The Department of Water, Land and Biodiversity Conservation



Barossa Prescribed Water Resources Area Groundwater Monitoring Status Report 2003

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Report DWLBC 2004/07

Government of South Australia

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FOREWORD

South Australia's natural resources are fundamental to the economic and social well-being of the State. One of the State's most precious natural resources, water is a basic requirement of all living organisims 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 the 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, Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation

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SI UNITS COMMONLY USED WITHIN TEXT

Name of unit	Symbol	Definition in terms of other metric units	
Millimetre	mm	10^{-3} m	length
Metre	m		length
Kilometre	km	10^{3} m	length
Hectare	ha	10^{4} m^{2}	area
Microlitre	µL	10^{-9} m^{3}	volume
Millilitre	mL	10^{-6} m^{3}	volume
Litre	L	10^{-3} m^{3}	volume
Kilolitre	kL	1 m^{3}	volume
Megalitre	ML	10^{3} m^{3}	volume
Gigalitres	GL	10^{6} m^{3}	volume
Microgram	µg	10^{-6} g	mass
Milligram	mg	10^{-3} g	mass
Gram	g		mass
Kilogram	kg	10^{3} g	Mass

Abbreviations Commonly Used Within Text

Abbreviation		Name	Units of measure
TDS	=	Total Dissolved Solids *(milligrams per litre)*	mg/L
EC	=	Electrical Conductivity *(micro Siemens per centimetre)*	µS/cm
PH	=	Acidity	
δD	=	Hydrogen isotope composition	$^{o}/_{oo}$
CFC	=	Chlorofluorocarbon *(parts per trillion volume)*	pptv
$\delta^{18}O$	=	Oxygen isotope composition	$^{o}/_{oo}$
^{14}C	=	Carbon-14 isotope *(percent modern Carbon)*	pmC
Ppm	=	Parts per million	
Ppb	=	Parts per billion	

1 INTRODUCTION

In 2002, a report on the Barossa Prescribed Water Resources Area (BPWRA) groundwater monitoring was prepared in order to provide the North Adelaide and Barossa Catchment Water Management Board (NABCWMB) and interested stakeholders with vital information on the current condition of the groundwater resources. The report presented the latest simplified hydrostratigraphic nomenclature (Brown, 2002) and analysed water level and salinity data which Department of Water, Land and Biodiversity Conservation (DWLBC) has been monitoring for more than 40 years. It presented some baseline information such as stratigraphy and hydrostratigraphy, climate and water level and salinity trends.

The 2003 report gives an update of water level and salinity information collected during the past year. The approach in presenting the water level information differs from that undertaken last year, where hydraulic continuity between aquifers was assumed. In this report a potentiometric surface map was generated for each aquifer separately, both for winter and summer.

A list of wells engaged in aquifer storage and recovery (ASR) has been compiled and presented in Figure 1. Even though the list is not complete, a majority of the wells (37 out of 41) that have been conducting ASR were identified. Also, an additional eleven bores have been listed as potential ASR wells. It is very important to include ASR wells when assessing the groundwater resources in the Barossa PWRA. More importantly, the amounts of water to be recharged and sources of water need to be identified, since it can have significant impact on the integrity of aquifers and water quality.

The Resource Allocation Division in DWLBC is currently finalising licencing and reporting requirements for establishing ASR wells in the Barosswa PWRA. This is to be finalised for the beginning of the 2004-05 water use year and will enable reporting on volumes stored and recovered through ASR wells in subsequent groundwater monitoring reports.

At the time of preparing this report information concerning extraction demand for irrigation and industrial use was not available. Considerable work has been underataken reconciling records within the Resouce Allocation Division of water use in the Barossa PWRA. This information will be available in future reports providing a more comprehensive assessment of pumping impacts on the groundwater systems.

Finally, the purpose of the report is to identify changes in the condition of groundwater resources and assess if these are acceptable or are resulting in undesirable impacts on the groundwater system.

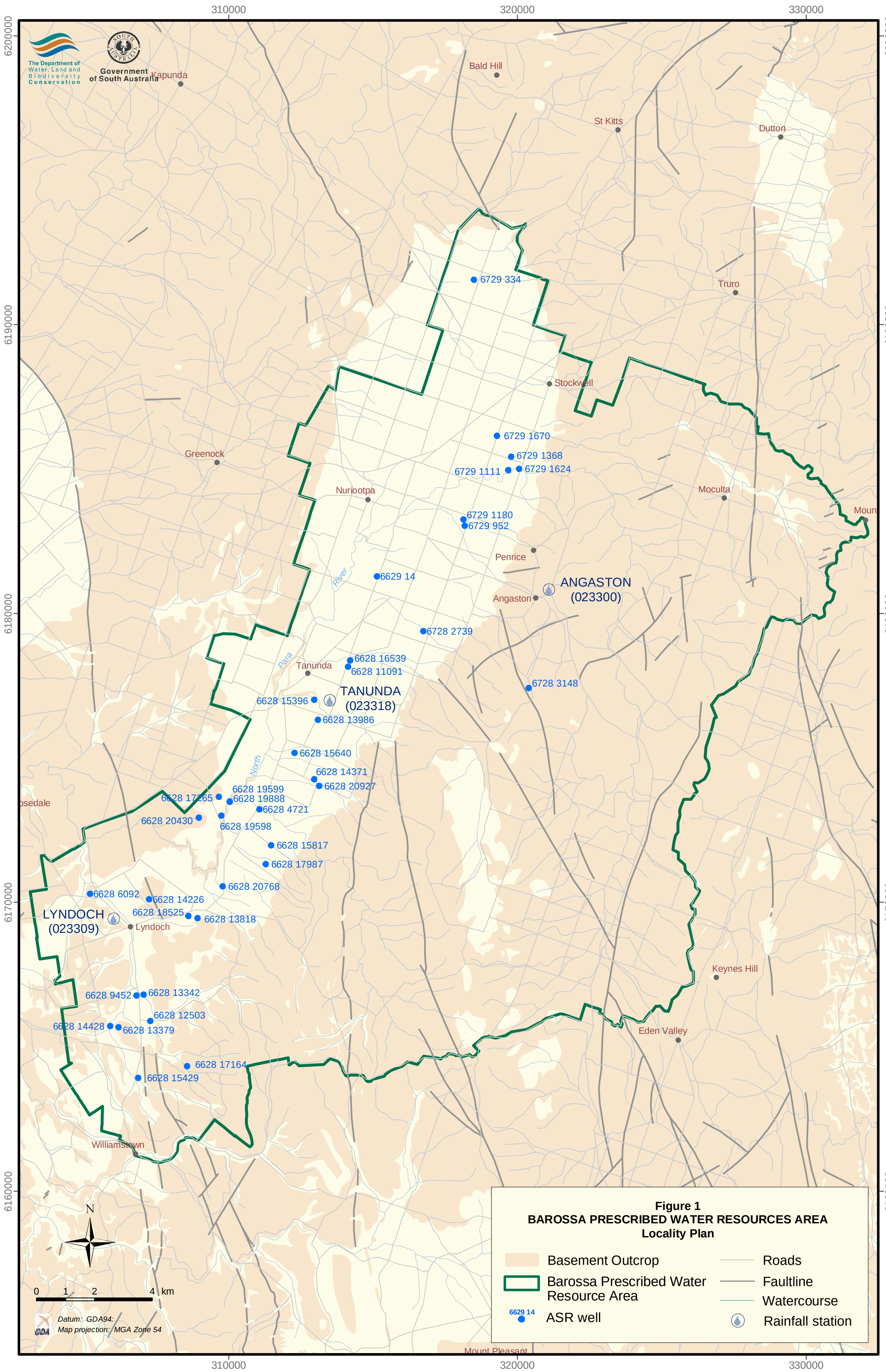

Figure 1
BAROSSA PRESCRIBED WATER RESOURCES AREA
Locality Plan

2 CLIMATE

Three rainfall stations located in the Barossa Prescribed Water Resources Area were selected as representative of the rainfall pattern throughout the area:

- Angaston, station 23300
- Tanunda, station 23318
- Lyndoch, station 23309.

The rainfall records are available for a period of over 110 years. The annual average rainfall for Angaston and Lyndoch is 560 mm, while Tanunda on average receives 548 mm annually. Rainfall is winter dominant, with the monthly averages for these three stations shown in Table 1.

Figure 2 shows the monthly rainfall and cumulative deviation from monthly mean obtained from these stations for the period 1960 to 2002. Although the records span over a 110-year period, the period shown is selected for comparison against groundwater level monitoring data.

