. SA Water will

transport the water to the Warren Reservoir and thence to the agreed offtake point on the Warren trunk main. The Warren transfer main, which has a present capacity of 14 ML/d, controls the rate of transfer. The continuous annual capacity of this transfer main is 5110 ML. The Warren Reservoir has a total capacity of about 5080 ML. Consequently, the present system can theoretically accommodate an annual transfer of the initial 5000 ML/a of 7000 ML even before the practical effect of run-off from the Warren catchment is considered. In practice, most of this water will be used in the Barossa between November and March each year with the Warren being filled by a combination of catchment run-off and transfers from the River Murray. This means that any surpluses of water derived from a combination of local run-off and the initial 5000 ML transfer by BIL will result in a benefit to SA Water, i.e. the arrangement enables SA Water to utilise the catchment capacity of the Warren in other parts of the SA Water system. SA Water upgrading the Warren Transfer Main can accommodate the future increase in demand from BIL to 7000 ML/a.

It should be noted that there is no compulsion for BIL's customers to take their water entitlement. In the unlikely event that seasonal conditions are such that the nominal 100mm annual application cannot be taken, either in whole or in part, then BIL's charges to the customer are reduced to reflect the reduction in BIL's costs. Whilst the customer will still be required to pay a reduced price for water not taken, this has been accepted by customers as the cost of ensuring access to water during dry periods which have previously had a significant negative impact on their revenues.

The extent of the new supplementary infrastructure is shown on Figure 2.1.

3.0 SCOPE OF THE ENVIRONMENTAL ASSESSMENT

3.1 Study Area

The general area of the Barossa Valley is shown on Figure 3.1.

The main study area, for detailed assessment is defined by the distribution of properties (BIL customers) which have applied for water. However, a wider area of the valley has been considered, particularly in relation to surface water and existing salinity patterns and trends.

3.2 Main Environmental Issues Examined

The key environmental issues examined are:

- The potential for the use of BIL water to result in a rise in regional water tables.
- The effects on the salt budget and the potential for increases in the salt load entering surface drainage as base flow.
- The potential for the creation of perched water tables, with adverse effects on plant growth and for migration off-site.
- The effects of any changes in salinity and chlorine residuals on ecosystems and the implications of interbasin transfer of water.

A pipeline route for the distribution system has been selected so as to avoid any disturbance to native vegetation. This has been separately reported, (see EMS 2000).

4.0 PHYSICAL ENVIRONMENT – REGIONAL CONTEXT

4.1 Topography

The Barossa Valley proper is a relatively flat plain about 290 metres AHD which passes into an area of subdued relief in the Tanunda-Lyndoch area. To the east lie the Angaston Hills and Barossa Ranges where elevations are greatest reaching 595 metres at the Kaiserstuhl. To the west lie the lower Greenock Hills which are a series of roughly north-south basement ridges reaching a height of 353 metres at the Greenock Trig. To the north west these hills merge with the Kapunda Hills whilst to the west-southwest lies the flat alluvial plain in the Daveyston-Sheoak Log area. The majority of the BIL project lies within the Barossa-Lyndoch Valley floor and the Greenock Hills and does not encompass the eastern ranges.

The geology and groundwater are discussed separately in Section 5.0.

4.2 Climate

The area has a typical Mediterranean climate with hot, dry summers and cool moist winters. Most rain falls between April and October with summer thunderstorms providing an erratic but sometimes significant contribution to the annual rainfall (Table 4.1). Topography influences rainfall e.g. the average annual rainfall is 503 mm at Stockwell in the north east of the valley floor increasing to 771 mm at Pewsey Vale in the eastern ranges in the upper catchment of the North Para River. Class A pan evaporation recorded at Nuriootpa averages nearly 1500 mm per year, about three times the average rainfall, with over 70% of pan evaporation recorded from October to March inclusive. The corresponding high level of evapotranspiration necessitates some level of supplementary irrigation over the summer growing period. This situation is marginally heightened to the west of the Greenock Hills e.g. Turretfield where evapotranspiration increases and average annual rainfall decreases.

Table 4.1 Average Monthly and Annual Rainfall (mm) for Selected Recording Stations

BUREAU OF MET. STATION & NO.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YR
Stockwell 023317	20	22	21	40	56	62	61	64	54	46	31	26	503
Nuriootpa 023312	20	21	22	41	58	65	64	67	56	47	31	27	519
Tanunda 023118	22	21	23	45	64	73	68	70	60	50	31	26	553
Angaston 023300	21	23	23	44	64	71	70	72	61	51	33	27	560
Pewsey Vale 023313	26	26	29	61	90	111	106	105	82	64	40	31	771

4.3 Surface Water Resources

4.3.1 Surface Hydrology

The surface water resources of the Barossa Valley proper are dominated by the North Para River and its main tributaries the Duck Ponds, Angaston, Tanunda and Jacob Creeks. A low water divide occurs in the northern third of the valley floor with drainage north of it leading to the Light River. This low watershed area is poorly drained and the low-lying areas are generally waterlogged after heavy rain. The main

drainage lines in this area are the Stockwell Creek and the St Kitts Creek. To the south Lyndoch Creek drains the ranges in the Williamstown area and runs north along the Lyndoch Valley to join the North Para River in the vicinity of the Yaldara gauging station. Runoff in the west is concentrated in the Greenock Creek catchment which drains in a southerly then westerly direction changing its name to Salt Creek on the Daveyston-Sheoak Log plain. From here it runs in a general southerly direction meeting the North Para River in the vicinity of the Turretfield Research Station.

All surface drainage is intermittent. Flow in the creeks is important as a source of recharge to the groundwater resources of the Barossa and Lyndoch Valleys. Significant losses in surface flows can be noted by visual inspection as the creeks discharge from the eastern hills and traverse both valley floors. By comparison the North Para River south of Nuriootpa in a normal year acts as a drain for shallow groundwaters. During occasional years flow is maintained in the North Para River through Tanunda whilst in years with relatively dry winters base flow is generally maintained only into early January.

4.3.2 Surface Water Salinities

Water quality with respect to salinity is flow dependent. Initial flows tend to be of poor quality because of admixture with saline springs, groundwater discharging directly into the watercourses as the water table rises and the rapid solution of surface salts accumulated over summer. As flow increases water quality improves rapidly but as flow diminishes during spring and early summer water quality gradually worsens as groundwater base flow becomes dominant.

Whilst this pattern is common to the area, the salinities of the various flow phases in each stream vary markedly reflecting the variability in incident rainfall and catchment runoff characteristics, the catchment soil types and geology and the local water table salinity. Consequently, for example, all phases of flow in Jacobs Creek have a markedly lower salinity than the main streams of the North Para River, Lyndoch Creek and particularly Greenock Creek and the other smaller western sub-catchments.

The CSIRO has recently compiled salinity data for the major South Australian catchments, including the North Para catchment, with the aim of assessing the risks of dryland salinity on water resources (Jolly *et al.* 2000).

The study tentatively revealed that salinity levels have declined in the upper reaches of the North Para (at Penrice) during the period 1977-1998. In the lower reaches of the river, salinity levels were not found to vary significantly over the period 1972-1998.

In the Jacob Creek tributary, which flows into the North Para downstream of Tanunda, a minor decreasing trend in salinity was observed over the period 1973-1997.

In general the available data indicates that salinity in the North Para catchment has not changed significantly over the past 20-30 years.

All available salinity data from continuous monitoring data, grab sample analysis and a survey specifically undertaken for this study to provide additional information, has been collated and reviewed. This review is included in Appendix 1. The salinity status of the surface watercourses is summarised in Figure 4.1, which also indicates zones of recharge and discharge for groundwater. A salinity profile along the length of the North Para River is also included in Figure 4.2.

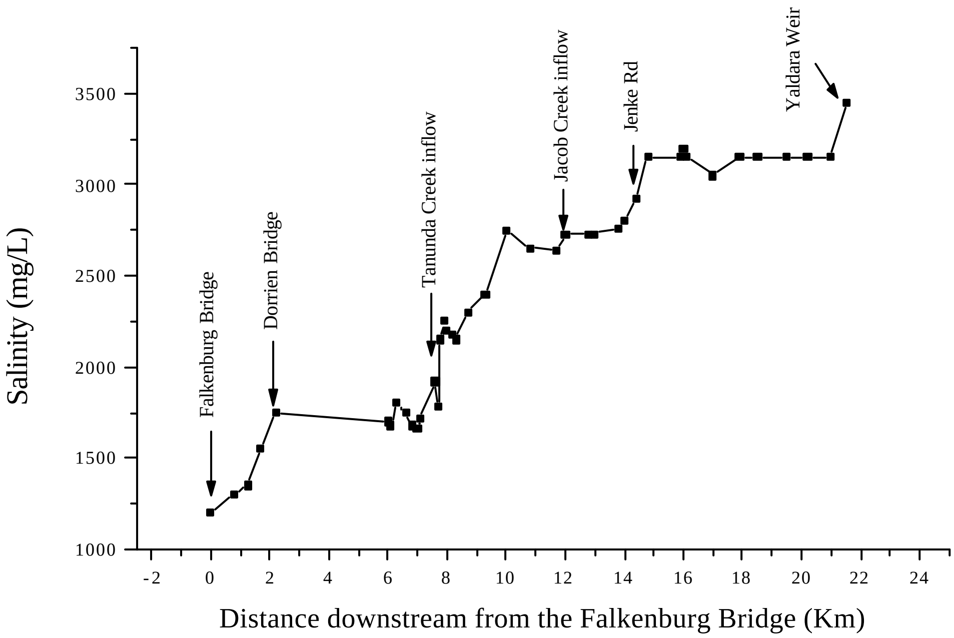

Figure 4.2

Salinity profile in the North Para River during May 1979, showing the trend in increasing salinity with distance downstream from the Falkenburg Bridge (Source: Cobb 1982)

5.0 GROUNDWATER

5.1 Regional Context

The area serviced by the BIL scheme is characterised by two distinct but interconnected environments:

- the sedimentary infill of the Barossa and Lyndoch Valleys, and
- the hard rocks surrounding and underlying these sediments.

The Barossa Valley (floor) proper is arcuate in plan with a north-south length about 25 km and an average width of 6 to 8 km. It is an asymmetric depression up to 140 metres deep adjacent its eastern boundary (Stockwell Road) and is infilled with a range of sediments from coarse gravels to continuous/discontinuous clay layers (Figure 5.1). This results in a complex variously interconnected three-dimensional aquifer system with a wide range in well yields and in salinity distribution.

Sediment thickness in the Lyndoch Valley is much less than the Barossa Valley being restricted to alluvial gravels and sands (with overlying clays) associated with Lyndoch Creek and its tributaries.

The hard rocks that surround and underlie the valleys contain groundwater within the breaks and fractures developed within them by tectonic activity.

They rarely contain any primary porosity or permeability except where deeply weathered. A wide range of rock types exist from tight siltstones giving low well yields of saline groundwater to well fractured marbles yielding good supplies of irrigation quality water.

In general terms better quality groundwater in the hard rocks is found under the Barossa Valley floor and in the Flaxman Valley area of the eastern highlands. Higher salinity groundwaters are found in the Duck Ponds Creek Catchment in the east and in the hard rocks west of the North Para River (e.g. Greenock Creek Catchment).

As any change in irrigation practices or the development of new irrigation ventures brought about by the importation of water may impact on the regional water table (the first permanent groundwater encountered) plans of depth to the water table and its salinity were prepared and are shown on Figure 5.2 and 5.3 respectively. These were prepared by manually assessing well information held within the Department for Water Resources drill hole database. Some generalising was required in areas where values fluctuated widely over small distances.

5.2 Barossa Valley Floor

5.2.1 Current Water Usage

The sediments of the Barossa Valley floor form a complex multi-level interlensing aquifer system. Gill (2000) gives the following metered extractions from these sediments and the underlying hard rocks (note-the current licensed allocation is 5000 ML).

Year	1993/94	1994/95	1995/96	1996/97	1997/98
Volume ML	3600	4687	3381	2934	2566

The salinity of this extracted groundwater, used for irrigation, covers a wide range and varies between aquifers and within each aquifer. Gill (2000) states that based on the most recent data:

- 54% of metered wells representing 55% of the groundwater 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.

5.2.2 Water Budget

Cobb (1986) provided an estimate of the water budget for the whole of the valley floor for the period February 1979 to February 1980. Through data constraints assumptions had to be made in calculating the individual components of the budget. The methods used to calculate the individual components were as follows:

* Recharge through the soil profile	climatological data; the chloride content of the water table; fluctuations in the water table elevations.
* Recharge from creeks	staff gauge installation, calibrating and monitoring; monitoring of shallow piezometers adjacent the stream bed.
* Recharge and discharge from hard rocks	water table contours and rock hydraulic conductivities; head difference between the basal sediment aquifer and the underlying hard rocks.
* Seepage into creeks	Yaldara gauging station flow data with base flow separation techniques.

* Evapotranspiration from the water table	potential evapotranspiration and depth to the water table.
* Pumping withdrawals	Australian Bureau of Statistics irrigation survey data and crop use estimates.

The resultant budget was:

Inflows

Recharge through the soil profile	3630 ML
Recharge from creeks	1471 ML
Recharge from hard rock aquifers	1676 ML

	6777 ML

Outflows

Seepage into creeks	2510 ML
Outflow into hard rock aquifers	45 ML
Evapotranspiration from the water table	2534 ML
Pumping withdrawal (all aquifers)	1591 ML

	6680 ML

Note that some components of the water budget can change significantly year to year such as recharge from creeks but other components such as flow into or out of the hard rocks reflect more long term changes. No subsequent attempt has been made to calculate a total water budget.

For the above 1979/80 water budget the Australian Bureau of Statistics data were available only for Council areas and hence had to be recast to estimate withdrawals within the valley floor. With well metering data subsequently becoming available Sibenaler (1991) suggested that the 1591 ML estimate above would more realistically have been within the range of 2000-2400 ML for that year. More recent withdrawals were given in Section 5.2.1.

The above water budget was for the whole sedimentary aquifer thickness whereas in terms of potential impacts of the BIL scheme it is the upper unsaturated/water table portion of the sedimentary sequence that is important. Figure 5.4 schematically shows the water budget recast for this upper zone with the main differences between this and the above budget being:

- a reduction in the magnitude of the inflow and outflow hard rock components because the depth of their seepages faces have been reduced, and
- the pumping from the deeper sedimentary aquifers and the underlying hard rocks now becomes an input to the upper system.

Whilst not shown on Figure 5.4 there is now also a downward leakage component from the water table zone to the next underlying aquifer. The magnitude of this

leakage is dependent on the head difference between the two, which fluctuates over the seasons, and the vertical permeability of the upper materials. Insufficient data are available to calculate the magnitude of this leakage. However, as the BIL scheme will replace a portion of deeper groundwater use this leakage component should reduce with time. This has the advantage of reducing the downward movement of saltier water from the water table zone to the next lowermost aquifer.

5.2.3 Salt Budget

To estimate the salt budget for the upper (water table) groundwater system for the valley floor as indicated on Figure 5.4 the following components and typical or average salinities were used:

Inflows

From creeks	-	North Para River 1280 ML at 1200 mg/L
	-	Tanunda Creek 68ML at 1000 mg/L
	-	Jacobs Creek 123 ML at 300 mg/L
From hard rocks	-	east, seepage face 20m, 148 ML at 1000 mg/L
	-	west, seepage face 10m, 1.3 ML at 2500 mg/L
From rainfall	-	3630 ML at 50 mg/L
From irrigation	-	2000 ML at 1500 mg/L (Sibenaler, 1991 values)

Outflows

To creeks	-	south, 1870 ML at 3500 mg/L
	-	north, 640 ML at 4000 mg/L
To hard rocks	-	south, 13 ML at 1500 mg/L
	-	north, 1.5 ML at 4000 mg/L

Consequently, the estimated salt budget for the February 1979 – February 1980 season for the water table under the valley floor becomes:

Salt Inflows

From creeks	1640 tonnes
From hard rocks	150 tonnes
From rainfall	180 tonnes
From irrigation	3000 tonnes
	4970 tonnes

Salt Outflows

To creeks	9100 tonnes
To hard rocks	26 tonnes
	9126 tonnes

Whilst many assumptions were made in the original water budget and in the subsequent selection of typical salinity values the data suggests the natural drainage of the water table by the creek system is resulting in a net removal of salt. This natural removal of salt was in force before the groundwater flow components were modified by the commencement of irrigation.

Note that for the Gill (2000) withdrawal data given in Section 5.2.1, salt loads ranging from 3850 tonnes (1997/98) to 7030 tonnes (1994/95) would have been brought to the unsaturated/water table zone at an average well salinity of 1500 mg/L.

5.3 Lyndoch Valley

In the Lyndoch Valley groundwater is obtained from valley alluvium and the underlying and surrounding hard rocks both of which are unconfined. The majority of wells are located in the alluvium but an unknown number of these are completed in the underlying fractured rocks. Salinity is generally less than 2000 mg/L in the central and eastern portion of the area increasing to the west and northwest (Sibenaler, 1991).

A water budget is not available for this area but Sibenaler (1991) made the following component estimates to determine the limit on the availability of groundwater:

- Infiltration recharge (rainfall) : 250 ML/year
- Recharge from stream losses : 300-500 ML/year

Based on land use data and estimates of crop use he estimated the groundwater extraction in 1986 to be 557 ML and 491 ML in 1991 both figures being close to his suggested limit on extraction.

Gill (2000) gives the following metered extractions for the Lyndoch Valley:

Year	1993/94	1994/95	1995/96	1996/97	1997/98
Volume ML	649	883	882	700	786

She comments that based on observation well data these extraction rates are considered to be greater than the current recharge to the system supporting Sibenaler's conclusions.

5.4 Greenock Creek Region

West of the Barossa Valley floor groundwater is contained within fractured rock aquifers dominated by shales and slates with a few interbedded north-south trending quartzite beds (Figure 5.1). These rock types are poor aquifers reflected in the low well yields and high salinities recorded. Higher yields of better quality water can be obtained by careful well siting in more prospective units such as the quartzites but these are the exception rather than the rule.

Consequently groundwater use in the area is small being mostly for stock water purposes. Whilst there is some lateral flow of groundwater from the Barossa Valley floor into these hard rocks recharge is dominated by incident rainfall. Outflow is by lateral flow in a general westerly direction, evapotranspiration from the water table when it is shallow enough and by base flow into the surface drainage system in the lower areas of each catchment.

The salinity of this base flow is high, reflecting the naturally high salinity of the water table e.g. the median salinity value of the samples collected in Greenock Creek from 1977 to 1980 was 3250 mg/L which included some direct runoff flow components.

6.0 DESCRIPTION OF SOILS

6.1 Introduction

Soils are infinitely variable. Even apparently uniform soils on the surface display significant variations down the profile which will affect drainage characteristics and water-holding capacity. Soils in the Barossa region are extremely variable with all of the major variants present ranging from deep siliceous sands to heavy black cracking clays.

Most of the inner Barossa area has been covered by very detailed CSIRO soil surveys completed in the 1950's (Northcote, *et al* 1954, Northcote 1957, Northcote 1959 and Wells 1959). This existing data, which were only available in hard copy, has now been digitised into a Geographical Information System (GIS), for interpretation and use in this study. The individual coverages are included in Appendix 2. PIRSA soil association maps (French, Matheson, and Clarke, 1968) have also been used to extend the soil mapping at the margins, particularly on the western side of the study area. This is an area of possible future expansion of viticulture. Very small supplies of suitable irrigation water from wells are found on the western side of the North Para River which has previously limited expansion in this area. Up until this point expansion would require the use of mains water.

CSIRO survey data has been grouped and simplified to ten major soil types appropriate for the purpose of developing management profiles in relation to the use of imported water and/or the use of inefficient irrigation methods. The original data will still be invaluable in the assessment of soils on individual shareholder properties. This simplified soil map is shown on Figure 6.1.

In this study, of particular interest is the top metre of the soil profile. A root zone depth of one metre is adequate for the productive growth of vines and other crops when efficient irrigation technology is employed.

6.2 Soil Profile Description

Brief profile descriptions of the major soil types are provided in Appendix 3. The behaviour of various soils under irrigation is determined by the soil depth and the infiltration rate of the clay layer. Whole coloured red and red-brown clays indicate well drained soils whilst mottling and yellow and grey colours in the clay layer are a sure sign of poor drainage conditions and seasonal waterlogging. The latter soils are those where the control of irrigation systems and amounts of water applied are critical in the prevention or exacerbation of existing waterlogging, drainage, or perched water table (shallow perched groundwaters) problems.

From the soil descriptions the sand-over-clay soil group, the solonetzic red-brown earths, and deep sands fit into this difficult group of soils. The podsolics of the ranges also have poor drainage characteristics but invariably occur on the mid-slopes where lateral drainage avoids any immediate problem but incorrect irrigation practices (too much water) can cause waterlogging or salinity problems in the valley below.

The soil characteristics that give rise to drainage/water table problems are exactly the same as those causing potential salinity problems. The two problems most frequently occur together. They can occur as a result of overwatering with salty irrigation water, resulting in lateral movement of excess water and rising water tables on flat land below. Water tables need not be salty to kill vines and other plants. Waterlogging alone will have a very similar impact if the water table intrudes to within two metres of the soil surface.

6.3 Waterholding Capacity of the Major Soil Types

Waterholding capacity of soils is determined by soil texture, e.g. the relative proportions of sand, silt, and clay. Clays hold a lot of moisture, sands very little. However it is possible for plants to extract most of the water held in a sandy soil but only about half of that held in a clay. "Available" water is that portion of the total that can be extracted by plants and is the difference between the water held at "field capacity" and "wilting point". Field capacity is the water content after a saturated soil has drained for 24 hours. A soil at field capacity therefore has some air space allowing plants roots to grow. No root growth occurs in a saturated soil which is why water tables have such a devastating effect, even if the water is not salty. Wilting point is the moisture content after a suction of 1500kPa has been applied and is theoretically the point at which plants can no longer extract moisture. Table 6.1 gives these values for soils of different textures and illustrates the large differences between soils and why different irrigation strategies should be used. For example, it can easily be seen why a shortage of irrigation water or a drought will have a proportionally greater effect on a heavy clay soil and why overwatering of a shallow sand-over-clay soil will lead to lateral movement of drainage water.

Table 6.1 Soil Moisture (mm/m of soil depth)

	Coarse Sand	Fine Sand	Sandy Loam	Loam	Clay Loam	Clay
Field capacity	54	108	141	249	299	415
Wilting point	21	42	50	91	116	208
Available Water	**33**	**66**	**91**	**158**	**183**	**207**

Using these data together with an accurate description of the depth and texture of soil horizons (layers) it is a simple matter to calculate the available waterholding capacity of the top metre of the soil profile or down to a barrier to root growth (e.g. rock), if this occurs within the top metre. These figures can then be used to control the amount and timing of irrigations in order to wet the soil to a given depth and/or to ensure water does not move out of the root zone.

The calculations have been made for the "typical profiles" given in Appendix 3 and the values are given in Table 6.2.

Table 6.2 Available Water in a Range of "Typical" Soil Profiles to 1m

Soil Type	Available Water (mm)
Skeletal soils	23
Podsols	111
Sand-over-clay soils	181
Deep sands	101
Transitional red-brown earth	161
Loamy red-brown earth	172
Clayey red-brown earth	188
Dark brown cracking clay	201
Terra rossa	164
Alluvial soils	125

Relatively more water can be extracted by plants from a loam soil than sands or clays.

6.4 Infiltration Rates

The soil intake rate for water determines the upper limits for application through the irrigation system. Water cannot be delivered faster than the soil can absorb it or runoff and/or lateral drainage along a subsoil clay surface will occur. Infiltration rate is determined by the texture of the soil and the presence of impermeable soil layers below the surface. Table 6.3 gives some approximate infiltration rates for soils of various textures. These are only approximate as the physics of soil water relationships is extremely complex and highly variable.

Table 6.3 Approximate Infiltration Rates for Water

Soil Texture	mm/hour
Sand	20
Fine sand	15
Fine sandy loam	10
Sandy loam	7
Clay loam	5
Clay*	1

* However, massive, unstructured sandy clays that underlie the sand-over-clay and deep sand soils may be as low as 0.01 mm/hr. These soils are therefore more difficult to irrigate efficiently because once the sandy topsoil is full, runoff or subsoil drainage along a sloping clay surface will occur and a higher level of management is therefore required.

A drip system using 4L/hr drippers delivering water to 1250 vines per hectare applies water at a rate of 120kL/ha/day. This represents a delivery rate of 12mm/day or 0.5mm/hr which is well within the rates given in Table 6.3. However, it is substantially higher than the intake rate for some of the most difficult clays that underlie the sand-over-clay soils. Infiltration rate is therefore a factor that must be considered along with the capacity of the topsoil above the clay. This information should be used to decide the timing and amounts of irrigation water applied if drainage of excess water is to be avoided.

