



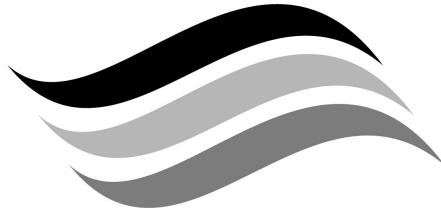
**The Department of  
Water, Land and  
Biodiversity  
Conservation**

**Northern Adelaide Plains Prescribed  
Wells Area groundwater monitoring  
status report 2002**

**Report DWLBC 2002/14**



Government  
of South Australia



**The Department of  
Water, Land and  
Biodiversity  
Conservation**

**Northern Adelaide Plains  
Prescribed Wells Area  
groundwater monitoring status  
report 2002**

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*Groundwater Assessment  
Department of Water, Land and Biodiversity Conservation*

*August 2002*

*Report DWLBC 2002/14*



Government  
of South Australia

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## Foreword

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South Australia's natural resources are fundamental to the economic and social wellbeing of the State. One of the State's most precious natural resources, water is a basic requirement of all living organisms and is one of the essential elements ensuring biological diversity of life at all levels. In pristine or undeveloped situations, the condition of water resources reflects the equilibrium between rainfall, vegetation and other physical parameters. Development of these resources changes the natural balance and may cause degradation. If degradation is small, and the resource retains its utility, the community may assess these changes as being acceptable. However, significant stress will impact on the ability of a resource to continue to meet the needs of users and the environment. Understanding the cause and effect relationship between the various stresses imposed on the natural resources is paramount to developing effective management strategies. Reports of investigations into the availability and quality of water supplies throughout the State aim to build upon the existing knowledge base enabling the community to make informed decisions concerning the future management of the natural resources thus ensuring conservation of biological diversity.

**Bryan Harris**

Director, Resource Assessment Division  
Department of Water, Land and Biodiversity Conservation

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## INTRODUCTION

The groundwater observation well network for the Northern Adelaide Plains (NAP) Prescribed Wells Area (PWA) was established in the early 1960s, in order to monitor groundwater levels and salinity (Fig. 1). The number of wells monitoring water levels, particularly in the Tertiary Aquifers (T1 and T2) has been increasing in response to groundwater extraction for irrigation purposes. In the last two years the observation network was upgraded with 20 new and two replacement observation wells completed into T1 and T2 Aquifers. The purpose of a successful network is to identify areas that may be under stress because of over-pumping of groundwater or areas that may be at risk from salinisation. The introduction of the reclaimed water through the Virginia pipeline scheme required establishment of an observation network (1999), which targeted the area in which the bulk of the recycled water is to be applied and therefore should provide sufficient early warning should there be any unacceptable accessions to the perched watertable and Q1 Aquifer. During October–November 2001, this network was upgraded by thirteen shallow monitoring wells (perched watertable and Q1 Aquifer), which were installed as a part of a hydrogeological investigation in response to reports of rising shallow watertables in the area northwest of Virginia. These wells were included in the existing network and are monitored every three months. Four wells from this network are equipped with data loggers.

Currently, a total of 165 wells throughout the NAP PWA and Kangaroo Flat Restricted Area are monitoring groundwater levels. The monitoring is carried out by Groundwater Assessment Group within the Department of Water, Land and Biodiversity Conservation (DWLBC) on a three-monthly basis. The 165 observation wells are comprised of 151 government drilled and 14 private wells.

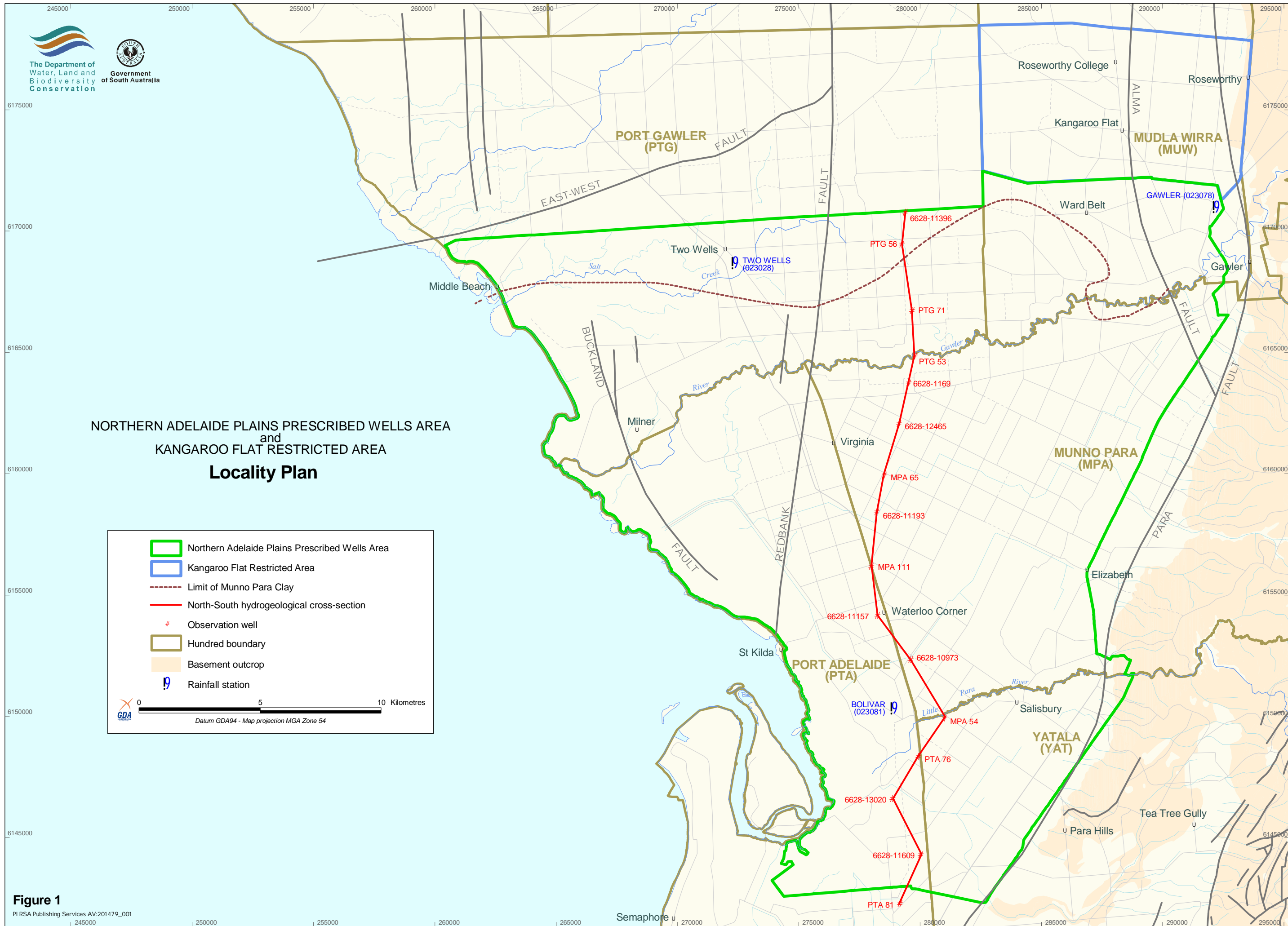
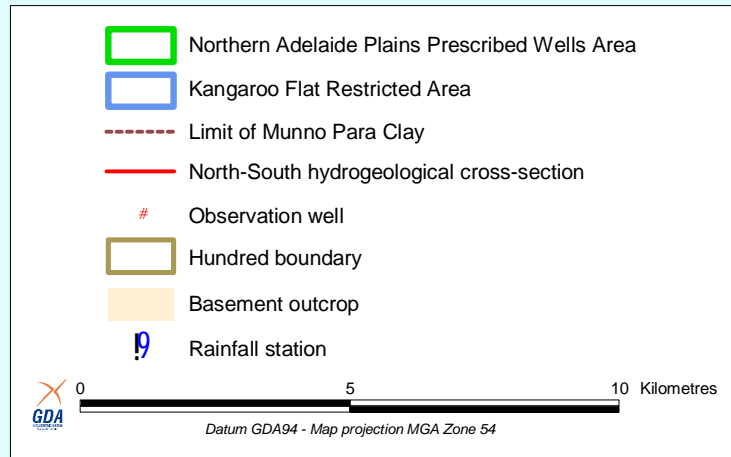
The numbers of observation wells monitoring each aquifer are presented in Table 1.

**Table 1. Current observation wells**

	<b>Aquifer</b>	<b>Government owned wells</b>	<b>Privately owned wells</b>	<b>Total</b>
Quaternary	Perched	19	–	19
	Q1	17	–	17
	Q2	12	–	12
	Q3	16	–	16
	Q3 + Q4	4	–	4
	Q4	10	–	10
Tertiary	T1	21	7	28
	T2	46	7	53
	T3–T4	6	–	6
	<b>Total</b>	<b>151</b>	<b>14</b>	<b>165</b>

Available data has been analysed and presented in this report as potentiometric surface, water level and salinity maps for all aquifers. Also, representative hydrographs for all aquifers and monthly rainfall with cumulative rainfall deviation for the period 1973 to 2002 are shown.

NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
 and  
 KANGAROO FLAT RESTRICTED AREA  
**Locality Plan**



**Figure 1**



## **SUMMARY OF AQUIFERS**

---

The first major hydrogeological assessment of the NAP was undertaken by Shepherd (1968; and later in 1975) who described it as a complex hydrogeological system. Since then the description of the hydrostratigraphy, shown in Table 2, has not considerably changed. Generally, two aquifer systems, Quaternary and Tertiary, are recognised in the area.

Quaternary sediments containing mainly four, in some areas up to six, aquifers while the Tertiary Aquifers contain up to four aquifers (Gerges, 2001). Both the Quaternary and Tertiary Aquifers were designated identifiers in order of increasing depth.

### ***Shallow Quaternary Aquifers***

The main lithology of the Quaternary sediments is mottled clay and silt interbedded with sand, gravel and thin sandstone layers (Hindmarsh Clay). The shallowest aquifer is the Perched Aquifer, which is irregular in occurrence and exists because the infiltrating surface water is hindered by a confining layer. The distribution of this aquifer over the area is not well known. Underneath this aquifer there are generally up to three Quaternary Aquifers (Q1–Q3) over most of the region and are represented by sands, gravels and sandstones. However, in the southern area five or six Quaternary Aquifers have been recognised. Below the shallow Quaternary Aquifers, the Hindmarsh Clay generally forms a confining layer to the underlying lower Quaternary Aquifer (Q4).

### ***Q4 Aquifer***

The Q4 Aquifer, called Carisbrooke Sand Aquifer, occurs over the whole area, except within 4–5 km of the coast. The aquifer consists of multicoloured, poorly-sorted, fine- to medium-grained quartz–sand and silt, with some clay and thin gravel beds. In some areas it is hydraulically connected to the overlying Quaternary Q3 Aquifer or to the underlying T1 Aquifer along the Little Para River (Fig. 2a).

### ***Tertiary Aquifers***

The underlying Tertiary Aquifer sediments contain several confined aquifer systems, each may comprise various sub-aquifers. These aquifers are designated T1, T2, T3 and T4 in order of increasing depth.

The aquifers exhibit large variations in thickness, lithology, salinity distribution and yield. The first and second Tertiary Aquifers (T1 and T2) are recognised as superior aquifers in terms of salinity and yield.

### ***First Tertiary Aquifer (T1)***

The first Tertiary Aquifer (T1) is defined as the saturated and permeable Tertiary sediments intersected above the Munno Para Clay member. An exception is the area located a few kilometres north of Gawler River and west of Red Banks Fault, where the Munno Para Clay is absent and the T1 Aquifer is immediately overlying the T2 Aquifer, forming virtually one aquifer.

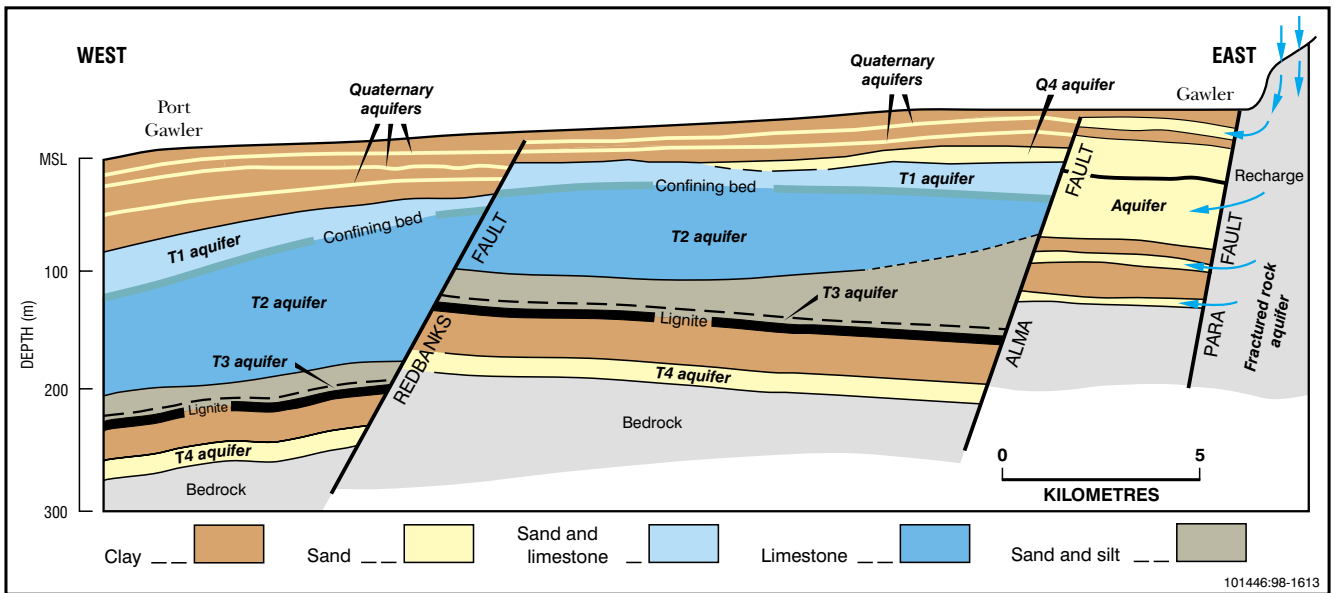


Figure 2 Northern Adelaide Plains diagrammatic east-west cross-section along Gawler River showing aquifers and confining layers

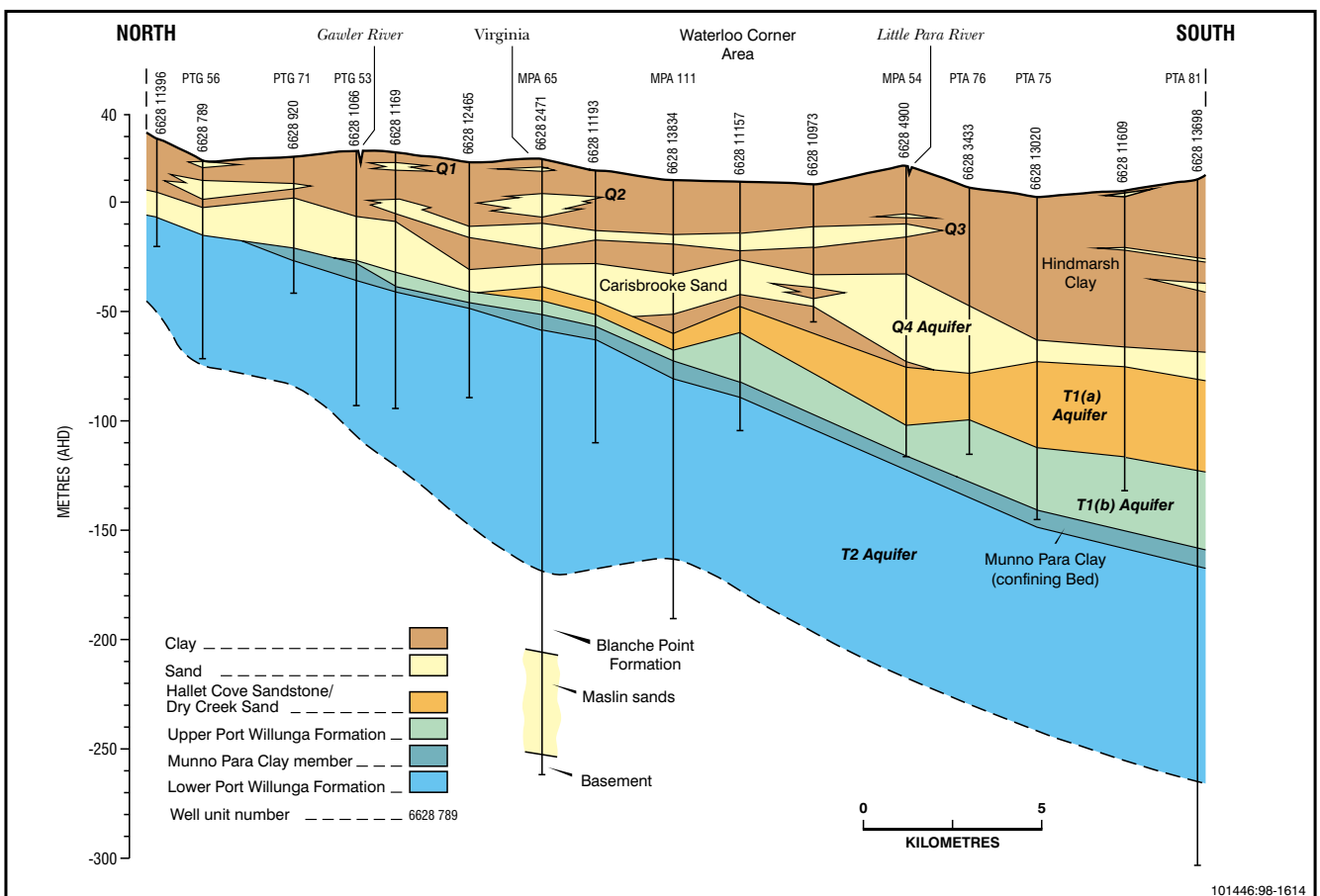


Figure 2b Northern Adelaide Plains north-south hydrogeological cross-section, see Figure 1 for location

**Table 2. Stratigraphy and hydrostratigraphy of the Northern Adelaide Plains**

AGE		STRATIGRAPHY		HYDROSTRATIGRAPHY		
		Unit	Lithology	Unit	Description	
<b>Quaternary</b>	Holocene	Saint Kilda Formation	Shallow marine deposits including shell beds, sands and clay (coastal areas).	<b>Unconfined aquifer</b>	Unconfined aquifer, groundwater salinity at least equal to seawater.	
	Late Pleistocene	Pooraka Clay	Alluvial clays, silts and sands.	<b>Aquitard</b>	Confining bed.	
	Middle Pleistocene	Glanville Formation	Shallow marine deposits including sand and shell beds (adjacent to coast).	<b>Aquifer</b>	Contains highly saline groundwater.	
	Early Pleistocene	Hindmarsh Clay	Fluviatile and alluvial clays, silts, sands and gravels in outwash areas. Occurs over almost whole of basin.	<b>Aquitard, Q1 Aquifer, Q2 Aquifer, Q3 Aquifer</b>	Up to three semi-confined aquifers. Relatively saline groundwater, except near streams and low yields. Domestic and stock use.	
	?Pliocene/ Pleistocene	Carisbrooke Sand	Fluviatile, alluvial, multicoloured fine sands and silts with some clay and thin gravel beds in outwash areas. Occurs over whole area except within 4–5 km of the coast.	<b>Q4 Aquifer</b>	Confined aquifer; not widely developed because of low yields. Possible hydraulic connection with T1 Aquifer in some areas (near Little Para River).	
<b>Tertiary</b>	Late Pliocene	Hallett Cove Sandstone – Dry Creek Sand	Limestone, calcareous sandstone and sands of marine deposition. Usually abundantly fossiliferous. Occurrence generally restricted to an area south of Two Wells.	<b>T1 Aquifer</b>	<b>T1a</b>	Confined aquifer; developed for irrigation stock and domestic purposes.
		Croydon facies				Semi-confining aquitard
	Middle-Early Miocene	Port Willunga Formation (upper part)	<b>Undifferentiated Tertiary sediments</b>		Fossiliferous sandy limestone, fine grained, occurring south of Two Wells.	<b>T1b</b>
		Early Miocene		Munno Para Clay		
	Early Miocene to Late Eocene	Port Willunga Formation (lower part)		Fossiliferous limestone with sands and sandstones, grading to a dense siliceous unit towards the base.	<b>T2 Aquifer</b>	Confined aquifer, salinity ranges between 500–2000 mg/L in the Gawler River area to >3000 mg/L to the north and south. Developed mainly for irrigation.
	Late Eocene	Chinaman Gully Formation		Dark-brown to black lignitic silt and clay.	<b>Aquitard – T3 Aquifer</b>	Confining bed; Chinaman Gully sands–aquifer.
		Blanche Point Formation		Marls, siltstone, limestone, fossiliferous and glauconitic.	<b>Aquitard</b>	Generally confining bed, but may be a low-grade aquifer in some areas.
		South Maslin Sand		Marginal marine sands, glauconitic and poorly fossiliferous.	<b>T4 Aquifer</b>	Confined aquifer, highly saline.
	Late to Middle Eocene	Clinton Formation		Grey to blue clay, carbonaceous and silty.	<b>Aquitard</b>	Confining bed where present.
	Middle to Early Eocene	North Maslin Sand		Pebbly quartz-sand, slightly clayey, carbonaceous; fluviatile and estuarine deposition. Contains thin impure lignite in places.	<b>T4 Aquifer</b>	Confined aquifer, highly saline.
<b>Proterozoic</b>	Undifferentiated Adelaidean	Slates, quartzite, dolomites, tillites, shales and limestone.		<b>Fractured Rock Aquifer</b>	–	

In the north-east of the NAP the T1 Aquifer is absent (Fig. 16). The T1 Aquifer may consist of several stratigraphic units, varying in lithology and thickness.

The first Tertiary Aquifer in the NAP area consists of two major sub-aquifers (Gerges, 1987):

- Sub-aquifer T1a — consists of Hallett Cove Sandstone and Dry Creek Sand, and permeable portions of the 'Croydon facies' and is hydraulically connected to the Carisbrooke Sand (Q4) Aquifer (along Little Para River area only).
- Sub-aquifer T1b — consists of limestone of the upper Port Willunga Formation.

A semi-confining bed comprising the remaining part of Croydon facies separates both Sub-aquifers but information about its extent is very limited.

East of the Alma Fault the T1 Aquifer may be connected with the undifferentiated Tertiary sands, this hydraulic connectivity is considered to be minor.

### ***Second Tertiary Aquifer (T2)***

The second Tertiary Aquifer comprises saturated and permeable Tertiary sediments intersected below the Munno Para Clay Member. The Aquifer occurs throughout the entire NAP PWA. It consists of well-cemented limestone of lower Port Willunga Formation.

In the area north of Gawler River and east of the Redbank Fault (Fig. 2a, 16), the Munno Para Clay and the T1 Aquifer are not present and the Q4 Aquifer overlies the T2 Aquifer.

In the area between the Alma Fault and Para Fault (Fig. 2), lithology suggests that this aquifer consists mostly of undifferentiated Tertiary quartz-sand and minor clay. Assuming hydraulic connectivity occurs across the Alma Fault it is considered that these sediments are the continuation of the T2 Aquifer. A better understanding of this portion of the Tertiary Aquifer system will occur as further investigation are undertaken.

### ***Third Tertiary Aquifer (T3)***

The distribution of the T3 Aquifer is not well known, but it is considered that it occurs in most of the NAP as a thin sandy layer with an average thickness of 5 m (Gerges, 2001). Few records relating to the T3 Aquifer are available from drillholes in the Port Gawler and Virginia areas. At the old Virginia Primary School site the Aquifer consisting of Aldinga Member and Chinaman Gully Formation sands was intersected at 215 m and the water level rose to 5 m above ground level (PTA 88, unit number 6628-15843).

### ***Fourth Tertiary Aquifer (T4)***

The fourth Tertiary Aquifer consists mainly of South Maslin Sand and occasionally North Maslin Sand.

## CLIMATE

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The Mediterranean type of climate is characterised by winter dominant rainfall. Three rainfall stations were selected as representative of the rainfall pattern throughout the area: Two Wells (station 23028), Gawler (station 23078) and Bolivar (station 23081). Annual average rainfalls for selected stations are 400, 473 and 445 mm, respectively. The average monthly rainfall is shown in Table 3.