The rainfall records for Angaston show a below average trend from 1960 until around 1973, with above average recorded in 1963,1968 and 1971. Two periods, 1973-76 and 1978-82 show a distinctive above average trend. From 1984 until 1992 the trend generally was near average, with a high rainfall period during 1992–93. The post 1993 until 2000 rainfall shows a continuous declining trend, suggesting that the rainfall was below average.

Both the Lyndoch and Tanunda rainfall stations show a similar below average pattern until 1968 and an average trend between 1983 and 1992 with a sharp increase in 1992-93. From 1993 until 2000 the Lyndoch station shows a continuous below average trend, while the Tanunda station generally shows an average trend with the exception of 1994-95, which where below average.

There was a short increase in 2001; however since 2002 a decreasing trend has been observed on all three stations.

Table 1. Average monthly rainfall (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angaston	21	22	23	43	63	71	70	72	64	52	33	27
Tanunda	21	20	24	42	62	71	69	69	62	50	31	26
Lyndoch	19	19	21	43	61	75	73	74	64	53	31	25

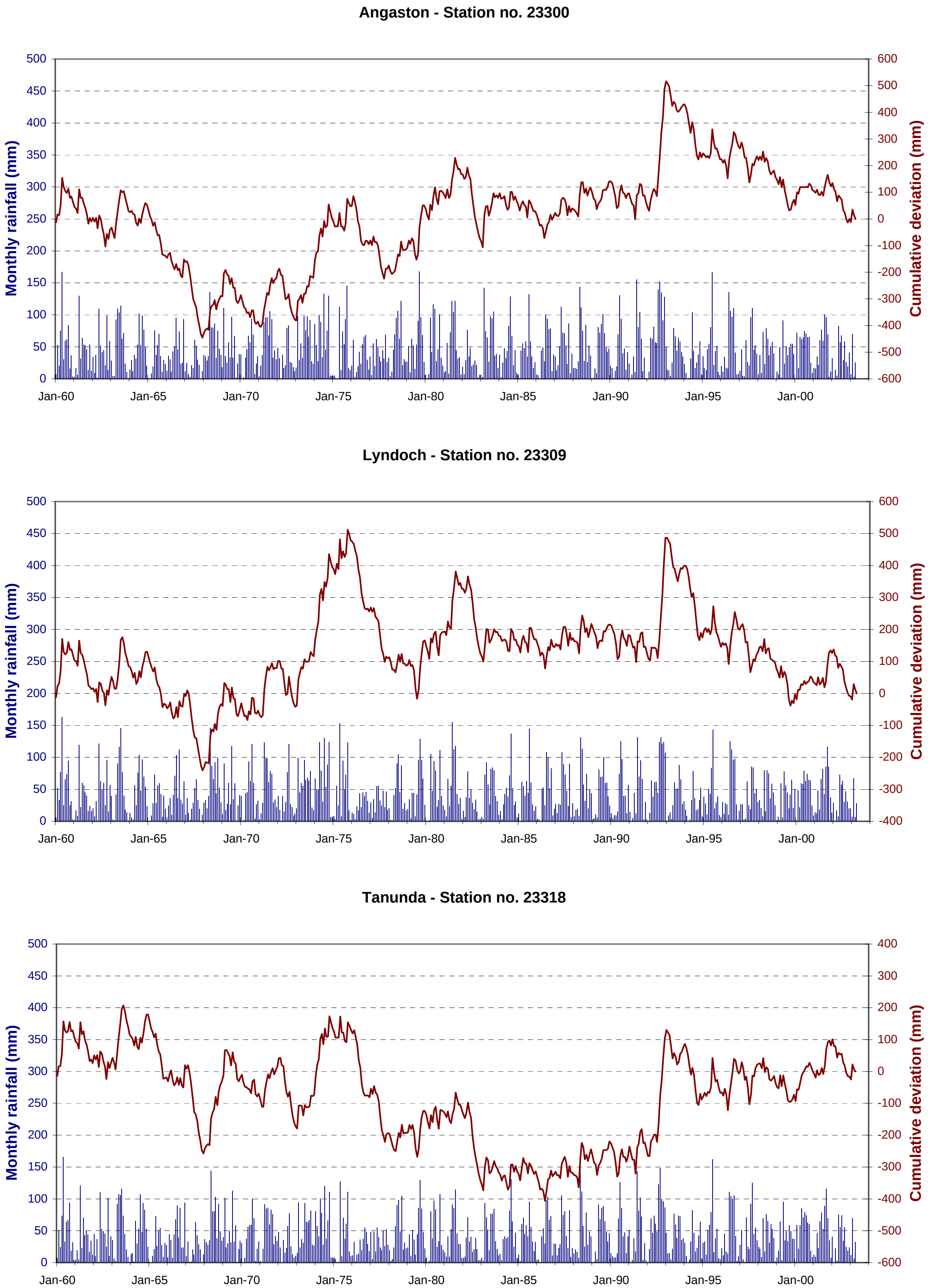

Figure 2. Monthly rainfall and cumulative deviation

3 SUMMARY OF AQUIFERS

The first major investigation of the water resources of the Barossa Valley was undertaken by Chugg (1955), who recognised the complex nature of the hydrological environment. Subsequent authors have also recognised this complex relationship particularly interflow between each aquifer. The latest classification by Brown, shown in Appendix A has attempted to simplify this complex hydrogeological system by recognising three principal aquifer systems:

- Upper Aquifer
- Lower Aquifer
- Fractured Rock Aquifer.

It must be stressed that the aquifers identified in the latest hydrostratigraphic classification are to varying degrees hydraulically connected, i.e., an aquifer can be both a source of recharge or a point of discharge to one or both of the other aquifers depending on its location within the Valley. The simplified system therefore does not imply that the flow system is simple, quite the contrary, it is a recognition of its complexity and the associated difficulty in the conceptualisation of the flow regime.

3.1 Fractured Rock Aquifer

The Fractured Rock Aquifer occurs in the Pre-Cambrian and Palaeozoic rocks that consist of sandstones, siltstones and schists, where groundwater is stored and flows through fractures and fissures in the rock. The upper part of this aquifer is generally highly weathered and this clayey, weathered layer acts as a confining layer between the Fractured and two sedimentary aquifers. Bores completed in the Fractured Rock Aquifer have very low yields and when increased groundwater extraction occurs significant changes in hydraulic head are observed.

3.2 Lower Aquifer

The Lower Aquifer is a confined aquifer, which consists of the Tertiary carbonaceous clays, gravels, sands, and silts that were formed in the deepest part of the basin. In reality, this is a composite aquifer — a complex system of interconnected subaquifers. This aquifer is not present beneath the whole basin because the carbonaceous clay layer that separates this aquifer from the overlying Upper Aquifer is absent to the west of the North Para River. The western limit of the Lower Aquifer is shown in Figures 3 and 4. This aquifer shows very high seasonal fluctuation, due to its confined storage response.

3.3 Upper Aquifer

Upper Aquifer is considered to be all of those sediments within the Basin lying above the Lower Aquifer. It includes the aquifers previously referred to by Cobb (1986) as the middle, upper gravel and watertable aquifers. The Upper Aquifer includes Tertiary non-carbonaceous sands, non-continuous sands and gravels in the Quaternary clays and the Holocene gravels and sands associated with the drainage channels. The Quaternary red clay covers most of this aquifer on the eastern side of the valley, and in these places the aquifer is confined. However, in places where Holocene creek alluvium cuts through the clay into the underlying sands the Upper aquifer is unconfined. The alluvium generally does not fully penetrate the clay and therefore is separated from the rest of the basin sediments. Even though these sediments offer an important source of water on a localised scale, they are still considering as part of the Upper Aquifer.