7.0 DESCRIPTION OF THE EXISTING BIOLOGICAL ENVIRONMENT

7.1 Introduction

An examination has been made of the current ecological status of the watercourses, with regards to available information on aquatic fauna and the habitat condition.

An examination has also been made of the occurrence of remnant native vegetation, along watercourses and on public and private land. The focus has been to determine whether there would be any potential effects on the remnant vegetation. If there is no effect then it can be confidently assumed that the project would also have no effect on the occurrence of any native fauna using or dependent on the vegetation.

7.2 Flora, Regional Perspective

The landscape of the Barossa Environmental Association is described by Laut et al (1977) as:

> *an intra montane basin below gentle foot slopes and fans. The Barossa Valley is a mosaic of vineyards and grazing paddocks. In the distance is the Barossa Range with remnants of native vegetation on the crests but otherwise cleared for grazing.*

Specht (1972) describes the native vegetation of this area as woodland to open forest with herbaceous understorey, consisting of *Eucalyptus camaldulensis* or *Eucalyptus leucoxylon* ± *E. viminalis, E. odorata* and *Casuarina stricta* (now called *Allocasuarina verticillata*).

Data received from Planning SA further expands Specht's description by identifying the following additional associations.

Woodlands with associated understoreys dominated by the following eucalypt species: - *E. obliqua; E. fasciculosa; E. camaldulensis; E. viminalis; E. cosmophyla; E. baxteri and E. behriana.*

Forests with associated understoreys dominated by the following eucalypt species: -*E. camaldulensis and E. obliqua.*

Mallees with associated understoreys dominated by the following eucalypt species: - *E. dumosa; E. socialis* and *E. incrassata.*

These associations are shown in Figure 7.1.

7.3 Current Status of Native Vegetation

A significant proportion of native vegetation has been cleared from the project area. Patches of remnant vegetation do occur, as discussed below.

7.3.1 Native Vegetation in Remnant Blocks, both on Public and Private Land

A large number of these are on elevated ground or on ridgetops. In all places examined, remnant native vegetation species present appeared to be generally in good health. However, diversity is not high as many of these blocks have no native understorey remaining, as they are used for grazing.

7.3.2 Remnant Roadside Vegetation

This mostly consists of mature eucalypt trees with occasional patches of understorey. Some areas have been totally cleared of trees but contain remnants of native grasses and subshrubs. Generally, more intact native vegetation is found above roadside cuttings. Again, at all places examined which contained remnant native vegetation, the species present appeared to be in good condition, and therefore not affected by current farming or irrigation practices. An example of remnant roadside vegetation adjoining agricultural land is shown in Plate 7.1

Plate 7.1 Remnant Native Vegetation along Roadsides

7.3.3 Native Vegetation along Undeveloped Gazetted Roads

Many gazetted roads have never been developed and are currently under lease to adjoining landholders who use them for grazing or cropping. These have been either totally cleared of native vegetation or contain only a scattering of mature eucalypt trees over pasture. Unleased gazetted roads often contain remnant native scrub with only a winding track through them. Rarely do vineyards occur adjacent to such road reserves as the land is usually used for grazing or cropping.

7.3.4 Native Vegetation along Creeklines

It has been observed that all channels in the project area are ephemeral except for the main channel of the North Para River. These channels were found to be either completely dry (± occasional pools), or were barely flowing streams - despite recent rains. At all places examined, native vegetation appears to have been mostly cleared. Generally watercourse vegetation has been reduced to exotic plant species as shown in Plate 7.2.

Plate 7.2 Showing Typical Ephemeral Watercourse with only Exotic Vegetation

At other places examined, the only native riparian vegetation evident was River red gums over exotic species. This is illustrated in Plate 7.3. In a few locations a few species of aquatic macrophytes were also present.

As noted elsewhere, where the ground water table is shallow (<5m deep) it generally follows the creeklines. As discussed in Section 4.3.2, the watercourses are mainly a discharge zone for the natural saline groundwater. As can be expected, surviving native vegetation must therefore be quite salt tolerant. This indeed has been found by observation. At all places examined, surviving native vegetation appears to be limited to salt tolerant River red gums (*E. camaldulensis*) with occasional salt tolerant aquatic macrophyte species such as the Bulrush (*Typha* sp.), Common reed (*Phragmites australis*) and the Salt-club rush (*Bolboschoenus caldwellii*). These aquatic macrophytes species are also known to be tolerant to periodic dry conditions found in ephemeral watercourses. The remaining riparian vegetation consists of exotic plant species or pasture grasses as shown above in plates 7.2 and 7.3.

Plate 7.3 River red gums over Exotic Species

7.4 Aquatic Fauna

Few data are available on the aquatic communities of the watercourses. It is important to note that the communities, including the macroinvertebrates (used as general indicators of riverine health), fish and amphibians (frogs) will be affected by:

- changes to the natural flow patterns, as a result of water diversions, water harvesting (farm dams, pumping), land clearance, etc;
- loss of habitat, particularly riparian habitat, through land clearance, grazing, siltation/erosion, and
- changes in water quality through point source discharges (effluents), winery waste, urban and rural stormwater runoff.

Suter (1994) undertook a general survey of the macroinvertebrate communities of the North Para River. The objective of the study was to examine the effects of winery waste discharges.

The North Para River is described as an intermittent ephemeral stream, that regularly exhibits low flow, or nil flow during dry periods.

Suter recorded a total of 135 species. It was noted that the fauna were dominated by species which are tolerant of a broad range of environmental conditions, necessary for their survival in intermittent streams, and consequently similar faunal communities were generally found throughout the catchment.

Importantly these fauna would need to tolerate the naturally occurring seasonal peaks in salinity, as previously discussed. Many Australian native species are adapted to high salinities, e.g. the common yabbie (*Cherax destructor*) up to 10,000 mg/L. Most native fish species are very tolerant of high salinities, some above seawater concentrations.

8.0 POTENTIAL EFFECTS OF WATER IMPORTATION AND THEIR MANAGEMENT

8.1 Summary of Key Issues

As indicated earlier in Section 3.2, the main issues addressed are:

- the water budget resulting in rising regional water tables;
- the salt budget with increases in the salt load entering the surface drainage as base flow;
- the creation of perched water tables with adverse effects on plant growth and the potential for migration off-site; and
- the ecosystem through surface flow and salinity changes.

These issues are discussed in the following sections.

8.2 The Water Budget and Water Tables

The current proposal is to progressively import approximately 7000 ML/a into the region for irrigation purposes. Some of this will replace existing groundwater use, some will be mixed with current groundwater use to improve the salinity of the applied water, some will substitute for lack of runoff into dams and some will be for new irrigation ventures.

Soil moisture-holding characteristics can be used to give some idea of the depth of penetration of winter rainfall as there is little documented evidence for significant rainfall recharge of the water table except in wetter than normal years.

The mean April to October rainfall at Nuriootpa is 396 mm and decile 9 rainfall for the same period is 552 mm (i.e. over a long period of time only 10% of individual years would have an annual rainfall equal to or exceeding 552mm). Summer rainfall can be discounted completely as it is lost by evapotranspiration. Comparison of these values with those in Table 6.2 indicates that ‘winter’ rainfall may penetrate from 2.5 to 3.5 metres in average to above average seasons.

Indeed at the Nuriootpa Viticulture Research Station the average depth of winter penetration over a nine year period was 2.9 metres but varied between 0 metres in a drought to nearly 6 metres in one of the wettest years on record.

Poor management in the form of overwatering may 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. Figure 8.1 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.

With 80% irrigation efficiency only 20mm 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 60mm, in the area of irrigation.

After cessation of irrigation such a rise under the irrigation block would dissipate by lateral flow. For certain soil types the potential to instead create perched water tables is discussed in Section 8.4.

If irrigation over the summer months is efficient, i.e. no water escapes past the root zone, then the evapotranspiration component of the water budget will increase to compensate for the imported water (refer Section 4.2). Under these conditions there will be no net increase in vertical seepage to the regional water table. Consequently, there will be no change in regional water tables, apart from naturally occurring seasonal variation.

In terms of the water budget for the whole valley floor sedimentary sequence 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.

8.3 The Salt Budget

The maximum anticipated salinity for the imported water is 500 mg/L, about a third of the typical groundwater used currently for irrigation. However, if there was no replacement of existing more saline groundwater use, it would be an overall importation of salt into the catchment of the order of 2500 tonnes/a with 5000 ML/a of imported water, rising to 3500 tonnes/a with 7000 ML/a imported water.

This salt would eventually reach the regional water table and discharge as base flow in the catchment streams. However, the net effects are variable depending on whether the imported water is for new irrigation, replacement of current groundwater use or a mixture. Comments on the situation on the Valley floor, the Lyndoch Valley and the Greenock Creek region are summarised below.

(a) Barossa Valley Floor

For the initial 5000 ML/a, as indicated by the applications for water, about 1800 ML will be used on the Valley floor. It is not known if this water will totally replace existing groundwater use, will be mixed with current groundwater usage to reduce irrigation water salinity or will be for new irrigation. Notwithstanding assuming that irrigation is efficient then the overall water budget does not change with the applied water being removed by evapotranspiration. However with an upper limit of 500 mg/L for the BIL scheme water the salt budget does alter. For the worse case scenario with the imported water being used for new irrigation an additional 900 tonnes of salt per annum will be added to the unsaturated zone.

The base flow in the North Para River at Tanunda commonly fluctuates between 2800 and 4000 mg/L. In the above worse case scenario this theoretically could cause an increase in the base flow salinity of 350 mg/L which would not be recognisable in the current range of fluctuations. The situation is more complicated than this, however, in that the various properties are at different distances from the stream channel with the resultant differences in transit times.

For the case where the 1800 ML substitutes for say that amount from the high groundwater use figure of 4687 ML in 1994/45 then the surface salt accession reduces to (2887 x 1500 mg/L + 1800 ML x 500 mg/L) or 5230 tonnes compared to 7030 tonnes. Because of the uncertainty as to the full extent of replacement water, the exact degree of salt reduction is also uncertain. Importantly though, a reduction will occur. For example, for applicants for BIL water on soil associations 6 and 10 (Figure 6.1) in the Vine Vale-Bethany area, comparison of vineyard areas with volumes applied for allows an estimation of potential substitution ranging from 10% to100% on a property basis, but averages 66% over the whole two associations. A small proportion of this may be for mains water and surface water augmentation.

For every megalitre of imported water substituting for groundwater with an average salinity of 1500 mg/L, a net reduction of one tonne of salt per annum reaching the land surface is achieved. This nett benefit is reduced if imported and currently used groundwaters are blended to reduce irrigation water salinity but a benefit still exists.

(b) Lyndoch Valley

Approximately 530 ML of scheme water have been applied for in the Rosedale-Lyndoch Valley area. For the area in the Lyndoch Valley underlain by soil association 10 (Figure 6.1) data for the seven applicants for BIL water indicates that this water will replace existing supplies ranging from 32% to 100% on a property basis. As for the Barossa Valley floor assuming an irrigation rate of 1 ML/Ha, this translates to a 52% substitution on a volumetric basis.

(c) Greenock Creek Region

As little groundwater is used for irrigation any imported water will be used for new vineyards or to ‘drought proof’ a property relying on surface runoff into dams for subsequent irrigation. Approximately 3100 ML have been applied for in the Greenock Creek-Gomersal-Yaldara Weir area as part of the initial 5000 ML/a, which indicates an increase in the salt load over these catchments of around 1550 tonnes per annum. This would eventually be removed, with a net increase in the salinity of the various local creek base flows.

If all of the future increase in scheme water of 2000 ML is used in this catchment then the average annual increase in salt load to the soil surface will be 2550 tonnes.

As seen on Figure 5.3 the water table salinity throughout the Greenock Creek catchment is everywhere greater than 2000 mg/L and commonly greater than 3000 mg/L. This is reflected in the saline baseflows recorded when groundwater is the source of these low flows (Section 5.4). Salt importation would eventually be reflected in these values, not in surface-runoff generated flows.

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. Assuming a conservative 50% replacement of groundwater use for the Barossa Valley floor and Lyndoch Valley then these two areas would show a reduction of salt accession for the historical range of groundwater use. There will be a net increase in the Greenock Creek region.

It is important to bear in mind the rate of groundwater flow at the water table. For the current gradient on the water table under the central valley floor these velocities are of the order of one metre per year. In areas of higher material permeability higher velocities will result and conversely lower velocities with lower permeability materials. However, considering the nature of the materials in the upper water table zone in most of the catchment the above is an acceptable indicative value.

8.4 Perched Water Tables

As discussed in Section 6.0 the soils in the region are infinitely variable with a wide range in characteristics relating to drainage rates, water holding capacity and infiltration rates. Ten major soil groups or associations were recognised (Figure 6.1).

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 (Appendix 3).

The rating of the soil units 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

The rating of the individual soils is discussed as follows:

(a) Sandy and loamy red-brown earths (Unit 1)
Management Rating 2

Occur in a wide range of topography but even on flat land there are no known perched water tables at the present time due to adequate vertical drainage.

(b) Skeletal Soils (Unit 2)
Management Rating 1

These soils are not used for viticulture and therefore they are not likely to be irrigated. They are, however, natural intake areas for some of the groundwater recharge for the Barossa aquifers.

(c) Clayey red-brown earth (Unit 3)
Management Rating 1

Generally deep soils with excellent vertical drainage characteristics due to lime in the lower profile. This unit offers good potential for development with new water sources with almost no likelihood of problems with shallow groundwaters. These soils occur frequently in the Rosedale area.

(d) Terra rossa soils (Unit 4)
Management Rating 1

Once ripped for planting to destroy any hard capping to the lime layer the vertical drainage characteristics of these soils ensures minimal management to prevent groundwater problems.

(e) Dark brown cracking clay (Unit 5)
Management Rating 1

Very high waterholding capacity and excellent vertical drainage until fully wetted up ensure that it would be very difficult to ever have any problems from applying excess water to these soils.

(f) 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.

(g) 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.

(h) Yellow podsolic soils (Unit 8)
Management Rating 5

Midslope topography and lateral drainage ensure any potential problems occur off site even though the infiltration rate of the clay layer is poor and bedrock occurs usually within 75 cm of the soil surface. It is possible to have problems midslope when the soil depth decreases significantly or in cases where there is outcropping rock.

(i) Red podsolic soils (Unit 9)
Management Rating 4

Midslope topography and lateral drainage ensure any potential problems occur off site even though the infiltration rate of the clay layer is poor and bedrock occurs usually within 75 cm of the soil surface. It is possible to have problems midslope when the soil depth decreases significantly or in cases where there is outcropping rock.

(j) 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 three soil associations (Units 6, 7 and 10) that are considered to require careful irrigation management are shown on Figure 8.1 along with the zones where the regional water table occurs at a depth less than 5 metres below ground. This Figure also shows the current locations of applicants for water from the BIL scheme.

8.5 Effects on Fauna and Flora

8.5.1 Remnant Native Vegetation

As discussed in Section 8.6 below, BIL water will be managed to ensure that irrigation waters do not move below the root zone of vines. Essentially, this water will be applied at times when soil moisture is already low and sufficient used to make up for evaporation. Therefore, in a managed environment, excess water is unlikely to accumulate within the soil to create waterlogging or salinity issues. Consequently native vegetation adjacent to vineyards is unlikely to be affected by BIL water.

There are three soil associations, as noted in Figure 8.1, which have the potential for the creation of perched water tables close to the soil surface under certain conditions. The effects of this upon remnant native vegetation are discussed below.

Firstly native vegetation is generally shallow rooted, with roots generally found in the top 0.3-2 metres of soil. Specht and Rayson (1957) found that all ground layer plants and shrubs produced their roots within the top 0.3 to 0.5m of soil, with only a few species producing a tap root which extended 2m or more down through sand to the clay subsoil. These observations were confirmed by Dodd et al (1984). Perched water tables if they occur are unlikely within the top 0.3 to 0.5m of the soil. This surface layer of unsaturated soil is sufficient to ensure survivorship of native vegetation.

This generalisation holds true for tall mature trees including eucalypt trees. Moore (1995) states that mature trees generally possess a shallow, lateral root system that forms an extensive radiating root plate generally 0.2 to 0.5m deep. This provides the primary support system. Up to 90% of the tree's root mass can be found in this root plate. Tap roots generally die back after the first few years and are replaced by a number of descending 'sinker' roots which emanate from the root plate. Their function is to seek deep soil water in dry seasons and to provide additional support under strong winds. Here, again, mature trees are able to survive where the top 0.3 to 0.5m of topsoil remains unsaturated.

Secondly, native vegetation in low rainfall areas is naturally adapted to raised soil salinities. BIL water, if it has any effect at all, is likely to eventually reduce salinity rather than raise it therefore improving growth conditions for native vegetation.

Figure 8.2 shows the relationship between remnant native vegetation and properties demanding water in the three soil associations. Each of the three soil associations are discussed in more detail below with regard to native vegetation.

(a) Sand-over-Clay with Deep Sand Association

The only large patch of native vegetation in this soil association is found at Mengler's Hill and it adjoins several properties that will be irrigated from project water. However, this vegetation is upslope of the adjoining properties and therefore is most unlikely to be affected, even if a perched water table did occur.

The remaining small patches of native vegetation have been noted to consist of clumps of mature River red gums (*E. camaldulensis*) ± Blue gums (*E. leucoxylon*)

with weeds or pasture for understorey and are found along watercourses or gullies. Aquatic macrophytes rarely occur. These eucalypts and aquatic macrophytes are all very tolerant to soil salinity in excess of 5000mg/L and seasonal waterlogging.

(b) Sand-over-Clay Soils with Transitional Red Brown Earth

A number of blocks of remnant native vegetation occur within or adjacent to properties requiring water from BIL. Dominant overstorey species in these are River red gum (*E. camaldulensis*), SA blue gum (*E. leucoxylon*), Pink gum (*E. fasciculosa*) and White mallee (*E. dumosa*). These species are quite tolerant to saline soils.

Only their sinker (or descending) roots are likely to come into contact with any perched water tables if they occur, while the majority of their roots will remain in unsaturated soil. This is also true for their understorey vegetation, being smaller plants, which will predominantly have shallow roots (<0.2 to 2m) growing in sandy soil and are unlikely to penetrate the soil deep enough to come into contact with any perched water tables. Even if this was to occur, only a small percentage of roots would be affected, resulting in minimal or no effect on the vegetation.

As mentioned in section 8.4(g) potential problems of poor drainage and/or over watering are likely only on lower slopes, flat land or landlocked situations where there is a potential for perched water tables to develop. Examination of surface contour data indicates that the remnant blocks are 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. Other than riverine vegetation along watercourses, none of the remnant blocks of native vegetation appears to occur in depressions or low-lying locations. Any riverine vegetation present is tolerant of high salinity and periodic inundation of their root zones.

Given the fact that BIL water will be managed to ensure that irrigation waters do not move below the root zone of vines, it can be concluded that there is minimal or no risk to vegetation.

(c) Alluvial Soils adjacent to the Surface Drainage System

Little native vegetation is found in this association and where it does occur, it is limited to remnant clumps of mature River red gums (*E. camaldulensis*) ± Blue gums (*E. leucoxylon*) with exotic plants or pasture for understorey and are found along watercourses or gullies. Aquatic macrophytes rarely occur. These eucalypts and existing aquatic macrophytes are all very tolerant to soil salinity in excess of 5000mg/L and seasonal waterlogging.

8.5.2. Aquatic Fauna

The implications for aquatic fauna are discussed below in relation to salinity, chlorine residuals and interbasin transfers of water.

(a) Salinity

As discussed earlier, with the proposal as it now stands, there will be no increase in salinities in the Barossa Valley floor or Lyndoch Valley areas. With the partial replacement of saline groundwater, in the very long term there will likely be a net reduction. However, even this will be on a small scale compared to the naturally occurring seasonal variation. Consequently there will be no effect on fauna.

In the Greenock Creek Region, the watercourses are ephemeral and also exhibit a seasonal salinity variation. These ephemeral watercourses in the very long term may (refer Section 8.3) experience an increase in salinity, but this is also likely to be relatively small in relation to naturally occurring patterns. The major effect on aquatic communities in these first and second order streams has been the loss of habitat and flow pattern modification.

(b) Chlorine

Unlike the Onkaparinga River and Torrens River systems, watercourses are not being used as an aquaduct for water transfer. Consequently, any residual chlorine from disinfection will not affect any aquatic communities.

(c) Interbasin Transfer

For the same reason as (b) above, the proposed use of the Warren Reservoir (as it currently operates), the direct use of water to vine irrigation at very low application rates in the summer is unlikely to result in any increased risk of the introduction of any species from the Murray River to the North Para system.

8.6 Irrigation Management

8.6.1 Irrigation Requirements for Viticulture

At the outset it is important to appreciate what is involved in the proposed viticulture irrigation, which is basically supplementary watering only and the quantities (100mm) are relatively small.

The water allocations in the Barossa Prescribed Water Area were originally set at 100mm for vines and this was based on the amount of water estimated to be available rather than on the actual water needs of vines and other crops. However, this amount has since proven to be adequate to meet quality standards for grapes with the possible exception of black soils (Unit 5) in drier years where 150mm would be a more appropriate amount. However, the overriding need to protect and sustain the aquifer system and with the extreme difficulty of allocating water based on soil type, due to the variability of soils, this has proven to be the correct decision.

Vines obtain their annual water requirements from three sources:

- From soil storage – typically from 60mm in sands to 180mm from soils with a clay layer (Table 6.1).
- From irrigation – 100mm in the Prescribed Region.

- Rainfall from September to March inclusive – mean of 222mm for Nuriootpa but only a smaller portion is "useful" rainfall (enough to wet the canopy plus at least 15cm of soil), i.e. much is lost in evaporation leaving about 150mm as useful rainfall.

Total water use by vines is therefore in the range of 400-450mm of which only about 25-30% comes from irrigation. Schrale (1991) has shown that this is enough to produce near maximum yields of "quality" red grapes. The most important source of water is from the soil store of available water so the impact of soil surface management on water use efficiency can be very important. However, **the irrigation component is essential to "drought-proof" vineyards and ensure that potential yields are matured which in turn guarantees a supply of quality fruit to satisfy local, and more importantly, export market demands.**

The Barossa has always been short of good quality irrigation water and therefore a full "water on demand" irrigation system, as practised say in the Riverland, has rarely been possible. This type of system supplies all of the water needs of the crop plus an amount, usually an additional 10-15%, for leaching salts below the root zone. Irrigation on demand aims to keep available soil water to a predetermined level of say 75% of field capacity. When soil moisture sensors indicate that soil water has fallen to say 25% of field capacity then the pumps go on and the soil water store is refilled to the desired level. Irrigation in the Barossa has always been supplementary at best or a form of "deficit" irrigation.

8.6.2 Irrigation Strategies

The most important management objective for irrigation systems in the Barossa is to ensure that irrigation waters do not move below the root zone. With the small quantities of water used and appropriate management strategies this objective can be met. A monitoring system will be in place to keep a check on the system and all BIL clients will be required to submit an annual return which will be an integral part of the monitoring process. These procedures will ensure that the existing groundwater and surface water systems are not affected because all waters applied will be used by crops. There are many factors that will ensure that BIL waters are not used excessively, including:

- The amounts of imported irrigation water are relatively small in terms of the area to be irrigated.
- The fact that on the Barossa Valley Floor, the 1800 ML BIL water will be used as a potential replacement for approximately 66% of salty water currently used, i.e. in the more sensitive areas.
- Strategic monitoring for the occurrence of perched water tables (refer Section 8.7).
- The cost of the water is high.
- The strong negative correlation between yield and quality, especially with red grapes, and the fact that premium prices are only paid for quality standards attained.

For Barossa irrigators the critical decisions are:

1. When to start watering in order to avoid waterlogging and delay root development by starting too early and/or wasting valuable water.
2. Ensuring that there is enough water available at critical growth periods, especially at flowering (late November) and at veraison (end January) and during ripening to ensure maturity is not delayed. Veraison is the growth stage where the berries soften and the colour develops in red grapes.

In an average season on all soils with a permeable clay layer, watering before flowering is usually unnecessary. Irrigation normally starts sometime in December. In the simplest case (little water available e.g. 100mm) a strategy may simply be to divide the water up into say four irrigations of 25mm and apply at critical times. This approach should be modified to suit soil type if necessary. For example, smaller and more frequent irrigations are more appropriate on very shallow sand-over-clay soils to avoid lateral water movement or very deep sandy soils where applying too much water will also result in water moving out of the root zone. Under vine mulching can be usefully employed on very shallow soils to prevent moisture loss, extend irrigation periods, and make the most of limited water.