**Table 3. Monthly rainfall (mm)**

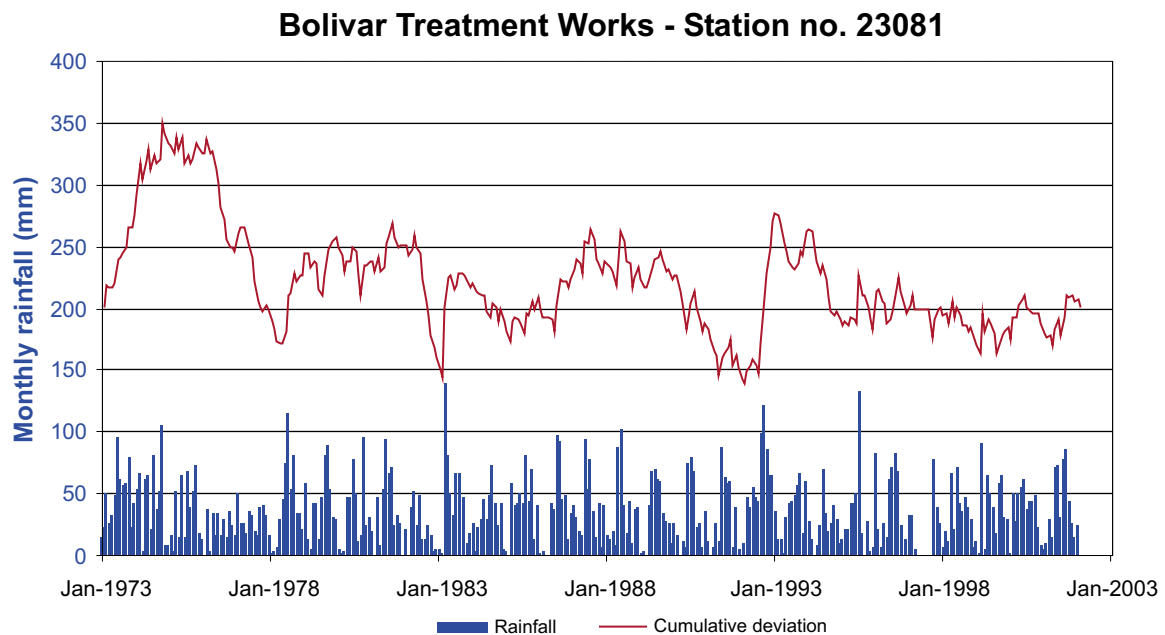
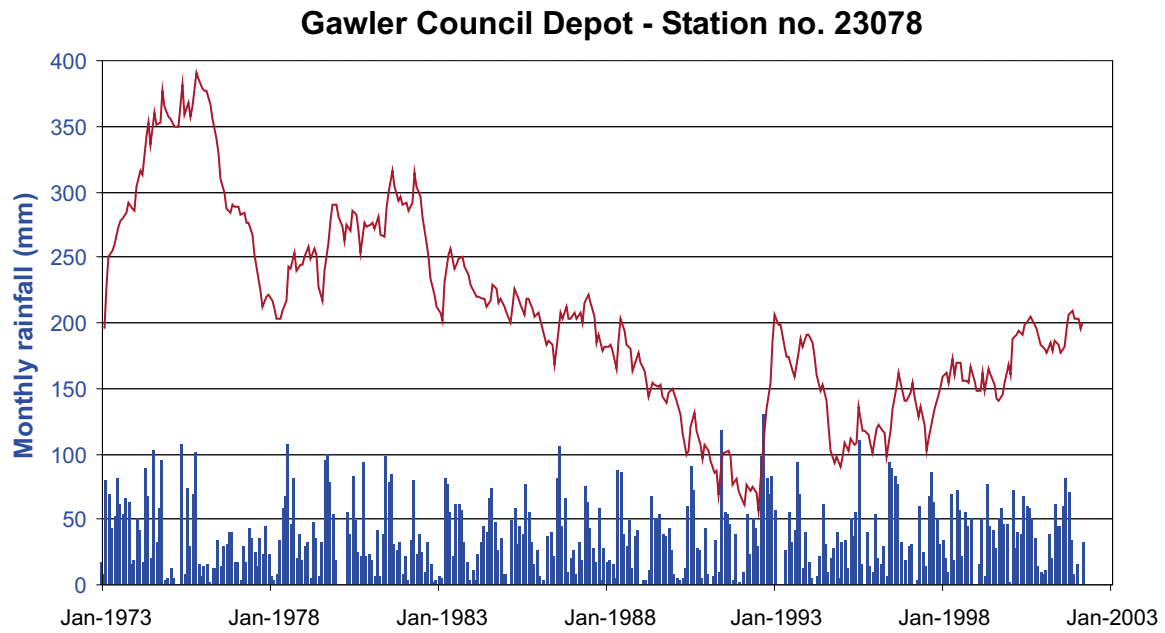
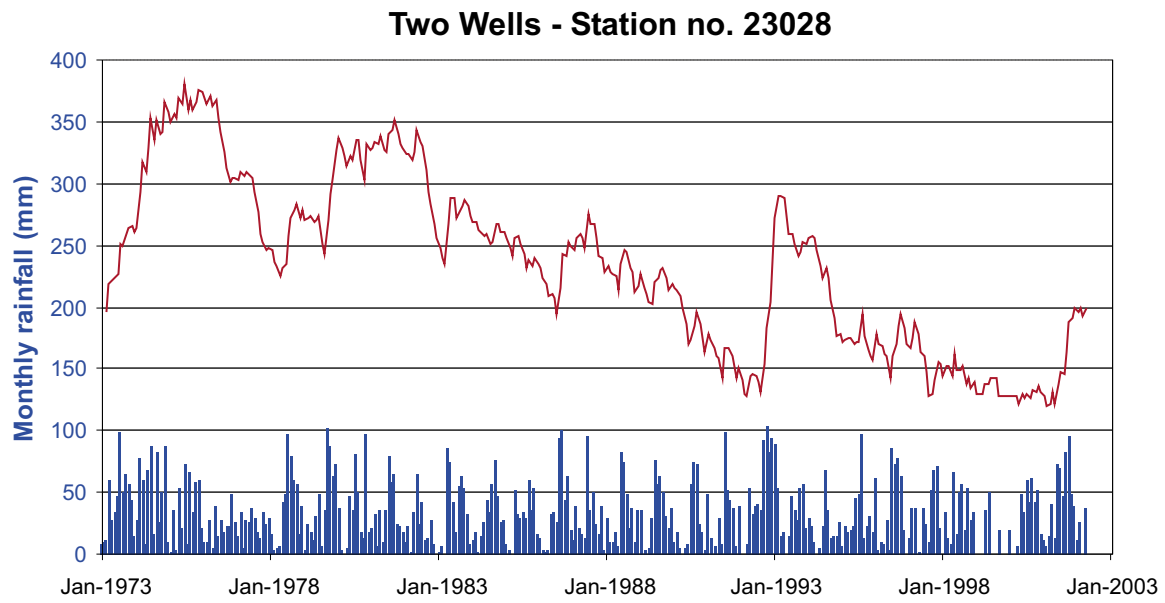
Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Two Wells	18	16	19	34	46	52	47	47	40	36	24	22
Gawler	18	16	24	40	55	62	56	56	52	43	27	23
Bolivar	21	15	27	31	45	56	57	51	46	47	23	23

The rainfall records are available for a period of over 120 years for Two Wells station and 140 years for Gawler station; however, there is no data for this station between 1924 and 1969. For the Bolivar station, the recording of rainfall started in the early seventies. Figure 3 shows the monthly rainfall and cumulative deviation from each monthly mean obtained from these stations for the period 1973–2002.

All three stations show similar short-term trends such as above-average rainfall during the 1973–75, 1978–80 and 1992 periods, and below-average rainfall during the 1976–77, 1982–85 and 1990–92 periods.

Over the sample period Two Wells has had generally below average rainfall. Gawler station has experienced generally below-average rainfall until 1993, then a period of above-average rainfall. The Bolivar station shows that over the sample period, the rainfall has generally been average.

As the aquifer system are not responsive to incident rainfall, this analysis may be a useful tool in analysing trends in groundwater extraction behaviour rather than recharge trends.



**Figure 3** Monthly rainfall and cumulative deviation

## **WATER LEVEL TRENDS**

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### ***Quaternary (Q) Aquifers***

The locations of current water level monitoring wells for all Quaternary Aquifers are presented in Figure 4.

There are a total of 78 wells monitoring the Quaternary Aquifers. The Perched (watertable) Aquifer is being monitored by 19 wells, Q1 Aquifer by 17 wells, Q2 Aquifer by 12 wells, Q3 Aquifer by 16 wells and Q4 Aquifer (Carisbrooke Sand Aquifer) by 10 wells. Four wells are completed in both Q3 and Q4 Aquifers.

Water level maps generated for the September 2001 and March 2002 for the Quaternary Aquifers are presented in Figures 5–10.

Long-term data hydrographs of Quaternary Aquifers (Q1–Q4) show an almost continuous decline in water levels (Figs 11–14).

On the other hand, short-term water level data (1999–2002) shows a rising trend in water levels in all observation wells completed in the Perched, Q1 and Q4 Aquifers on average of  $\sim 0.35$ ,  $0.3$  and  $0.6$  m/y, respectively. Most of the Q2 observation wells and half of the Q3 observation wells show an increasing water level trend, while the rest of them continue to decline. Water levels in the Perched Aquifer have risen between  $0.07$  and  $0.54$  m/y since March 2000 when the network was established (Figs 15, 15a). On average, the water level has risen  $\sim 0.35$  m/y. Increases in water levels were reported by farmers in October 2001. This resulted in upgrading of the existing network by 13 new shallow wells as a part of hydrogeological investigation of the Perched (watertable) Aquifer north of Virginia (Gerges, 2002).

### ***T1 Aquifer***

In the Hallett Cove Sandstone – Dry Creek Sand (T1a Aquifer) and upper Port Willunga Formation (T1b Aquifer) there is a total of 28 observation wells. Twenty wells are located inside the NAP PWA, while eight wells are part of both NAP and Metropolitan Adelaide observation networks (Fig. 16).

Potentiometric surface contour maps of the first Tertiary Aquifer (T1) for September 2001 and March 2002 have been considered representative of the winter and summer potentiometric surface and are presented in Figures 17 and 18. Generally, groundwater flow directions are from northeast–east towards southwest–west.

Extractions from T1 Aquifer occur from three distinctive areas: the Little Para River, Penrice (ICI) – SAMCOR and Waterloo Corner area, creating two cones of depression during summer (Fig. 18) in the Penrice and Waterloo Corner areas. The cone of depression in the Penrice area is permanent, while the potentiometric surface in the Waterloo Corner area recovers to near its pre-pumping level during winter. This has changed the local flow pattern from a general west direction to a radial flow toward the centre of the cones.

NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
and  
KANGAROO FLAT RESTRICTED AREA  
**Water level observation bores**  
**Quaternary Aquifers**  
current at August 2002

**Legend**

- Northern Adelaide Plains Prescribed Wells Area
- Kangaroo Flat Restricted Area
- Limit of Munno Para Clay
- Basement outcrop

**Observation wells and number**

# PTA101	Q (perch) Aquifer	# PTA101	Q3 Aquifer
# MPA145	Q1 Aquifer	# MPA145	Q3 and Q4 Aquifer
# MPA73	Q2 Aquifer	# MPA73	Q4 Aquifer

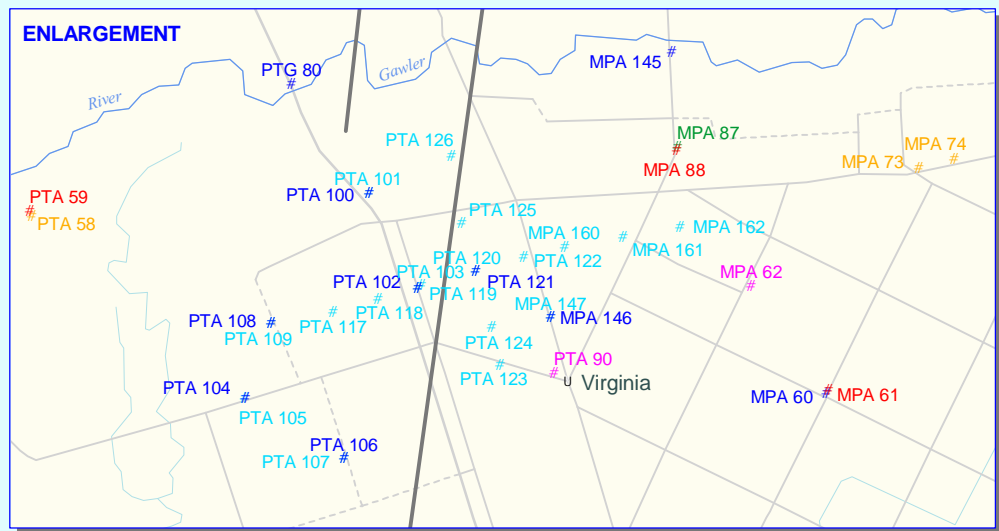
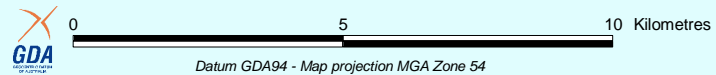
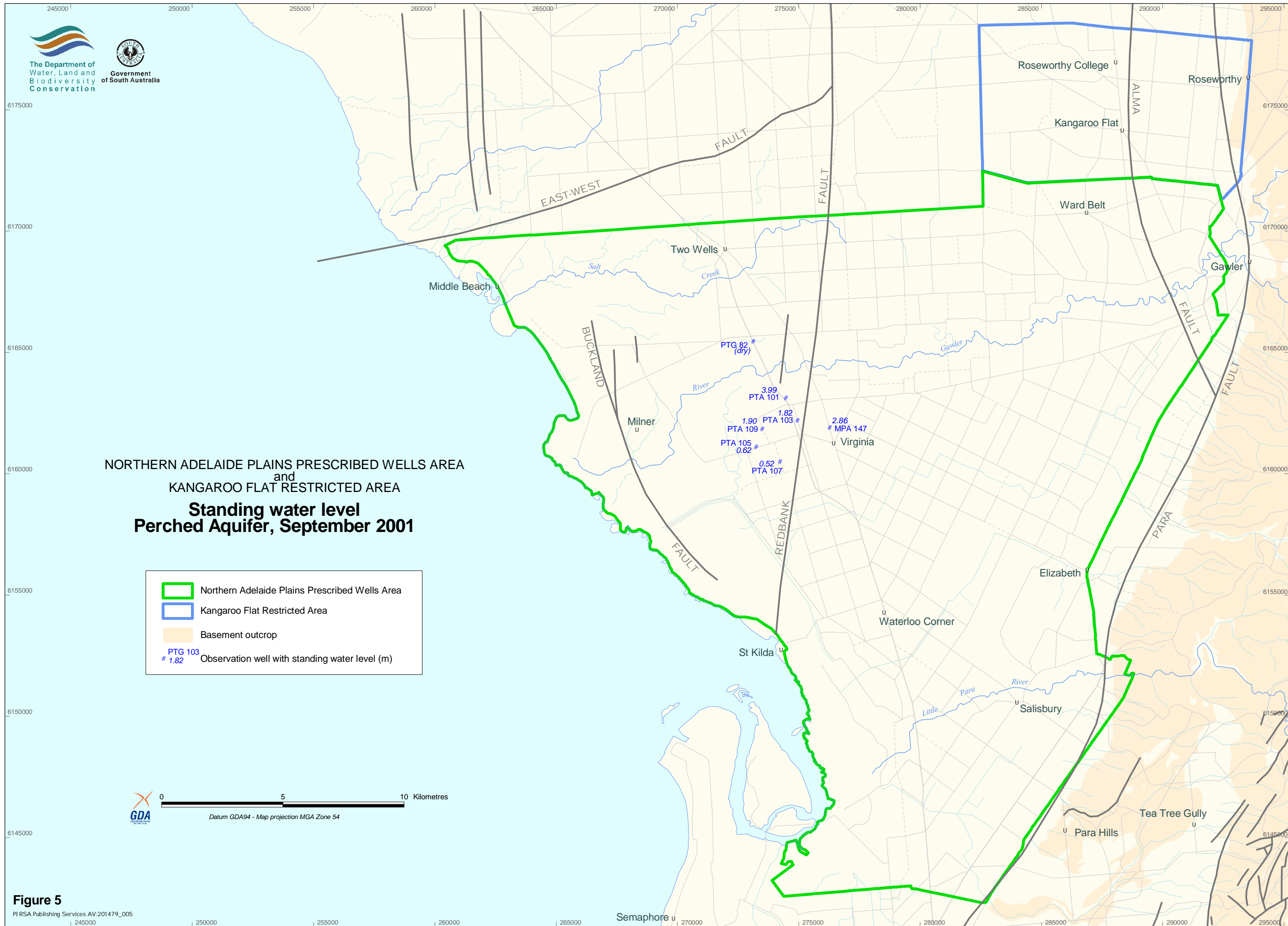


Figure 4

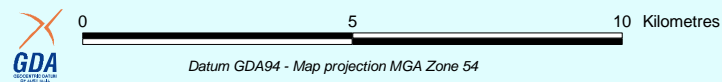




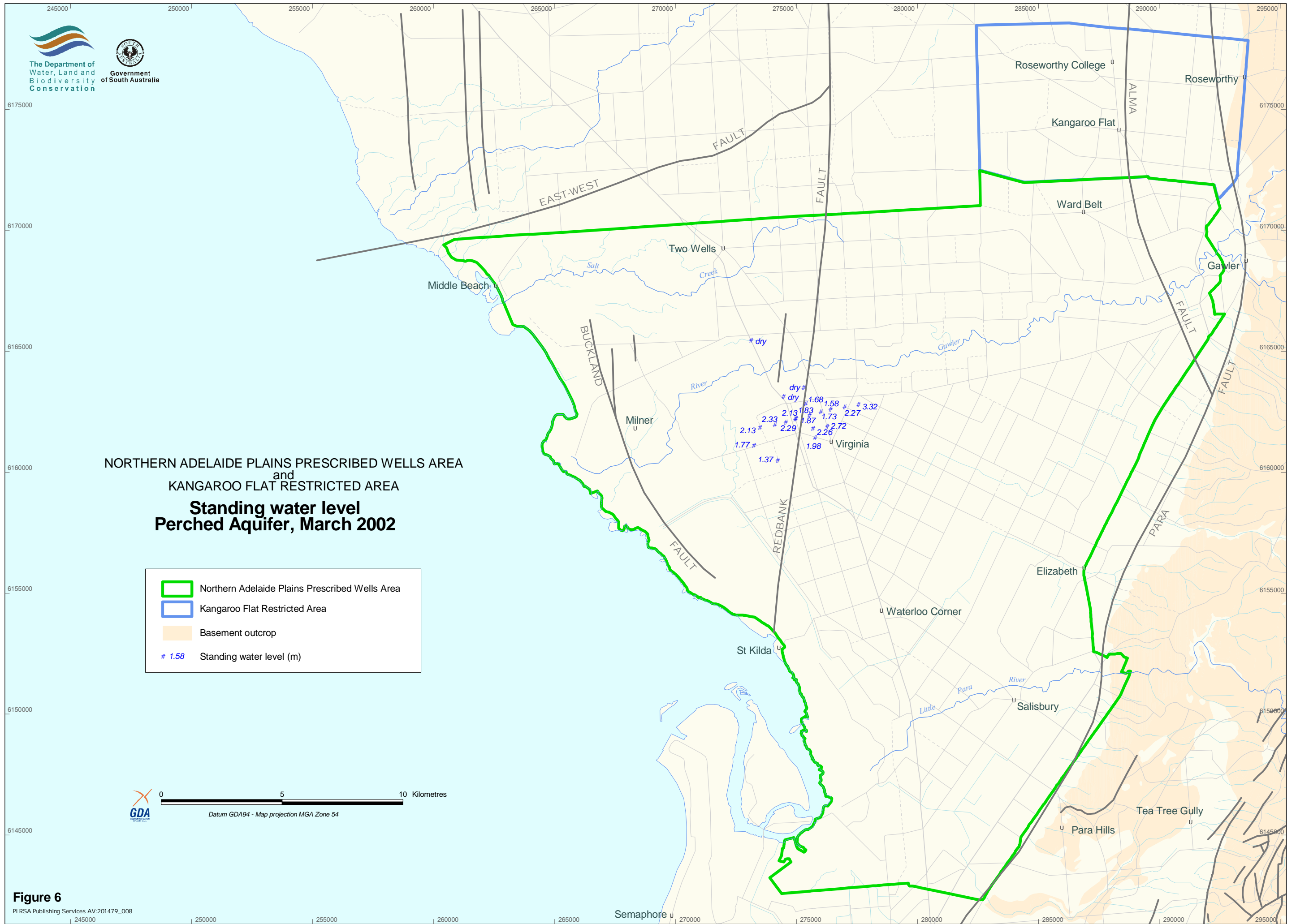
**Figure 5**

NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
 and  
 KANGAROO FLAT RESTRICTED AREA  
**Standing water level  
 Perched Aquifer, March 2002**






- Northern Adelaide Plains Prescribed Wells Area
- Kangaroo Flat Restricted Area
- Basement outcrop
- # 1.58 Standing water level (m)

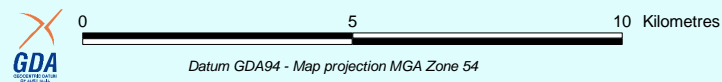


**Figure 6**

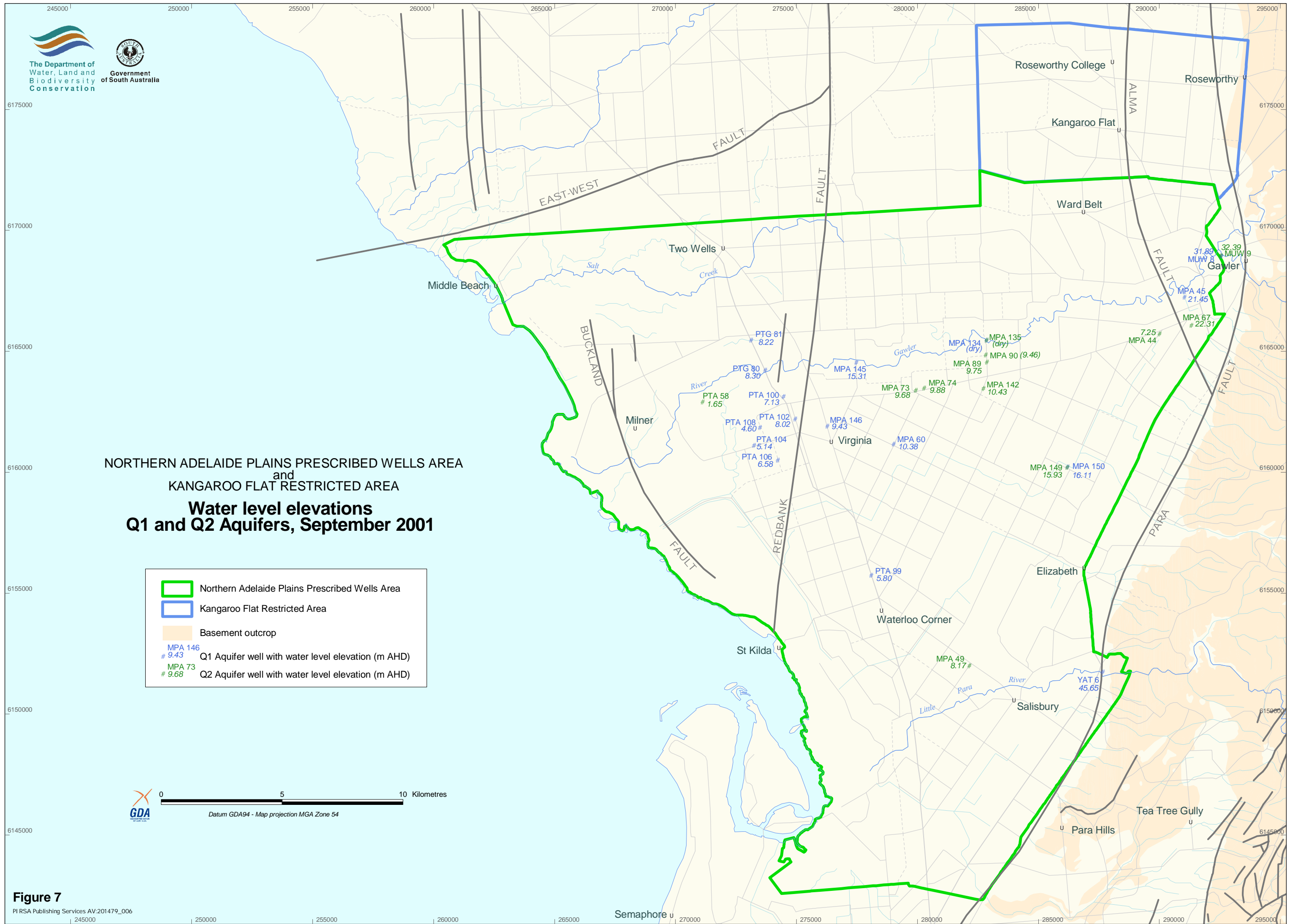


NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
 and  
 KANGAROO FLAT RESTRICTED AREA  
**Water level elevations  
 Q1 and Q2 Aquifers, September 2001**

	Northern Adelaide Plains Prescribed Wells Area
	Kangaroo Flat Restricted Area
	Basement outcrop
	Q1 Aquifer well with water level elevation (m AHD)
	Q2 Aquifer well with water level elevation (m AHD)