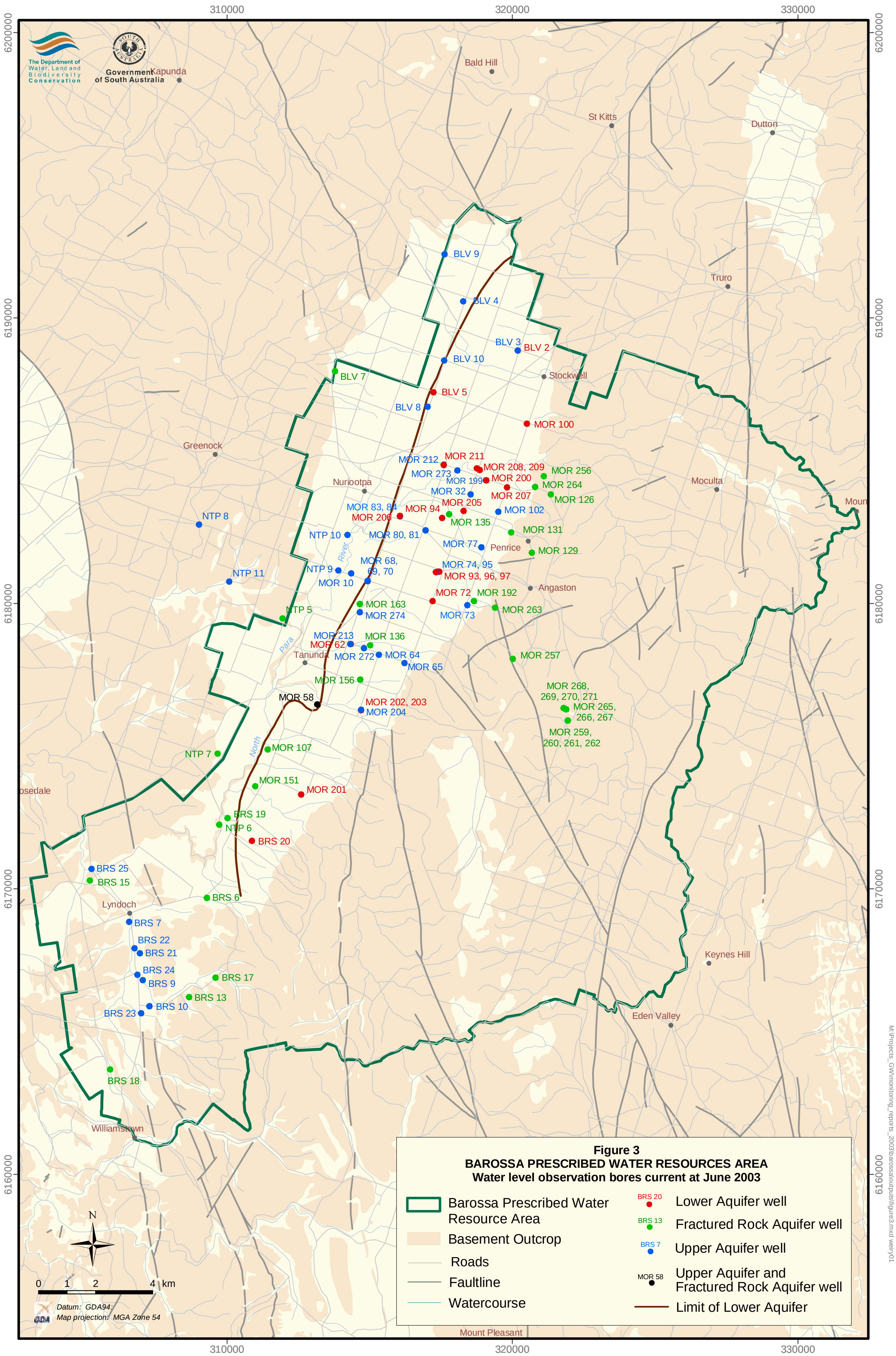

Figure 3
BAROSSA PRESCRIBED WATER RESOURCES AREA
Water level observation bores current at June 2003

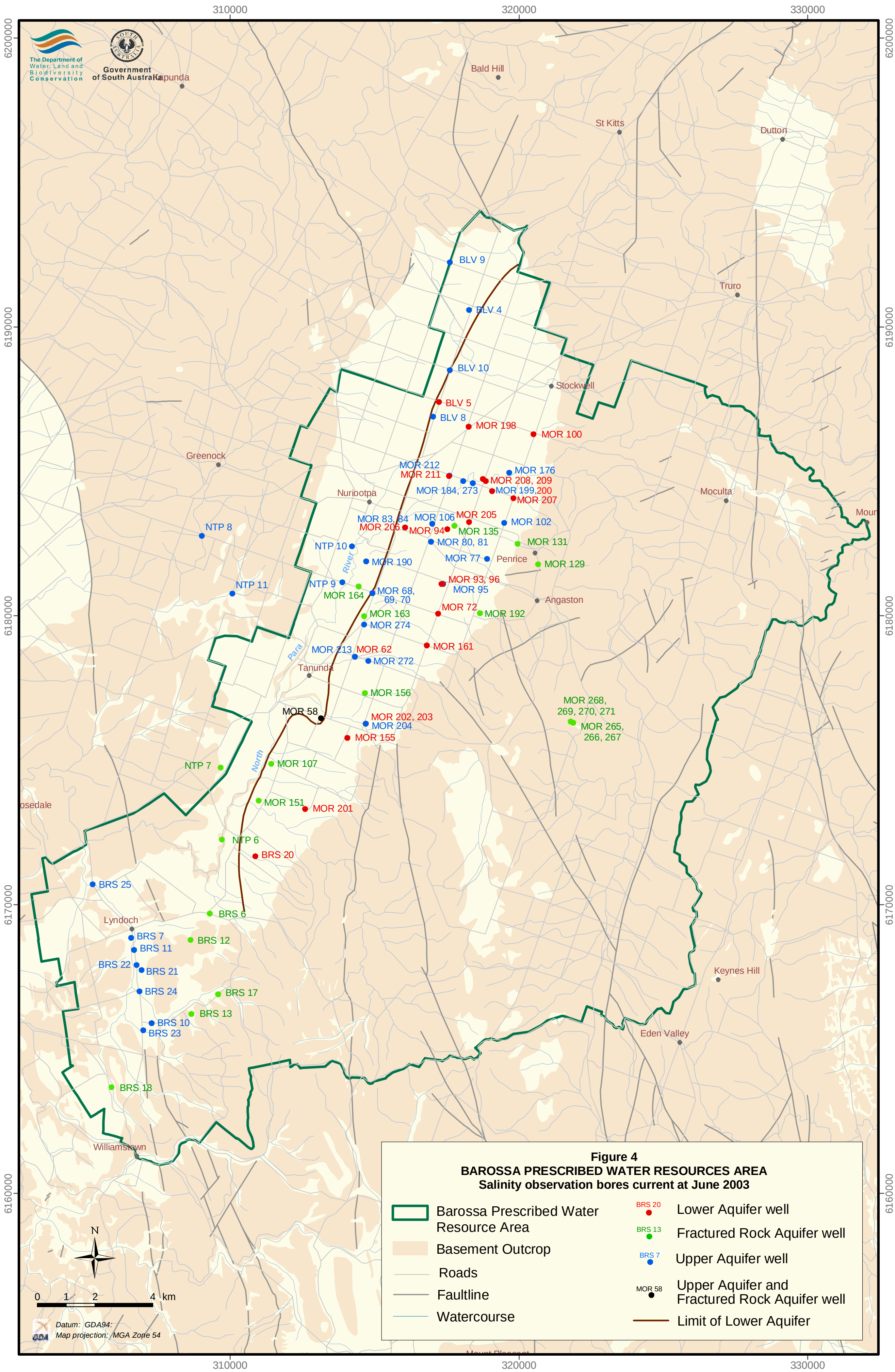

Figure 4
BAROSSA PRESCRIBED WATER RESOURCES AREA
Salinity observation bores current at June 2003

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4 MONITORING NETWORKS

The locations of current water level and salinity monitoring wells for all aquifers in the Barossa PWRA are presented in Figures 3 and 4. Water levels are monitored on a monthly basis, while salinity monitoring is random. Aside from the standard salinity monitoring, a group of production wells were selected to be monitored during the irrigation season. Initially, there were 28 wells in this group that have been monitoring salinity of all three aquifers; over time the number of wells was reduced to 22. A group of fourteen wells installed by Barossa Infrastructure Ltd (BIL) in 2001 is monitored every three months for water levels and every six months for salinity.

Numbers of wells monitoring each aquifer both in 2002 and 2003 are presented in Table 2.

Ta le 2. Current o servation ells

AQ F	ater level		Salinity	
	2002	2003	2002	2003
Upper	38	41	20	38
Lower	20	21	23	22
Fractured Rock	35	37	23	25
Upper and Fractured Rock	1	1	1	1
Total	**9**	**100**	**67**	**86**

In 2002 the Groundwater Group, DWLBC, drilled three new wells, two in the Fractured Rock Aquifer and one in the Lower Aquifer. The three wells were primarily investigation wells, installed in order to understand and quantify lateral flow from the Fractured Rock Aquifer (Mt Lofty Ranges) to the sedimentary aquifers underlying the valley.

One shallow well in the Upper Aquifer was drilled and is monitored by Primary Industries and Resources (PIRSA), but has been incorporated in the Barossa network. Two historic wells were re-activated in order to monitor effects of artificial recharge.