8.6.3 Elements of a Water Management Plan

All BIL applicants will be required to prepare an Irrigation Management Plan (IMP). It is essential to keep plans simple in order to ensure compliance. The plans should ensure, or identify:

1. Water application in a controlled way, i.e. a water meter is the simplest and most basic measurement device.
2. That soil types have been taken into account.
3. An appropriate method of application – drippers, (rate), under vine sprinklers.
4. The correct rate of water used on a per Ha basis.
5. Any under vine mulching on shallow soils.
6. Source of the water – wells, dams, mains.
7. Water quality (TDS mg/L) and whether or not the supplies are mixed in order to achieve a quality standard (<1500 mg/L).
8. Whether or not BIL water will replace existing supplies that are salty or used to facilitate "new" plantings.
9. Method of storage of mains water – well recharge, dams, lined or not.
10. Soil moisture monitoring systems employed.
11. When and how water applied – growth stage, frequency, amount, on advice from wine industry viticulturist.
12. The location of the vineyard – Section, Hundred.

The whole point of this exercise is to enable checks to be made of how much water is going on in specific locations and that this is consistent with the soils/management profile of the location. It will also clearly demonstrate whether the grower has thought constructively about the irrigation system and has the ability to manage it efficiently. 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.

There are many methods of monitoring soil moisture which range from the simple use of an auger or dig stick, tensiometers and gypsum blocks for either end of the soil moisture curve, meteorological measurements in order to estimate vine water use to the most sophisticated systems like Enviroscan. However, the automation of watering will only be possible if adequate water is available and, as already pointed out, in the Barossa this is rarely the case. However, it will be required that growers 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.

A proforma Irrigation Management Plan is included as Appendix 4.

Individual water users will be 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 have been 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.

8.6.4 Other Considerations

It is worth noting that to utilise expensive water effectively, water storages should be lined to prevent seepage losses. Even on the most impermeable clays, there is enough leakage to result in significant losses, and more importantly, if they are sited in areas that have an existing perched water table, waterlogging and/or salinity problems will quickly follow. There are already numerous examples of the poor siting of water storages in the Barossa, especially in relation to winery effluent dams.

8.7 Monitoring

In addition to the individual monitoring by growers of their own system, strategic regional monitoring will be undertaken to provide:

- an early warning of any adverse effects, and
- provide an opportunity for corrective action to be taken.

This will 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, and
- creation of perched water tables.

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

8.7.1 Water Table Monitoring

The Department for Water Resources currently have an 85 well monitoring network throughout the catchment though by far the majority are concentrated in the Barossa Valley floor and the Lyndoch Valley. Of the 85 only 4 monitor the water table (Gill, 2000).

Fourteen new water table monitoring wells have been established in the areas of soil associations 6,7 and 10 where the water table is nominally shallower than 5 metres (Figure 8.1).

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 the Department for Water Resources who will incorporate them into their existing network. The locations of future applications for scheme water will be scrutinized to see if any fall within the sensitive soil association areas. If so, the need for additional water table monitoring wells will be addressed.

8.7.2 Surface Flow Monitoring

As discussed earlier, the surface water flow system is the natural drain for shallow groundwaters throughout the catchment as seen in base flows. For most of the catchment base flows are quite saline reflecting the adjacent water table salinity. Salt deposited in the unsaturated zone through rainfall and irrigation accessions eventually is mobilised to the water table, through winter recharge events. However this process is highly variable both temporally and spatially hence it is a highly ‘buffered’ system and increasingly so as the distance from a groundwater discharge area increases. It is unlikely that changes to base flow salinity caused by alteration of the irrigation regime would be able to be separated from the natural fluctuations that are taking place.

For example, as stated in Section 5.2.3 an additional 900 tonnes per annum could be added to the salt budget of the valley floor if all imported water was for new irrigation.

With a base flow discharge of 2510 ML this theoretically could cause an increase in base flow salinity of 350 mg/L which currently fluctuates between 2800 and 4000 mg/L in the North Para River in Tanunda.

In the Greenock Creek region, there is no flow or long term salinity data to enable a quantitative assessment to confirm the effects of the new irrigation. Consequently it is recommended that a monitoring station be established in this region. There is no advantage in increasing the current surface water monitoring programme elsewhere in the valley.

8.7.3 Reporting

Monitoring of changes to the surface and groundwater hydrology of the catchment is a long-term process hence it is important that one organization be responsible for the collection, processing and analysing of the collected data and the preparation of regular status reports.

It is considered that the Department for Water Resources best fits this role as it currently has both a surface and groundwater monitoring network and data processing/storage facilities plus the expertise to interpret the results.

BIL has funded the establishment of 14 additional monitoring wells in the areas where its customers overlie the soil/groundwater regime requiring the highest order of irrigation management. The locations of future customers will be assessed to determine if further monitoring wells are required.

8.8 Areas for Potential Expansion of Viticulture/Horticulture

Referring to the soil association map (Figure 6.1), the areas with the best potential for expansion of irrigated horticulture with minimal management inputs would appear to be in three areas:

1. The area to the west of Stockwell on gently sloping loamy red-brown earth soils.
2. An area to the southwest of Rosedale on good clay loam red-brown earth soils.
3. Areas outside of the western rim of the valley, again on a variety of sandy and loamy red-brown earth soils.

Expansion into Unit 7 could cause either on-site or off-site problems and it is here that proposals should be more critical of irrigation systems and topographical situations.

High management Units 6 and 10 are already almost fully planted and further expansion in these areas within the valley is unlikely.

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APPENDIX 1

Surface Water Salinity Review

INTRODUCTION

Watercourses in the project area have been subject to salinity monitoring programs since the early 1970's by agencies such as the Department for Water Resources and the Environment Protection Agency. All the salinity data has been collated and used to obtain a picture of what the salinity levels are now, how they vary with stream flow and whether or not flow weighted salinity levels have been changing over the previous 3 decades.

Generally speaking, the North Para River is an intermittent stream flowing through the winery area of the Barossa Valley, with Tanunda Creek and Jacob Creek as major tributaries. Water quality in the North Para system varies with flow. For instance, salinity varies inversely to flow and is influenced by saline springs and groundwater intrusions (Suter 1984). Within the project area, there are 6 monitoring stations that have been set up by the Water Resources Branch of the Department of Environment and Heritage. These stations have been continuously monitoring flow, electrical conductivity (EC) and temperature since 1994. The EC data is temperature corrected and used to calculate salinity (as mg/L).

DATA COLLECTION

Continuous Monitoring

There are 4 continuous monitoring stations on the North Para within the project area, which were initiated at these stations in 1994:

- Mt McKenzie; Station 505533,
- Penrice; Station 505517
- Tanunda (upstream Tanunda Ck junction); Station 505536
- Yaldara; Station 505502

There is also a continuous monitoring station on the Tanunda Creek:

- Tanunda Ck; Station 505535

There is another monitoring station in the North Para catchment, at Turretfield (505504), although this is located outside of the project area, to the south west.

Grab Sampling

The Environment Protection Agency in the Department for Environment and Heritage has amassed a grab sample database known as the Environmental Data Management System (EDMS), which extends back to the early 1970's, although sampling frequency became reduced during the 1980's and 1990's. The majority of these samples were collected during low to medium flows (Jolly *et al.* 2000).

The EDMS grab sampling stations in the project area have been located at

- Mt McKenzie; Station 505533 (16 samples, 1989 – 1993)
- Penrice; Station 505517 (179 samples, 1973 – 1999)
- Yaldara; Station 505502 (161 samples, 1972 – 1997)

- Duck Ponds Creek junction; Station 505525 (1 sample in 1983)
- Jacob Creek; Station 505518 (104 samples 1973-1997)

EMS (1996) conducted a water quality and biological monitoring study of the North Para between Nuriootpa and Tanunda. Monthly samples were collected at 5 locations during 1994 and 1995.

On August 30 and 31, 2000, a survey of the main channel and its tributaries was conducted so as to fill in some of the gaps in the salinity data; particularly to the north and west of the North Para River. Stream vegetation was documented in addition to salinity.

SALINITY TRENDS

1970's - Present

The CSIRO compiled salinity data for the major South Australian catchments with the aim of assessing the risks of dryland salinity on water resources (Jolly *et al.* 2000). For the North Para catchment, the assessment utilised data from Stations 505502, 505517, 505533, 505535 and 505536 (including continuous and grab sample data).

The study tentatively revealed that salinity levels have declined in the upper reaches of the North Para (at Penrice) during the period 1977-1998. In the lower reaches of the river, salinity levels were not found to vary significantly over the period 1972-1998 (at Yaldara, 505502). Sampling at the Mt McKenzie (16 samples over 4 years) and the station above Duck Pond Creek station (1 sample) were too infrequent to be useful for trend analysis.

In the Jacob Creek tributary, which flows into the North Para downstream of Tanunda, a decreasing, albeit very minor trend in salinity was observed over the period 1973-1997.

In general then, salinity in the North Para catchment does not seem to have changed significantly over the previous 20-30 years.

Variation with Stream Flows

Over short time scales, salinities do change quite dramatically, as a consequence of variable stream flows. The continuous salinity and flow data collected at the 5 continuous monitoring stations is presented in the time series plots (A1 to A31) in the Appendix. Each plot represents salinity and flow over 12 months.

These plots clearly illustrate the large salinity decreases that occur during periods of high flow and the rapid salinity increase that typically follows the return of normal base flow at all the monitoring stations. This does not mean there is a correlation (ie a predictive relationship) between salinity and flow.

The large salinity fluctuations reflect the effects of rainfall-runoff dilution and the subsequent re-establishment of groundwater controlled base flows.

SALINITY DISTRIBUTION

North Para River

The saline groundwaters in the catchment strongly influence the stream salinities. Since the groundwater depth, flowrate and salinity varies widely across the catchment (Cobb 1982), a simple picture of this influence is difficult to obtain. It can be generalised, however, that the

North Para River is the main channel into which groundwater discharges, and as such its salinity tends to increase with distance along its length.

This trend is most notable in the reach between Nuriootpa and Tanunda. There is evidence for this from a study of North Para water quality during 1994-1995, where salinity in this reach was documented by EMS (1996). As indicated in Table 1 below, stations 1 to 5, there is a definite salinity increase between Station 2 (downstream of Kaiser Stuhl) and Station 3 (Seigersdorf Rd). This section of the North Para is recognised as a significant zone of groundwater inflow (Cobb pers com).

Table 1: Salinity (mg/L) in the North Para River during 1994-1995 at 5 monitoring points between Nuriootpa and Tanunda

Station	5/9/94	11/10/94	13/12/94	9/2/95	4/5/95	19/6/95	18/7/95
1	2800	1600	3300	2900	960	1200	750
2	1400	1500	2200	880	470	770	570
3	3700	2300	3400	3800	1700	1800	2000
4	3800	2500	3400	3300	2200	2100	1600
5	3400	2700	3000	3300	2400	1300	1500

The plots in the Appendix also illustrate this general pattern. For any given year between 1994 and 2000, some key points are apparent:

- Salinity is reasonably constant between Mt McKenzie and Nuriootpa .
- Salinity increases substantially between Nuriootpa and Tanunda.
- Salinity at the Yaldara site is consistently lower than at Tanunda. This is attributed to the diluting effect of inflows from the Tanunda and Jacob Creeks (particularly the latter).

Table 2 summarises the continuous salinity and flow data into annual mean, min and max values (with the number of days in each year where data was collected). In Figure 1, the mean annual flows for each station are plotted, which highlights the relatively wet 1996. In Figure 2, the mean annual salinities are plotted for the monitoring stations.

Greenock Creek and Salt Creek

The Greenock Ck and Salt Ck catchments, to the west of the North Para, are known to be saline although there has been no concerted documentation of salinity data in this area. Salinity was therefore measured (in situ) in these creeks on August 30 and 31, 2000. This monitoring was conducted only a few days after a series of rainfall events had passed through the Barossa, although there were still negligible flows observed (Salt Creek was completely dry). The lack of stream flows can be attributed to the unusually dry microclimate in these catchments (Chris Wright, pers comm).

The salinity levels in the Greenock Creek increased markedly with distance downstream from a minimum of 600mg/L (above Greenock) to a maximum of 3780mg/L before the creek dried out.

Table 2: Annual Salinity (mean, min and max) and Flow (mean, min and max) at five Continuous Monitoring Stations in the North Para Catchment (1994-2000)

	Salinity (mg/L)				Flow (cumecs)			
YEAR	**MEAN**	**MAX**	**MIN**	**COUNT**	**MEAN**	**MAX**	**MIN**	**COUNT**
Mt McKenzie; 505533								
1994	1520	2281	539	157	0.002	0.086	0	244
1995	1362	2731	162	186	0.052	7.51	0	365
1996	464	1569	68	128	0.246	21.4	0	300
1997	1574	1917	1060	77	0.005	0.624	0	326
1998	1892	3246	194	241	0.011	1.73	0	344
1999	1883	2927	927	141	0.006	1.92	0	365
2000	1540	4042	0	146	0.000	0.001	0	146
North Para @Penrice; 505517								
1994	1940	2610	1324	196	0.079	8.36	0.002	350
1995	1498	2909	281	351	0.359	32.8	0	326
1996	1243	2936	165	264	0.018	1.48	0	361
1997	1666	3028	908	318	0.014	0.651	0	365
1998	1651	3190	966	109	0.005	0.311	0	365
1999		NO DATA			0.000	0.403	0	138
2000		NO DATA						
North Para @Tanunda; 505536								
1994	3122	4048	1716	233	0.031	0.358	0	244
1995	2730	4879	473	354	0.122	9.71	0	354
1996	2433	4936	194	308	0.463	32.1	0	308
1997	2426	3303	656	261	0.044	2.75	0	260
1998	2362	3488	983	365	0.026	1.16	0	239
1999	2737	4830	1031	275	0.035	1.03	0	169
2000	2735	2800	1166	26	0.020	0.896	0	129
North Para @Yaldara; 505502								
1994	2857	3912	2232	240	0.036	0.366	0.003	240
1995	2376	5962	2340	274	0.237	20.3	0.167	274
1996	2175	5693	187	314	0.783	71.8	0	314
1997	3354	4890	2498	195	0.067	6.88	0.001	195
1998	2173	4403	427	287	0.070	3.14	0.002	287
1999	2148	4745	1749	164	0.046	1.36	0	164
2000		NO DATA						
Tanunda Creek; 505535								
1994	1297	1925	739	180	0.004	0.102	0	244
1995	793	1949	113	228	0.055	7.07	0	365
1996	684	2067	105	228	0.100	8.75	0	366
1997	1078	1877	238	111	0.018	3.62	0	365
1998	865	1687	428	203	0.013	1.33	0	365
1999	1254	1664	712	19	0.001	0.116	0	174
2000		NO DATA						

Groundwater Intrusion

Groundwater surveys of the area show that the northern and western regions of the project area are particularly prone to surface water salinisation due to groundwater intrusion (Cobb 1982). Indeed, the highest surface water salinity measurement in the whole data set was

recorded in one of the northern drainage channels (9900mg/L), where extensive samphire vegetation (indicative of long term salt intrusion) was also observed. Not surprisingly, the infrequent anecdotal reports of surface salt scalding have mainly been in this northern region (Chris Rudd pers comm).

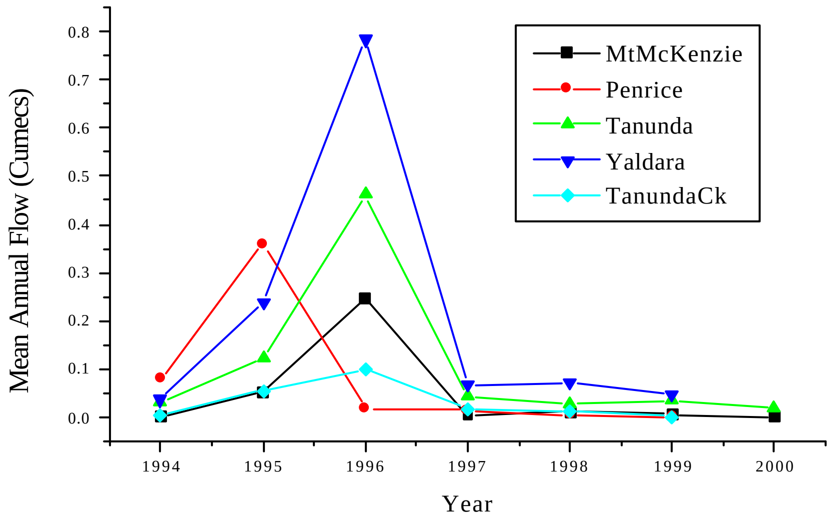

Figure 1 **Mean Annual Flows for 5 Continuous Monitoring Stations 1994-2000**

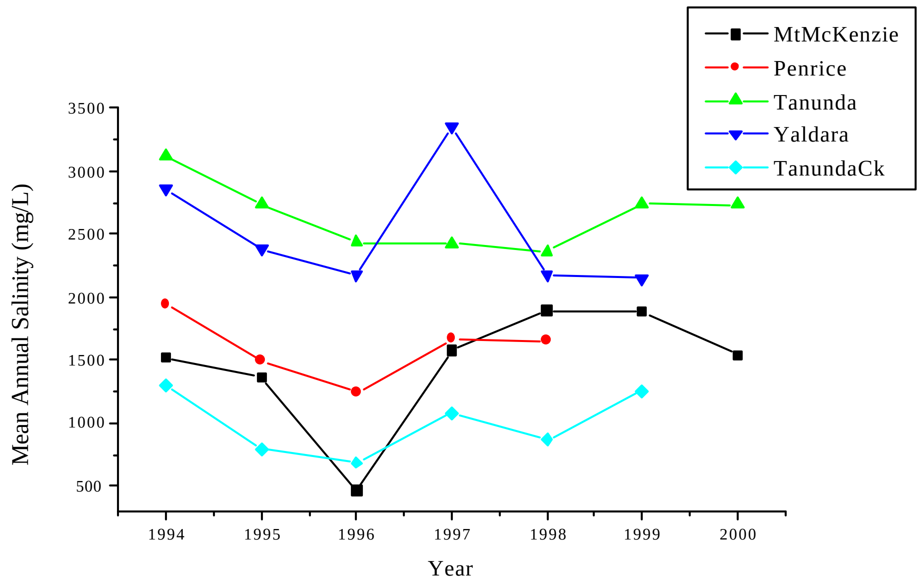

Figure 2: **Mean Annual Salinity for 5 Continuous Monitoring Stations 1994-2000**

Effect of Farm Dams

The then Engineering and Water Supply Department (EWS) reported on the effects of farm dams on water resources in the Barossa Valley (EWS 1991). One of their main conclusions was that the increased level of farm dam development has resulted in a significant decrease in stream flows (after accounting for the variation in rainfall).

It is considered likely that groundwater irrigation does not directly lead to an increase in stream salinity, since the irrigated quantity is only sufficient to keep the surface soil moist. It is possible, however, that an increase in soil salinity can occur. During substantial rainfall events this salt load can be transported down to the water table and subsequently to the local stream. The increased quantity of groundwater irrigation could eventually lead to an increase in stream salinities. However, no increase in salinity has been observed in the North Para River over the last 30 years.

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Grab Sampling Stations in the Project Area. Extracted from the EPA Environmental Data Management System

Site Name	Characteristic	Number	Start Date	End Date	Min Value	Max Value
Jacob Creek: Kitchener GS505518	conductivity at 25C	45	8/08/77 0:00	21/11/97 11:00	189	1560
Jacob Creek: Kitchener GS505518	conductivity at 25C	104	21/11/73 15:00	17/03/93 10:30	214	5900
Jacob Creek: Kitchener GS505518	total dissolved solids	45	8/08/77 0:00	21/11/97 11:00	98	860
North Para River at Penrice GS505517	conductivity at 25C	179	29/08/73 0:00	15/07/99 14:30	136	4605
North Para River at Penrice GS505517	conductivity at 25C	108	21/11/73 14:00	21/07/92 14:00	136	4605
North Para River at Penrice GS505517	total dissolved solids	87	5/08/77 0:00	15/07/99 14:30	206	2108
North Para River: Mt McKenzie GS505533	conductivity at 25C	4	25/07/89 11:00	20/11/90 15:00	644	2200
North Para River: Mt McKenzie GS505533	conductivity at 25C	16	25/07/89 11:00	15/03/93 11:20	242	3370
North Para River: Mt McKenzie GS505533	total dissolved solids	4	25/07/89 11:00	20/11/90 15:00	354	1216
North Para River: Turretfield GS505504	conductivity at 25C	57	30/08/71 0:00	5/11/97 11:30	291	14100
North Para River: Turretfield GS505504	conductivity at 25C	134	24/07/72 13:45	17/03/93 16:21	573	14008
North Para River: Turretfield GS505504	total dissolved solids	53	26/03/74 0:00	5/11/97 11:30	160	8158
North Para River: u/s Duck Ponds Creek junction GS505525	conductivity at 25C	1	30/03/83 8:33	30/03/83 8:33	5657	5657
North Para River: u/s Duck Ponds Creek junction GS505525	total dissolved solids	1	30/03/83 8:33	30/03/83 8:33	3170	3170
North Para River: Yaldara GS505502	conductivity at 25C	54	7/09/72 0:00	5/11/97 14:15	243	5190
North Para River: Yaldara GS505502	conductivity at 25C	161	8/06/72 12:30	17/03/93 12:15	128	7850
North Para River: Yaldara GS505502	total dissolved solids	50	27/03/74 0:00	5/11/97 14:15	133	2903

APPENDIX

Salinity and Stream Flows at the 5 Continuous Monitoring Stations on the North Para River