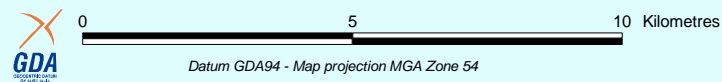
**Figure 7**



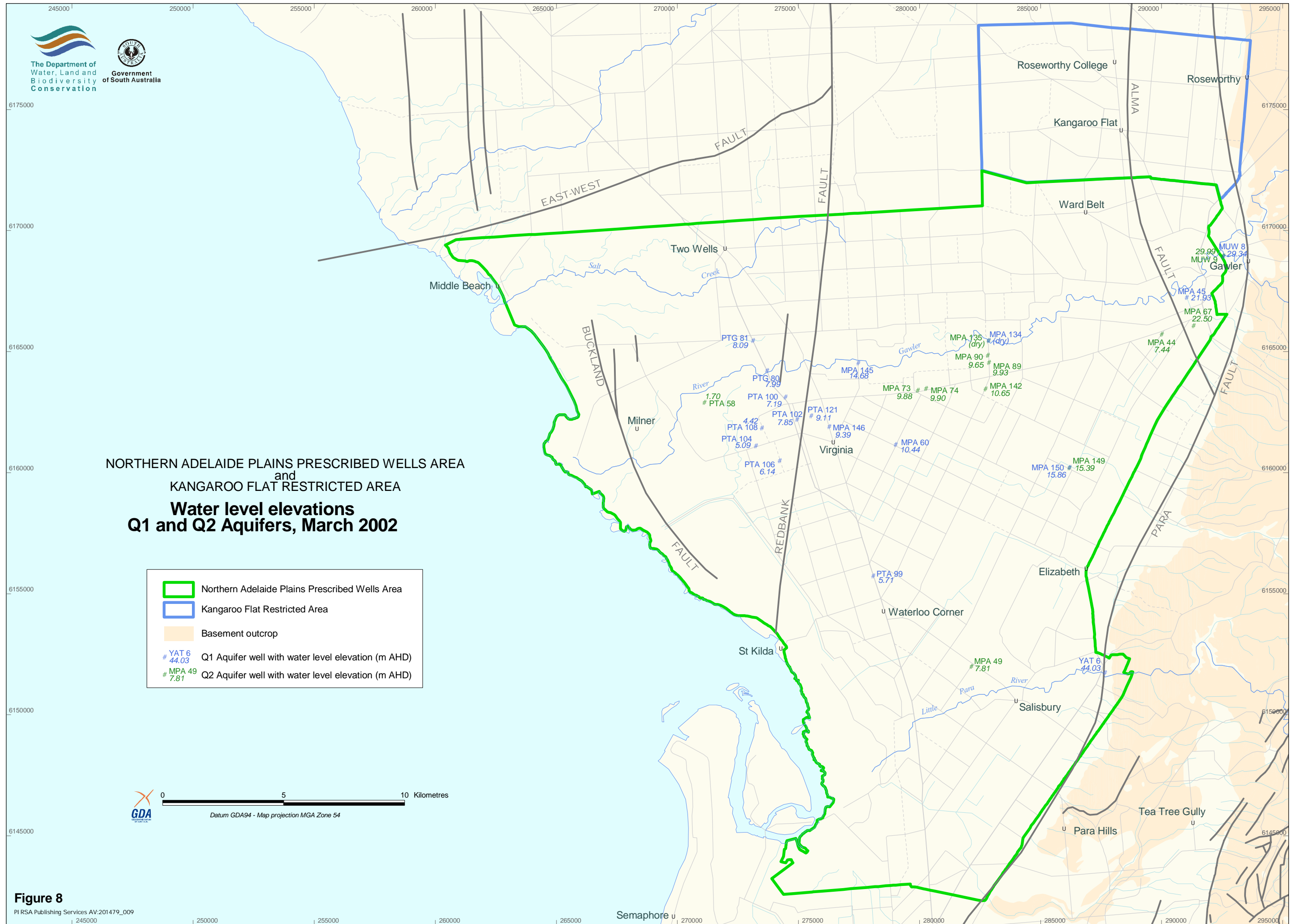


NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
and  
KANGAROO FLAT RESTRICTED AREA  
**Water level elevations  
Q1 and Q2 Aquifers, March 2002**







- Northern Adelaide Plains Prescribed Wells Area
- Kangaroo Flat Restricted Area
- Basement outcrop
- # YAT 6 Q1 Aquifer well with water level elevation (m AHD)  
# 44.03
- # MPA 49 Q2 Aquifer well with water level elevation (m AHD)  
# 7.81

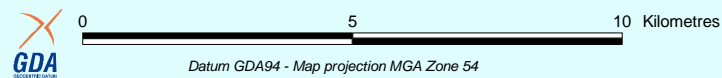


**Figure 8**

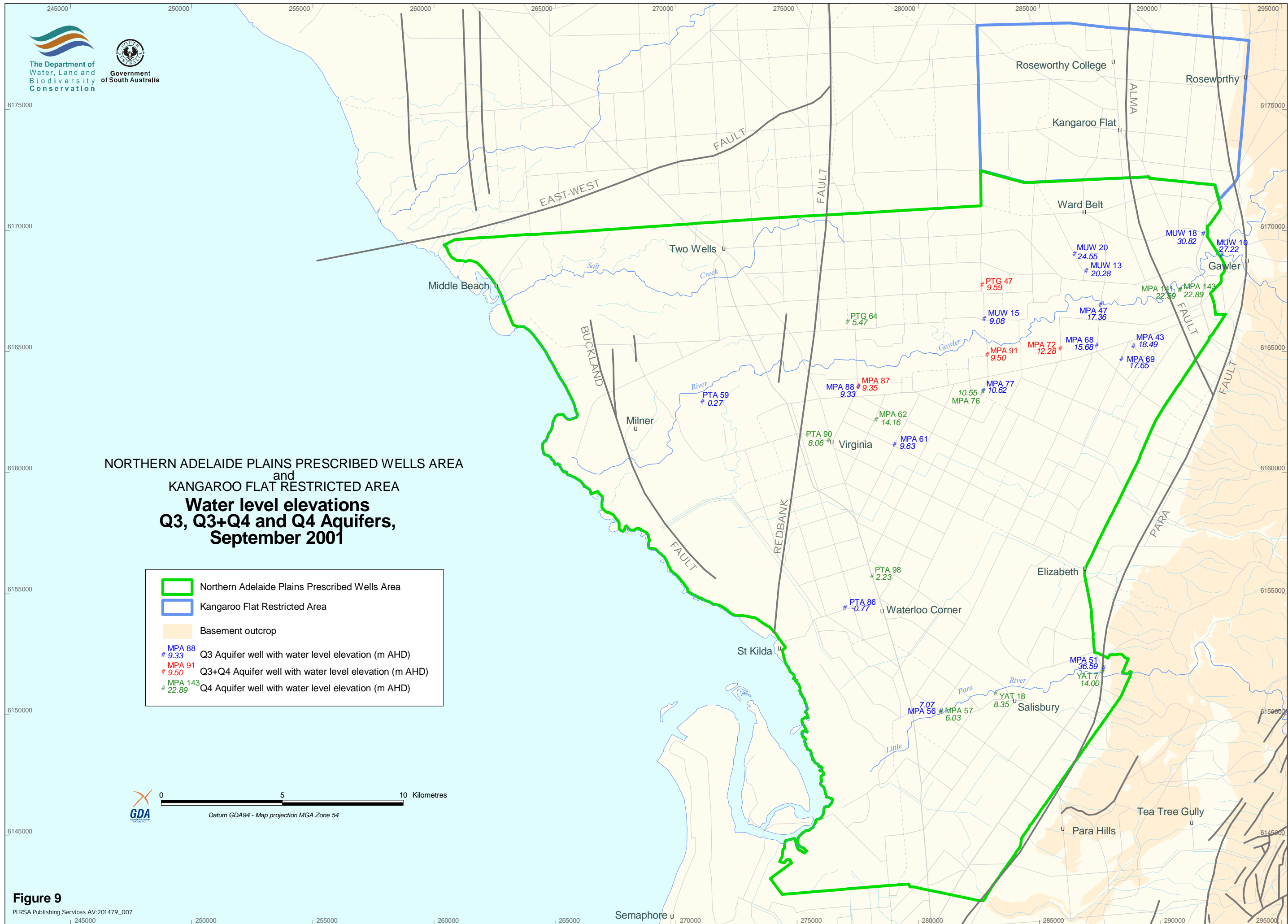


NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
 and  
 KANGAROO FLAT RESTRICTED AREA  
**Water level elevations  
 Q3, Q3+Q4 and Q4 Aquifers,  
 September 2001**

	Northern Adelaide Plains Prescribed Wells Area
	Kangaroo Flat Restricted Area
	Basement outcrop
	Q3 Aquifer well with water level elevation (m AHD)
	Q3+Q4 Aquifer well with water level elevation (m AHD)
	Q4 Aquifer well with water level elevation (m AHD)









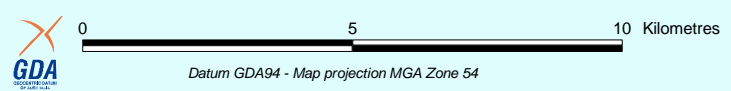
**Figure 9**  
 PI RSA Publishing Services AV:201479\_007



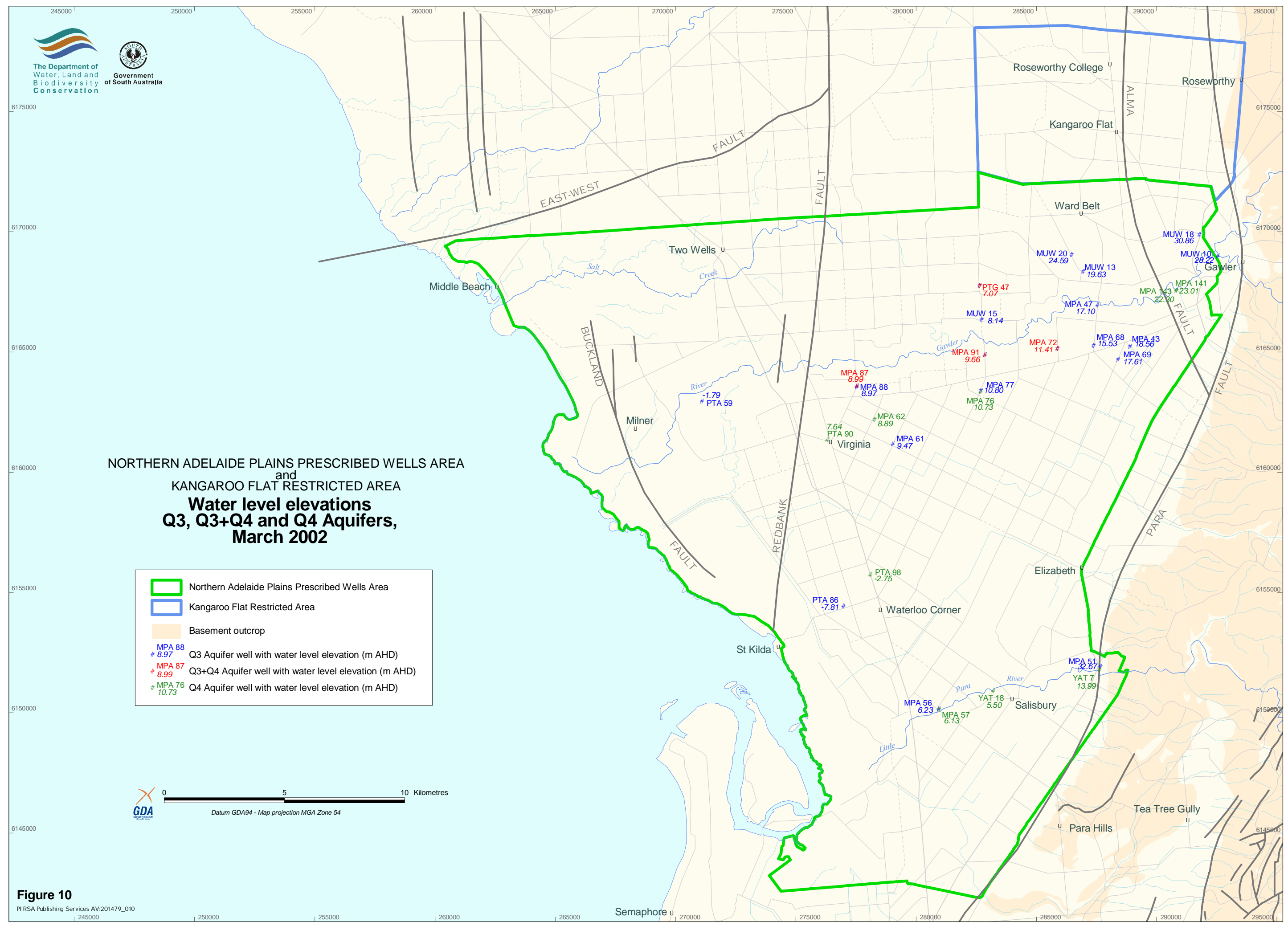


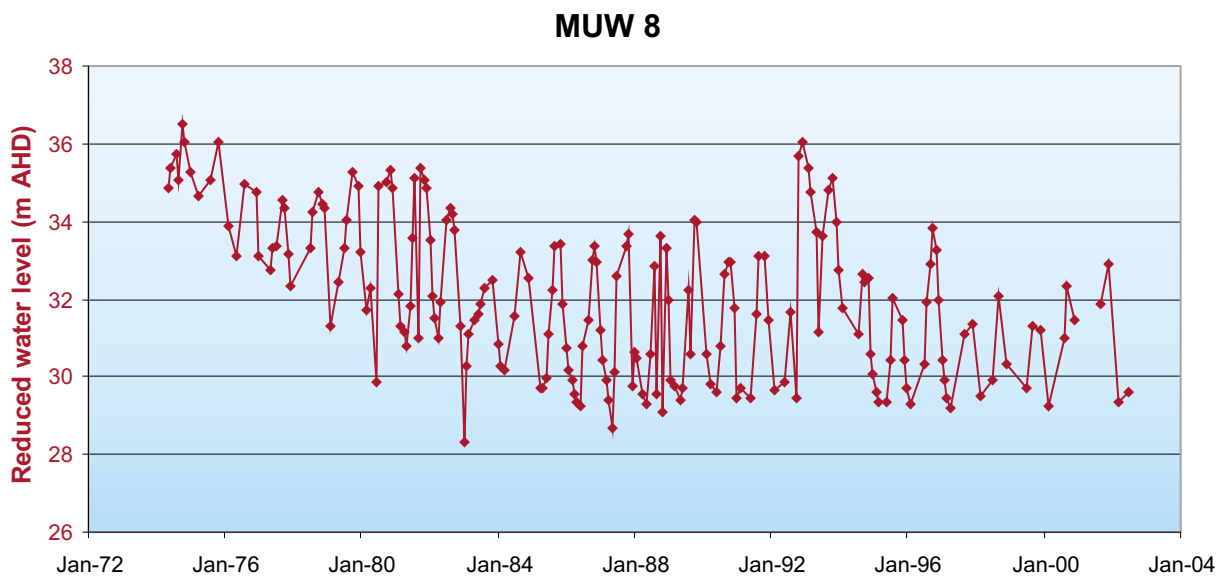
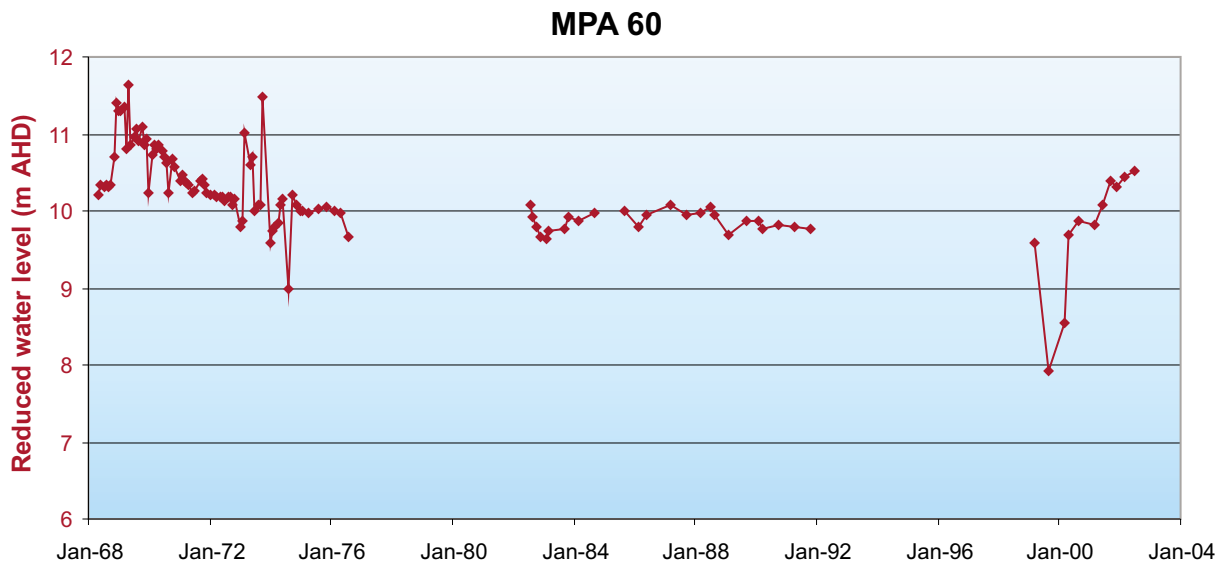
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
and  
KANGAROO FLAT RESTRICTED AREA  
**Water level elevations  
Q3, Q3+Q4 and Q4 Aquifers,  
March 2002**

	Northern Adelaide Plains Prescribed Wells Area
	Kangaroo Flat Restricted Area
	Basement outcrop
	Q3 Aquifer well with water level elevation (m AHD)
	Q3+Q4 Aquifer well with water level elevation (m AHD)
	Q4 Aquifer well with water level elevation (m AHD)

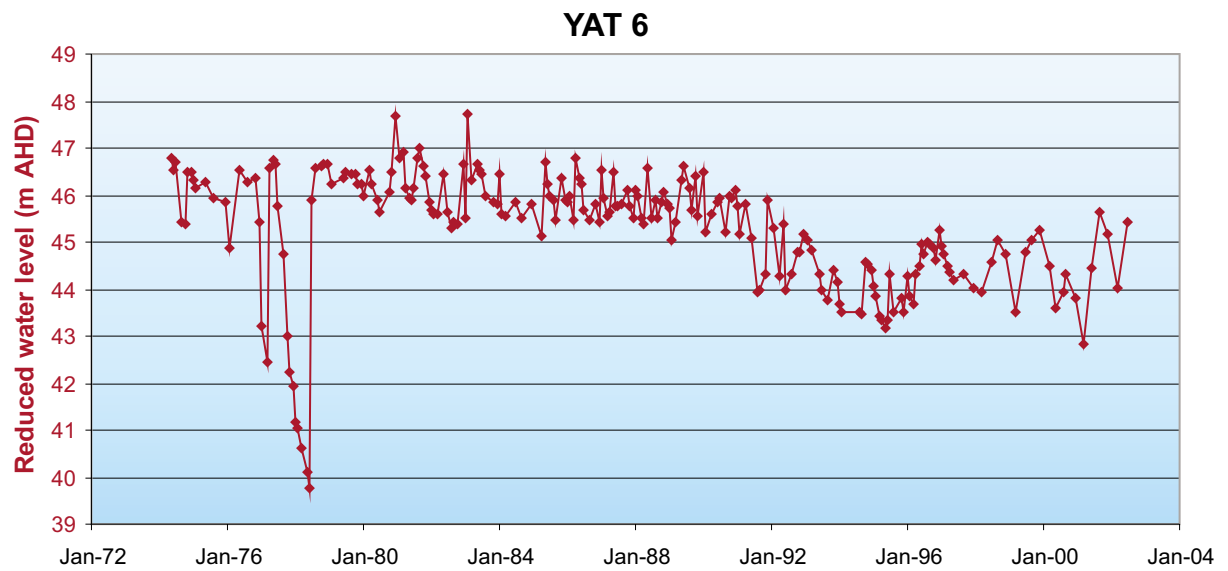
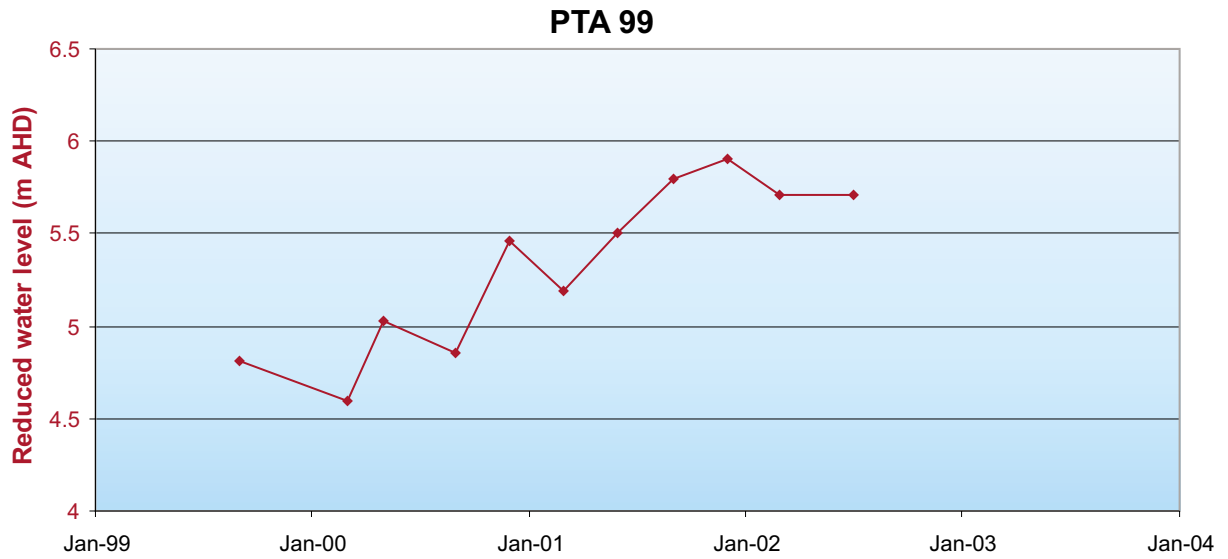


**Figure 10**



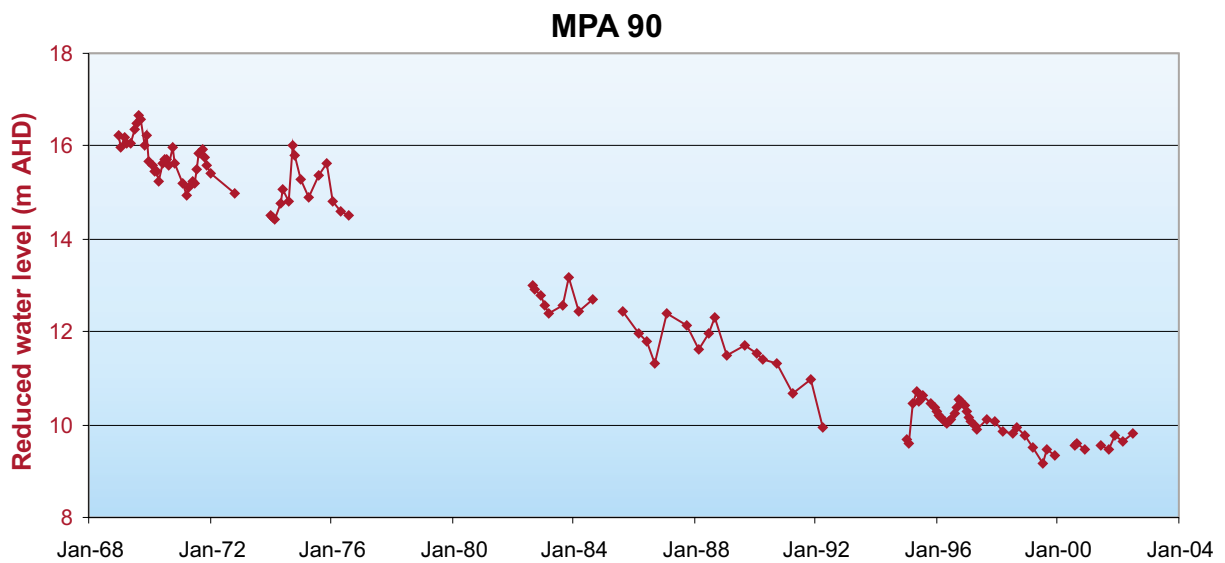
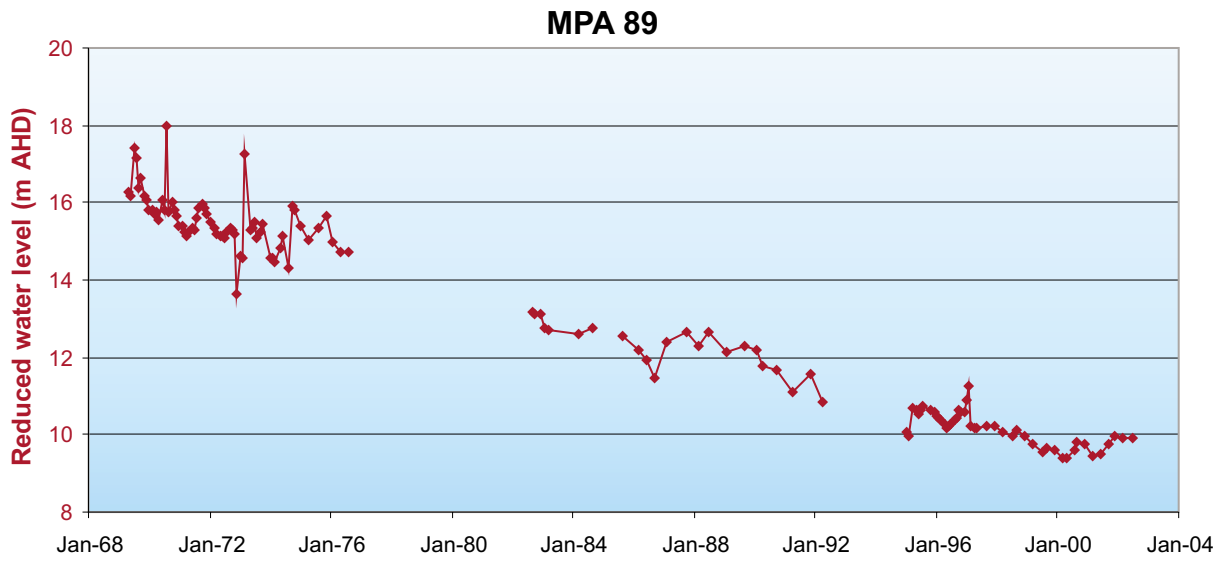
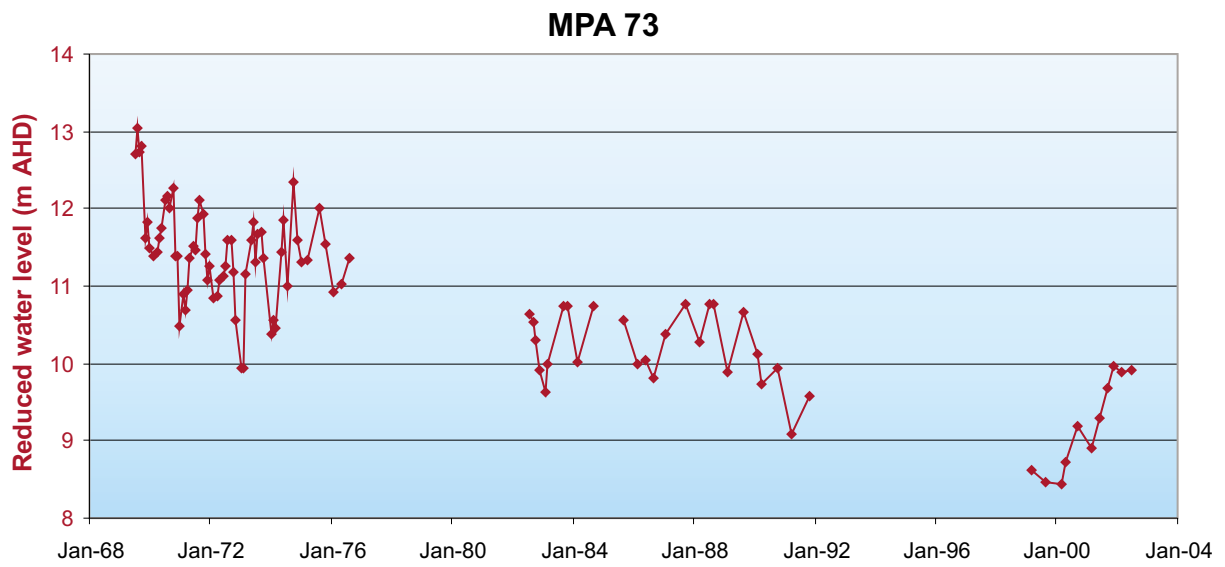