The difference in number of salinity monitoring wells in 2003 is due to incorporation of the fourteen BIL wells in the existing network. It should be, however, stressed that all these wells monitor the Upper Aquifer, and that only ten are currently suitable for sampling.

Up to date water level and salinity monitoring results are available on the Departments 'OBSWELL' web site.

https://info.pir.sa.gov.au/obswell/new/obsWell/MainMenu/menu

5 WATER LEVEL ANALYSIS

Flow in the Fractured Rock Aquifer generally follows the topographic contours; groundwater moves westward from the Mt Lofty Ranges, turning southwest beneath the plains. Potentiometric surface maps generated for September 2002 and March 2003 are presented in Figures 5 and 6. The potentiometric surface map for March this year shows a small cone of depression between Tanunda and Angaston, even though the Fractured Rock Aquifer is not significantly utilised for irrigation in this area. However, further analysis is not possible due to a lack of groundwater consumption data.

The long-term trends show a general decline consistent with below average rainfall. Typical examples of declining water levels are BRS 13 and MOR 264 (unit numbers 6628-12578, 6729-264) (App. B). BLV 7 (unit number 6629-328) shows a decline of over 10 m for 20 years, which appears to have stabilized in the past ten years. NTP 5 (unit number 6628-5897) shows a slight, but continuous increase observed since 1980.

Potentiometric surface maps of the Lower Aquifer for September 2002 and March 2003 are presented in Figures 7 and 8. Generally, groundwater flow directions are from north towards south, with the exception of the area between Tanunda and Angaston, where it flows towards southeast.

Long-term monitoring shows water levels in the Lower Aquifer generally have no significant increasing or decreasing trend (App. B), with the exception of MOR 62 (unit number 6628-6031), which demonstrates continuous declining trend until 1990. Hydrographs for selected bores monitoring water levels in the Lower Aquifer show large seasonal fluctuations, which are almost certainly due to the effects of seasonal extraction and the narrowness of the basin.

The Upper Aquifer potentiometric surface maps are presented in Figures 9 and 10. The groundwater flow is in the southwesterly direction similar to the Fractured Rock Aquifer flow beneath the plains. There is no significant difference between winter and summer potentiometric surfaces because generally the wells completed in the Upper Aquifer do not show a big seasonal response.

Long-term monitoring trends show a decreasing trend over the whole area where Upper Aquifer is monitored. Hydrographs (App. B) of bores completed in the Upper Aquifer generally show, as mentioned earlier, little seasonal response to natural recharge in those parts of the aquifer that underlie the Quaternary clay (except where extraction is occurring), for example BLV 3 and MOR 64 (unit numbers 6729-370, 6628-6007). It is inferred that very little direct rainfall recharge is occurring beneath the clays. A seasonal head response is observed in hydrographs located near the creek beds and the North Para River, suggesting recharge is occurring in these areas (BRS 10, unit number 6628-12503).

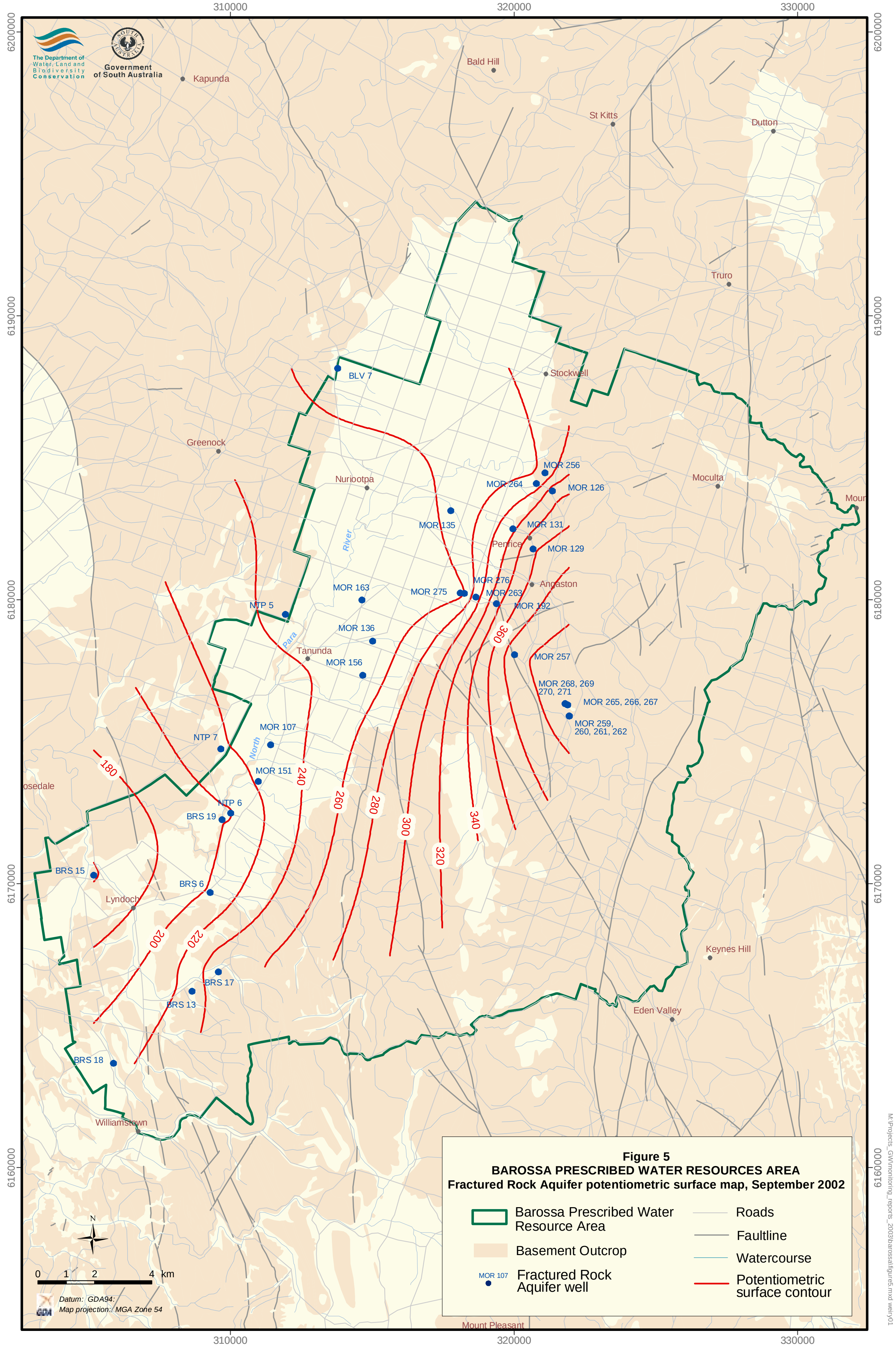

Figure 5
BAROSSA PRESCRIBED WATER RESOURCES AREA
Fractured Rock Aquifer potentiometric surface map, September 2002