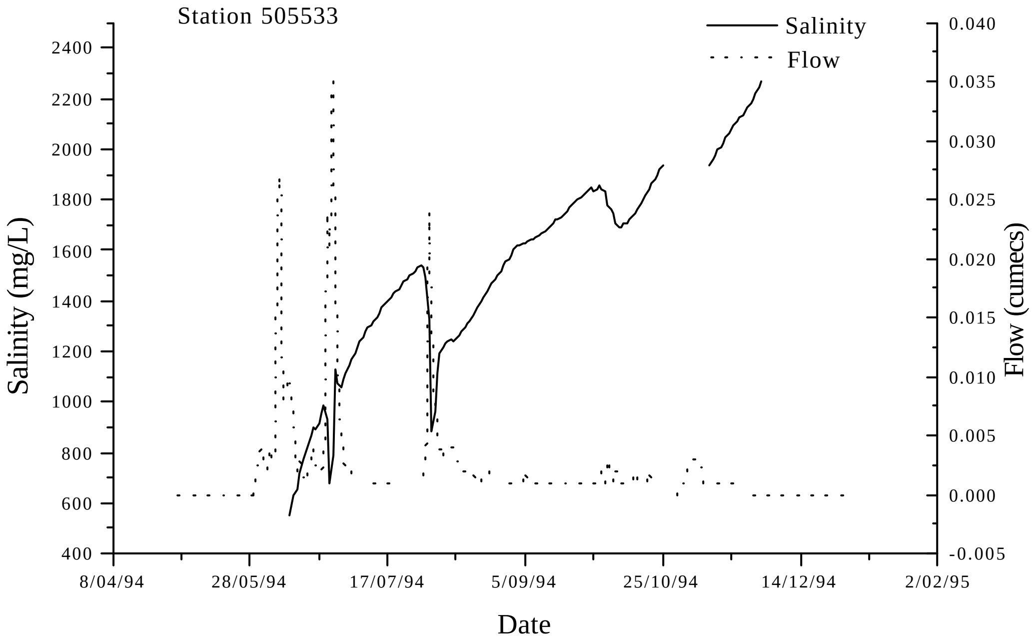


Figure A1: Station 505533 1994

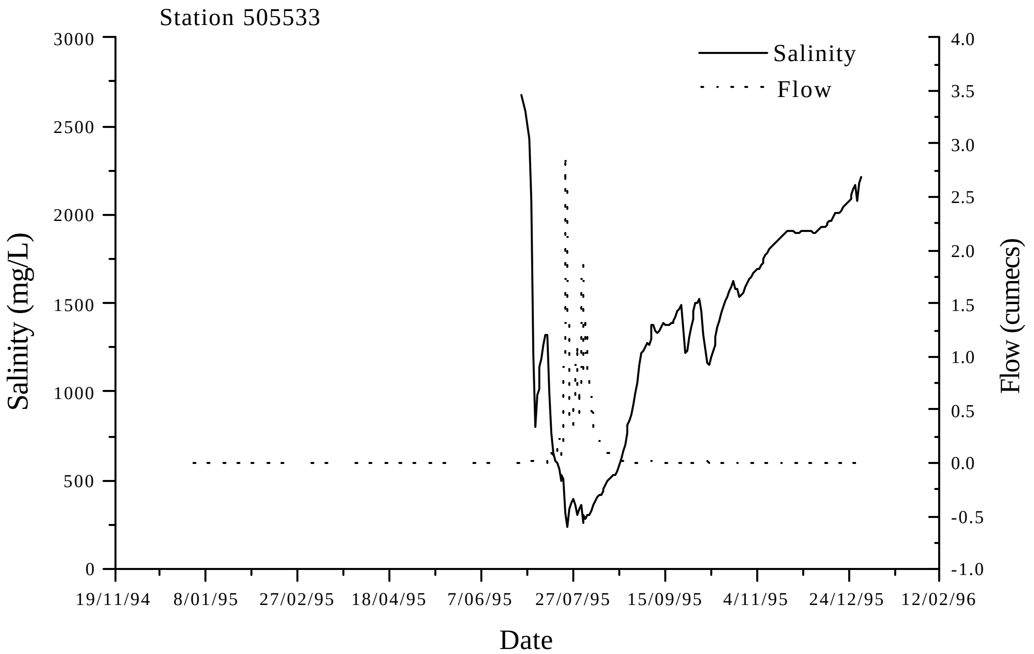


Figure A2: Station 505533 1995

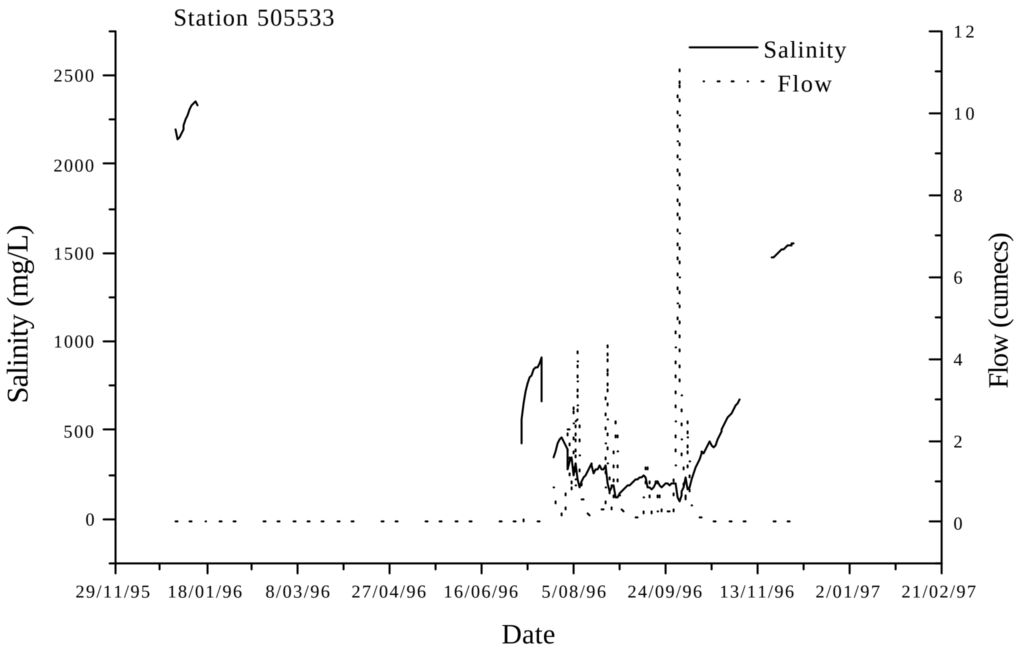


Figure A3: Station 505533 1996

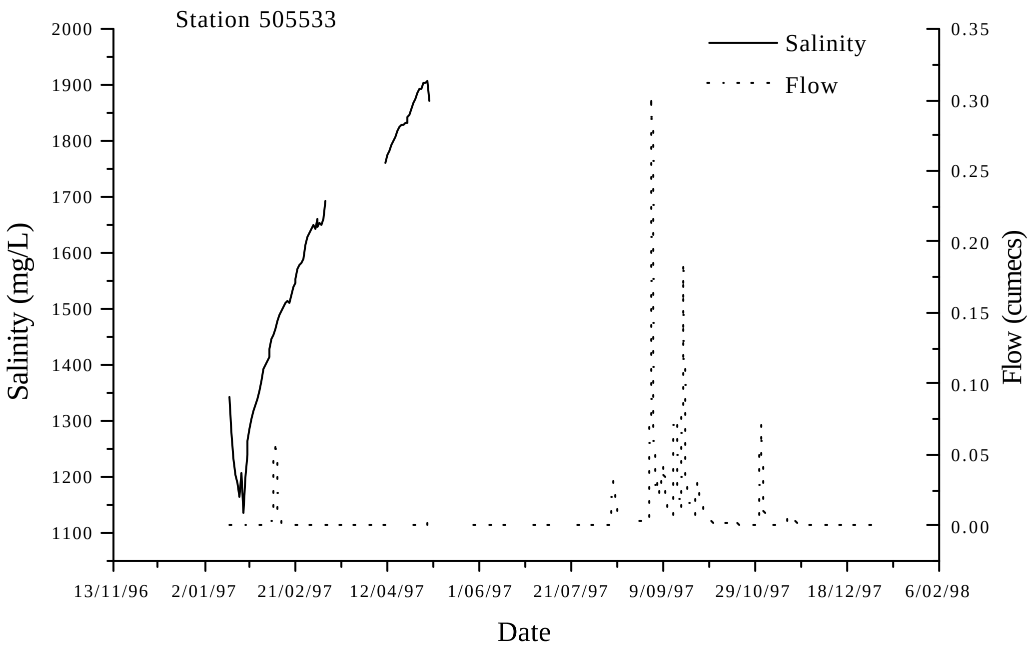


Figure A4: Station 505533 1997

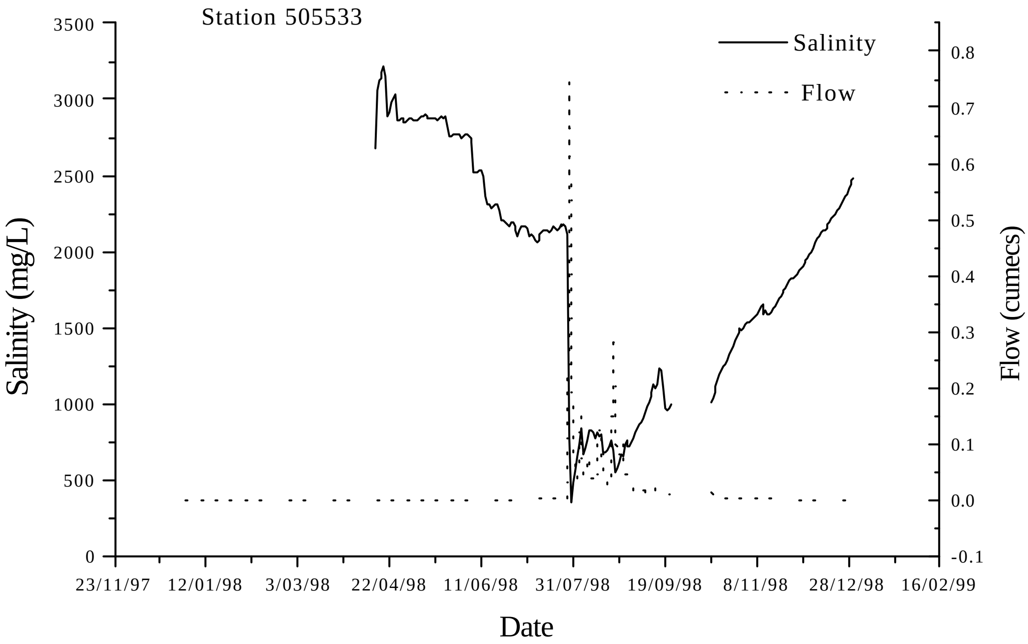


Figure A5: Station 505533 1998

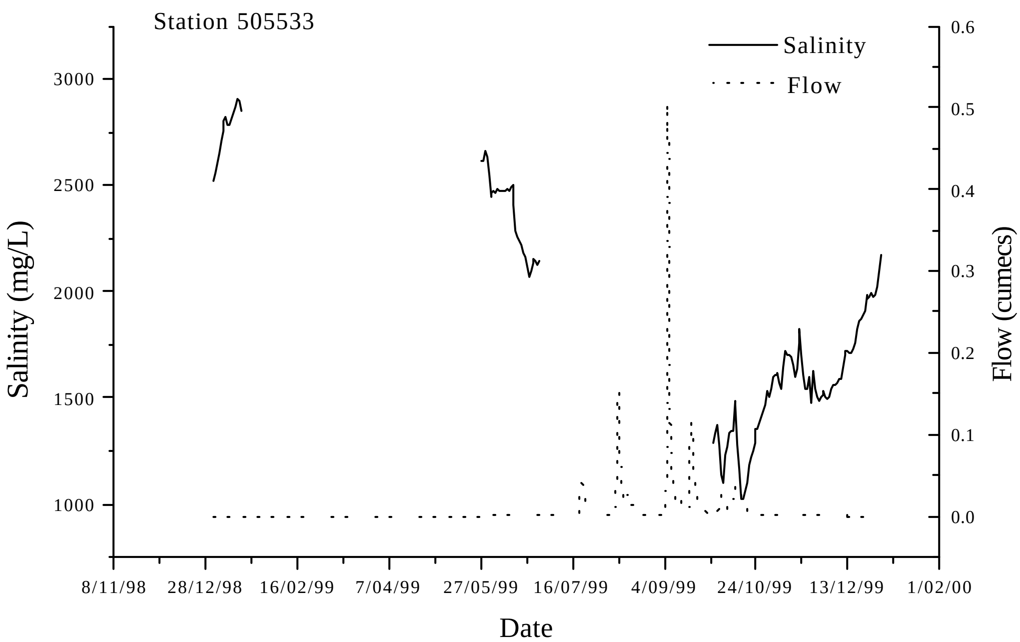


Figure A6: Station 505533 1999

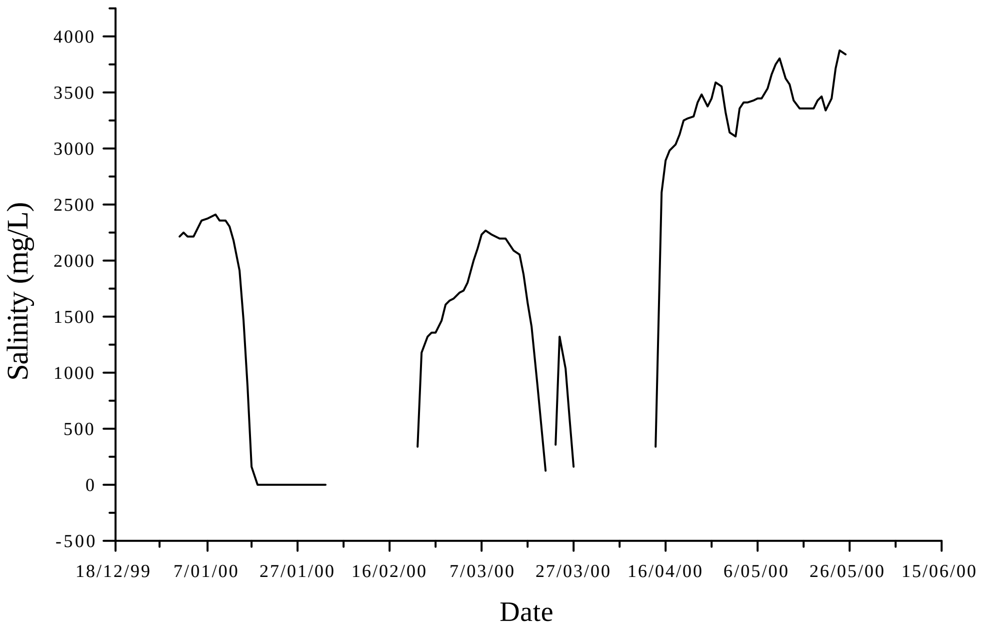


Figure A7: Station 505533 2000

	SALINITY				FLOW			
YEAR	MEAN	MAX	MIN	COUNT	MEAN	MAX	MIN	COUNT
1994	1520	2281	539	157	0.002082	0.086	0	244
1995	1362	2731	162	186	0.052244	7.518	0	365
1996	464	1569	68	128	0.24618	21.424	0	300
1997	1574	1917	1060	77	0.005488	0.624	0	326
1998	1892	3246	194	241	0.011096	1.731	0	344
1999	1883	2927	927	141	0.006266	1.925	0	365
2000	1540	4042	0	146	1.37E-05	0.001	0	146

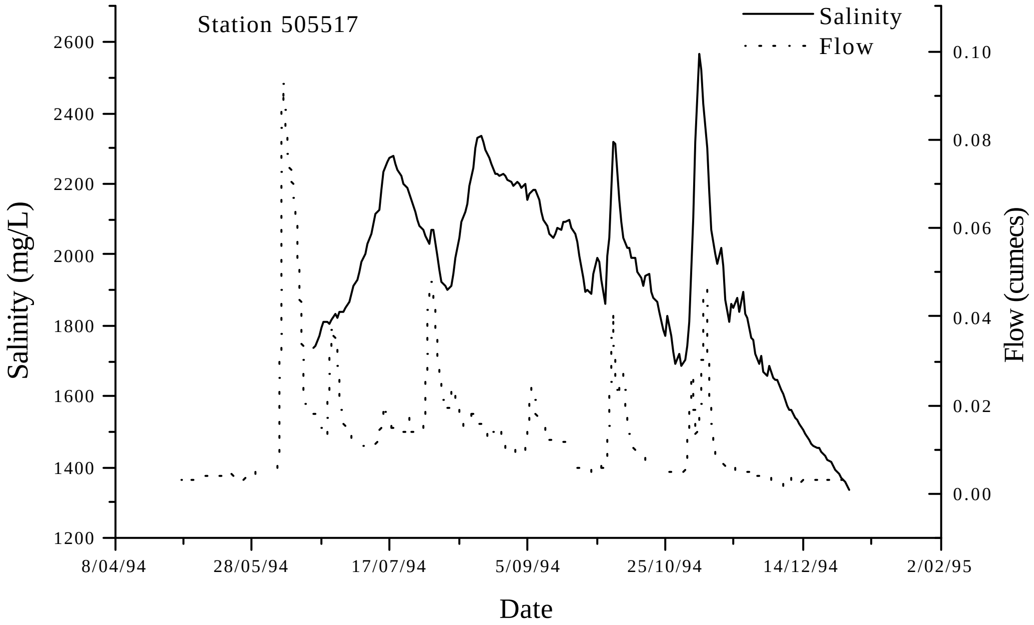


Figure A8: Station 505517 1994

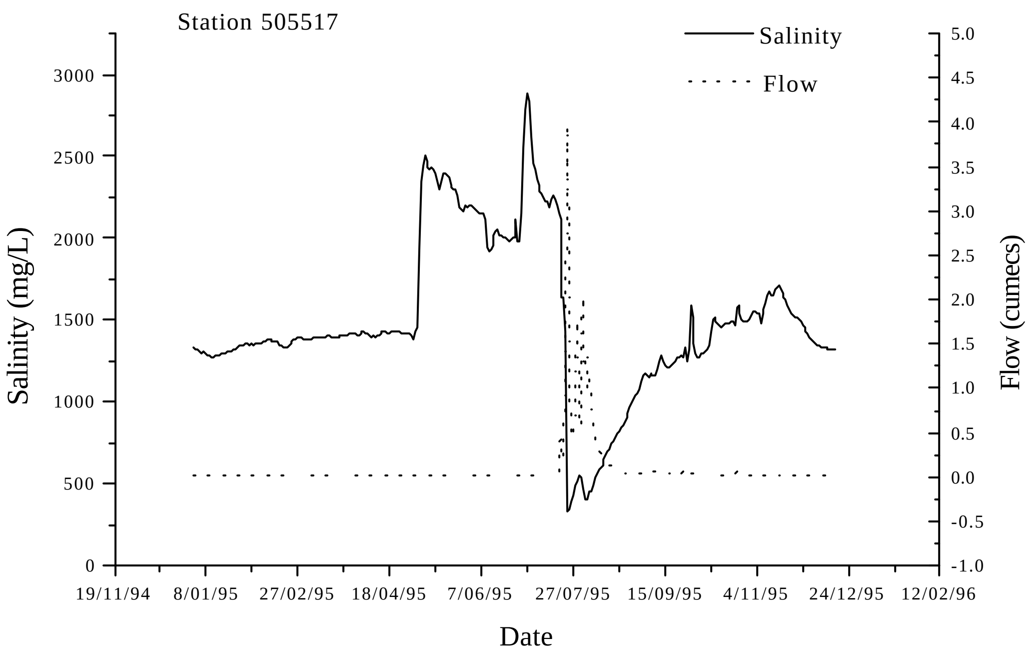


Figure A9: Station 505517 1995

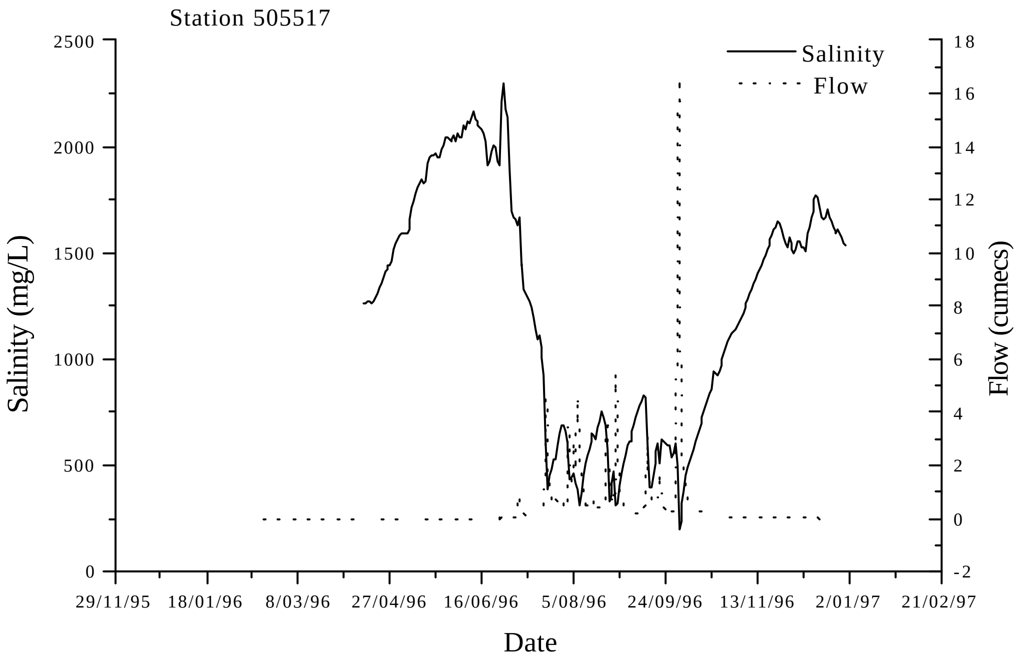


Figure A10: Station 505517 1996

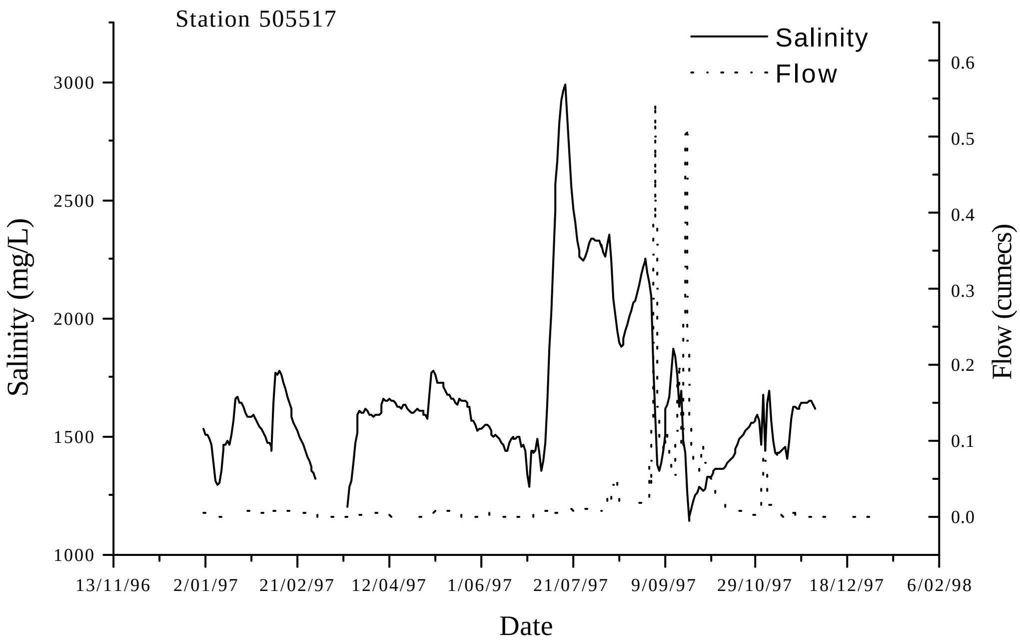


Figure A11: Station 505517 1997

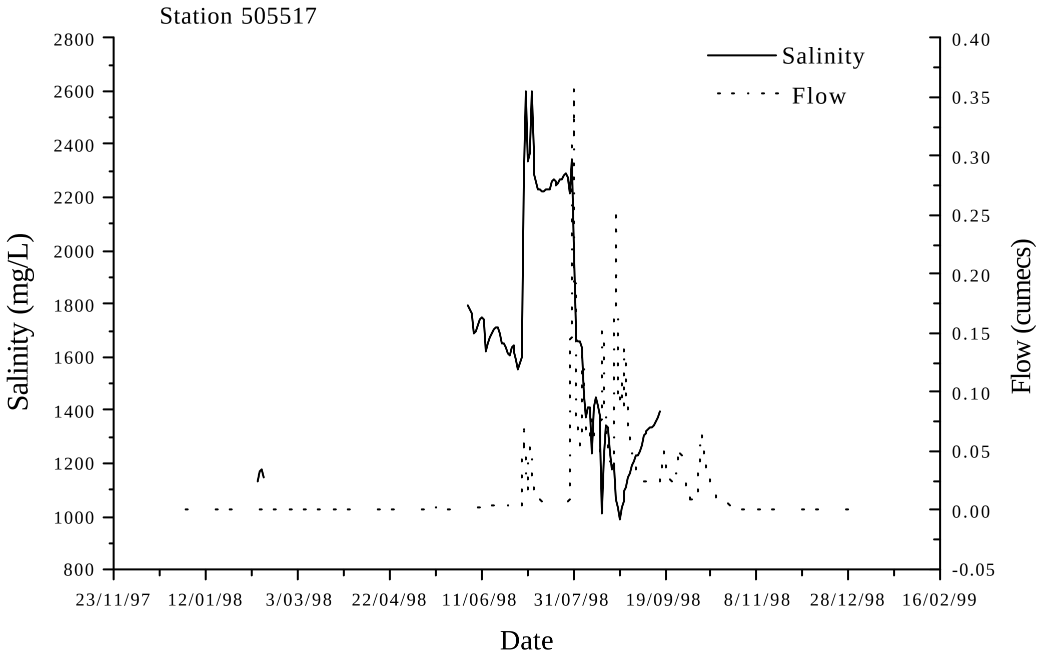


Figure A12: Station 505517 1998

	SALINITY				FLOW			
YEAR	MEAN	MAX	MIN	COUNT	MEAN	MAX	MIN	COUNT
1994	1940	2610	1324	196	0.013078	0.144	0.001	244
1995	1498	2909	281	351	0.078643	8.364	0.002	350
1996	1243	2936	165	264	0.359377	32.864	0	326
1997	1666	3028	908	318	0.018216	1.485	0	361
1998	1651	3190	966	109	0.014104	0.651	0	365
1999	No data	0	0	0	0.005477	0.311	0	365
2000	No data				0.00013	0.403	0	138