**Figure 11** Q1 Aquifer hydrographs

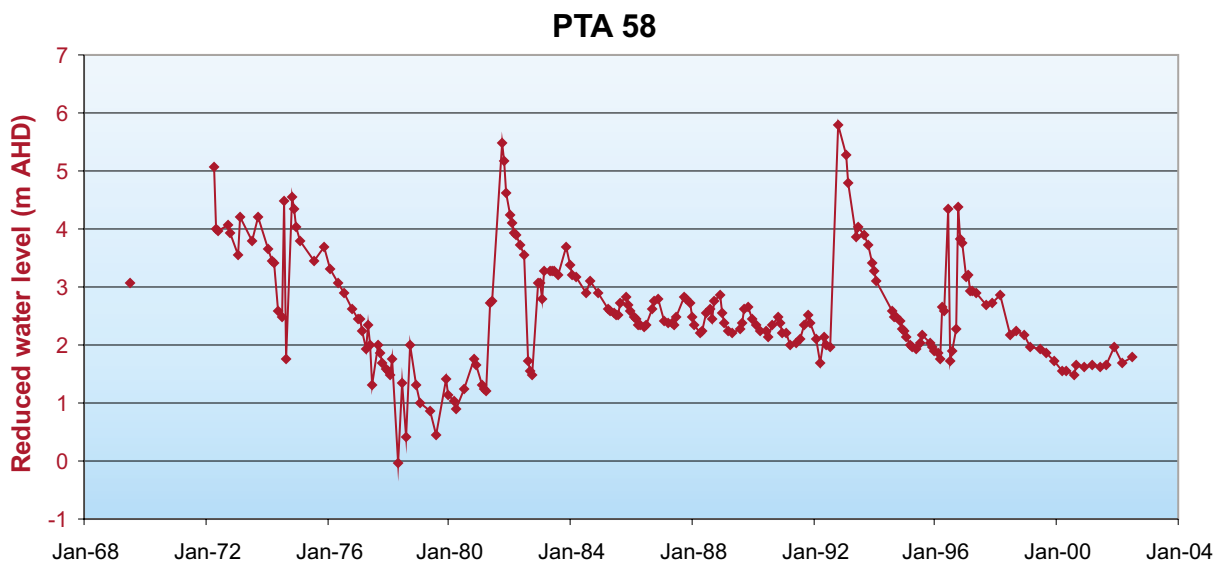
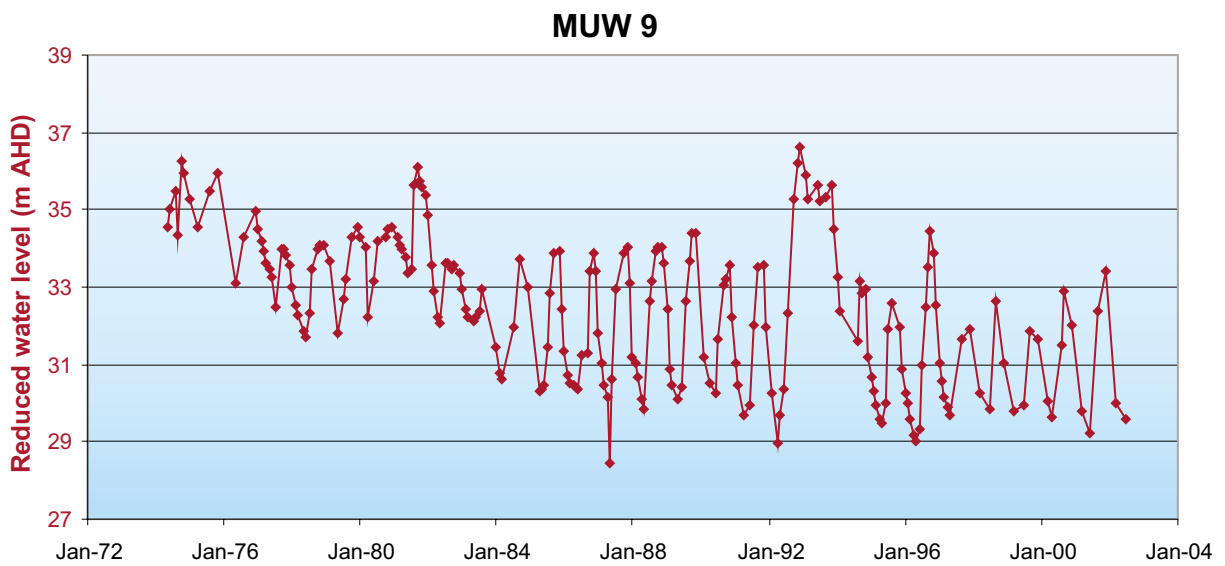
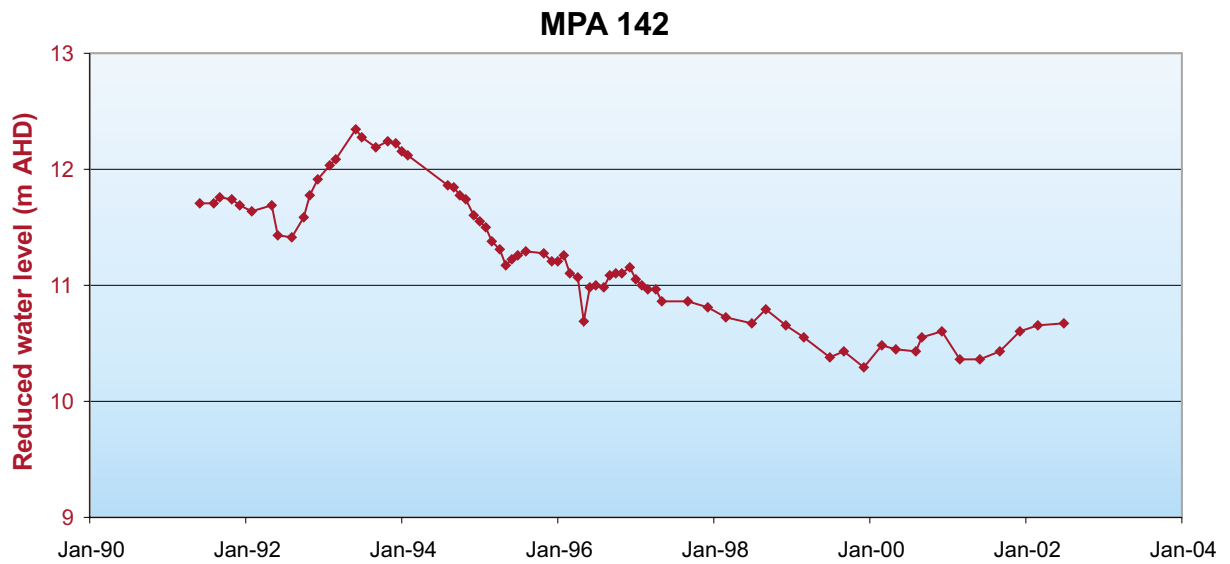


**Figure 11a** Q1 Aquifer hydrographs

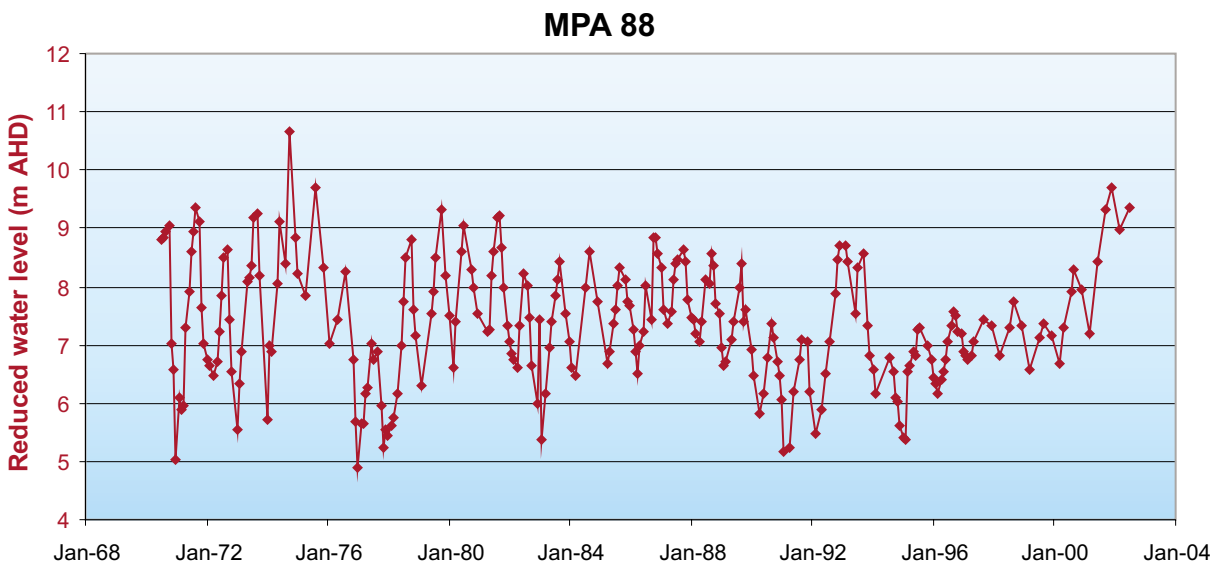
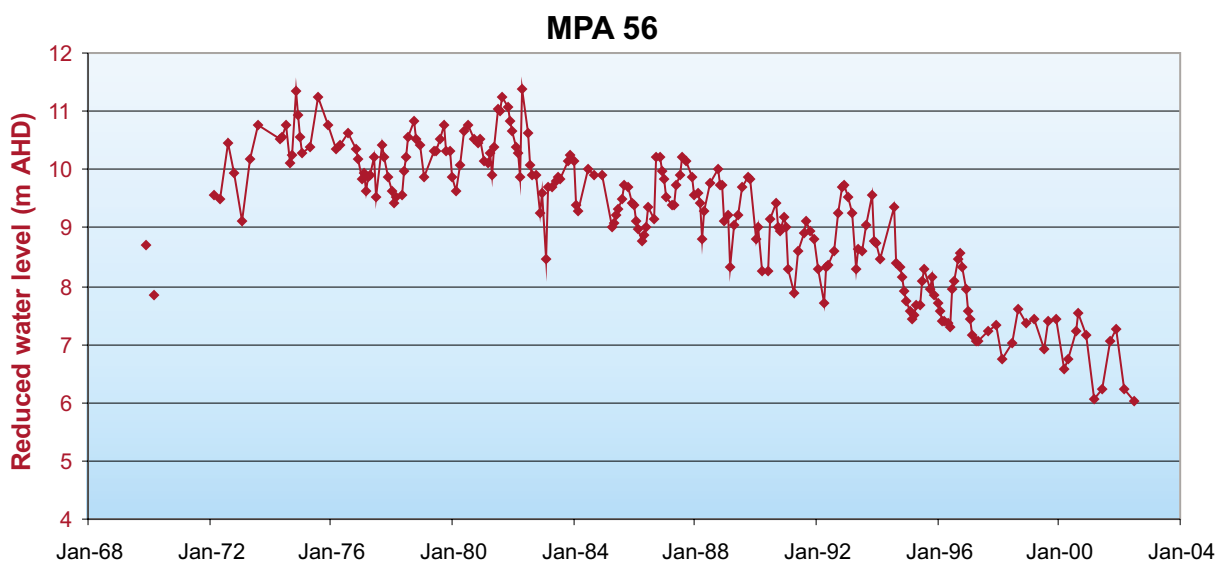
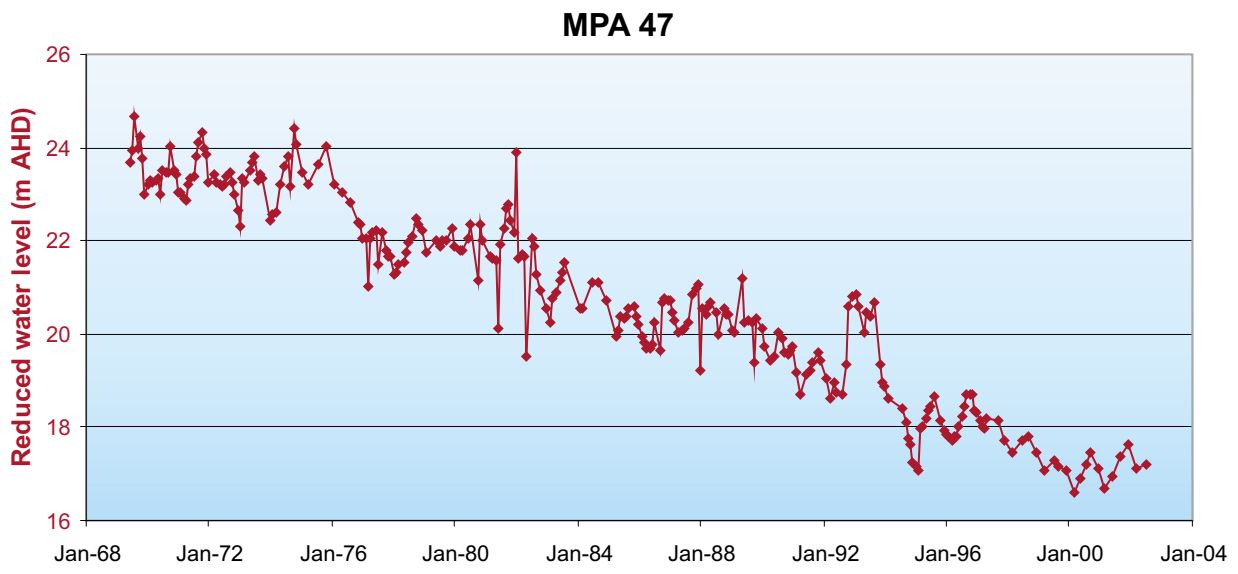




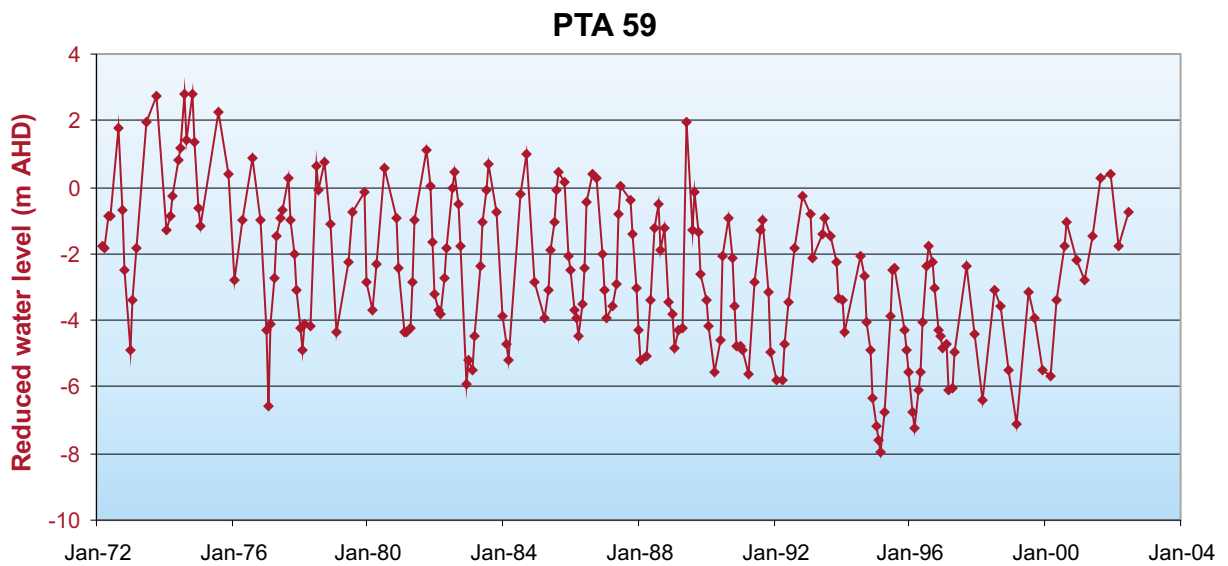
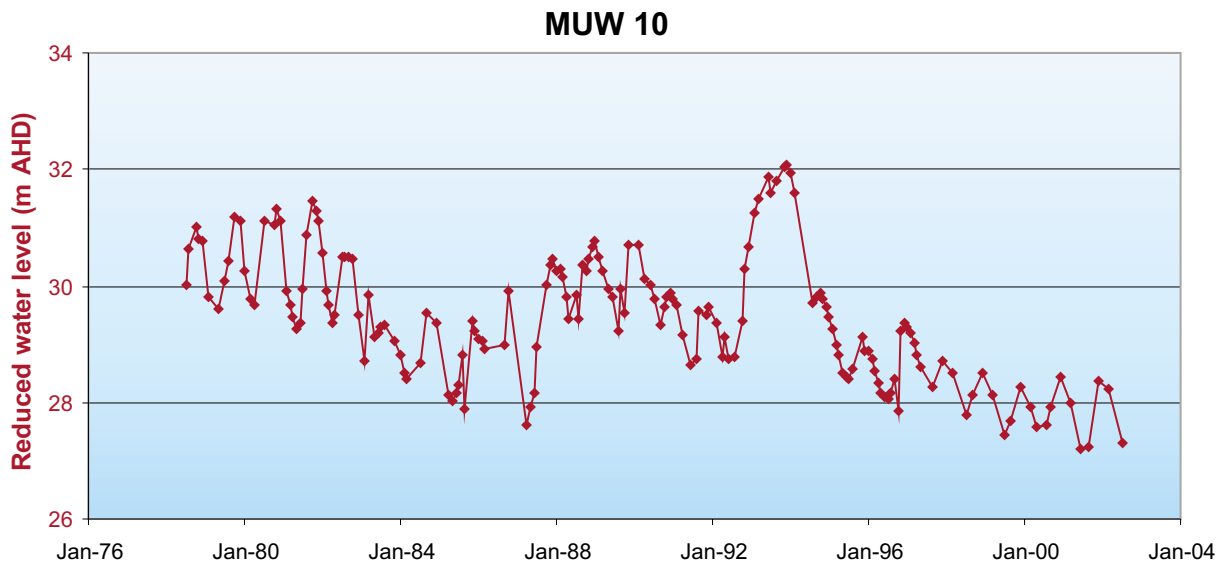
**Figure 12** Q2 Aquifer hydrographs



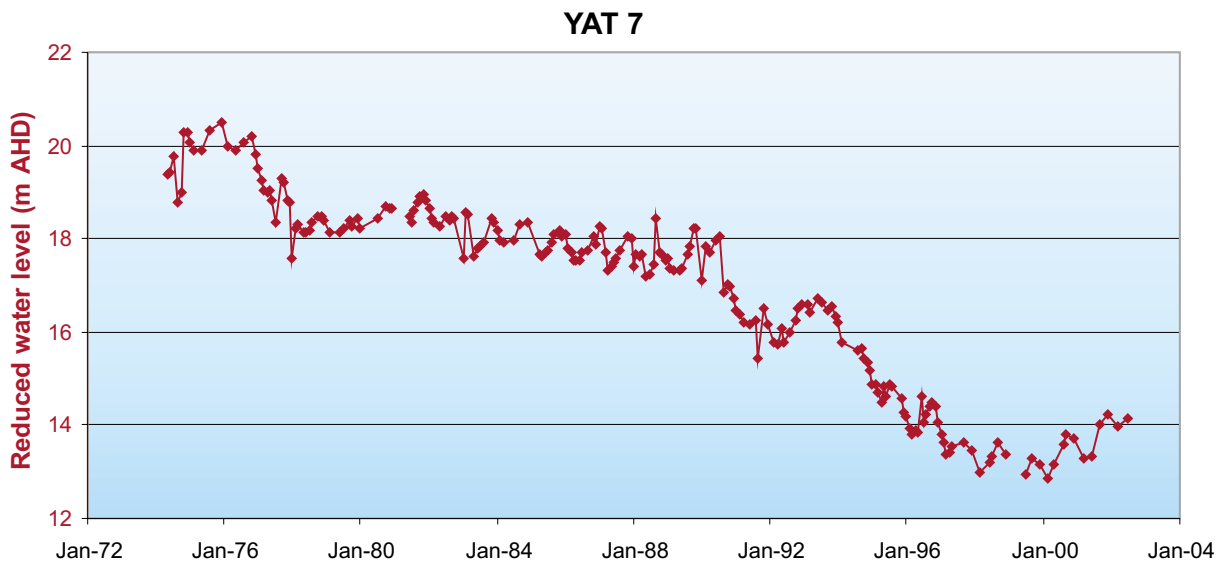
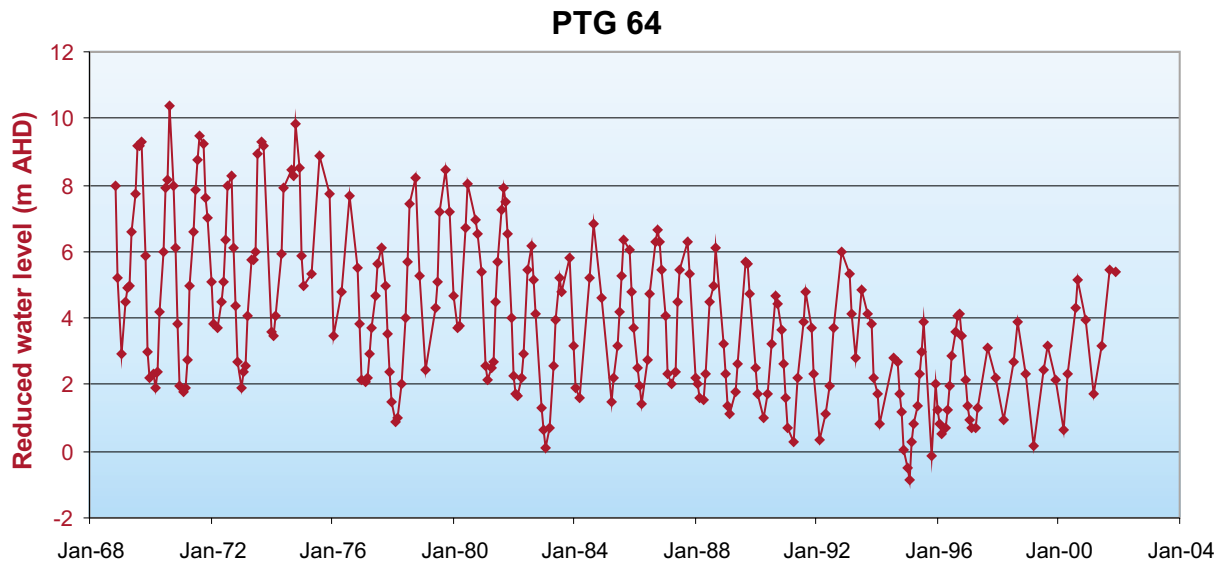
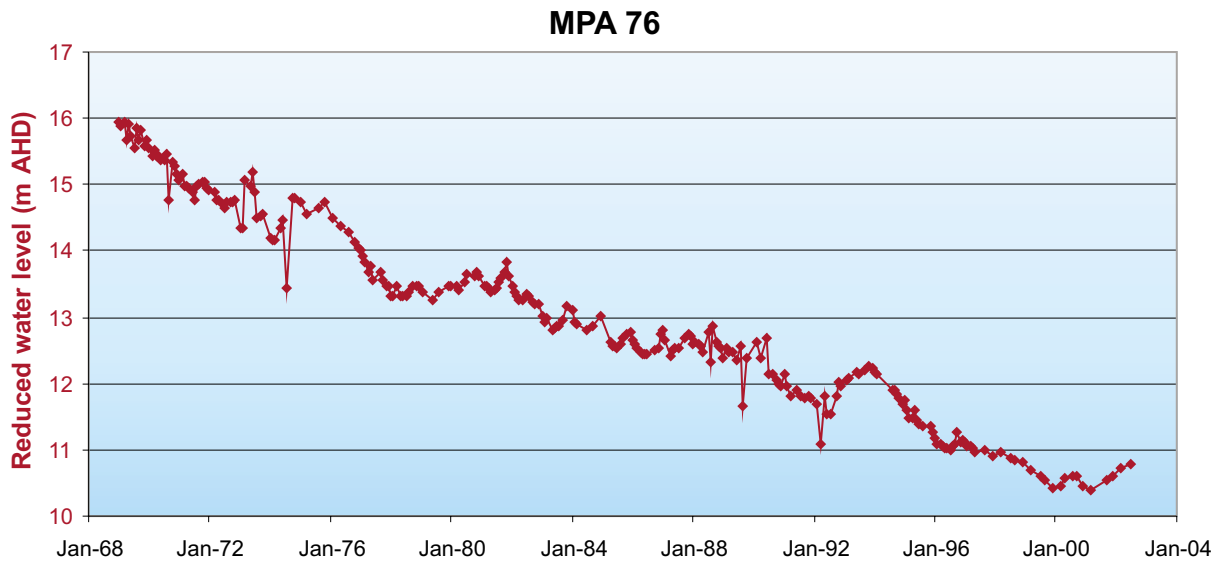
**Figure 12a** Q2 Aquifer hydrographs