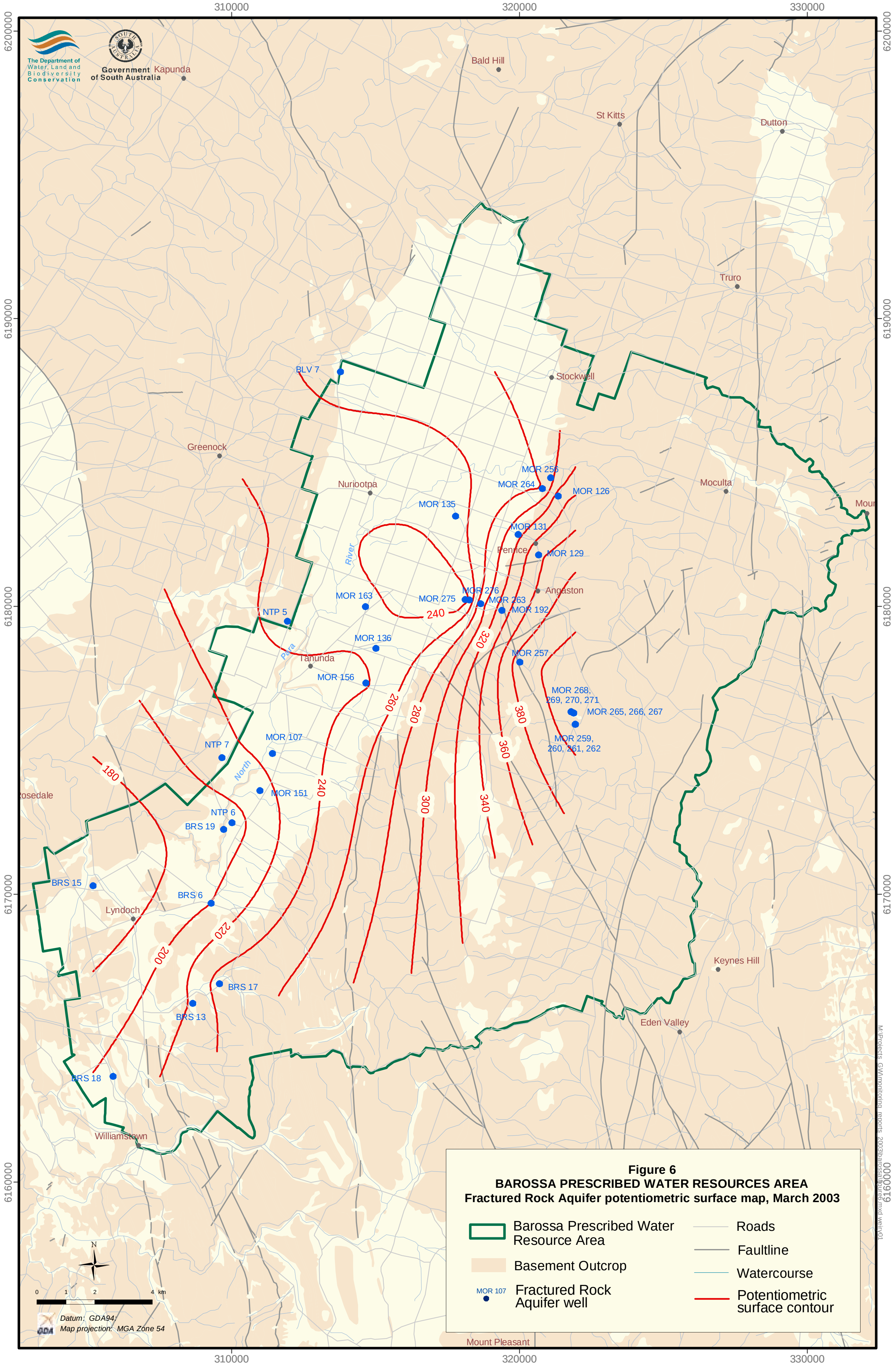

Figure 6
BAROSSA PRESCRIBED WATER RESOURCES AREA
Fractured Rock Aquifer potentiometric surface map, March 2003

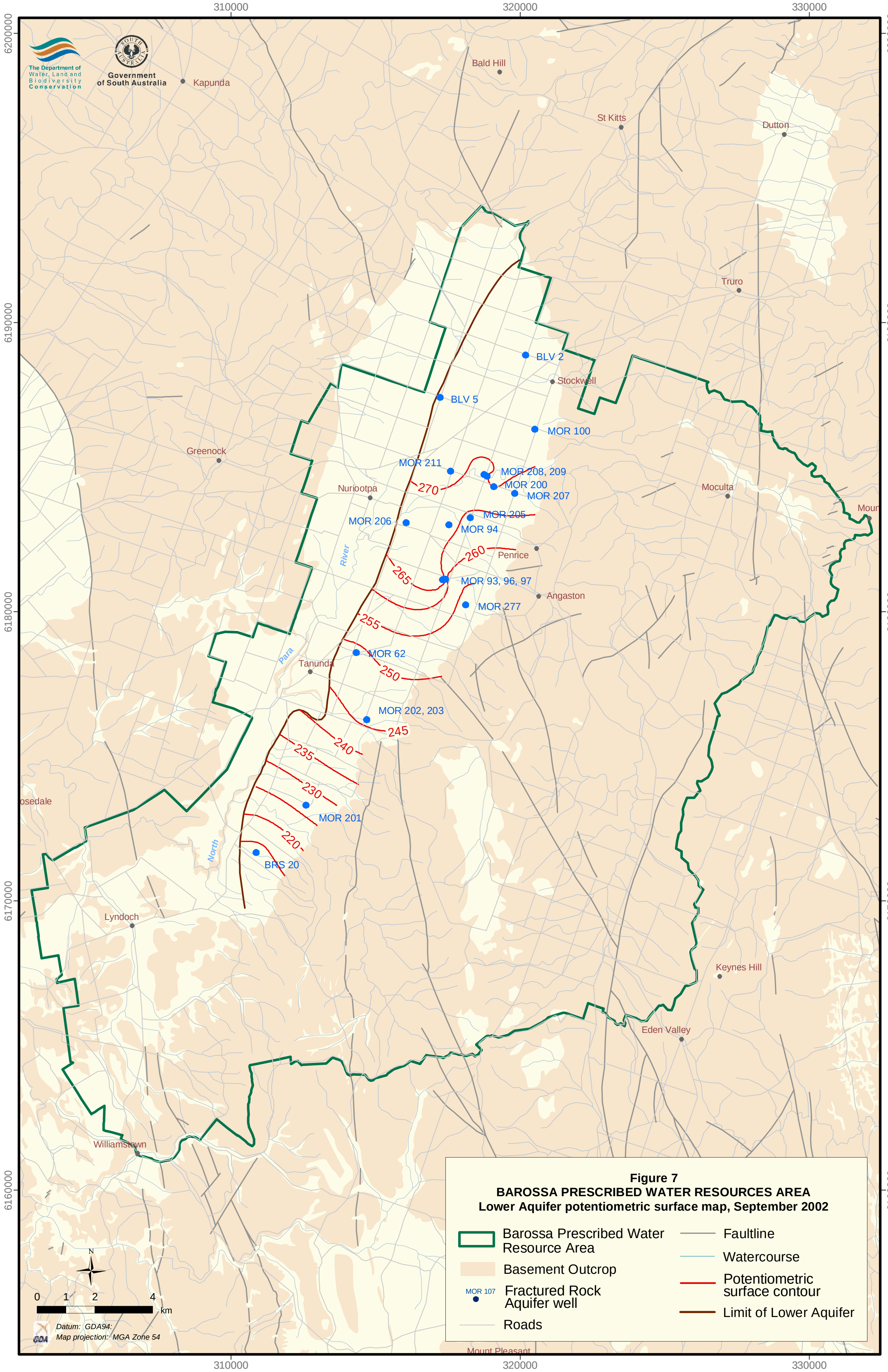

Figure 7
BAROSSA PRESCRIBED WATER RESOURCES AREA
Lower Aquifer potentiometric surface map, September 2002

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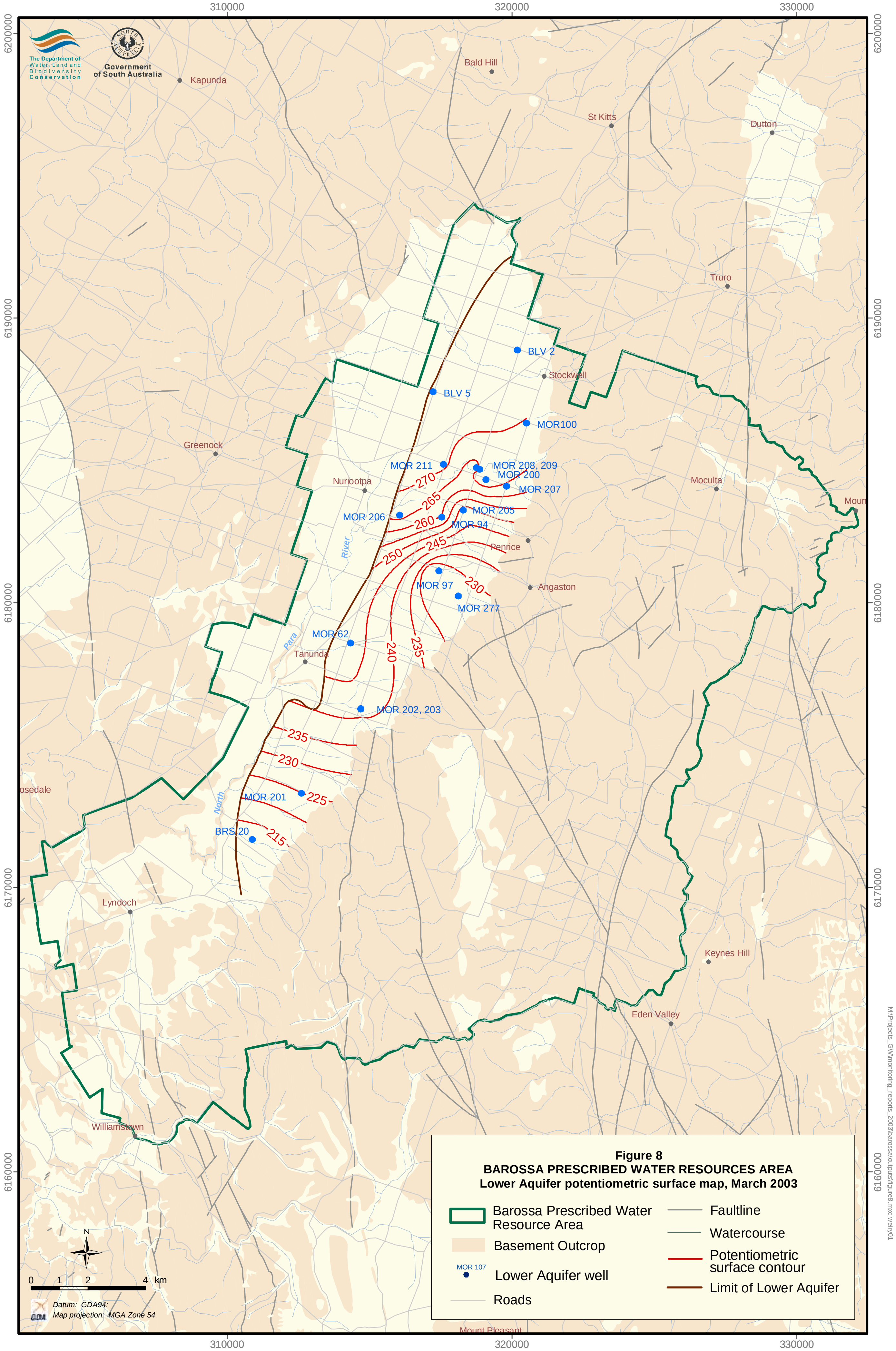