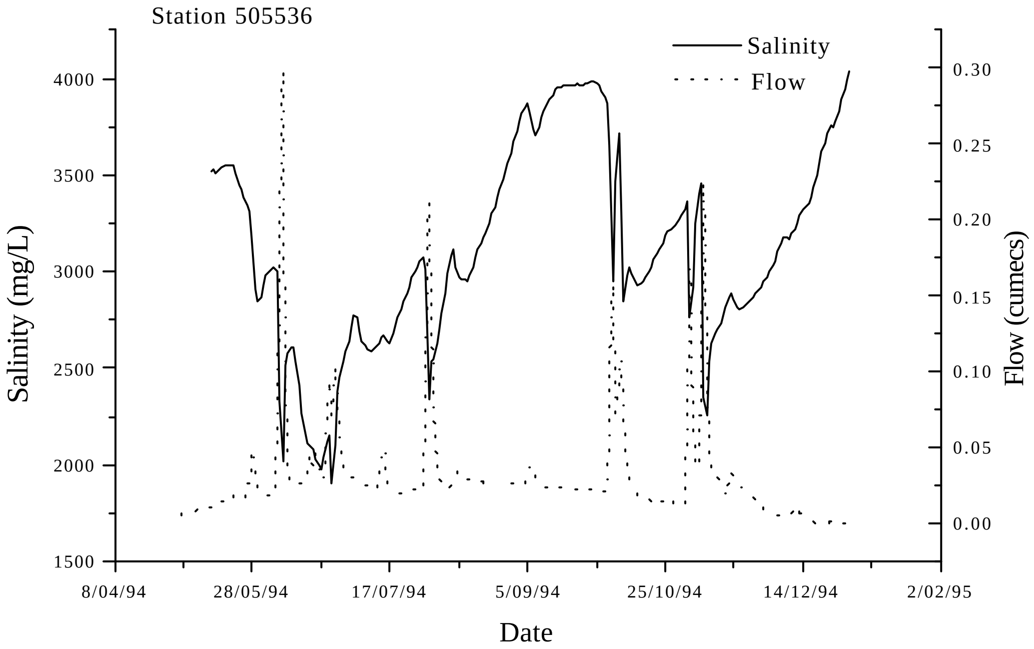


Figure A13: Station 505536 1994

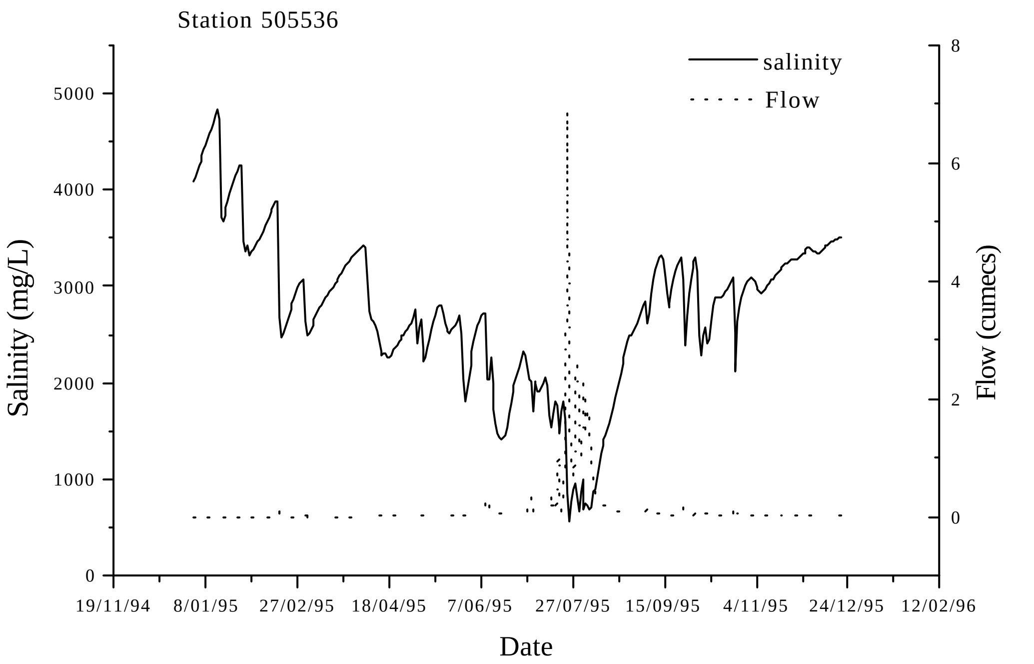


Figure A14: Station 505536 1995

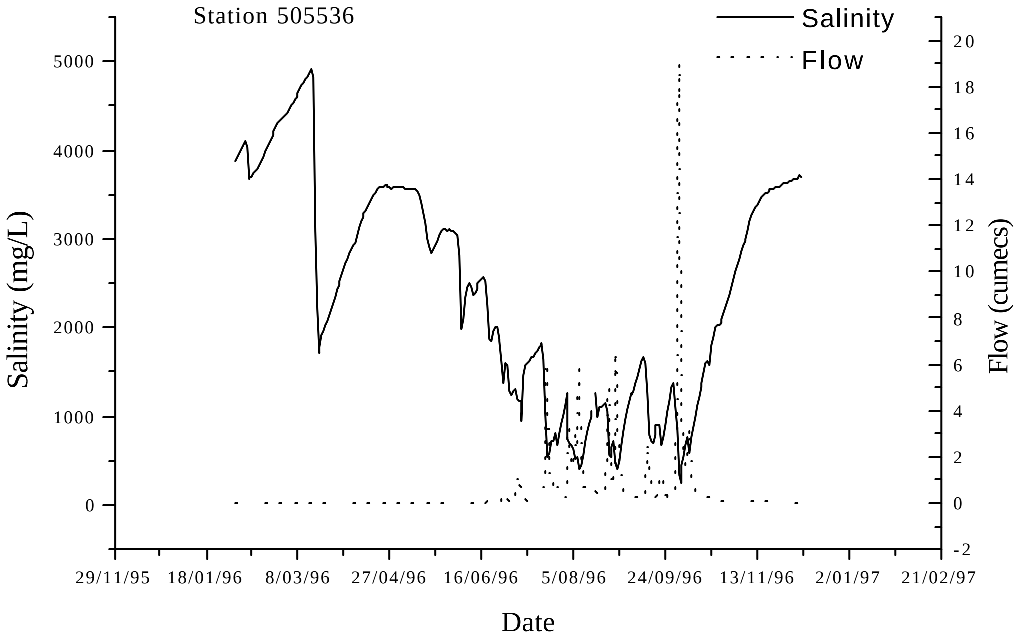


Figure A15: Station 505536 1996

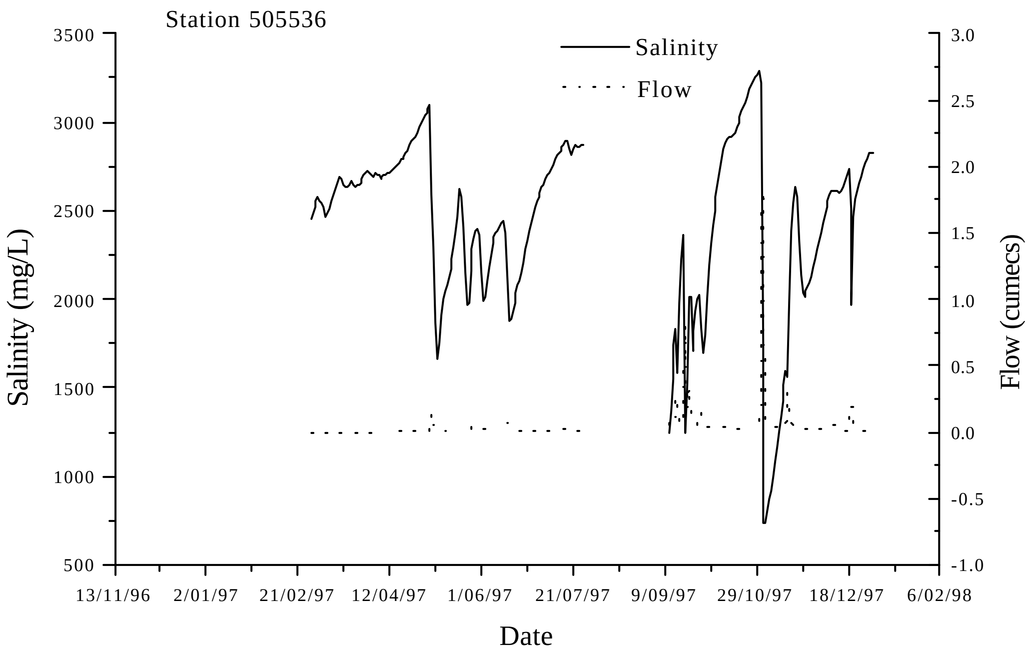


Figure A16: Station 505536 1997

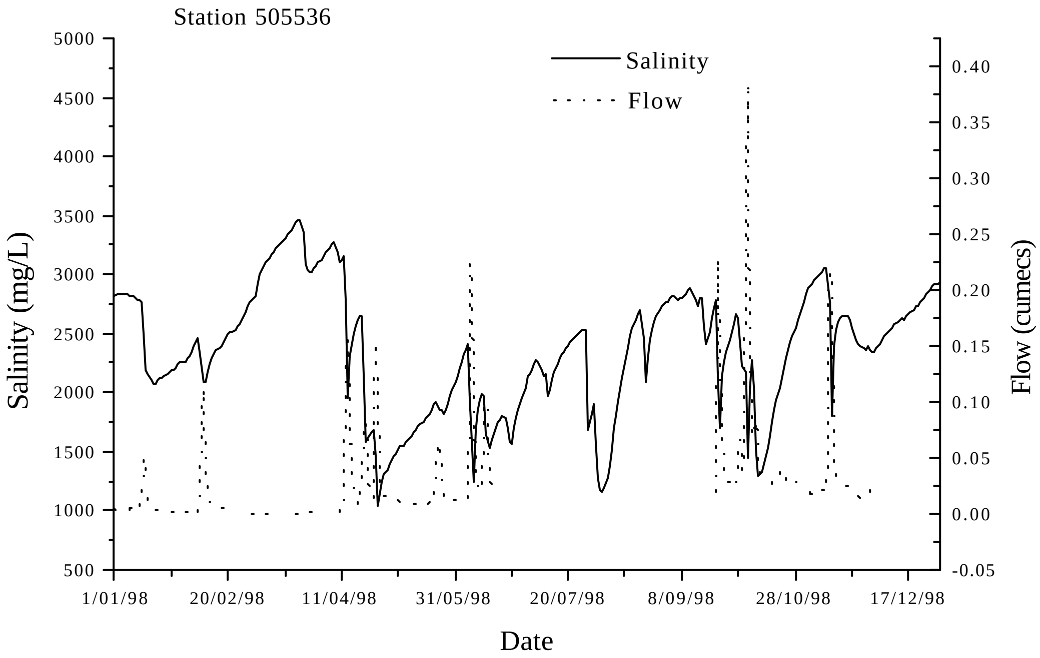


Figure A17: Station 505536 1998

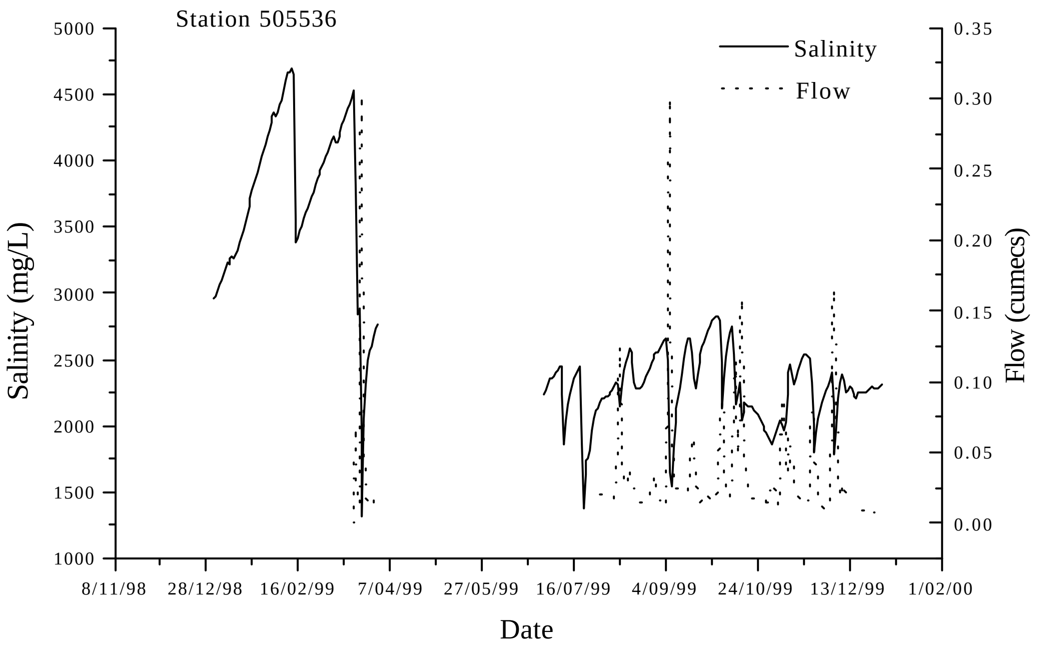


Figure A18: Station 505536 1999

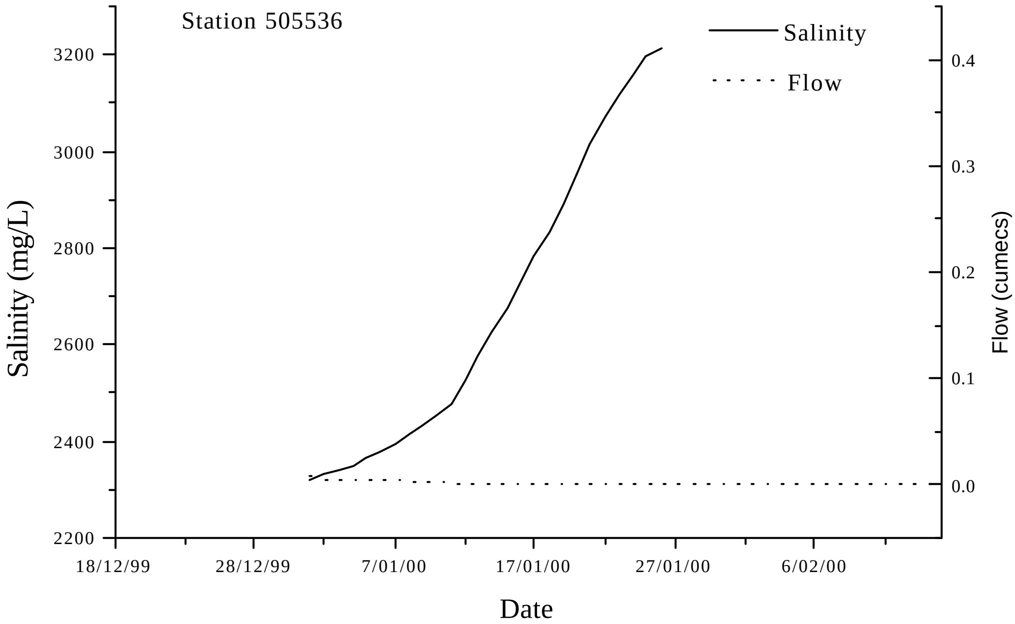


Figure A19: Station 505536 2000

	SALINITY				FLOW			
YEAR	MEAN	MAX	MIN	COUNT	MEAN	MAX	MIN	COUNT
1994	3122	4048	1716	233	0.031	0.358	0	244
1995	2730	4879	473	354	0.122	9.71	0	354
1996	2433	4936	194	308	0.463	32.1	0	308
1997	2426	3303	656	261	0.0441	2.75	0	260
1998	2362	3488	983	365	0.026	1.16	0	239
1999	2737	4830	1031	275	0.035	1.03	0	169
2000	2735	2800	1166	26	0.020	0.896	0	129

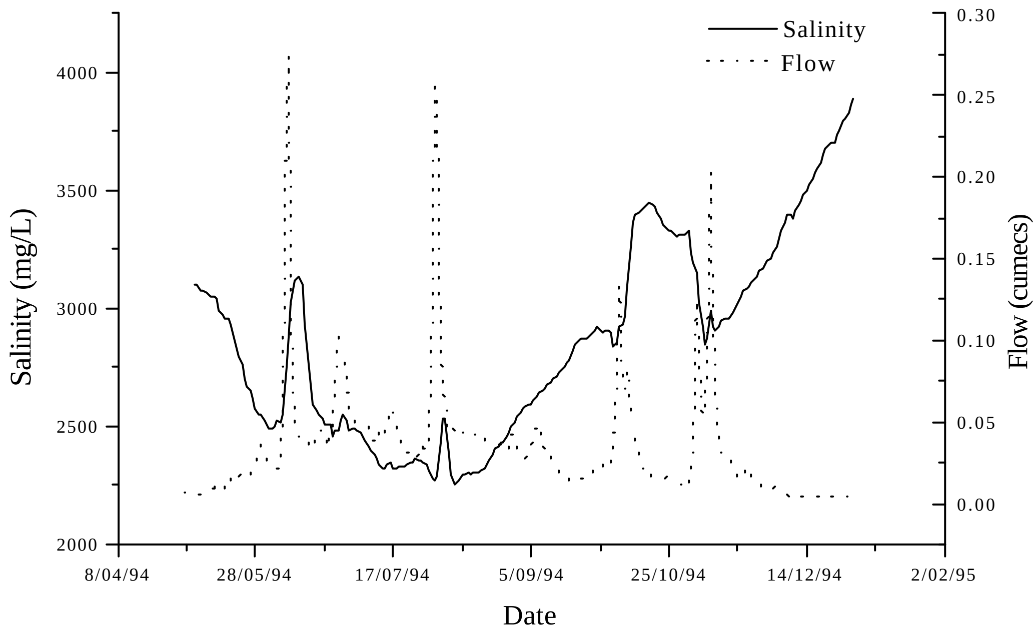


Figure A20: Station 505502 1994

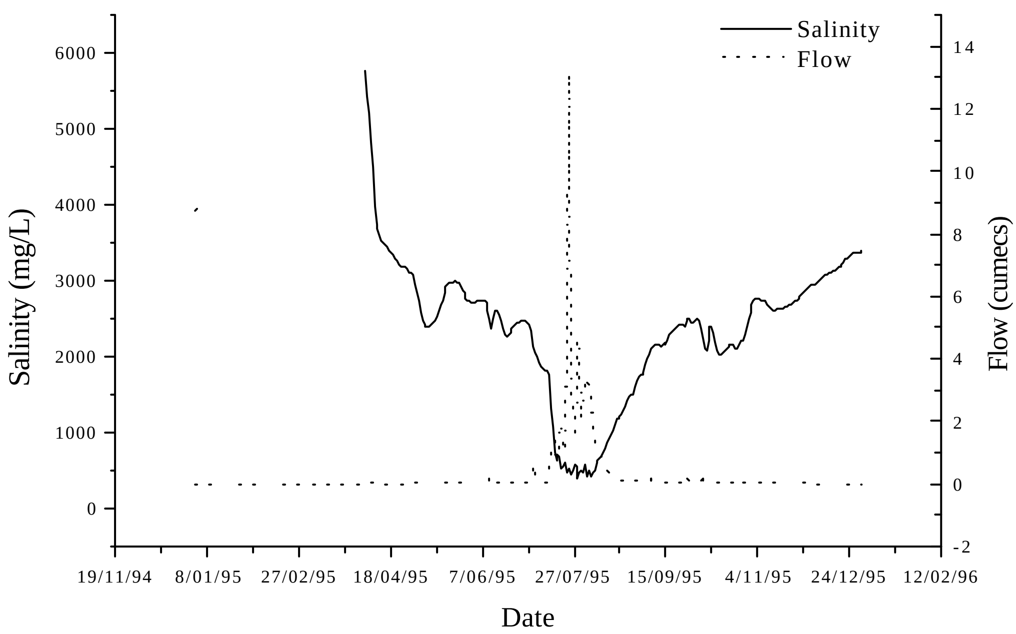


Figure A21: Station 505502 1995

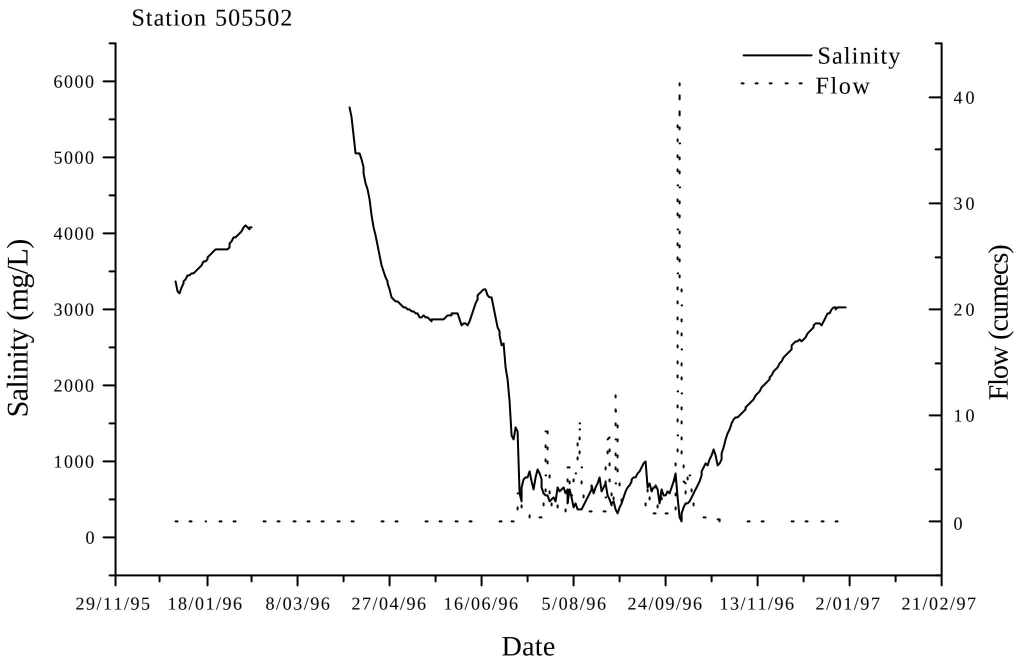


Figure A22: Station 505502 1996

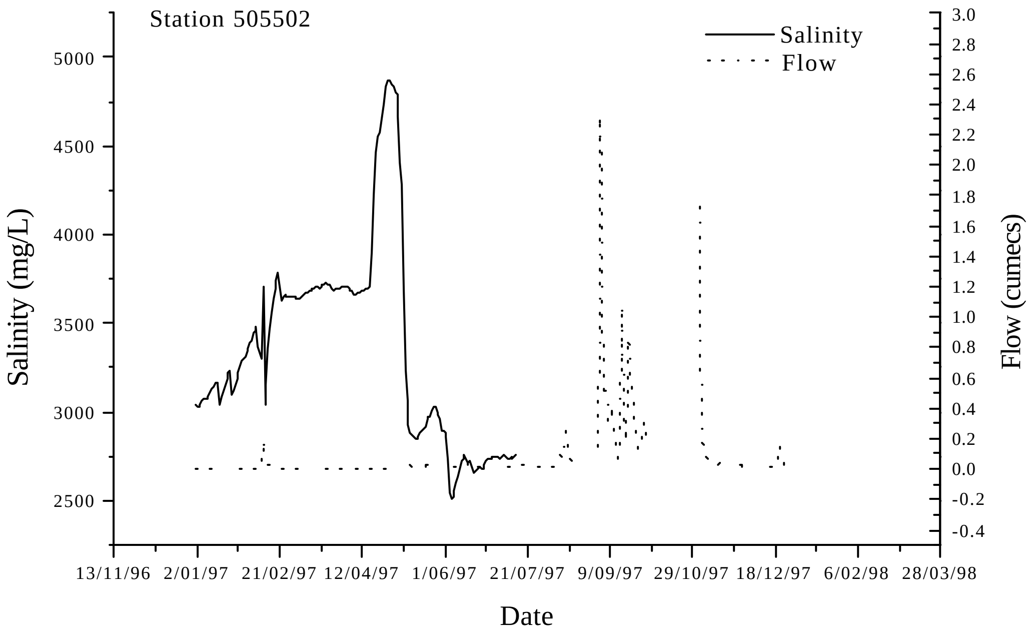


Figure A23: Station 505502 1997

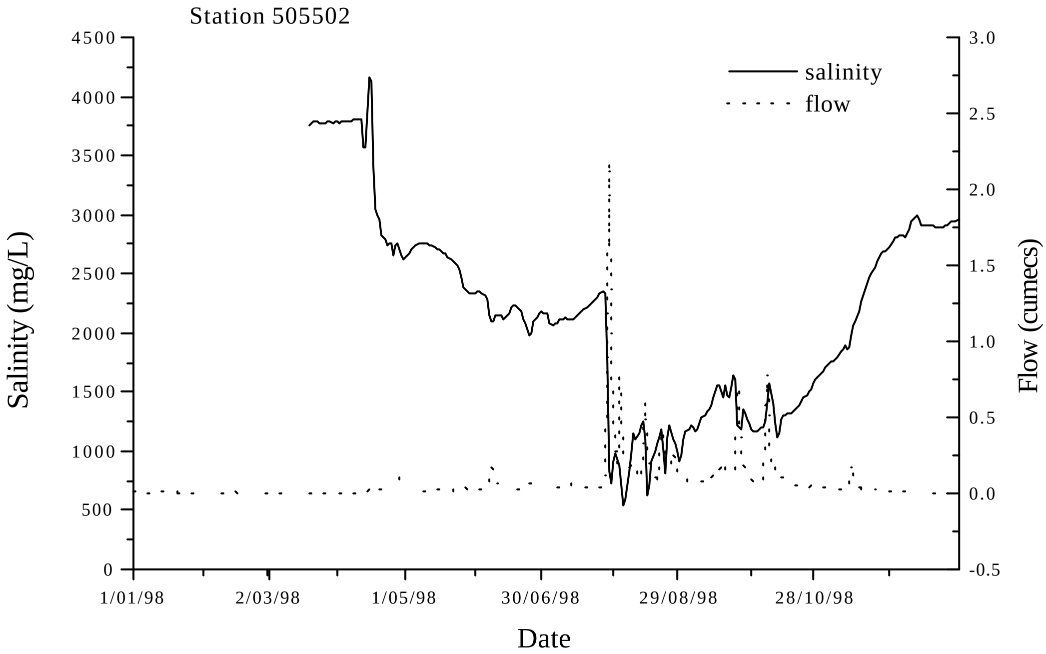


Figure A24: Station 505502 1998

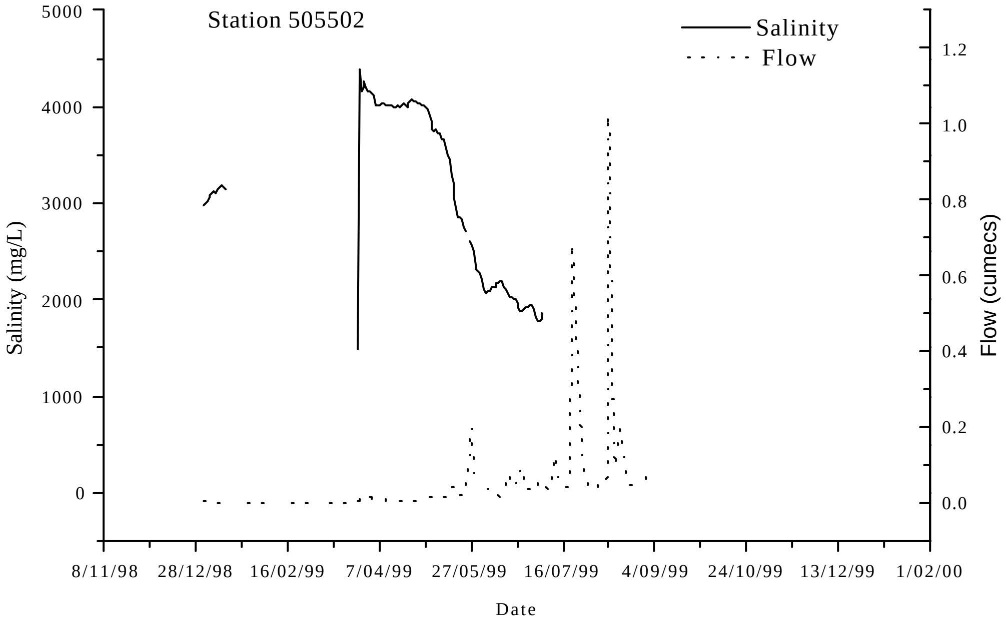


Figure A25: Station 505502 1999

	SALINITY				FLOW			
YEAR	MEAN	MAX	MIN	COUNT	MEAN	MAX	MIN	COUNT
1994	2857	3912	2232	240	0.0359	0.366	0.003	240
1995	2376	5962	2340	274	0.2374	20.301	0.1678	274
1996	2175	5693	187	314	0.7839	71.817	0	314
1997	3354	4890	2498	195	0.0674	6.884	0.001	195
1998	2173	4403	427	287	0.0701	3.141	0.002	287
1999	2148	4745	1749	164	0.046	1.363	0	164
2000	NO DATA							