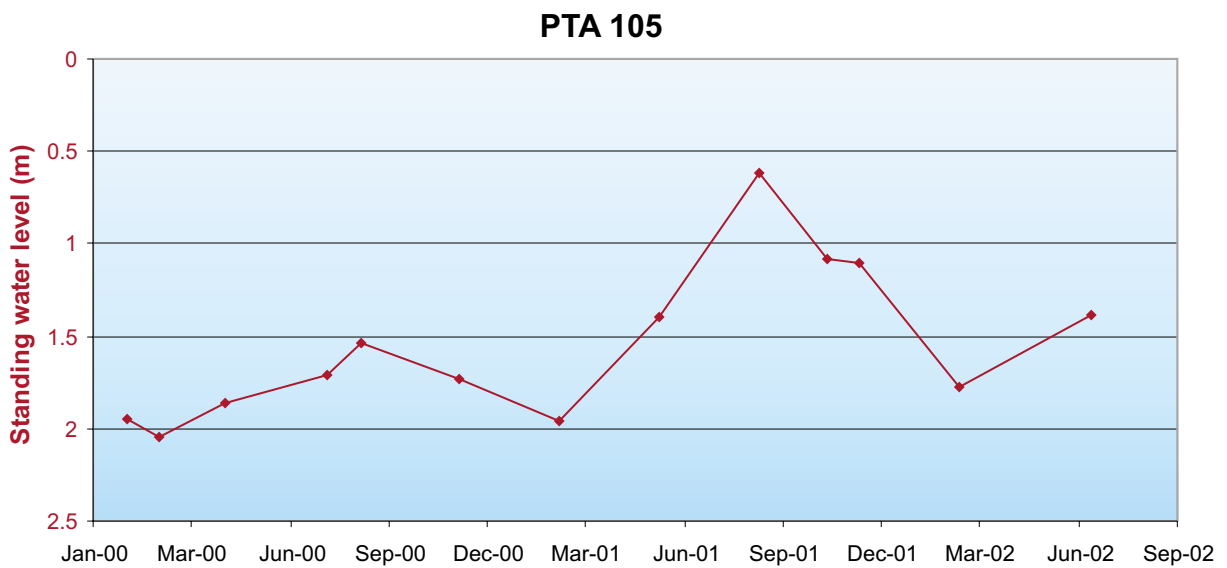
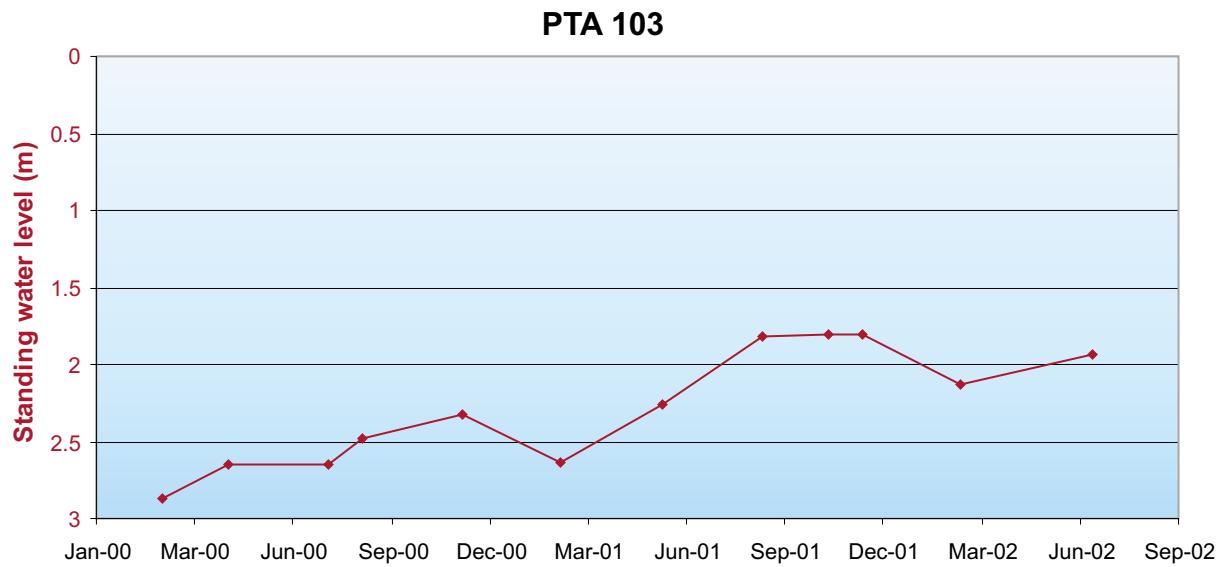
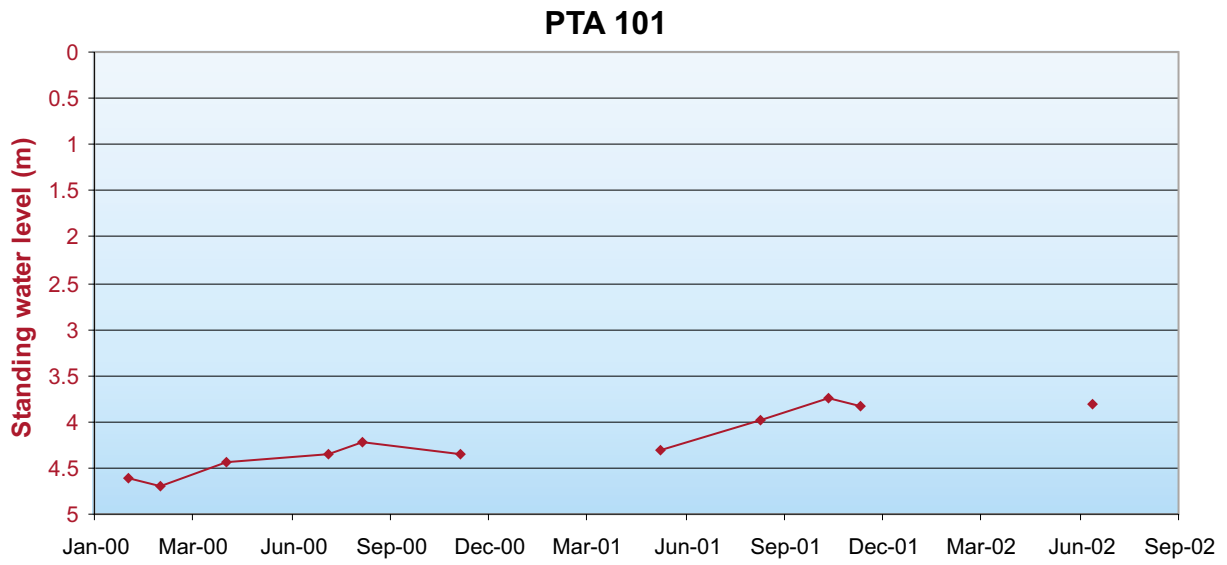
**Figure 13** Q3 Aquifer hydrographs



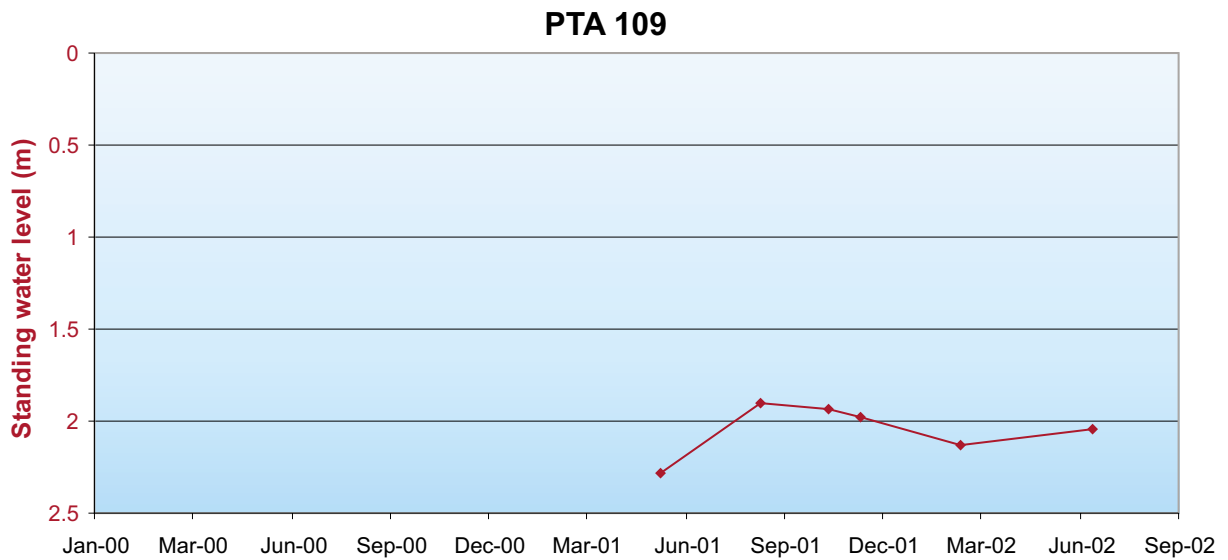
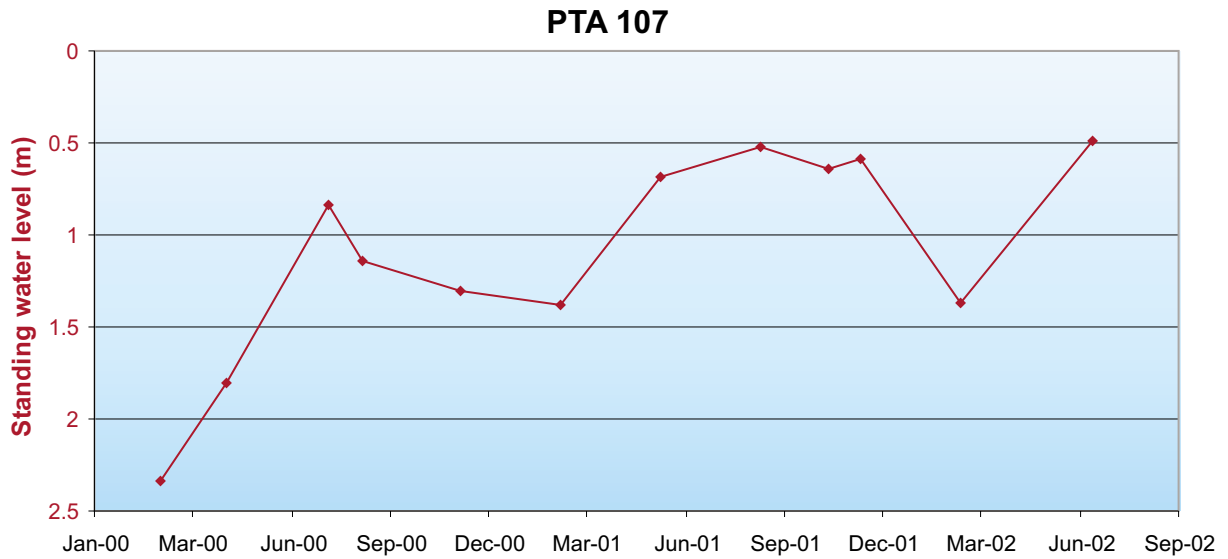
**Figure 13a** Q3 Aquifer hydrographs



**Figure 14** Q4 Aquifer hydrographs



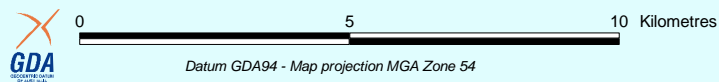
**Figure 15** Perched Aquifer hydrographs



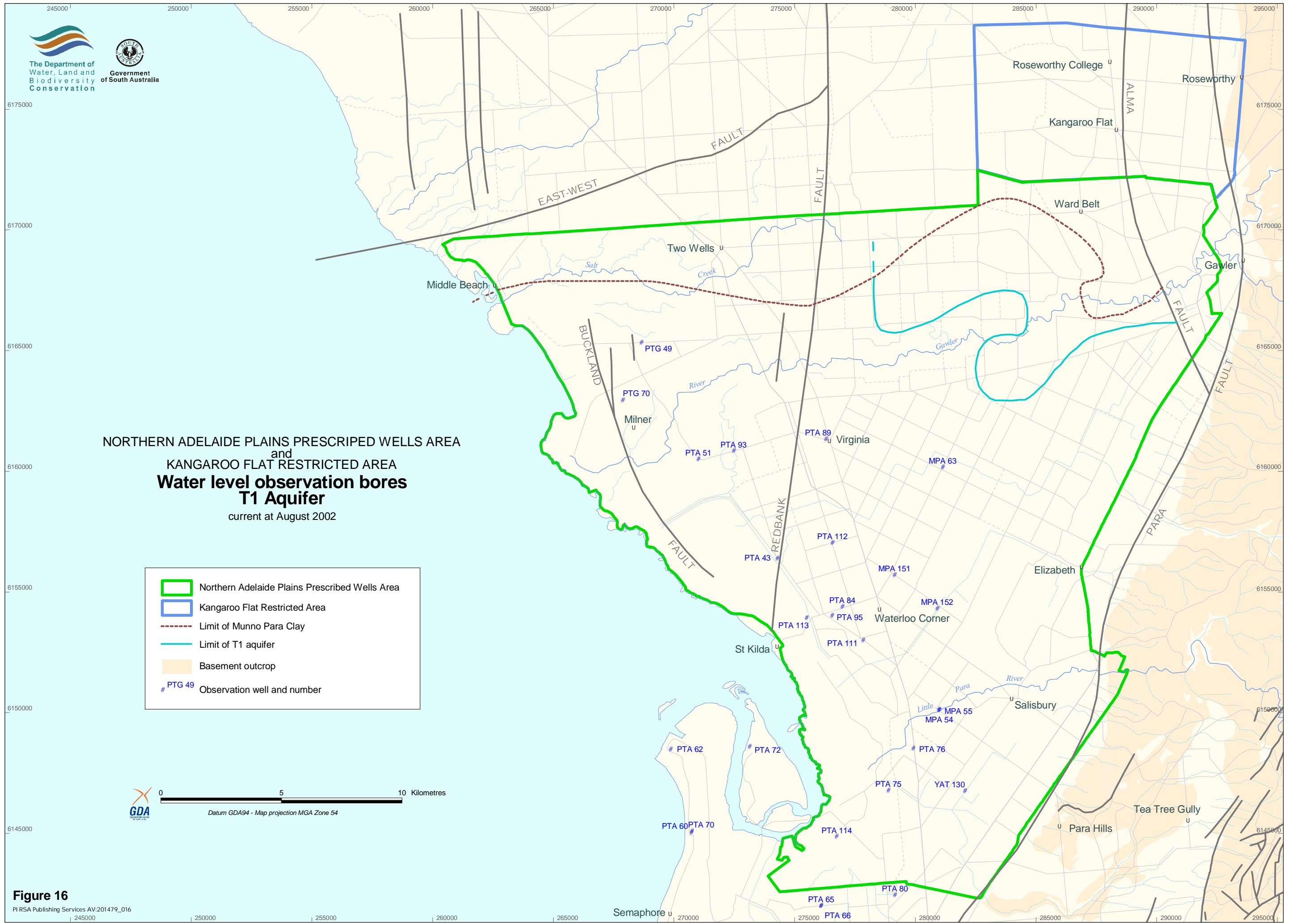
**Figure 15a** Perched Aquifer hydrographs

NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
 and  
 KANGAROO FLAT RESTRICTED AREA  
**Water level observation bores**  
**T1 Aquifer**  
 current at August 2002

- Northern Adelaide Plains Prescribed Wells Area
- Kangaroo Flat Restricted Area
- Limit of Munno Para Clay
- Limit of T1 aquifer
- Basement outcrop
- # PTG 49 Observation well and number











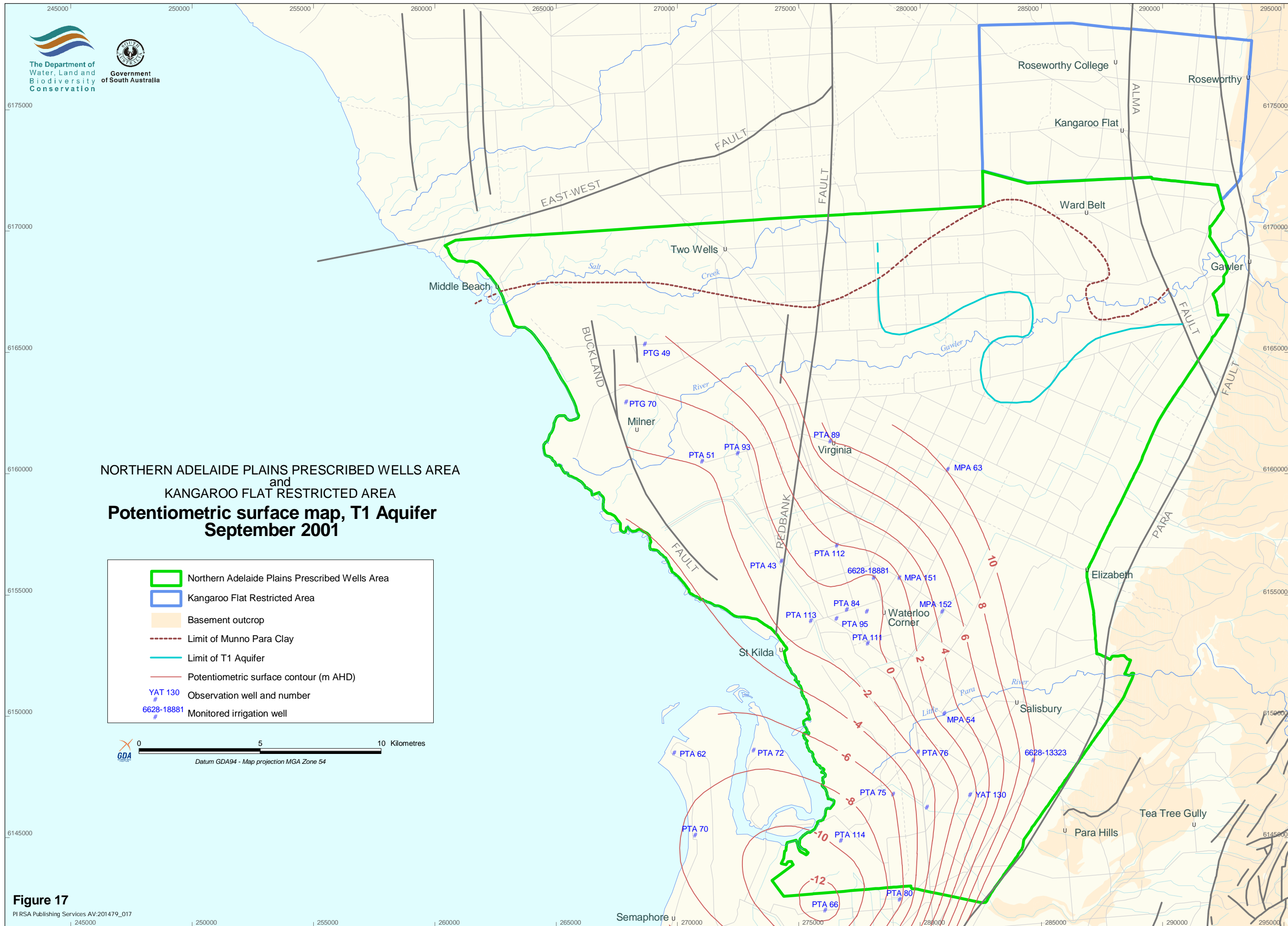
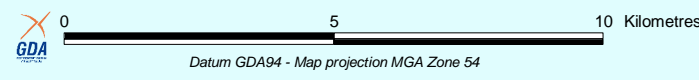
**Figure 16**  
 PI RSA Publishing Services AV:201479\_016













NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
 and  
 KANGAROO FLAT RESTRICTED AREA  
**Potentiometric surface map, T1 Aquifer  
 September 2001**

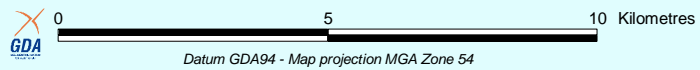
-  Northern Adelaide Plains Prescribed Wells Area
-  Kangaroo Flat Restricted Area
-  Basement outcrop
-  Limit of Munno Para Clay
-  Limit of T1 Aquifer
-  Potentiometric surface contour (m AHD)
-  Observation well and number
-  Monitored irrigation well



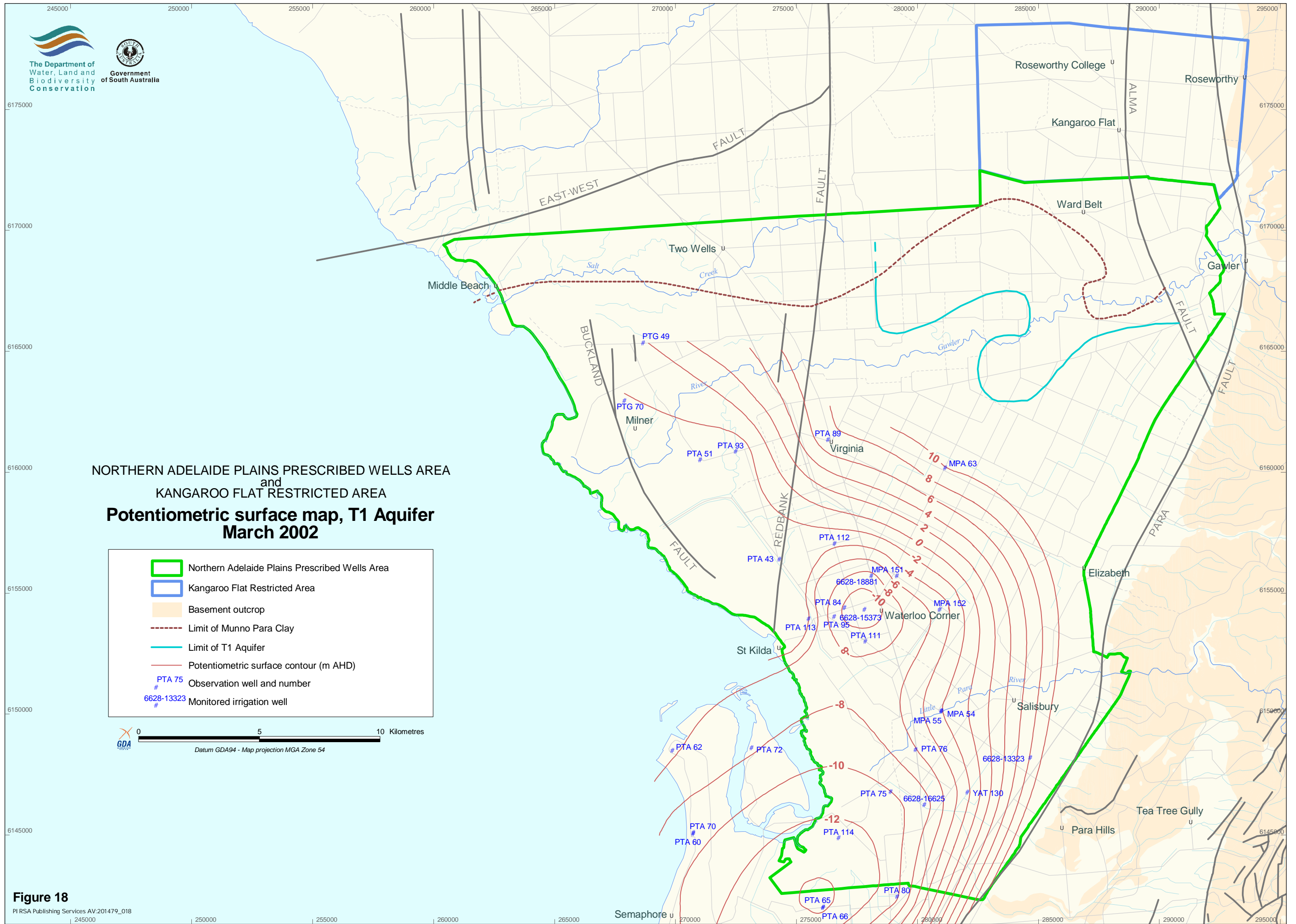
**Figure 17**  
 PI RSA Publishing Services AV:201479\_017

NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
 and  
 KANGAROO FLAT RESTRICTED AREA  
**Potentiometric surface map, T1 Aquifer  
 March 2002**

-  Northern Adelaide Plains Prescribed Wells Area
-  Kangaroo Flat Restricted Area
-  Basement outcrop
-  Limit of Munno Para Clay
-  Limit of T1 Aquifer
-  Potentiometric surface contour (m AHD)
-  # PTA 75 Observation well and number
-  # 6628-13323 Monitored irrigation well



**Figure 18**



Analysed hydrographs from the heavy pumping areas where long-term records exist (Figs 19, 19a) show fluctuations from seasonal extraction and an overall decline in potentiometric surface. However, the exact decline values can not be defined due to discontinuous recording; for example in the early to mid nineties. Short-term potentiometric surface trends, analysed for the period 1999–2002, show that the average rate of recovery for the potentiometric surface is ~1 m/y.