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Dutton
Truro
BLV 2
Stockwell
BLV 5
MOR100
Greenock
MOR 211
MOR 208, 209
MOR 200
MOR 207
Nuriootpa
Moculta
MOR 206
MOR 205
MOR 94
Penrice
MOR 97
MOR 277
Angaston
MOR 62
Tanunda
MOR 202, 203
MOR 201
BRS 20
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Figure 8
BAROSSA PRESCRIBED WATER RESOURCES AREA
Lower Aquifer potentiometric surface map, March 2003
Barossa Prescribed Water Resource Area
Basement Outcrop
MOR 107
Lower Aquifer well
Roads
Faultline
Watercourse
Potentiometric surface contour
Limit of Lower Aquifer

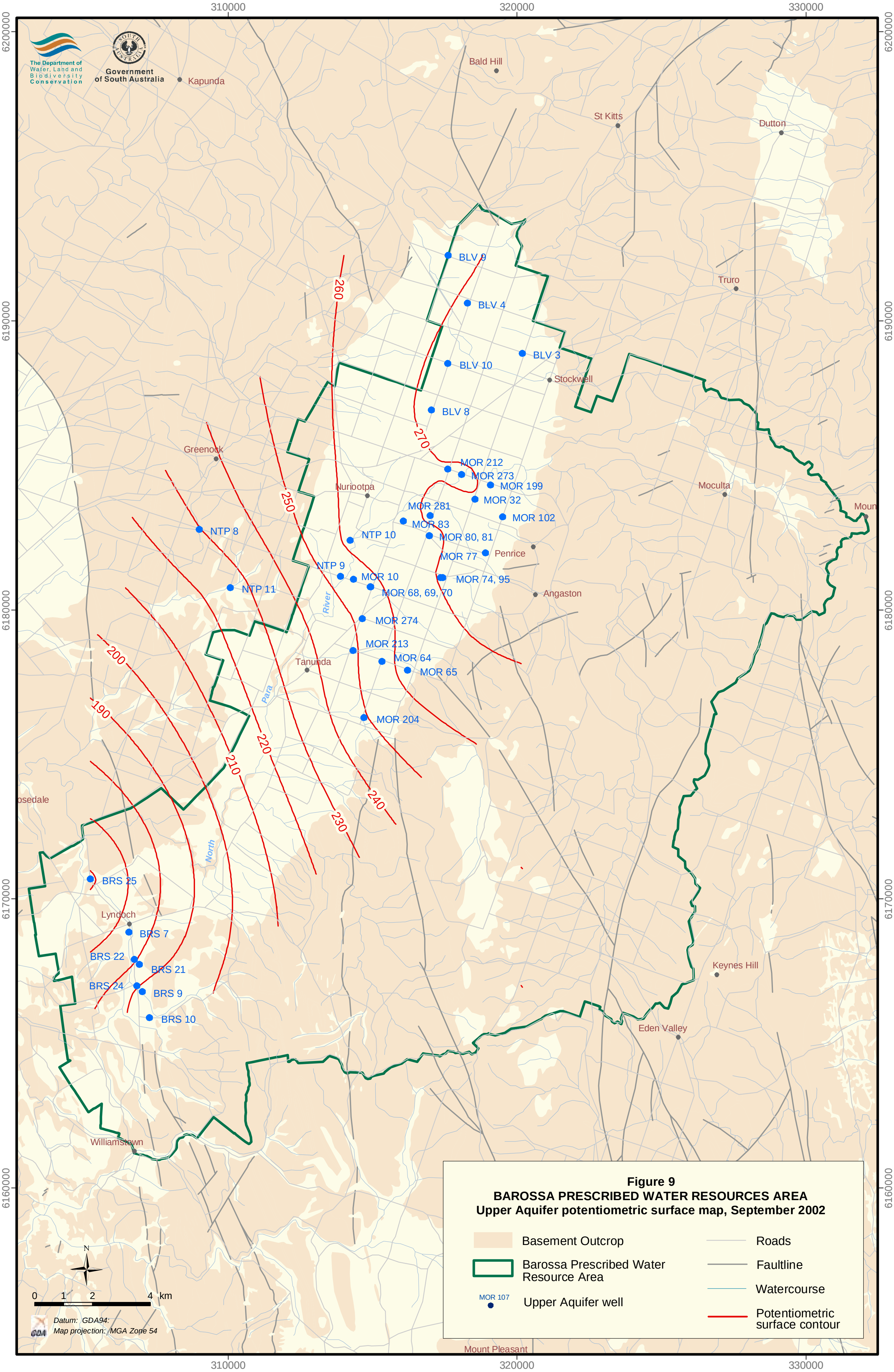

Figure 9
BAROSSA PRESCRIBED WATER RESOURCES AREA
Upper Aquifer potentiometric surface map, September 2002

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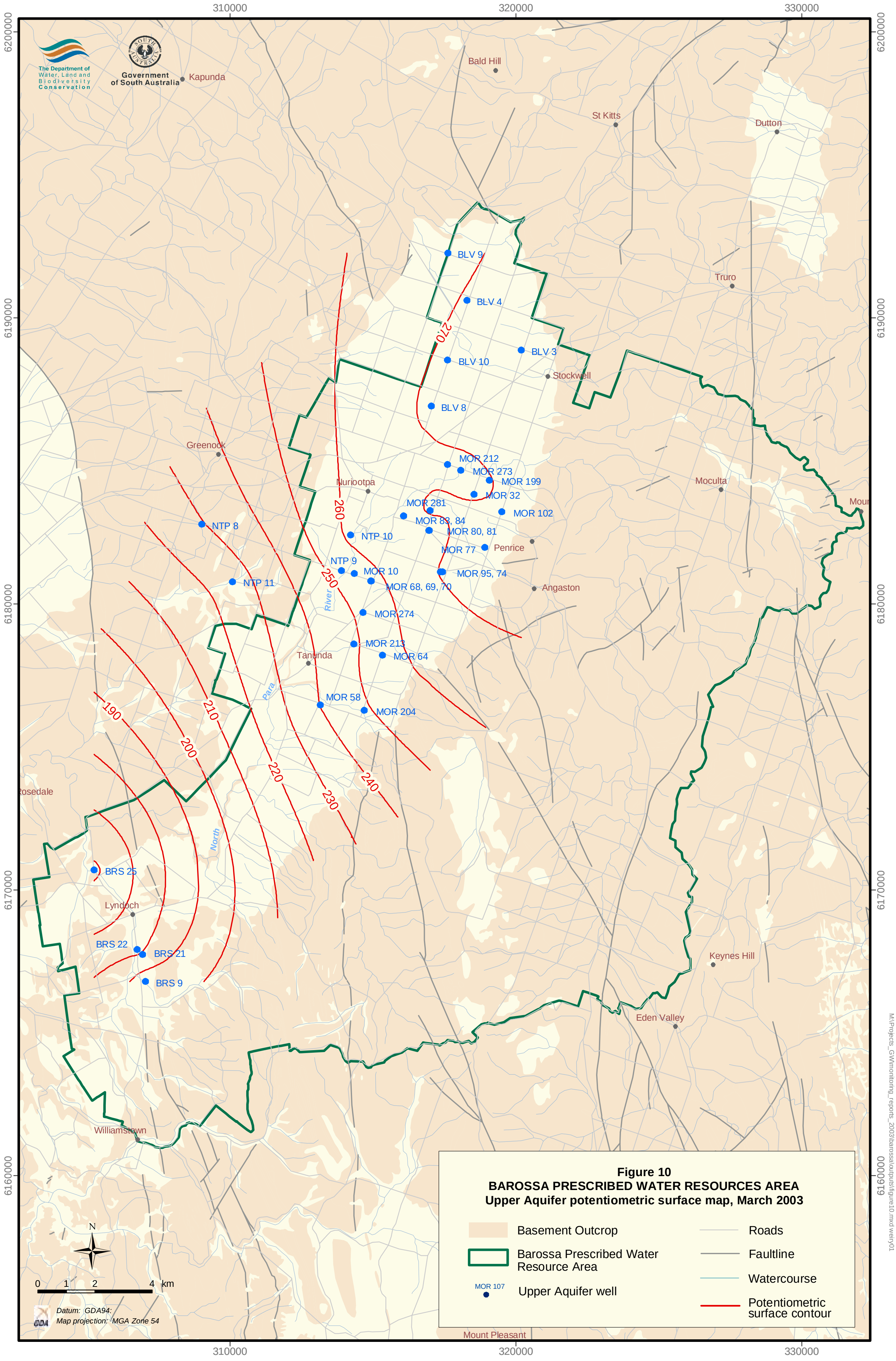