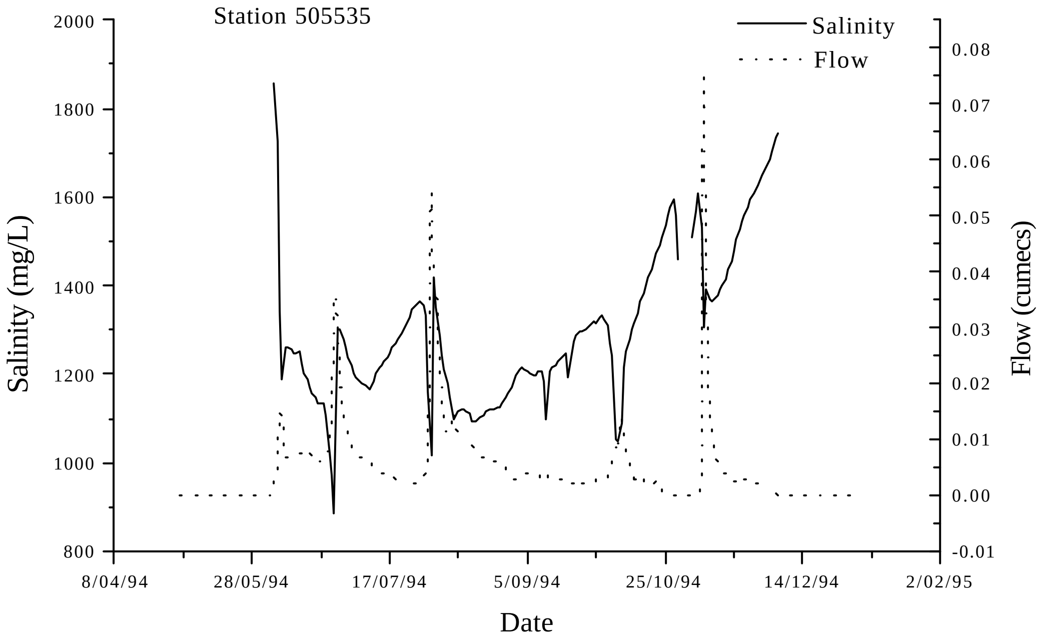


Figure A26: Station 505535 1994

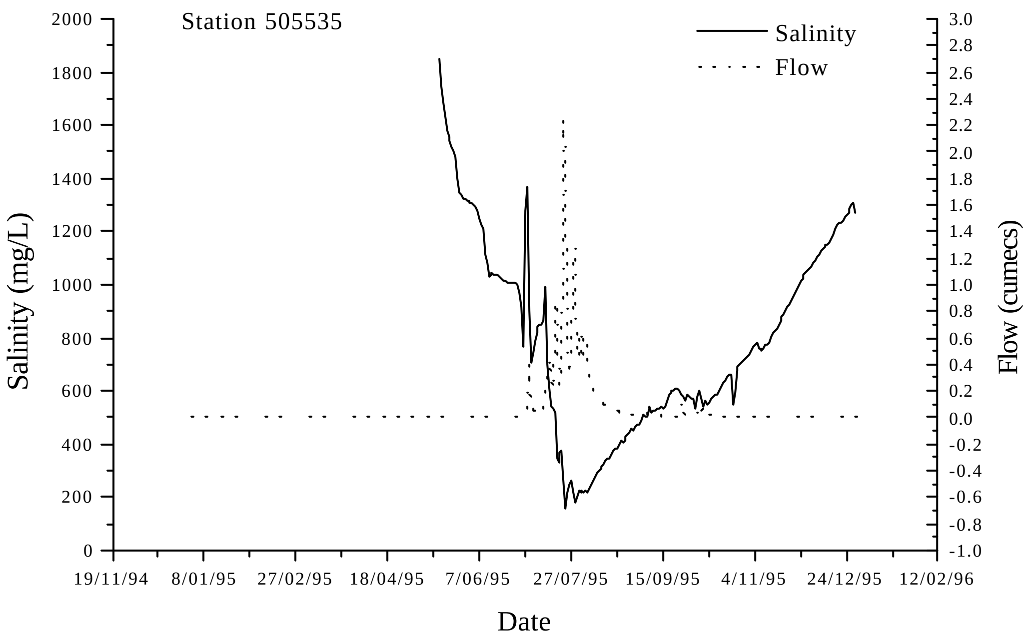


Figure A27: Station 505535 1995

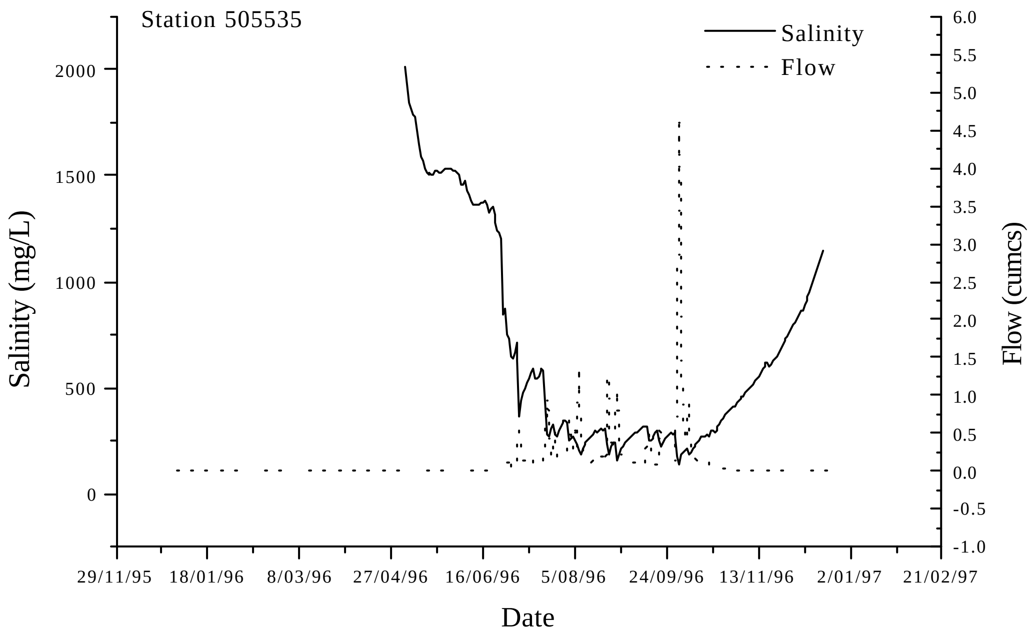


Figure A28: Station 505535 1996

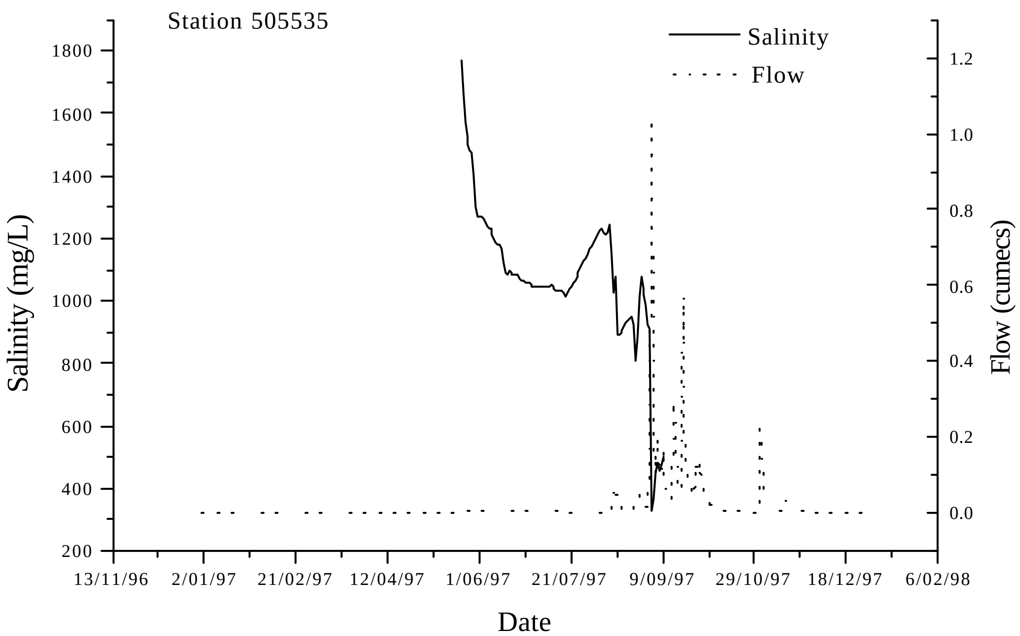


Figure A29: Station 505535 1997

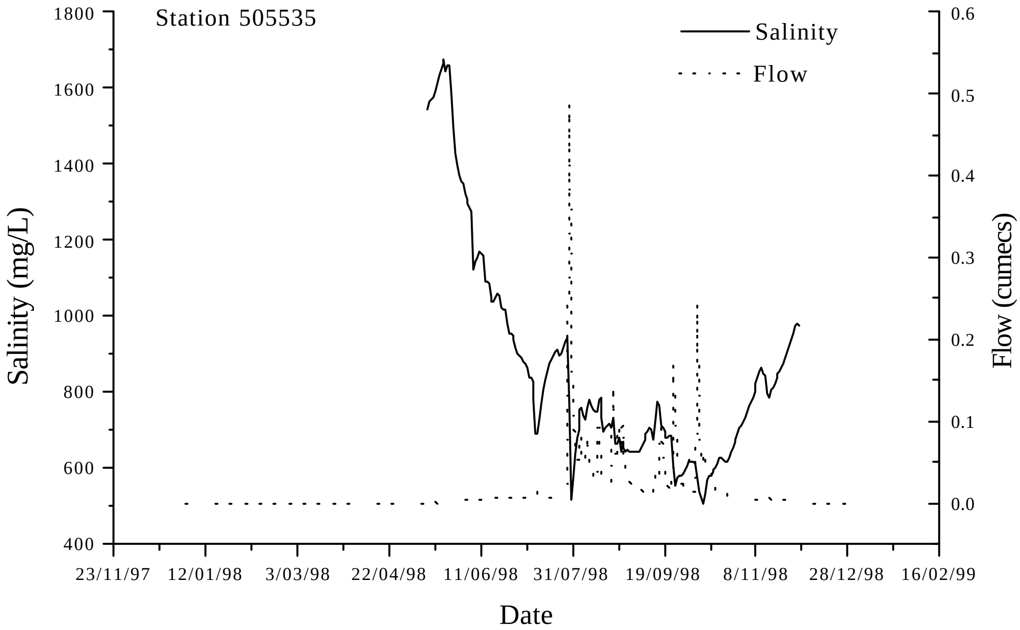


Figure A30: Station 505535 1998

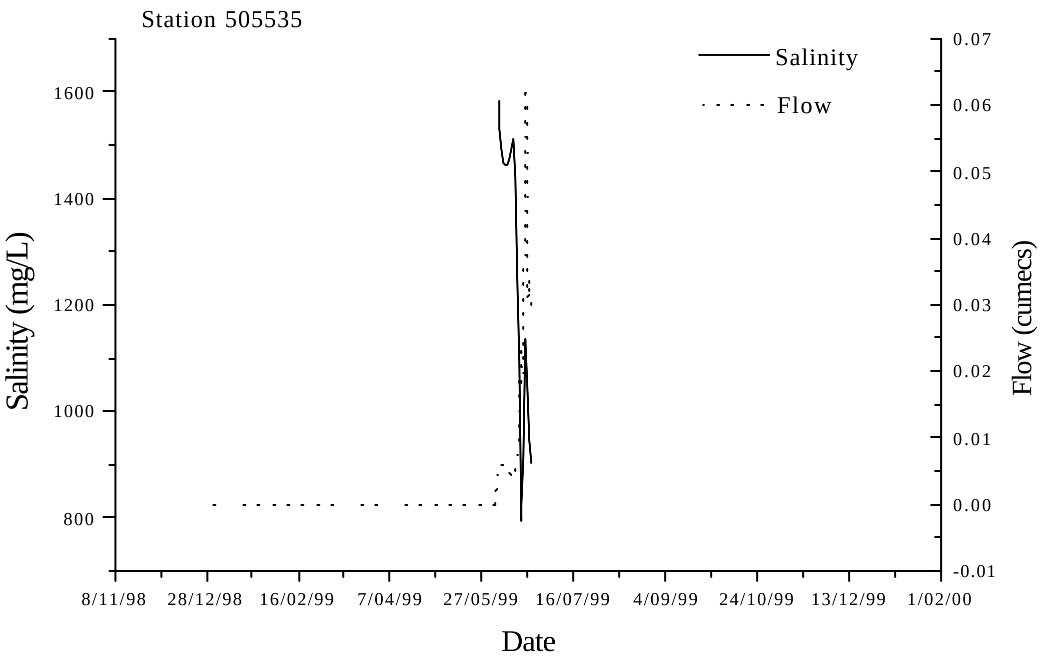


Figure A31: Station 505535 1999

	SALINITY				FLOW			
YEAR	MEAN	MAX	MIN	COUNT	MEAN	MAX	MIN	COUNT
1994	1297	1925	739	180	0.004975	0.102	0	244
1995	793	1949	113	228	0.055118	7.077	0	365
1996	684	2067	105	228	0.100653	8.757	0	366
1997	1078	1877	238	111	0.01814	3.625	0	365
1998	865	1687	428	203	0.01377	1.333	0	365
1999	1254	1664	712	19	0.001753	0.116	0	174
2000	NO DATA							

APPENDIX 2

Detailed CSIRO Soil Maps

Greenoch – Gomersal Area
Stockwell – Nuriootpa Area
Lyndoch –Williamstown Unit
Tanunda – Rowland Flat Area

APPENDIX 3

Typical Soil Profile Description

Appendix 3 "Typical" Soil Profile Descriptions

Skeletal Soils

Soils of the ridgetops – not used for viticulture but occur in association with podsolic soils.

Depth (cm)	Description of horizon
0-20	grey sandy loam
20-25	decomposing micaceous schist
25-100+	parent rock – micaceous schist or sometimes, sandstone

Podsolic Soils

Soils of the higher rainfall zones – Barossa Ranges.

Depth (cm)	Description of horizon
0-15	grey to light grey sandy loam
15-30	light grey to white loamy sand, often with some quartz or ironstone gravel above the clay
30-50	mottled red-brown or yellowish grey to grey clay
50-75	mottled clay with decomposing parent rock
75-100+	parent rock

Solodised Solonetz and Solodic (sand-over-clay) soils

These soils occur frequently in the northern areas of the Barossa Hills, all along the western rim of the valley, in the Lyndoch area, and the north-western portion of the valley floor. The poor drainage characteristics of this soil group indicate potential problems, especially when they occur on flat land.

Depth (cm)	Description of horizon
0-10	light grey-brown sandy loam
10-20	light grey to brownish white fine sand often with some ironstone or quartz gravel
20-60	yellowish brown to grey brown mottled columnar clay
60-100+	yellowish brown to grey brown clay with or without (solods) some fine lime or lime concretions

Deep Sands

Occur in association with the sand-over-clay soils. These are essentially Aeolian (windblown) deposits.

Depth (cm)	Description of horizon
0-25	light grey brown fine sand
25-75	light brownish grey to white fine sand
75-100+	massive yellow brown sandy clay

Solonetzic (Transitional) Red-Brown Earths

Occur frequently in the northern extremities of the Barossa Hills (Keyneton to Moculta) and on the western rim of the valley in association with the sand-over-clay soil group. Drainage problems are also a feature of these soils.

Depth (cm)	Description of horizon
0-10	grey brown sandy loam to loam
10-25	brownish white sand often with gravel above the clay
25-45	mottled brownish red massive clay
45-100+	mottled yellow brown sandy clay often with inclusions of decomposing parent materials or lime

Sandy and Loamy Red-Brown Earths

Used extensively for viticulture on the northern valley floor and west of the western rim.

Depth (cm)	Description of horizon
0-20	grey brown fine sandy loam
20-30	light brown to grey brown sandy loam
30-80	whole coloured reddish brown friable clay
80-100+	brown clay with fine lime

Clay Loam Red-Brown Earths

Highly productive soils mainly to the south west of the Barossa Valley in the Rosedale area.

Depth (cm)	Description of horizon
0-25	brown clay loam
25-45	whole coloured friable red clay
45-100+	red-brown clay with fine lime

Dark Brown Cracking Clays

Highly productive soils to the south and west of Tanunda. Deep cracking on drying is a feature of these soils which have a high water requirement, especially when used for horticulture in dry years. Traditionally were left for cereal, hay, and grain legume production.

Depth (cm)	Description of horizon
0-25	dark brown clay loam with some lime grit
25-75	dark brown to black cracking clay
75-100+	brown clay with fine lime

Terra Rossa

Prized sols for viticulture but only found north of the Para River in the Lyndoch/Rosedale area and on the gentle slopes near Penrice on the eastern valley rim.

Depth (cm)	Description of horizon
0-25	red to red-brown clay loam
25-100+	limestone rubble and marl, often with hard capping

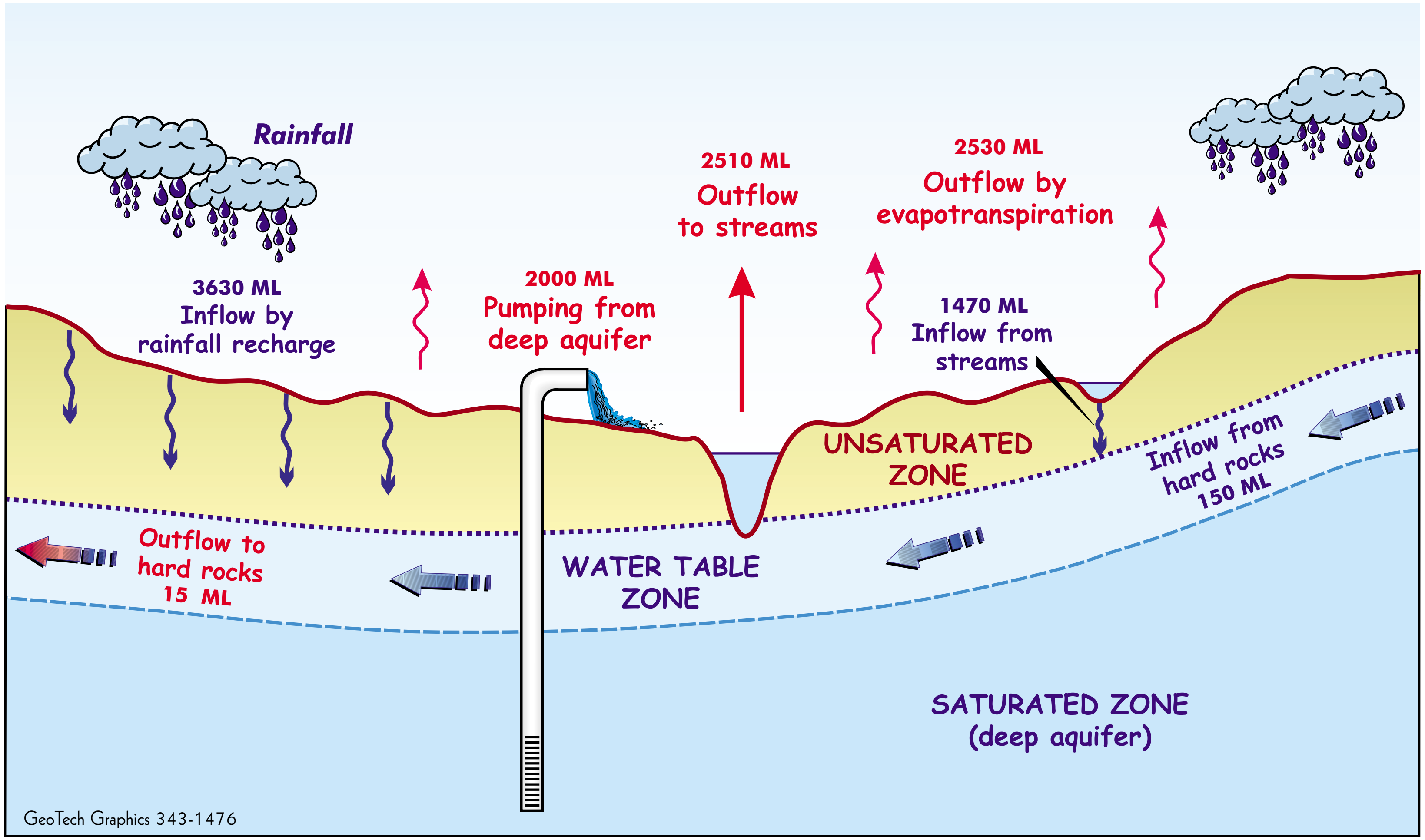
Alluvial Soils

Soils on flats adjacent to the drainage system comprised of fairly recent deposits of silt and sand.