## ***T2 Aquifer***

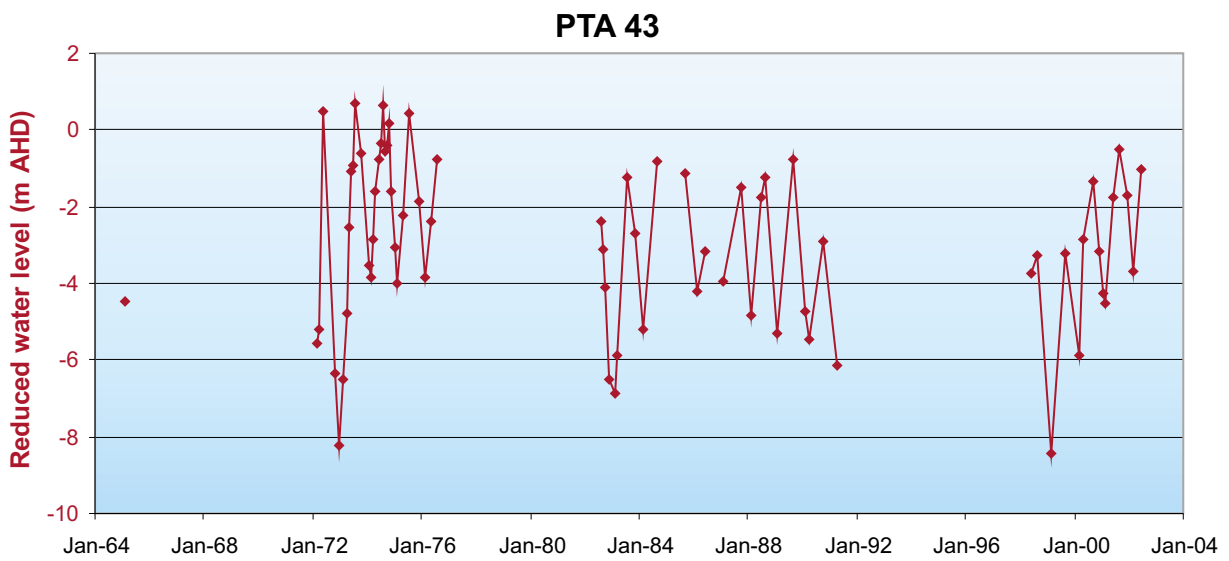
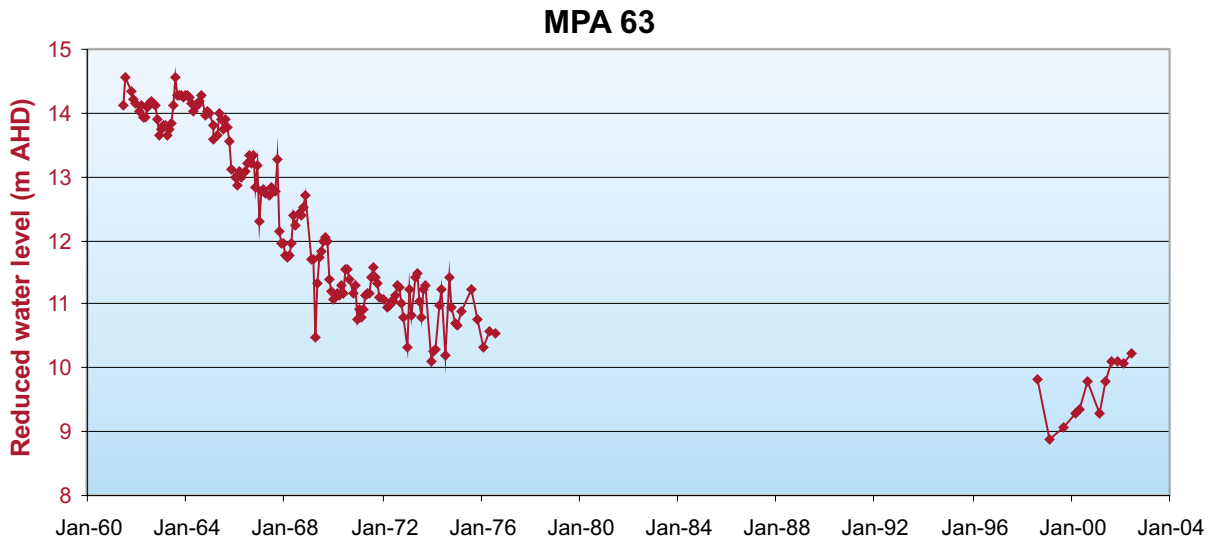
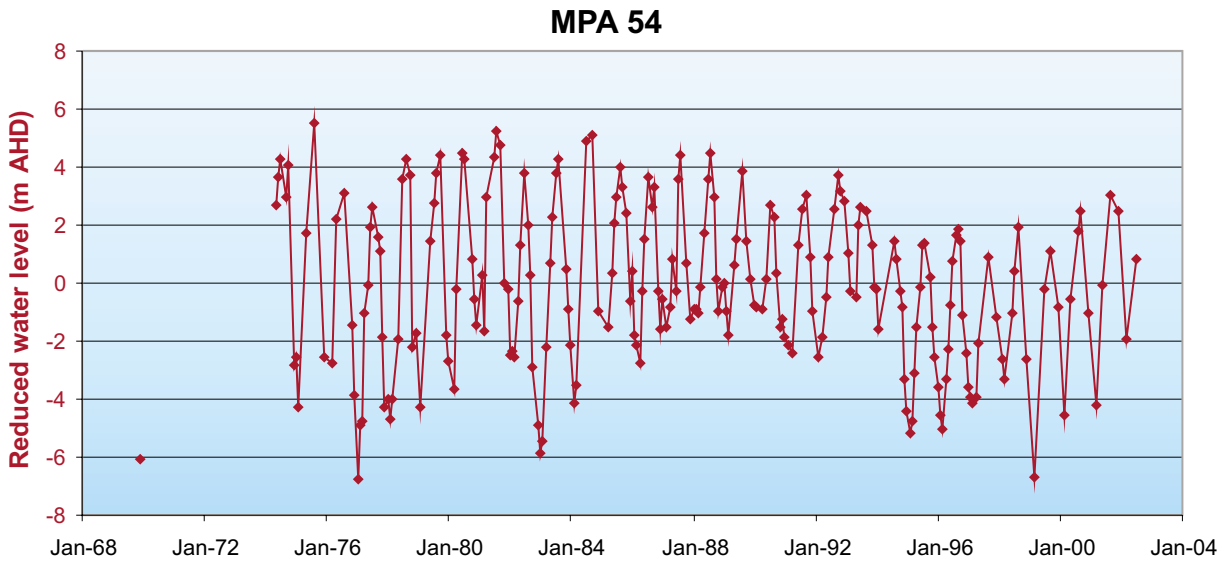
The T2 Aquifer (lower Port Willunga Formation) is monitored by a total of 53 wells. Four wells were completed in the undifferentiated Tertiary sediments, 48 wells are located inside the NAP PWA, three wells are located inside the Kangaroo Flat Restricted Area and two wells are part of both the NAP and Metropolitan Adelaide observation networks (Fig. 20).

The second Tertiary Aquifer occurs throughout the entire prescribed wells area. The current observation wells monitoring water levels in the T2 Aquifer are presented in Figure 20. The latest potentiometric surface maps for September 2001 and March 2002 (Figs 21, 22) show a regional cone of depression formed in the Virginia – Angle Vale area. During the winter season, the T2 Aquifer recovers but does not reach the pre-development groundwater level. Recently, another cone of depression has been recognised (formed) in the Kangaroo Flat area during the summer irrigation season.

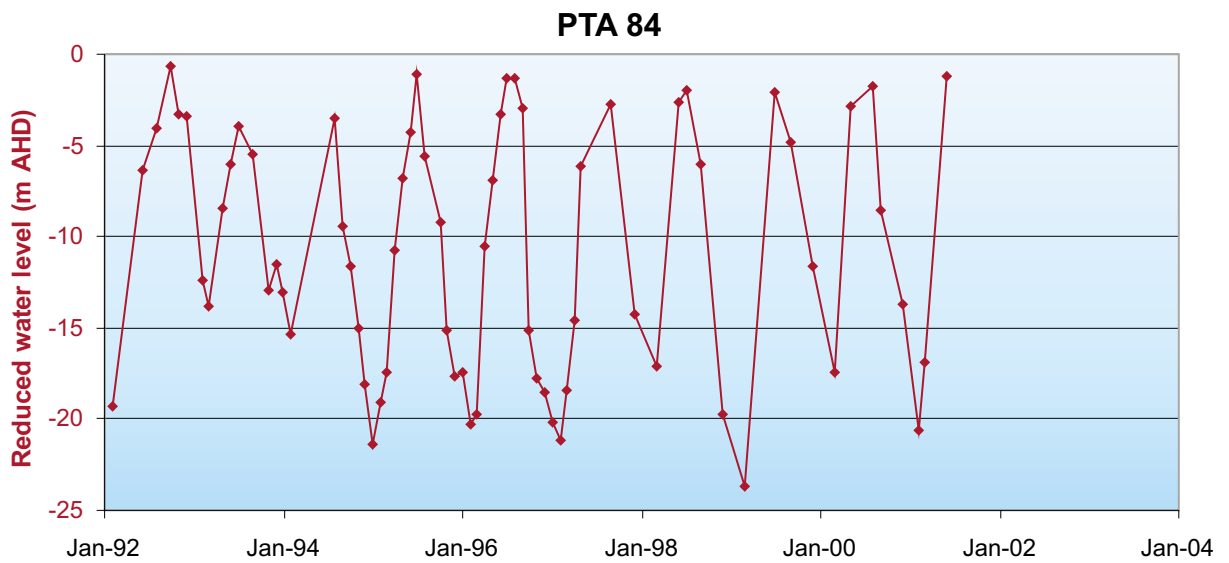
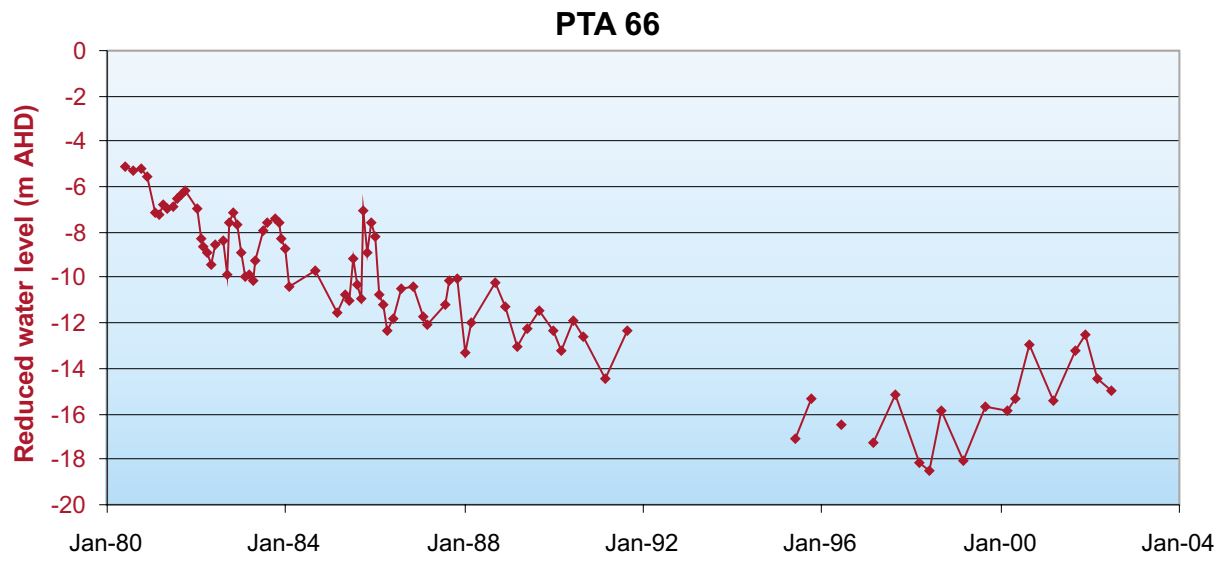
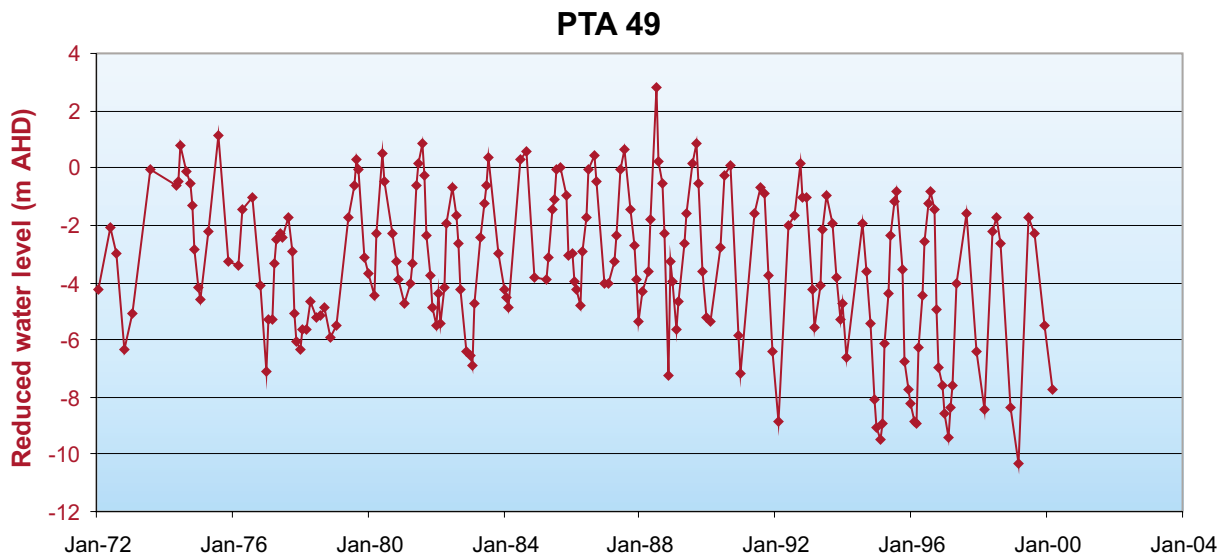
Selected hydrographs with the longest period of records (Fig. 23–23b) generally show the overall decline of potentiometric surface. Sixteen wells with continuous long-term water level records (1987–2002) have been analysed in order to define the rate of this decline. Fourteen wells show declining trend ranging from 0.04 to 0.61 m/y, while the average decline is 0.22 m/y. Only two wells show rising trends. However, short-term potentiometric surface trends analysed for the period 1999–2002 show that the average rate of recovery for the potentiometric surface is ~2 m/y.

## ***T3 and T4 Aquifers***

A total of six wells monitor the T3 and T4 Aquifers. Two wells monitor South Maslin Sand Aquifer (PTG 76, unit number 6528-533, PTA 92, unit number 6528-535), one is completed in each North Maslin Sand (MPA 65, unit number 6628-2471), Aldinga Member – Chinaman Gully Formation sands (PTA 88, unit number 6628-15843), Clinton Formation Sand (PTG 75, unit number 6528-550) and Blanche Point Formation (YAT 68, unit number 6628-5253; Fig. 24). Four of these observation wells are artesian while two observation wells (MPA 65 and YAT 68) have potentiometric surface below ground level.



**Figure 19** T1 Aquifer hydrographs










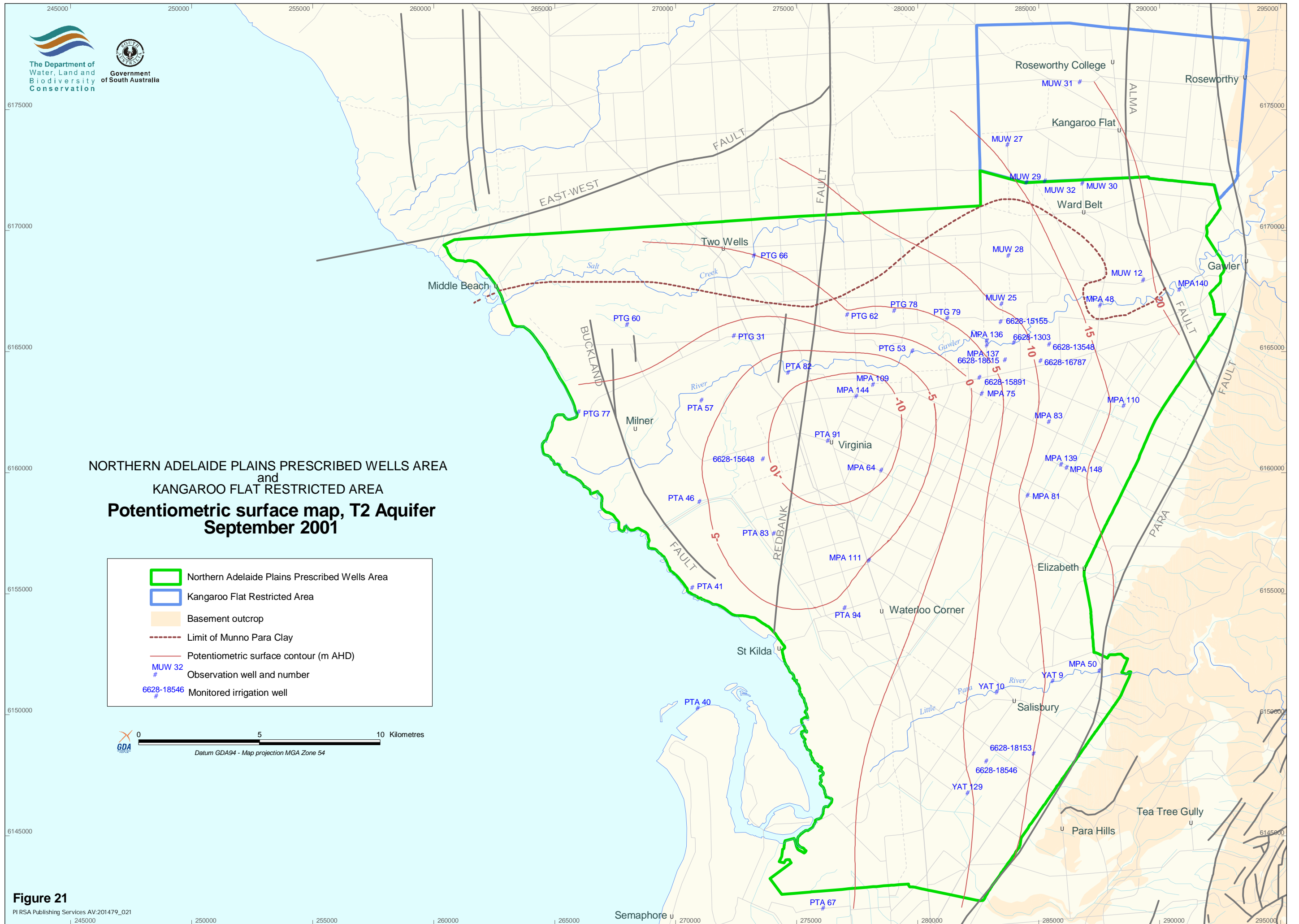
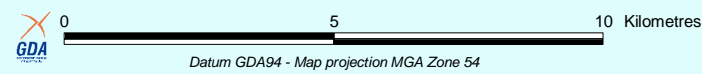
**Figure 19a** T1 Aquifer hydrographs





NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
 and  
 KANGAROO FLAT RESTRICTED AREA  
**Potentiometric surface map, T2 Aquifer  
 September 2001**








-  Northern Adelaide Plains Prescribed Wells Area
-  Kangaroo Flat Restricted Area
-  Basement outcrop
-  Limit of Munno Para Clay
-  Potentiometric surface contour (m AHD)
-  MUW 32  
# Observation well and number
-  6628-18546  
# Monitored irrigation well

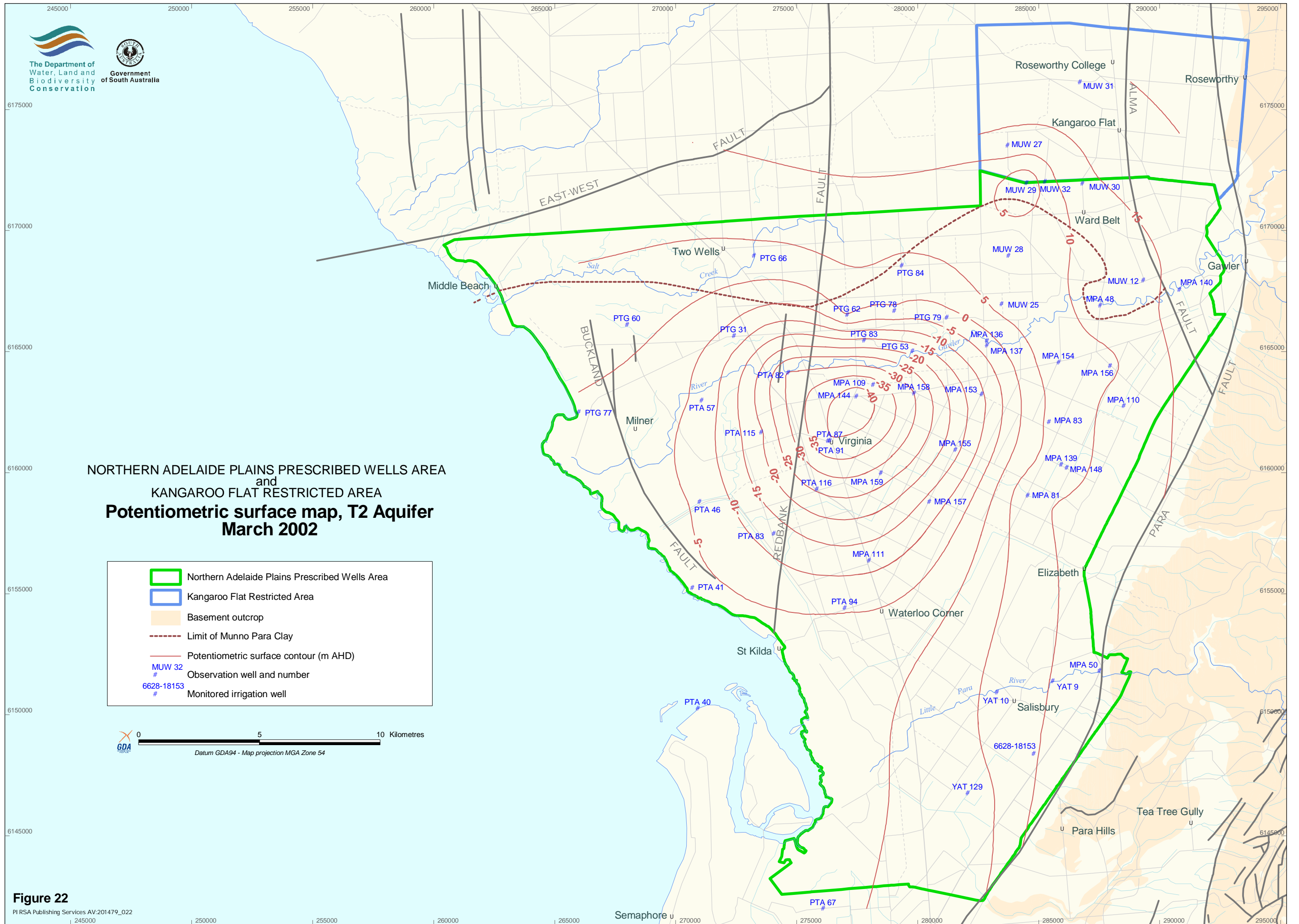
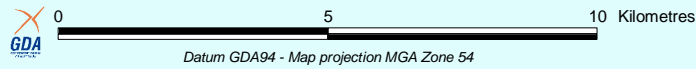