Figure 10
BAROSSA PRESCRIBED WATER RESOURCES AREA
Upper Aquifer potentiometric surface map, March 2003

6 SALINITY ANALYSIS

Last sampling undertaken by the DWLBC was conducted in March 2001. A comprehensive sampling program that aimed to sample all operational DWLBC wells was conducted in June 2003. In addition, there is a group of 22 irrigation wells that have been monitored regularly every year during the irrigation season. These wells are part of the regular monitoring network.

Groundwater salinity in the Fractured Rock Aquifer is variable because recharge and movement through the aquifer can occur quickly or slowly depending on preferential flow paths that dominate the system. It varies between ~300 and 3500 mg/L and is shown in Figure 11. The long-term salinity monitoring in the Fractured Rock Aquifer generally shows negligible changes (App. C), for example BRS 13 and 18 (unit numbers 6628-12578, 6628-15183). A number of monitoring wells show a slight increase (~10 mg/L/y), such as the observation well MOR 151 (unit number 6628-4788).

The Lower Aquifer groundwater salinity is shown in Figure 12. It is generally between ~600 and 2500 mg/L, except in the northwest part of the PWRA, where salinities of almost 7000 mg/L have been recorded in the observation well BLV 5. This is probably due to the well being located on the boundary of the western limit of the Lower Aquifer. Wells monitoring groundwater salinity in the Lower Aquifer show no significant increasing or decreasing trends, as shown in Appendix C (MOR 161, 198; unit numbers 6728-2038, 6729-966). Small declining trends are observed in some wells (MOR 177, unit number 6729-775), while increases of up to 20 mg/L/y are recorded in MOR 155 (unit numbers 6628-5938).

Groundwater salinity in the Upper Aquifer is in the 500 to 13 000 mg/L range. Salinity distribution for this aquifer is presented in Figure13. Salinity graphs for bores monitoring the Upper Aquifer are presented in Appendix C. The analysed salinity monitoring data shows no dramatic increasing or decreasing trends, similar to the Lower and Fractured Rock Aquifers. BRS 10, MOR 176 and 190 (unit numbers 6628-12503, 6729-1111, 6629-1261) are given as examples of typical no change, slight increasing and slight declining trends.

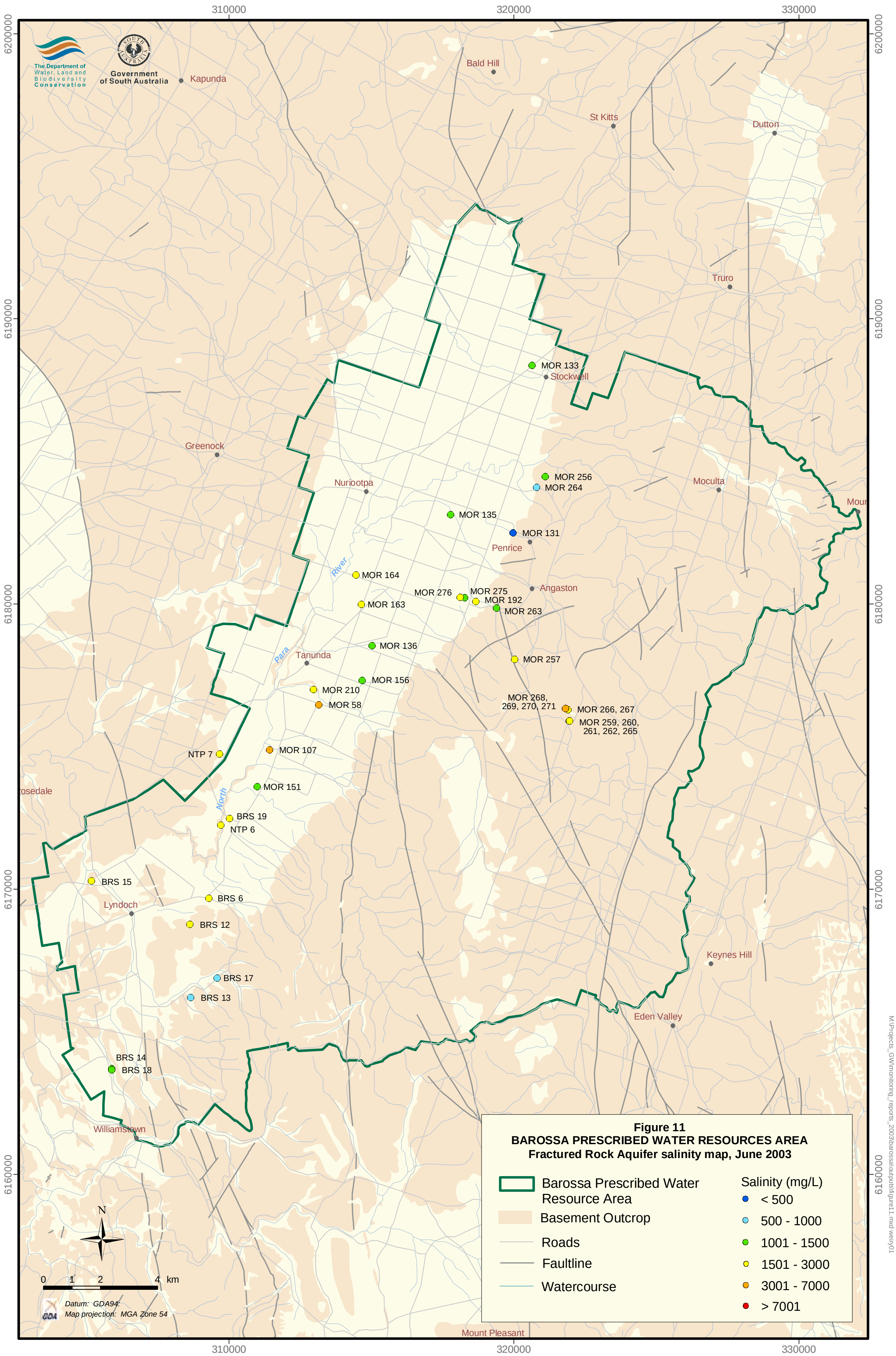


Figure 11
BAROSSA PRESCRIBED WATER RESOURCES AREA
Fractured Rock Aquifer salinity map, June 2003