Depth (cm)	Description of horizon
0-50	light grey brown fine sand to sandy loam
50-100+	light brown sandy loam to silty loam

APPENDIX 4

Proforma Irrigation Management Plan



Water Search
Groundwater & Geological Consultants

Barossa Infrastructure Limited

BAROSSA VALLEY FLOOR

Water Balance Components for Unsaturated and Water Table Zones

Figure 5.4

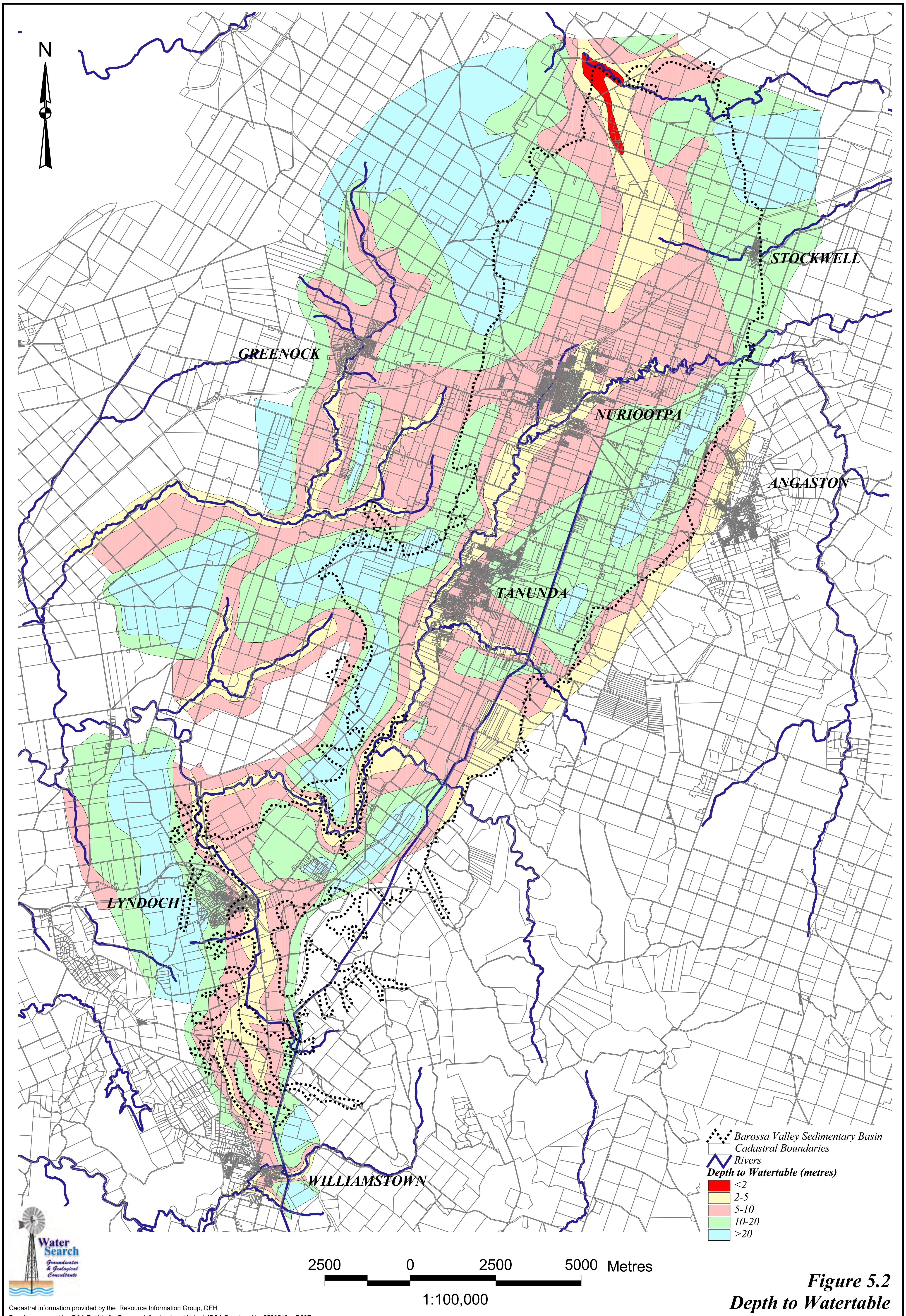
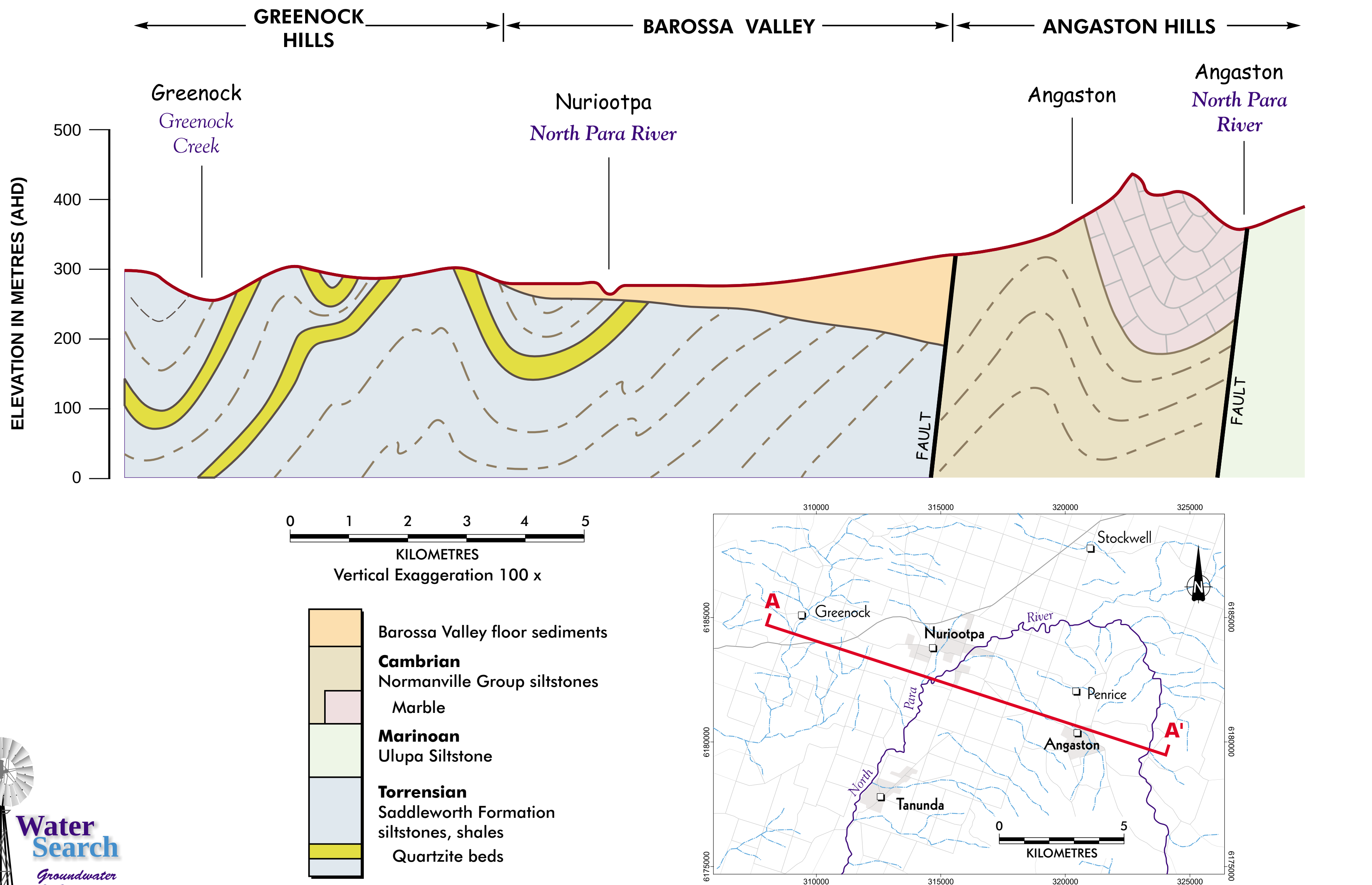


Figure 5.2
Depth to Watertable

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



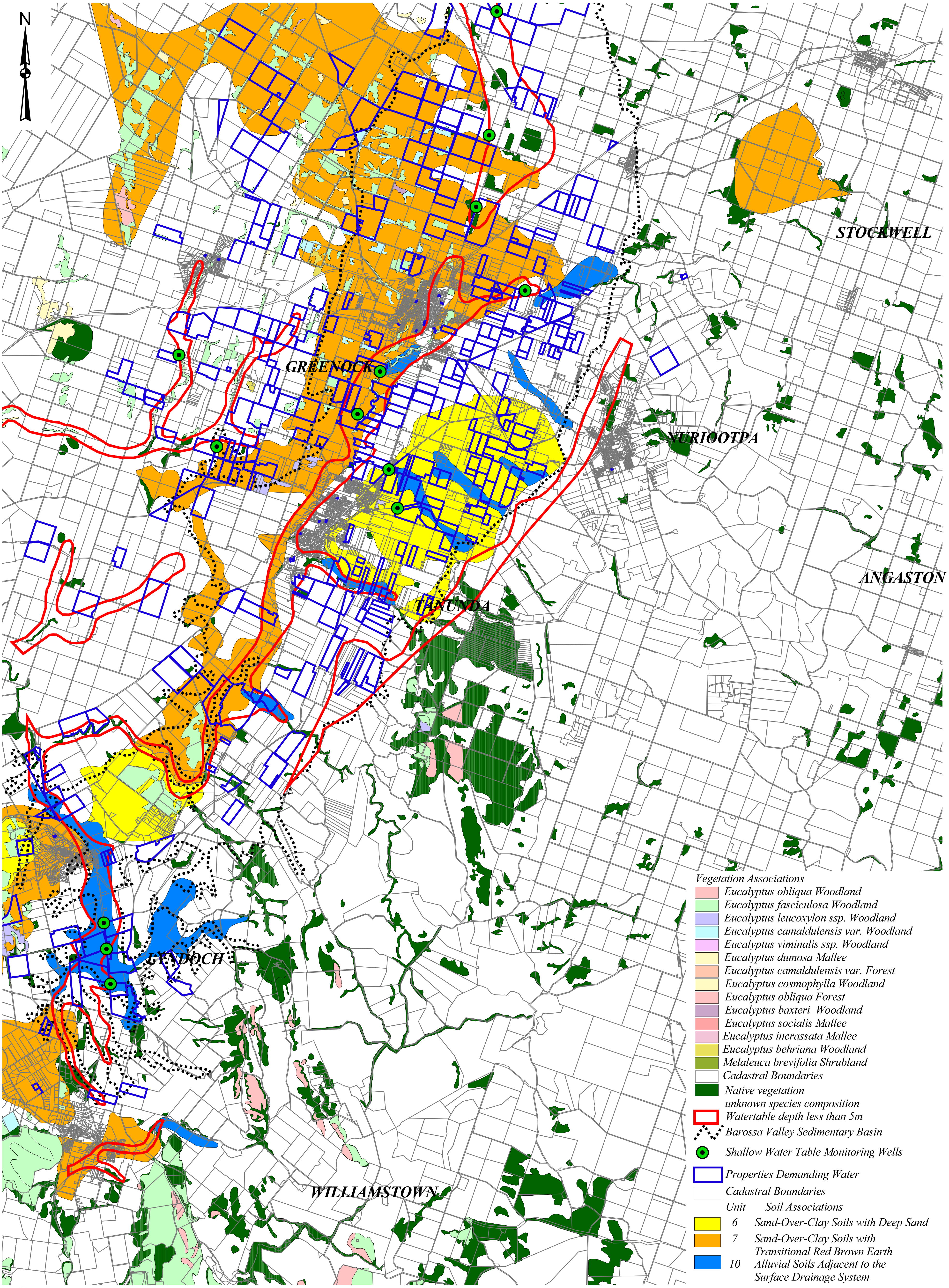
Barossa Infrastructure Limited

GEOLOGICAL SECTION A-A'

Figure 5.1

Water Search
Groundwater & Geological Consultants

GeoTech Graphics 343-1482



2500 0 2500 5000 Metres

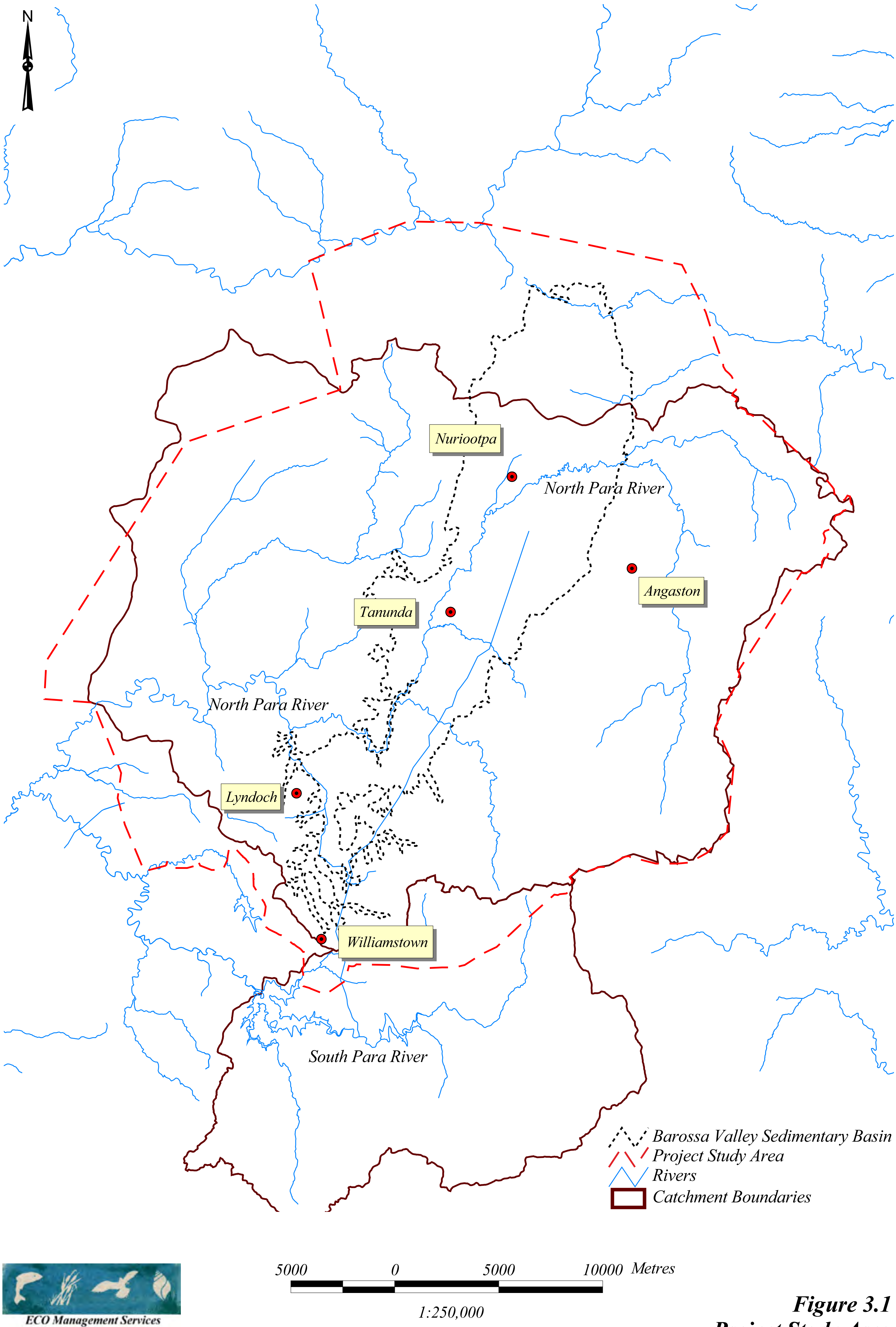
1:100,000

Water Search Groundwater & Geological Consultants

PRIMARY INDUSTRIES AND RESOURCES SA

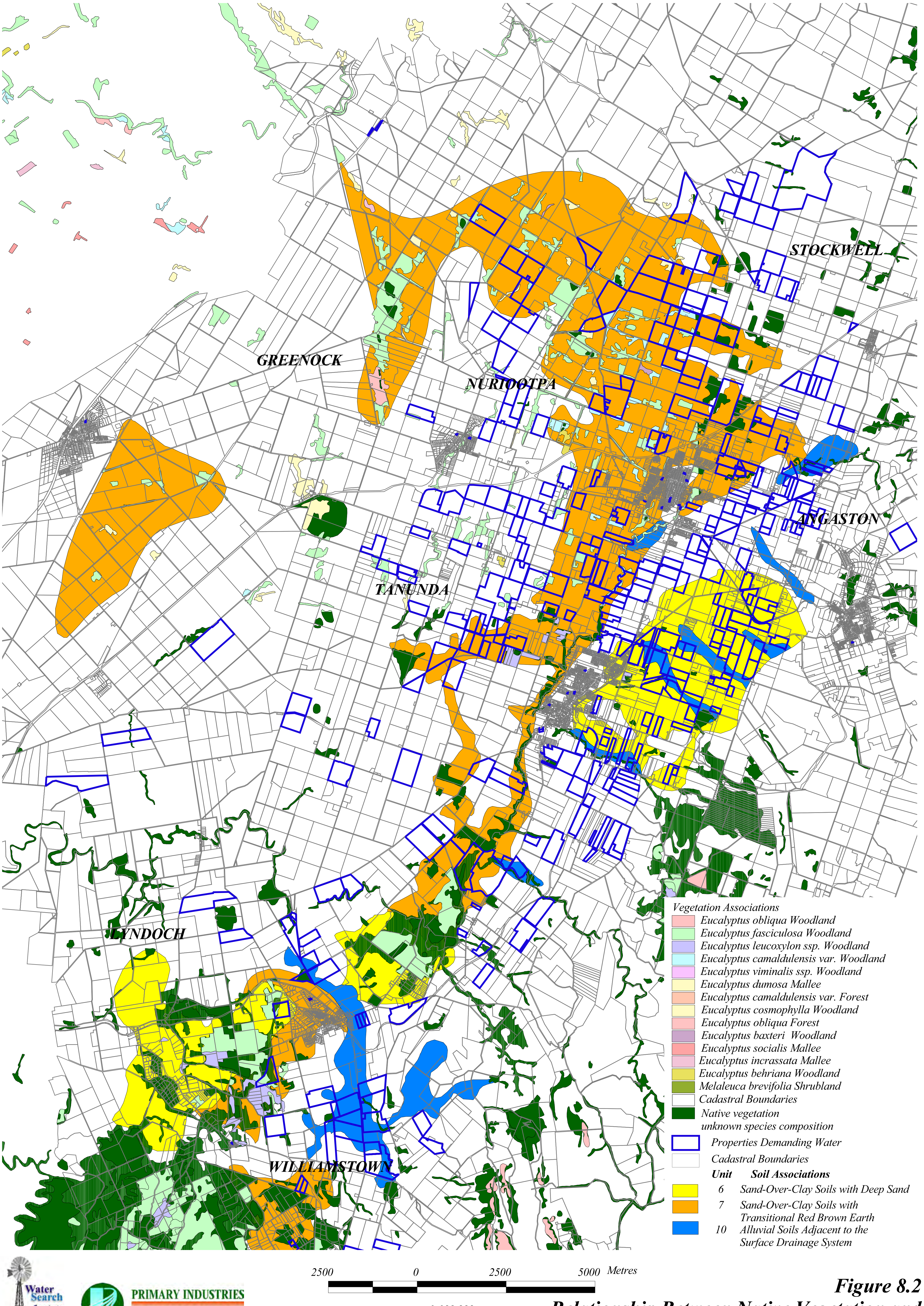
Figure 8.1
Priority Irrigation Management Areas:
Watertable depth less than 5m and sensitive soil associations

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



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

Figure 3.1
Project Study Area



Water Search Groundwater & Geological Consultants

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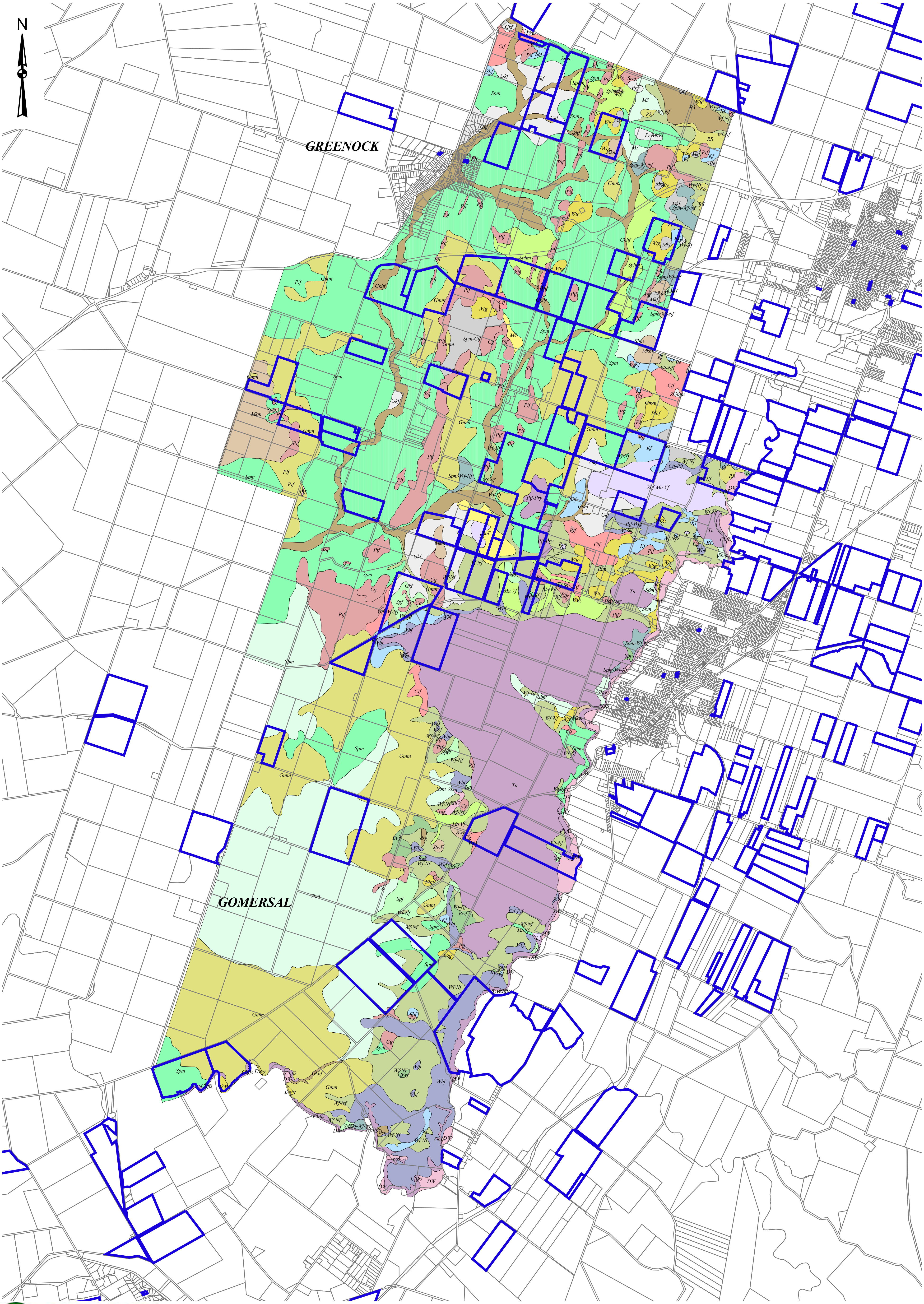
Figure 8.2

Relationship Between Native Vegetation and Properties Demanding Water in Areas of Sensitive Soil Associations

Vegetation Data Supplied by Planning 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 - D039



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1000 0 1000 2000 Metres

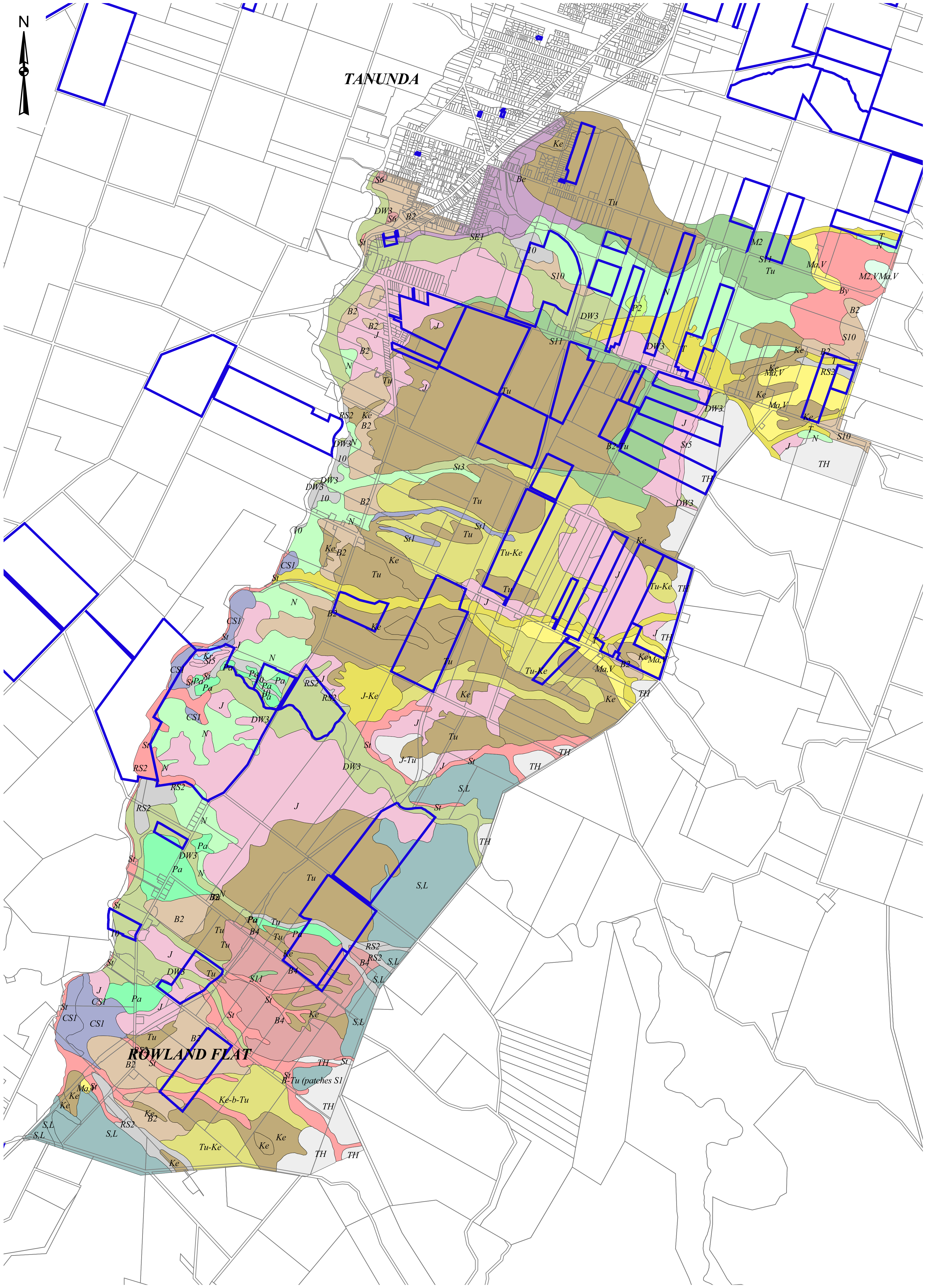
1:50,000

Detailed Soil Map
Greenoch - Gomersal Area

(Also showing location of properties that have applied for water)