**Figure 21**



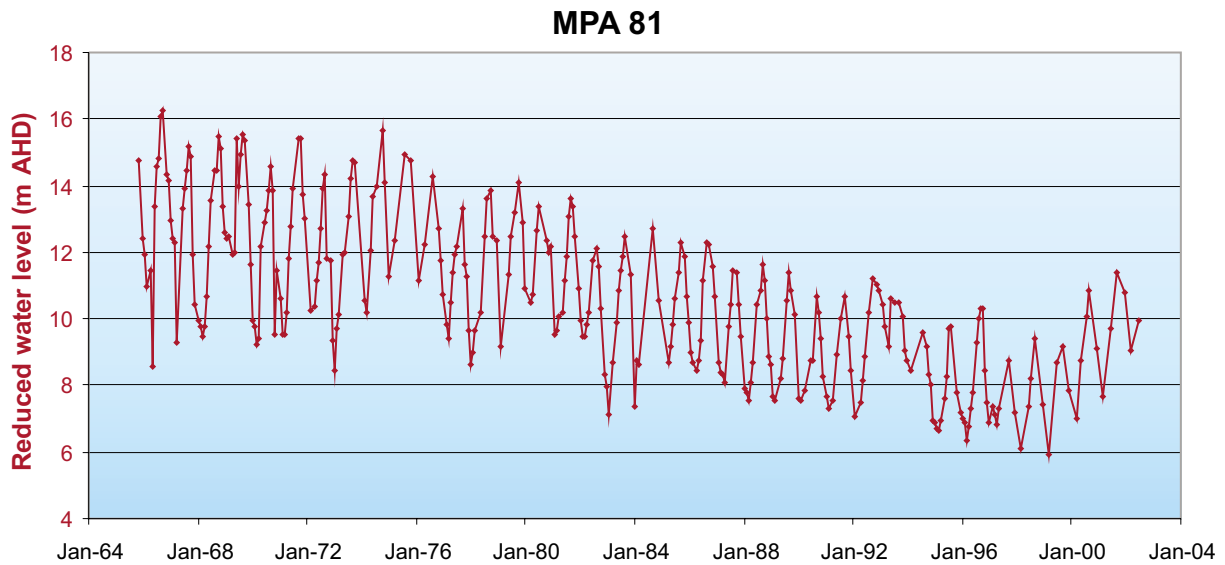
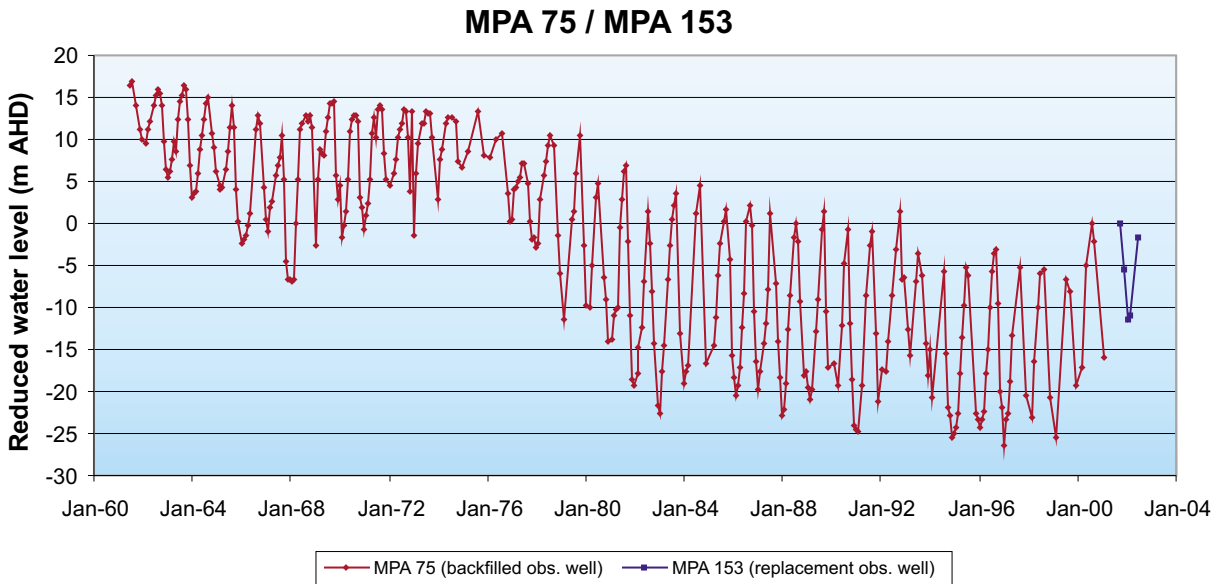
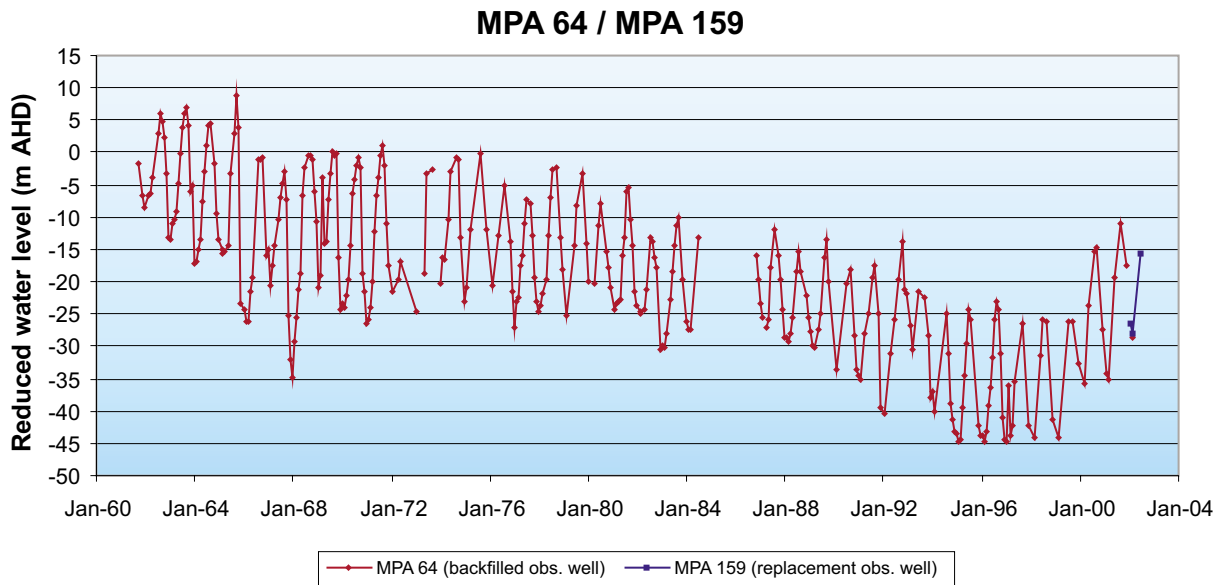
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
 and  
 KANGAROO FLAT RESTRICTED AREA  
**Potentiometric surface map, T2 Aquifer  
 March 2002**

-  Northern Adelaide Plains Prescribed Wells Area
-  Kangaroo Flat Restricted Area
-  Basement outcrop
-  Limit of Munno Para Clay
-  Potentiometric surface contour (m AHD)
-  MUW 32  
# Observation well and number
-  6628-18153  
# Monitored irrigation well

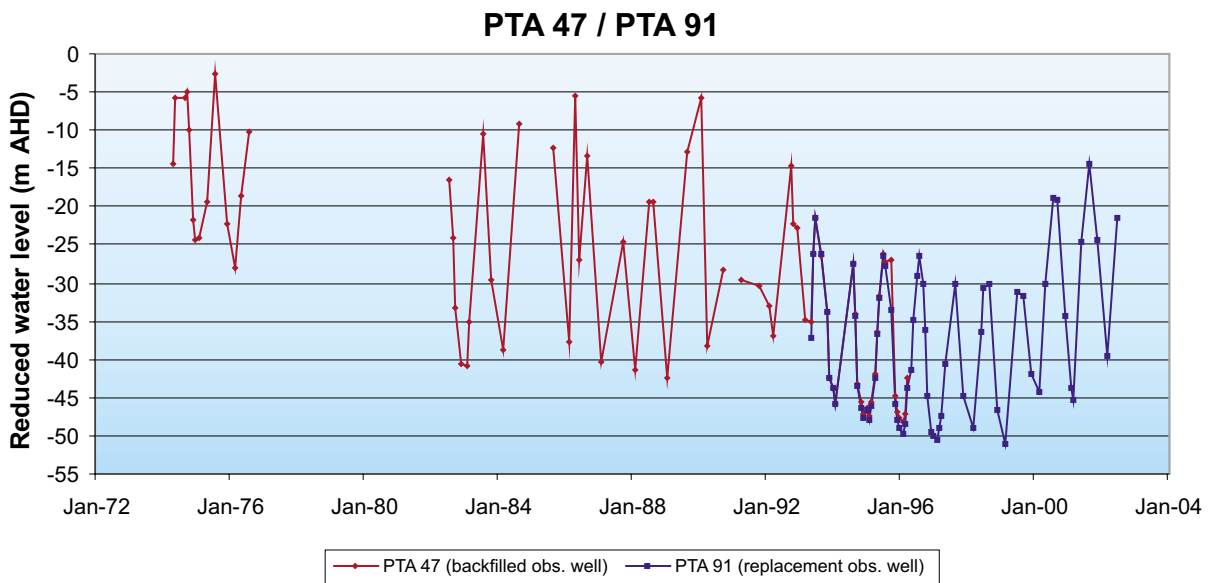
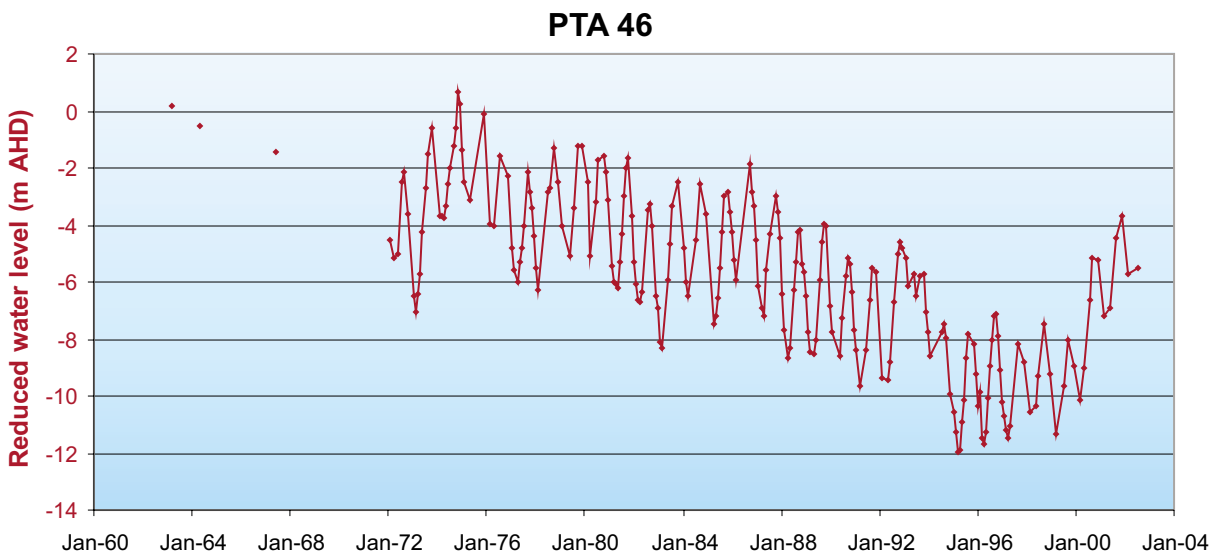
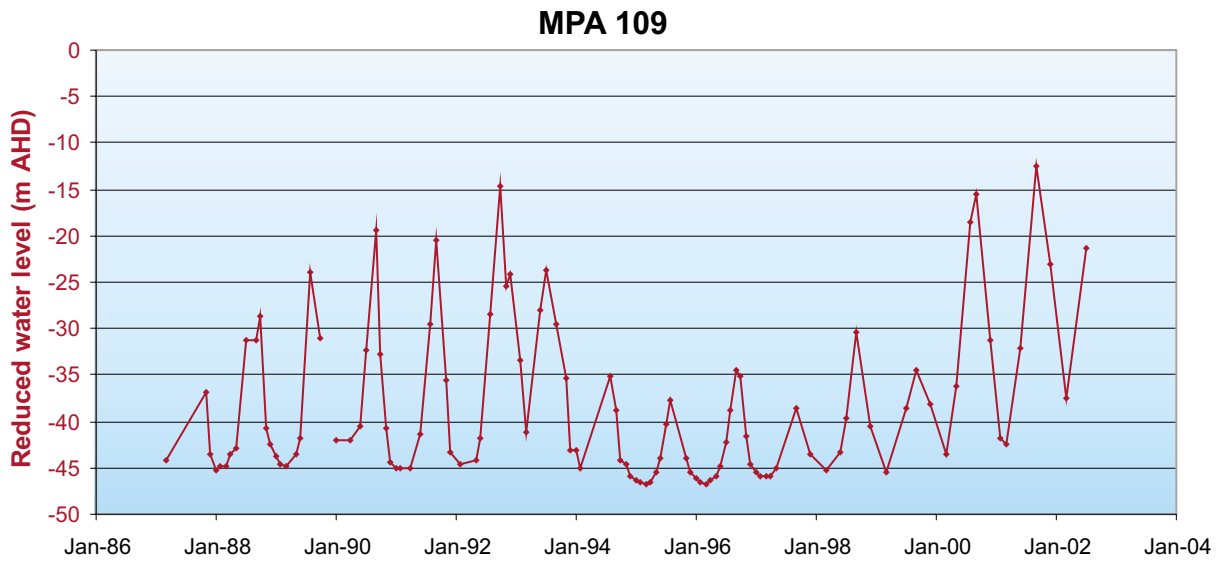


**Figure 22**  
 PI RSA Publishing Services AV:201479\_022

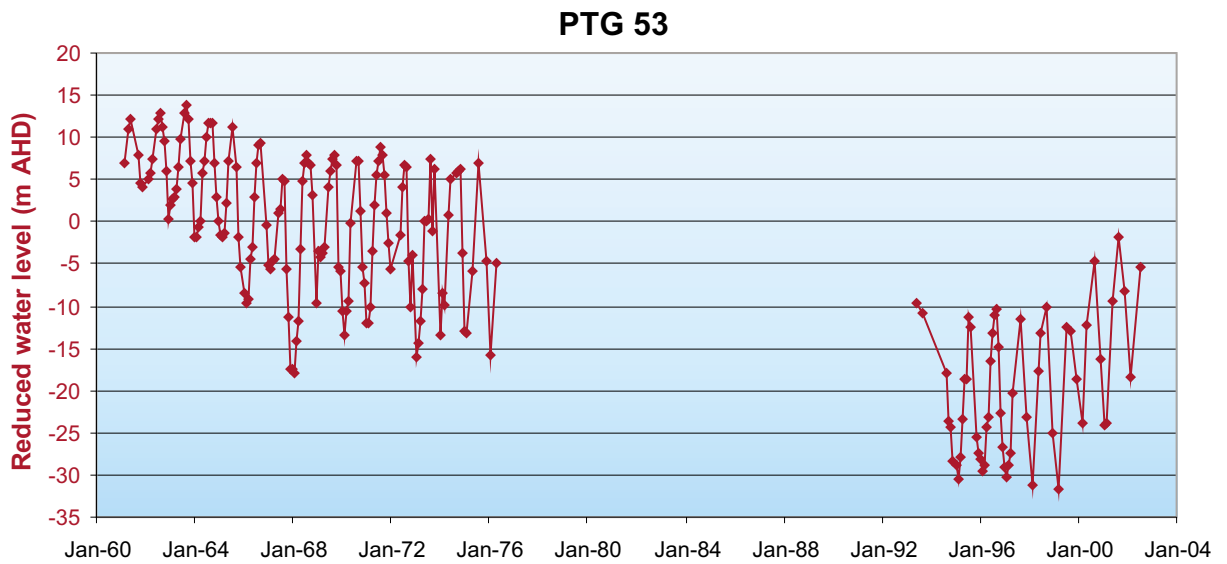
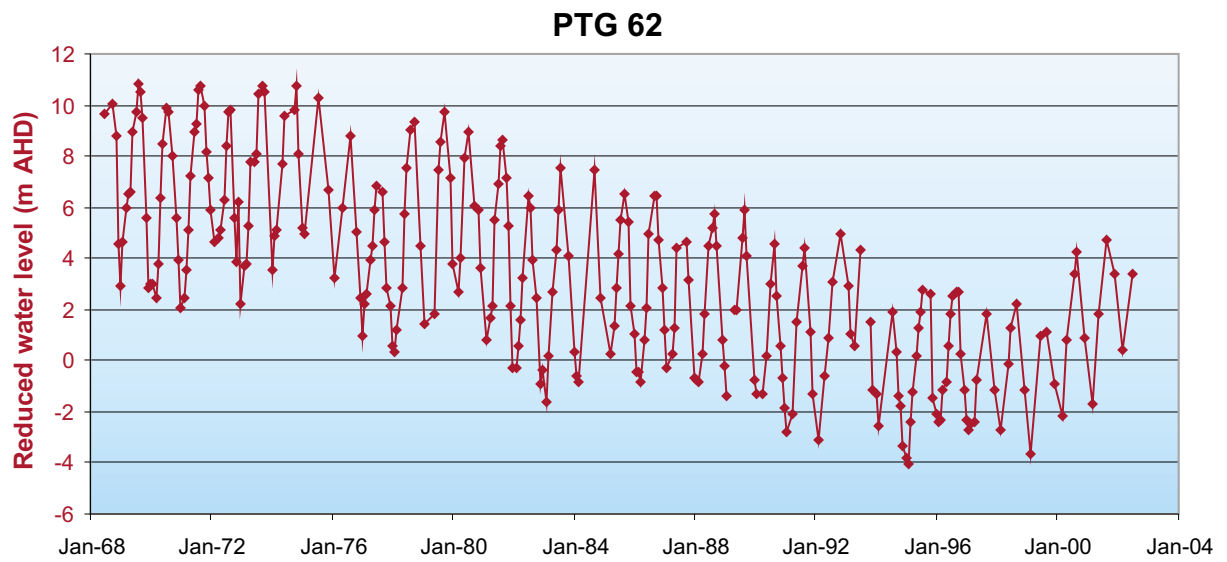




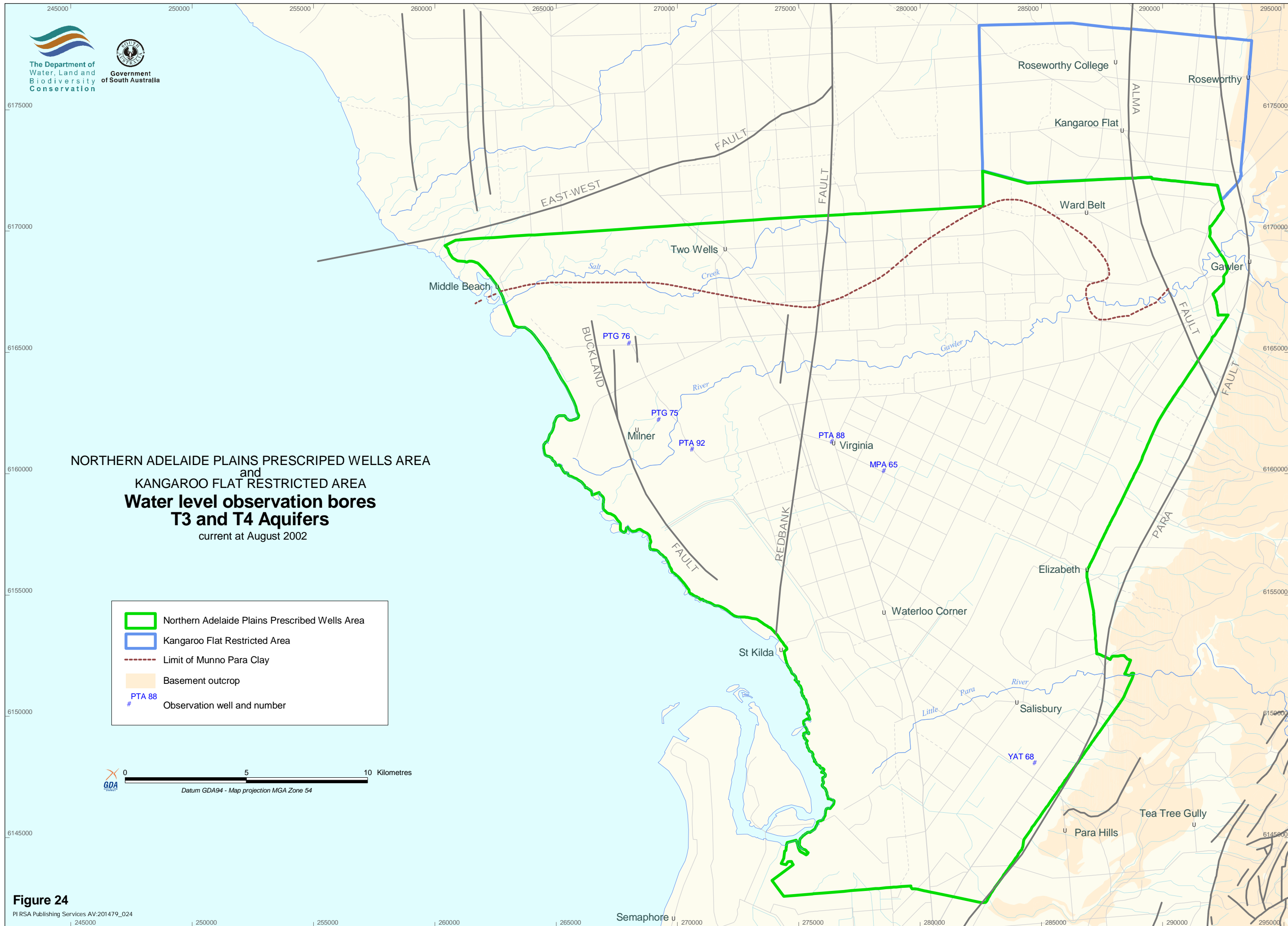
**Figure 23** T2 Aquifer hydrographs



**Figure 23a** T2 Aquifer hydrographs



**Figure 23b** T2 Aquifer hydrographs



**Figure 24**

## **SALINITY TRENDS**

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A network consisting of Quaternary and Tertiary observation wells was established in the early 1960s for salinity monitoring in the area. Mainly production (equipped) wells have been selected for water sampling and salinity examination. This network was observed regularly until the mid–late 1970s, but since then no regular sampling has been conducted in the area. At present, under regulation of the Water Allocation Plan (section 8, principle 4) all water licensees are required to submit an annual water sample from equipped production wells. Since June 1998 the number of sampled irrigation wells has been increasing each year. This should provide better data enabling a more comprehensive analysis of salinity trends in the area.

Latest available salinity records from 1998 to June 2002 for observation and irrigation wells have been used to generate salinity distribution maps for each aquifer.

### ***Quaternary (Q) Aquifers***

The salinity levels in the uppermost Quaternary Aquifers (Perched, Q1, Q2) are generally high and variable (Fig. 25). It varies from 2000 to 18 000 mg/L towards the coast. Salinity decreases with depth and in the Q3 Aquifer (Fig. 26) ranges between 1500 and 3000 mg/L, with only few above that range and one extremely high (12 200 mg/L) in the Waterloo Corner area. However, in some areas, such as in the vicinity of the Gawler and Little Para Rivers, the shallow Quaternary Aquifers (Q1–Q3) have low salinity in the range 400–1500 mg/L. In the perched watertable only four observation wells have salinity <2000 mg/L, while the rest of the records show much higher salinity of up to 14 000 mg/L. Monitoring of the perched watertable has been established recently (January 2000) in the area northwest of Virginia. The lower Quaternary Aquifer, Carisbrooke Sand Aquifer (Q4), is present over most of the region. Groundwater salinity within the Q4 Aquifer ranges from 400–1500 mg/L and is occasionally up to 3000–7500 mg/L (Two Wells and Waterloo Corner Area; Fig. 26).

### ***Tertiary Aquifers***

The underlying Tertiary sediments contain several aquifer systems that exhibit significant variations in thickness, lithology, salinity distribution and yield. There are two main deep aquifers, the T1 and T2 Aquifers, which act as a primary source of irrigation water in the region.

#### ***T1 Aquifer***

The shallowest Tertiary Aquifer known as T1 Aquifer, is composed of Hallett Cove Sandstone – Dry Creek Sand and upper Port Willunga limestone. The T1 Aquifer is the main source of irrigation water in the area south of Waterloo Corner. In 1999 salinity was analysed for a representative group of 37 T1 Aquifer irrigation wells (Schuster and Gerges, 1999; Gerges, 2001). The outcome of this analysis shows that generally average water salinity in the T1 Aquifer has increased by between 200–800 mg/L, and occasionally up to 6000 mg/L over the last 30 years, particularly near Waterloo Corner.

NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
and  
KANGAROO FLAT RESTRICTED AREA  
**Salinity map**  
Perched, Q1 and Q2 Aquifers  
latest salinity records 1998-2002

**Legend**

- Northern Adelaide Plains Prescribed Wells Area
- Kangaroo Flat Restricted Area
- Basement outcrop
- P PTA 126 Observation well
- T Production well

Perched Aquifer Salinity (mg/L)	Q1 Aquifer Salinity (mg/L)	Q2 Aquifer Salinity (mg/L)
<span style="font-size: 10px; vertical-align: middle;">P</span> < 500	<span style="font-size: 10px; vertical-align: middle;">U</span> < 500	<span style="font-size: 10px; vertical-align: middle;">S</span> < 500
<span style="font-size: 10px; vertical-align: middle;">T</span> 501-1000	<span style="font-size: 10px; vertical-align: middle;">U</span> 501-1000	<span style="font-size: 10px; vertical-align: middle;">S</span> 501-1000
<span style="font-size: 10px; vertical-align: middle;">T</span> 1001-1500	<span style="font-size: 10px; vertical-align: middle;">U</span> 1001-1500	<span style="font-size: 10px; vertical-align: middle;">S</span> 1001-1500
<span style="font-size: 10px; vertical-align: middle;">T</span> 1501-3000	<span style="font-size: 10px; vertical-align: middle;">U</span> 1501-3000	<span style="font-size: 10px; vertical-align: middle;">S</span> 1501-3000
<span style="font-size: 10px; vertical-align: middle;">T</span> 3001-7000	<span style="font-size: 10px; vertical-align: middle;">U</span> 3001-7000	<span style="font-size: 10px; vertical-align: middle;">S</span> 3001-7000
<span style="font-size: 10px; vertical-align: middle;">T</span> 7001-14000	<span style="font-size: 10px; vertical-align: middle;">U</span> 7001-14000	<span style="font-size: 10px; vertical-align: middle;">S</span> 7001-14000
<span style="font-size: 10px; vertical-align: middle;">T</span> > 14000	<span style="font-size: 10px; vertical-align: middle;">U</span> > 14000	<span style="font-size: 10px; vertical-align: middle;">S</span> > 14000

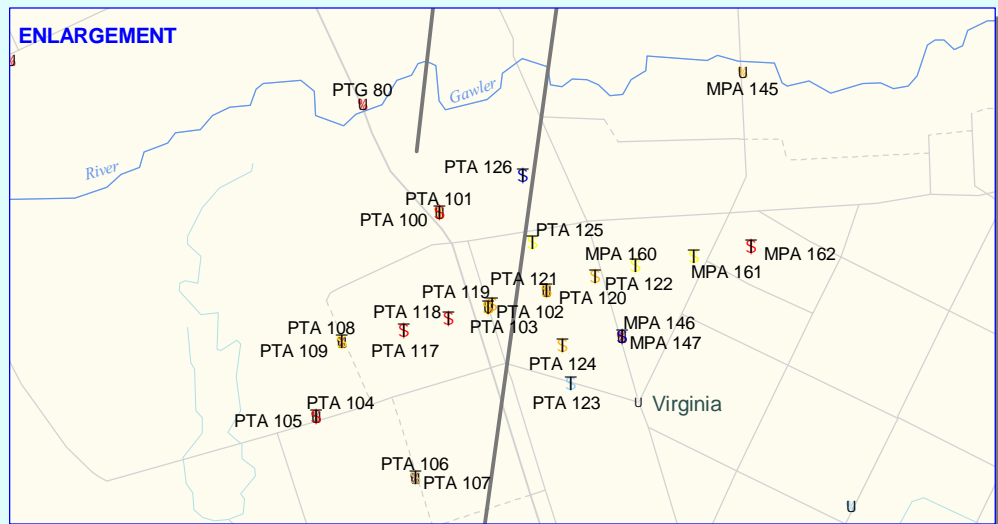
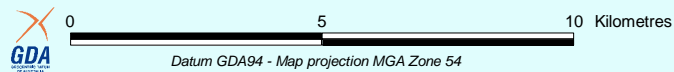
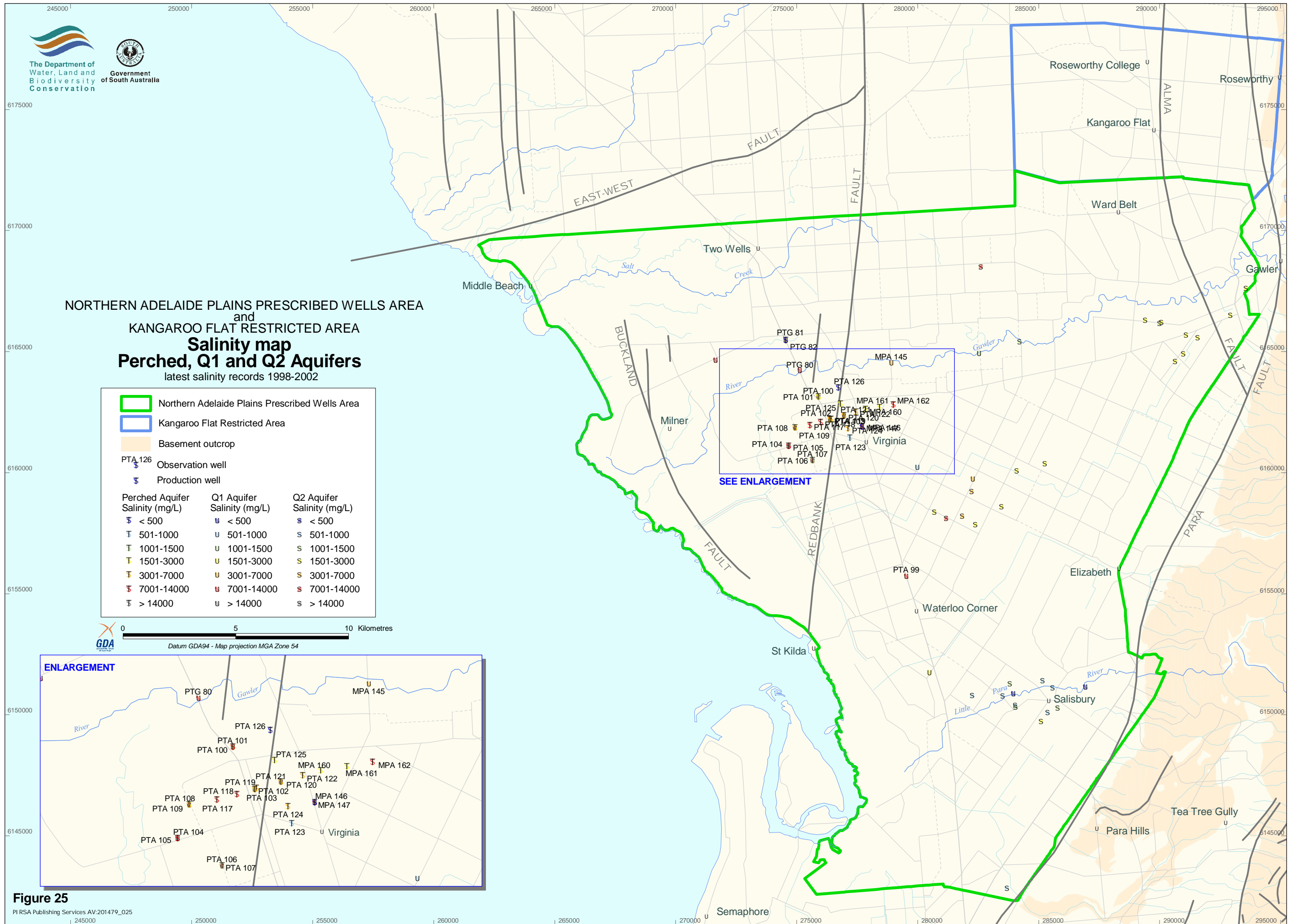


Figure 25




















































NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
and  
KANGAROO FLAT RESTRICTED AREA

**Salinity map  
Q3 and Q4 Aquifers**

latest salinity records 1998-2002

	Northern Adelaide Plains Prescribed Wells Area																
	Kangaroo Flat Restricted Area																
	Basement outcrop																
	Observation well																
	Production well																
<table border="0"> <tr> <th>Q3 Aquifer Salinity (mg/L)</th> <th>Q4 Aquifer Salinity (mg/L)</th> </tr> <tr> <td> &lt; 500</td> <td> &lt; 500</td> </tr> <tr> <td> 501-1000</td> <td> 501-1000</td> </tr> <tr> <td> 1001-1500</td> <td> 1001-1500</td> </tr> <tr> <td> 1501-3000</td> <td> 1501-3000</td> </tr> <tr> <td> 3001-7000</td> <td> 3001-7000</td> </tr> <tr> <td> 7001-14000</td> <td> 7001-14000</td> </tr> <tr> <td> &gt; 14000</td> <td> &gt; 14000</td> </tr> </table>		Q3 Aquifer Salinity (mg/L)	Q4 Aquifer Salinity (mg/L)	 < 500	 < 500	 501-1000	 501-1000	 1001-1500	 1001-1500	 1501-3000	 1501-3000	 3001-7000	 3001-7000	 7001-14000	 7001-14000	 > 14000	 > 14000
Q3 Aquifer Salinity (mg/L)	Q4 Aquifer Salinity (mg/L)																
 < 500	 < 500																
 501-1000	 501-1000																
 1001-1500	 1001-1500																
 1501-3000	 1501-3000																
 3001-7000	 3001-7000																
 7001-14000	 7001-14000																
 > 14000	 > 14000																

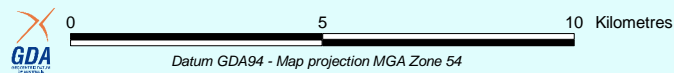
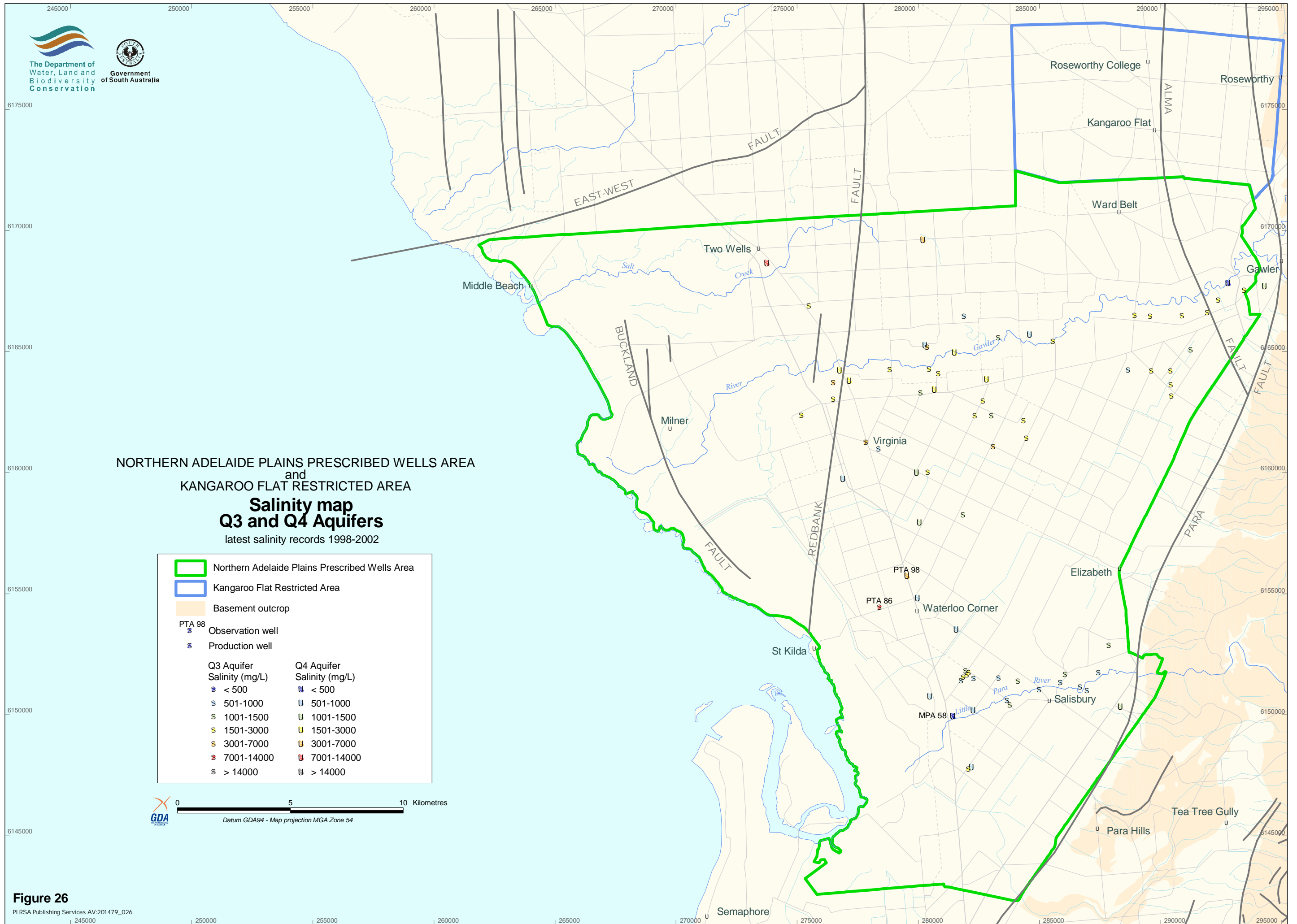


Figure 26



Latest groundwater salinities obtained from sampling done between 1998 and 2002 for 230 observation and irrigation wells have been used to generate a salinity distribution map (Fig. 27). Salinity ranges from ~500–2000 mg/L. Nine wells that have salinity >2000 and up to 6000 mg/L are located in the vicinity of Waterloo Corner.

## ***T2 Aquifer***

The second Tertiary Aquifer, known as T2 Aquifer, occurs throughout the entire region. It consists of well-cemented limestone of lower Port Willunga Formation. Salinity levels range from 600 mg/L in the Gawler River area to >3000 mg/L to the north and south. In 1999, salinity was analysed for a representative group of 162 T2 Aquifer irrigation wells (Schuster and Gerges, 1999; Gerges, 2001). The outcome of this analysis shows that, generally, the average water salinity in the T2 Aquifer has increased by 200 mg/L during last 30 years of pumping along some areas of the Gawler River. However, evidence suggests that in some areas negligible salinity increase has occurred (Gerges, 2001).

The salinity distribution map for the T2 Aquifer (Fig. 28) was generated using the latest groundwater salinities collected between 1998 and 2002. Salinities range mostly from ~500–2000 mg/L. Only 35 wells have salinity greater than 2000 mg/L.




















## ***T3 and T4 Aquifers***

Distribution of groundwater salinity within the two deep Tertiary Aquifers, known as T3 and T4, is not well known for most of the NAP area. Information available indicates that those Tertiary Aquifers contain groundwater of very high salinity of up to 80 000 mg/L, which is unsuitable for any irrigation purpose.



NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA and KANGAROO FLAT RESTRICTED AREA  
**Salinity map**  
**T1 Aquifer**

latest salinity records 1998-2002

	Northern Adelaide Plains Prescribed Wells Area
	Kangaroo Flat Restricted Area
	Basement outcrop
	Limit of T1 Aquifer
	Limit of Munno Para Clay
Irrigation wells Salinity (mg/L)	
	< 500
	501-1000
	1001-1500
	1501-3000
	3001-7000
	7001-14000
	> 14000
Observation wells Salinity (mg/L)	
	< 500
	501-1000
	1001-1500
	1501-3000
	3001-7000
	7001-14000
	> 14000

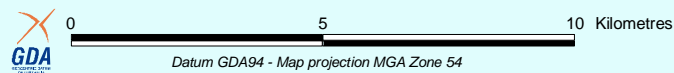
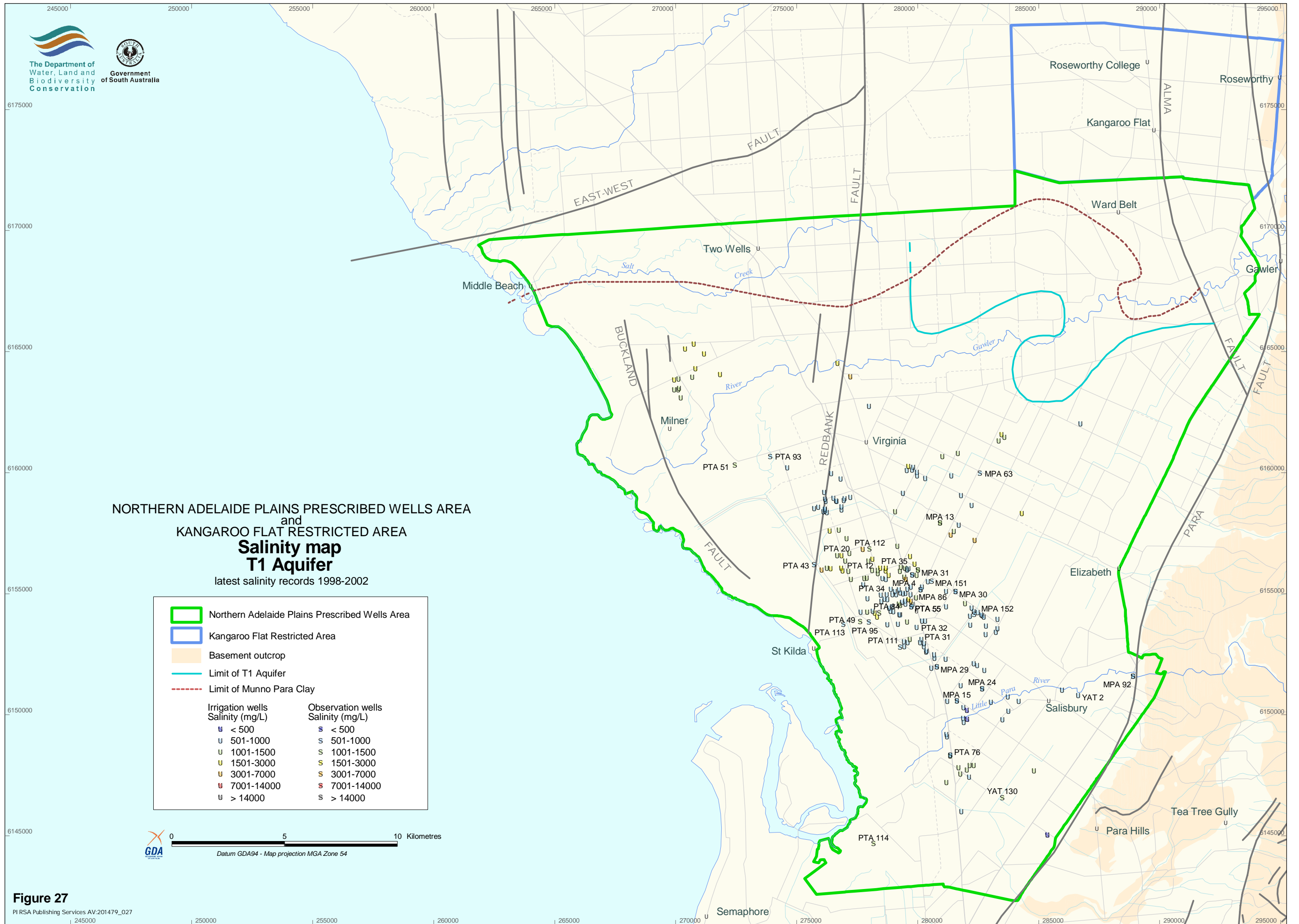
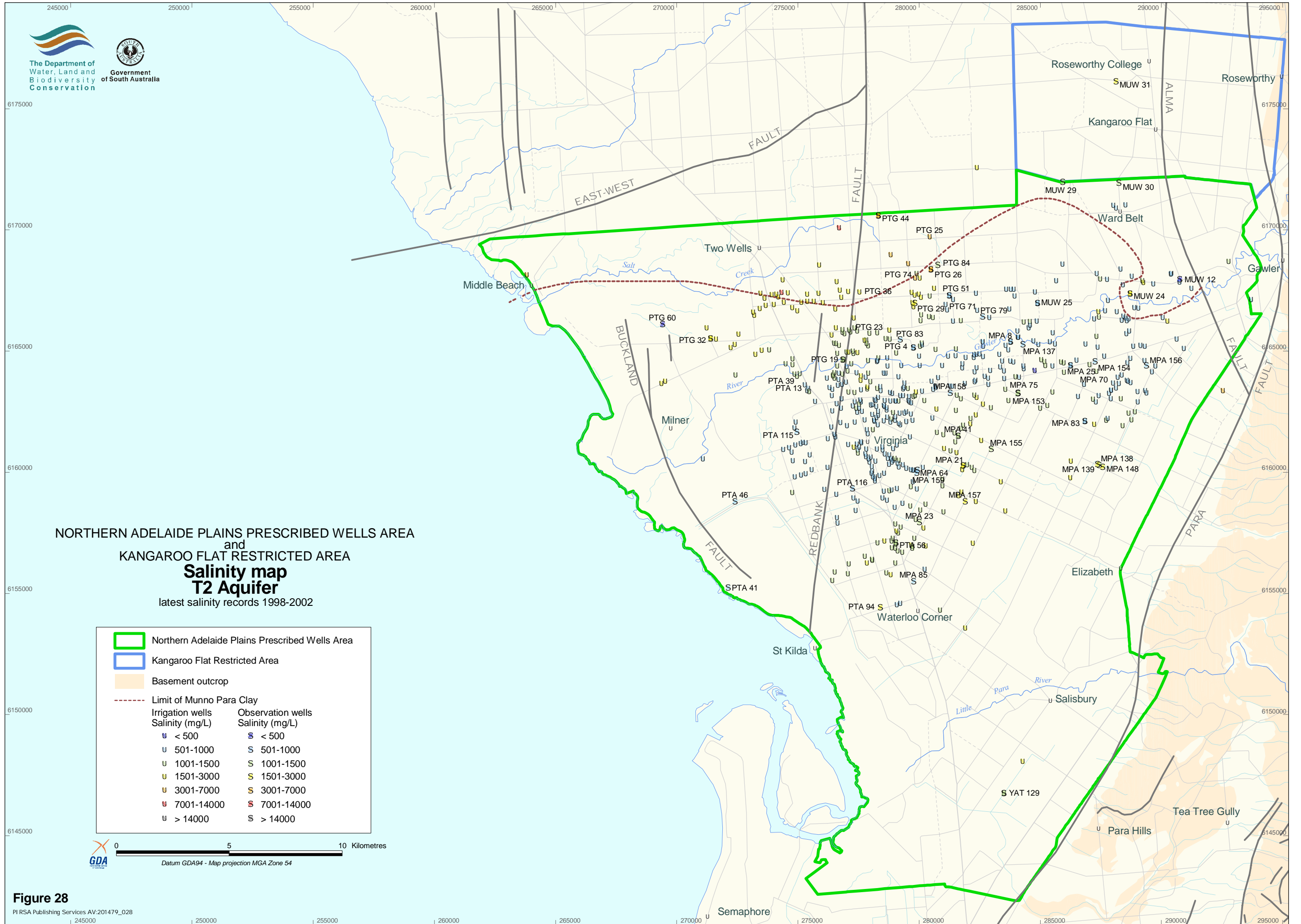


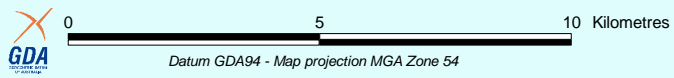
Figure 27





NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA  
and  
KANGAROO FLAT RESTRICTED AREA  
**Salinity map**  
**T2 Aquifer**  
latest salinity records 1998-2002

	Northern Adelaide Plains Prescribed Wells Area
	Kangaroo Flat Restricted Area
	Basement outcrop
	Limit of Munno Para Clay
<b>U</b>	Irrigation wells Salinity (mg/L)
<b>S</b>	Observation wells Salinity (mg/L)
<b>U</b> < 500	<b>S</b> < 500
<b>U</b> 501-1000	<b>S</b> 501-1000
<b>U</b> 1001-1500	<b>S</b> 1001-1500
<b>U</b> 1501-3000	<b>S</b> 1501-3000
<b>U</b> 3001-7000	<b>S</b> 3001-7000
<b>U</b> 7001-14000	<b>S</b> 7001-14000
<b>U</b> > 14000	<b>S</b> > 14000



**Figure 28**  
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## SHORTENED FORMS

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### ***Measurement***

<b>Name of unit</b>	<b>Symbol</b>	<b>Definition in terms of other metric units</b>	
Day	d		time interval
Gram	g		Mass
Kilometre	km	$10^3$ m	Length
Litre	L	$10^{-3}$ m <sup>3</sup>	Volume
Metre	m		Length
Metres per day	m/d		
Metres per year	m/y		
Milligram	mg	$10^{-3}$ g	Mass
Milligrams per litre	mg/L		
Millimetre	mm	$10^{-3}$ m	Length

### ***General***

<b>Shortened form</b>	<b>Description</b>
AHD	Australian height datum
DWLBC	Department of Water, Land and Biodiversity Conservation
NAP	Northern Adelaide Plains
PWA	prescribed wells area
SWL	standing water level

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