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 - D026



PRIMARY INDUSTRIES AND RESOURCES SA

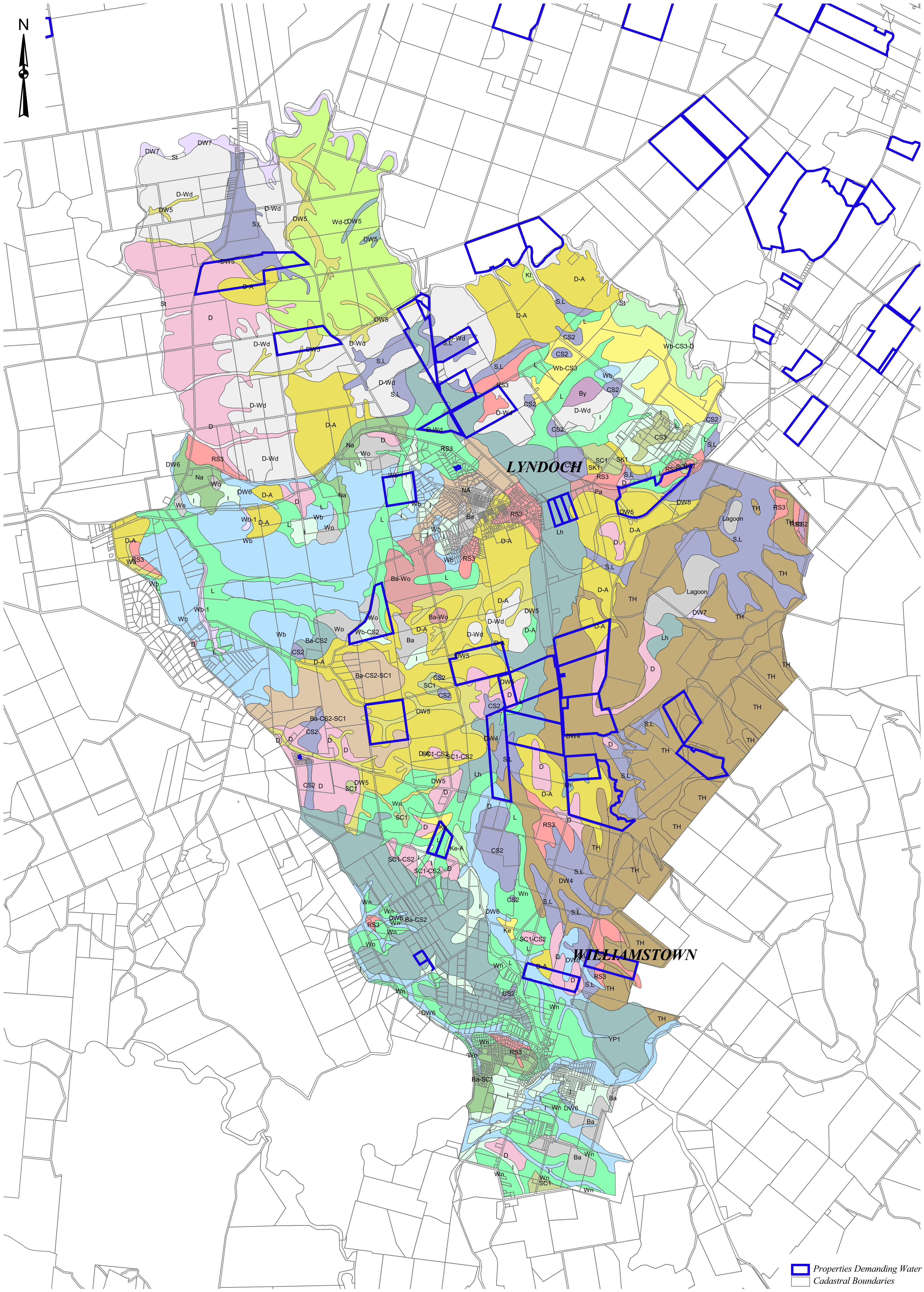
1000 0 1000 2000 Metres

1:30,000

Detailed Soil Map
Tanunda - Rowland Flat Area
(Also showing location of properties that have applied for water)

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 - D020



PRIMARY INDUSTRIES AND RESOURCES SA

1000 0 1000 2000 3000 Meters

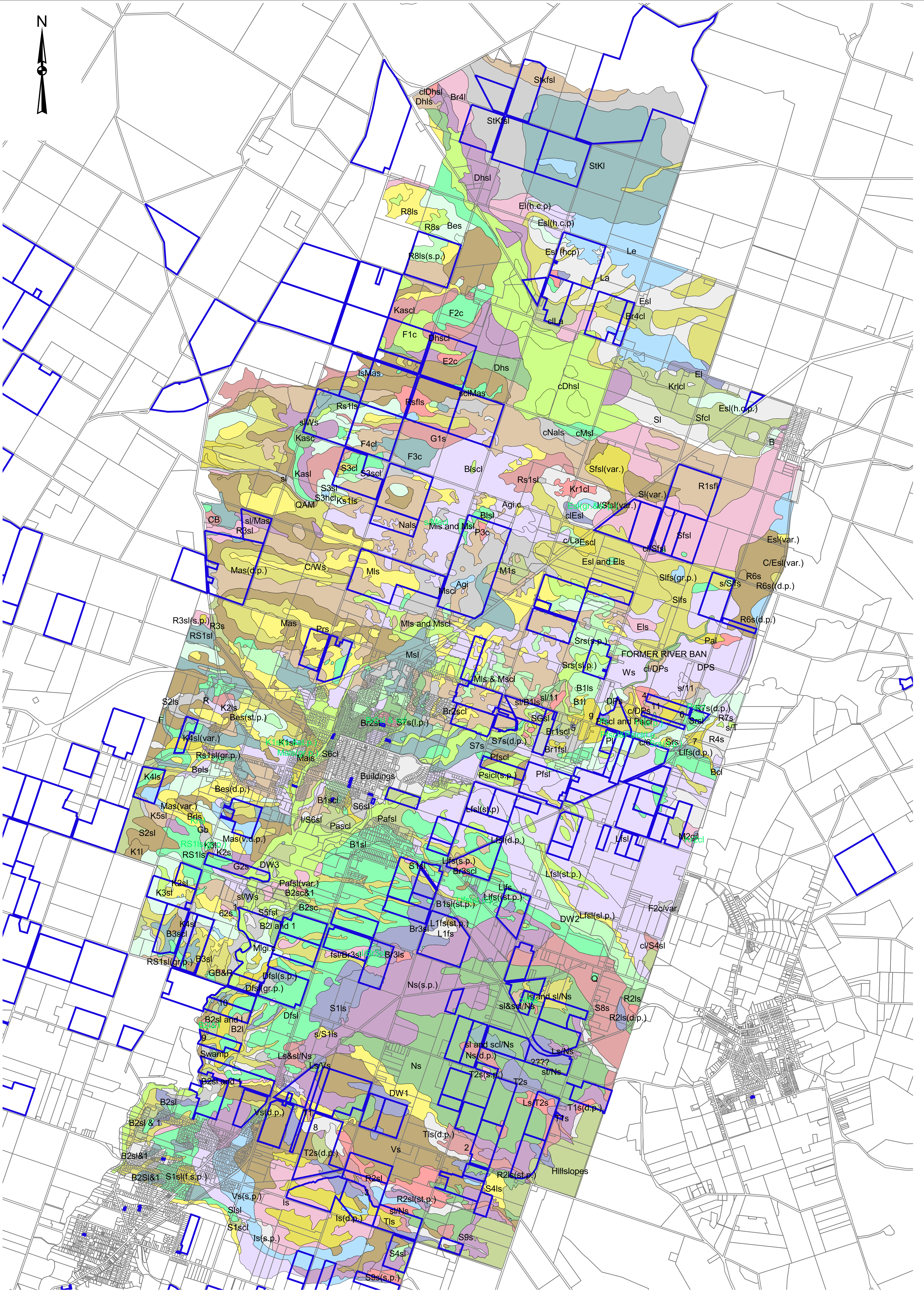
1:50000

Detailed Soil Map
Lyndoch - Williamstown Unit

(Also showing location of properties that have applied for water)

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 - D021



1000 0 1000 2000 3000 4000 Metres

1:45,000

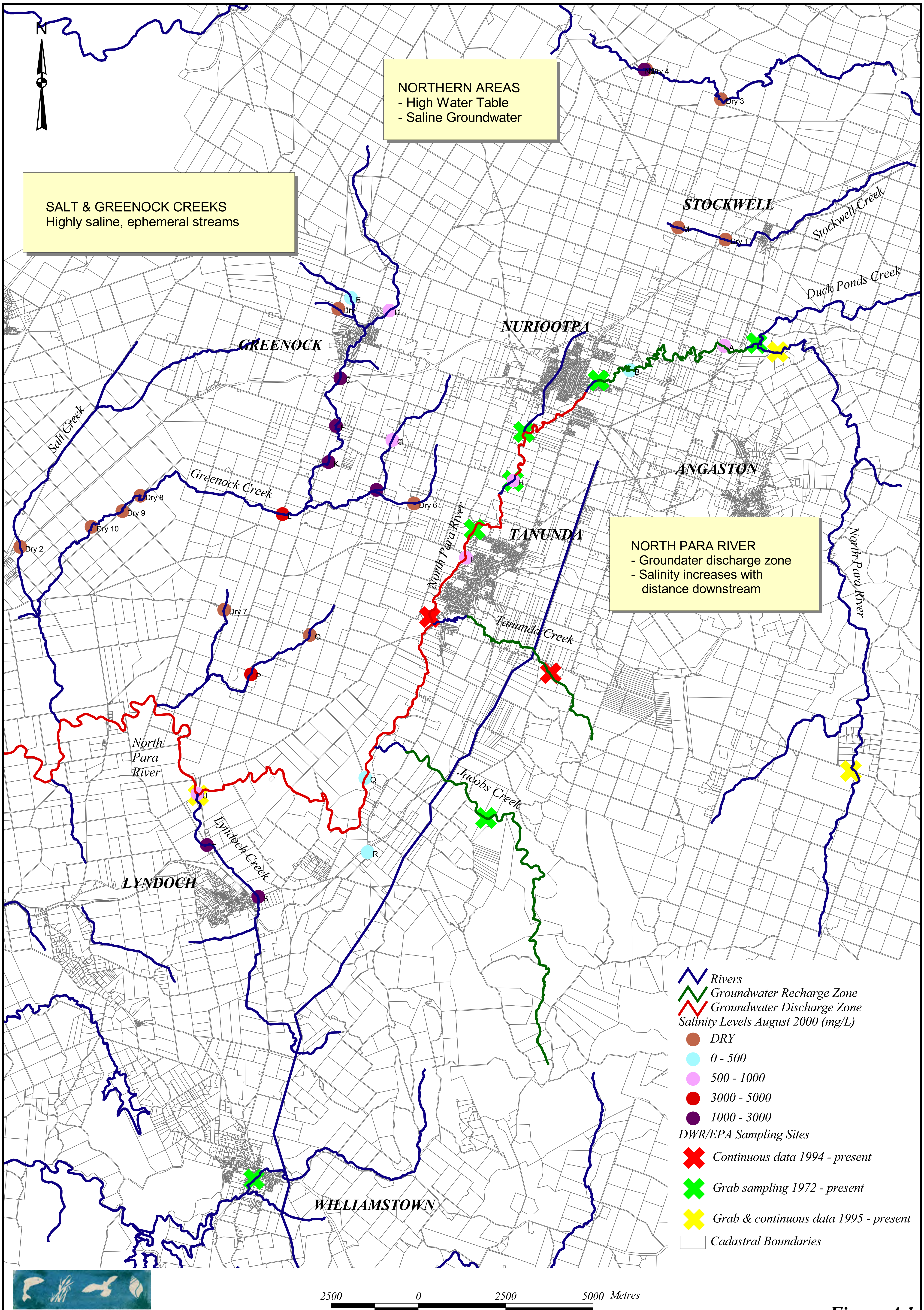
Detailed Soil Map
Stockwell - Nuriootpa Area

(Also showing location of properties that have applied for water)

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 - D024



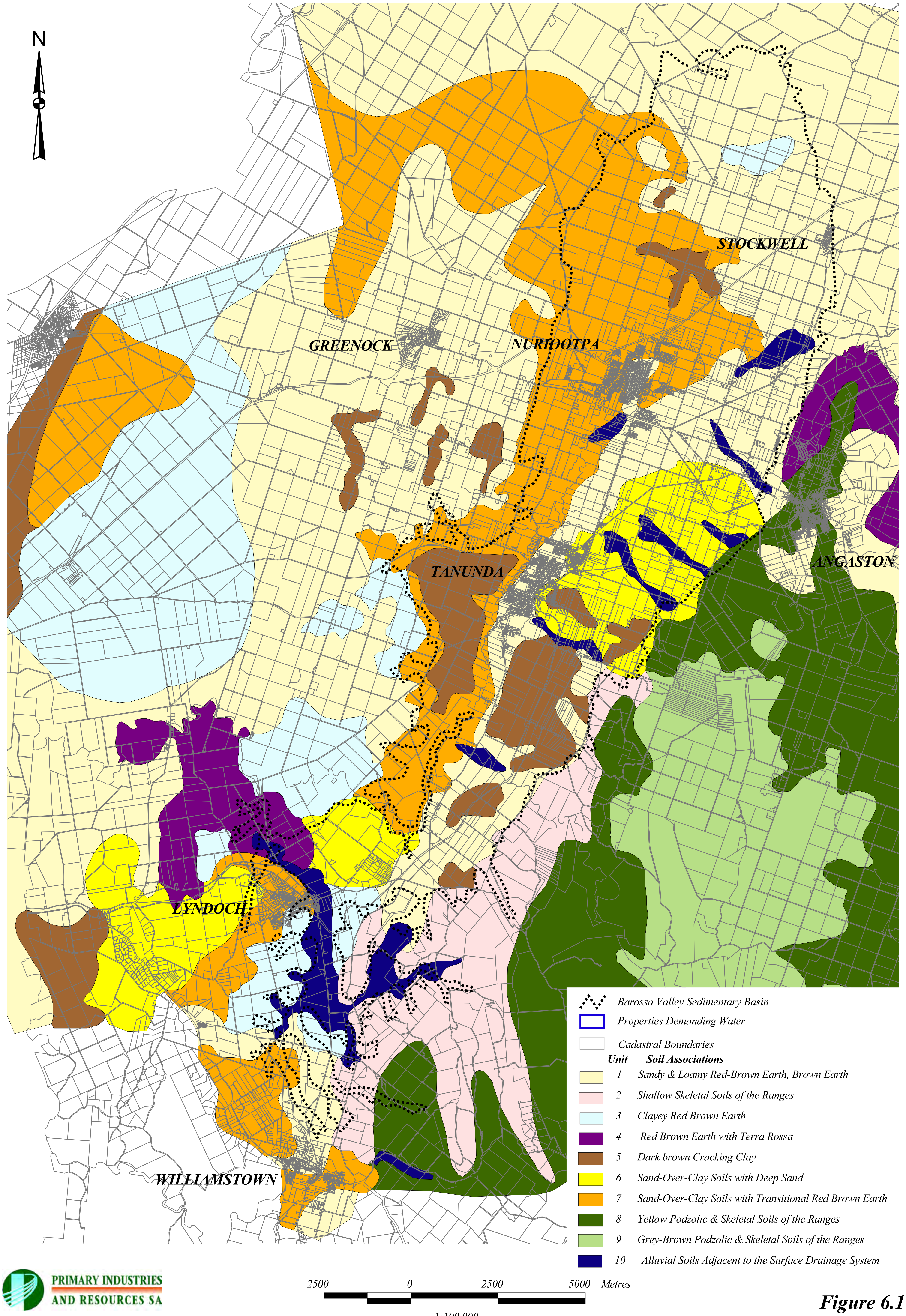
ECO Management Services

Water Quality Data Supplied by the Department for Water Resources, the Environment Protection Agency and Ecomanagement Services

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 - D030

Figure 4.1
Surface Water Quality



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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 6.1
Summarised Soil Associations

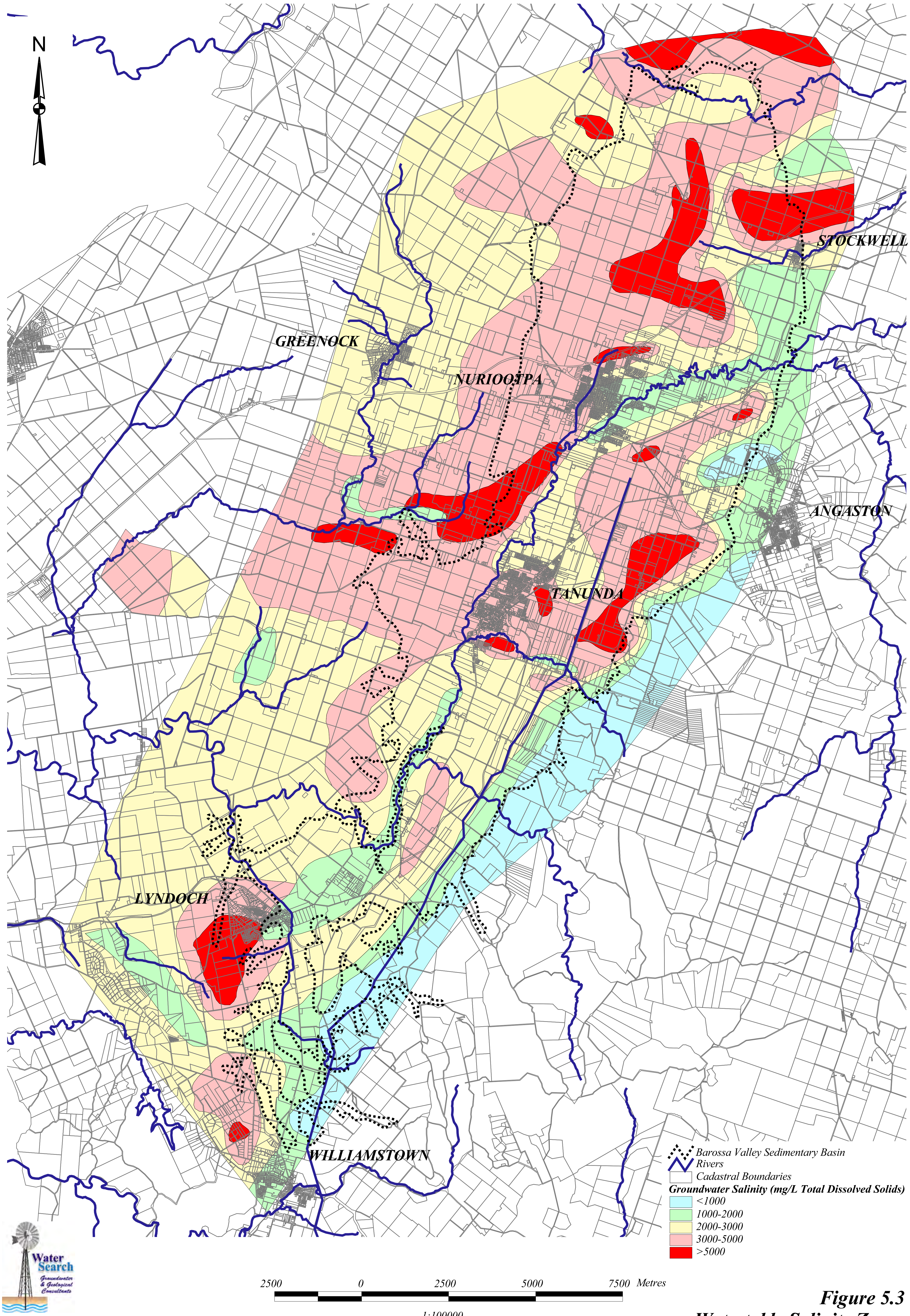
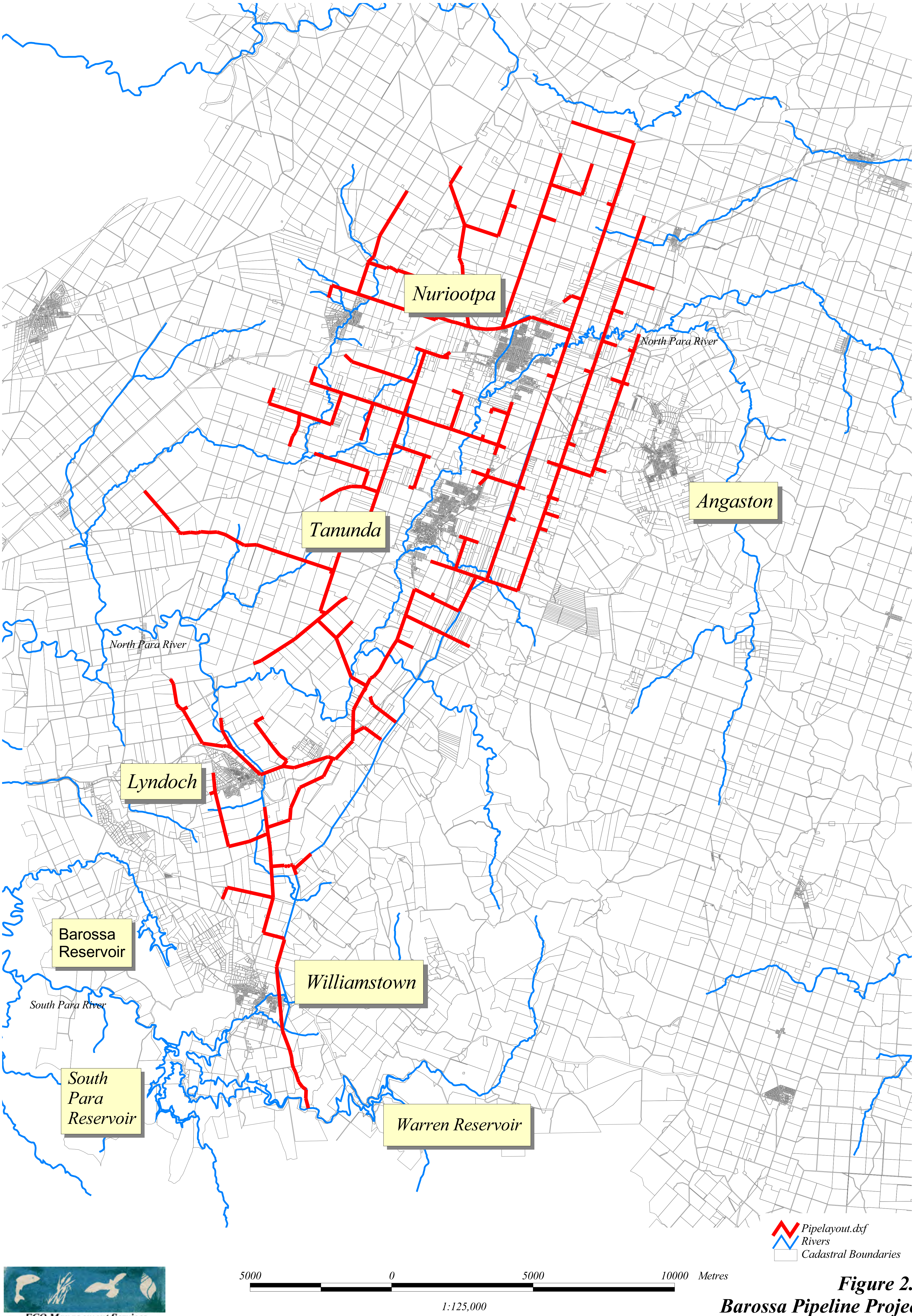


Figure 5.3
Watertable Salinity Zones

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



ECO Management Services

Figure 2.1

Barossa Pipeline Project

(Route maybe subject to minor adjustment during detailed design)

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 - D040