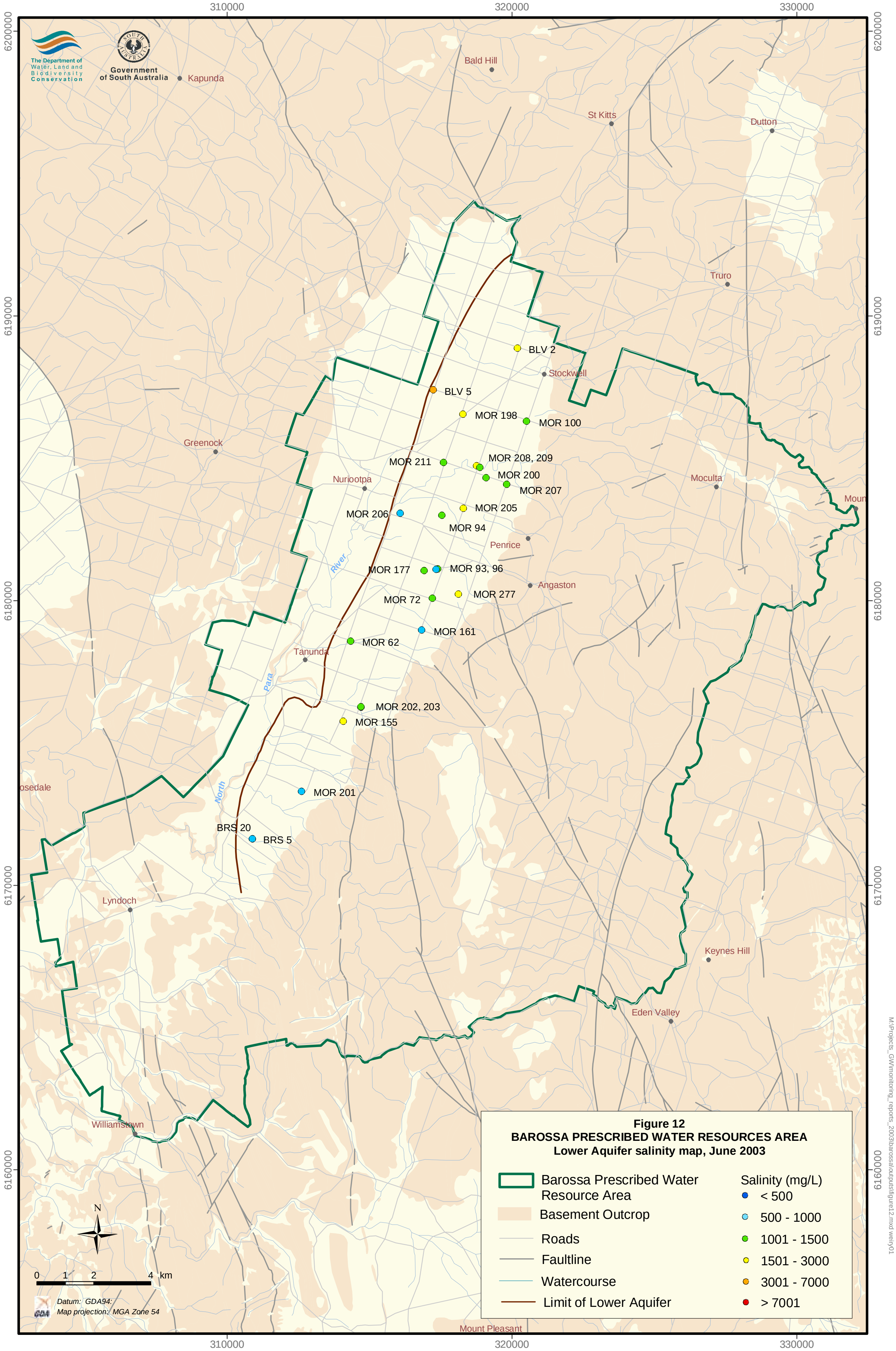
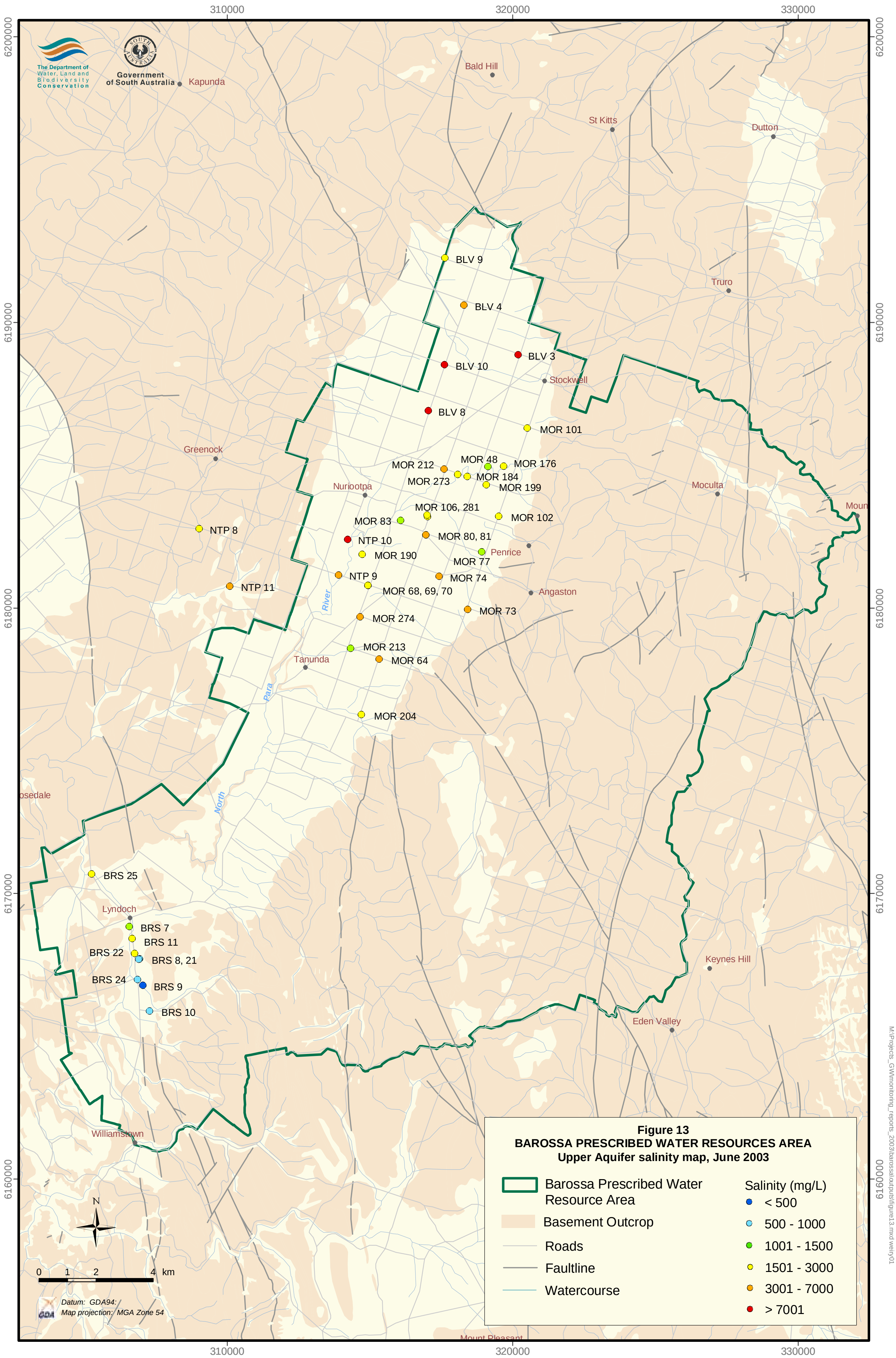


Figure 12
BAROSSA PRESCRIBED WATER RESOURCES AREA
Lower Aquifer salinity map, June 2003



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Government of South Australia
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St Kitts
Dutton
Truro
Stockwell
Greenock
Nuriootpa
Moculta
Penrice
Angaston
Tanunda
Lyndoch
Williamstown
Keynes Hill
Eden Valley
Mount Pleasant
BLV 9
BLV 4
BLV 3
BLV 10
BLV 8
MOR 101
MOR 48
MOR 176
MOR 212
MOR 184
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NTP 8
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NTP 9
MOR 74
NTP 11
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MOR 73
MOR 274
MOR 213
MOR 64
MOR 204
River
Para
North
BRS 25
BRS 7
BRS 11
BRS 22
BRS 8, 21
BRS 24
BRS 9
BRS 10
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0 1 2 4 km
Datum: GDA94:
Map projection: MGA Zone 54
Figure 13
BARROSSA PRESCRIBED WATER RESOURCES AREA
Upper Aquifer salinity map, June 2003
Barossa Prescribed Water Resource Area
Basement Outcrop
Roads
Faultline
Watercourse
Salinity (mg/L)
< 500
500 - 1000
1001 - 1500
1501 - 3000
3001 - 7000
> 7001

7 CONCLUSIONS

Rainfall records available for the BPWRA show a generally below average rainfall trend since 1960, with a high rainfall period during 1992/93 recorded across the State.

The number of monitoring wells increased during 2003, most of which are completed in the Upper Aquifer to assess any potential impacts as a result of imported water. Even though it appears that the number of wells monitoring all three aquifers is significant, it needs to be looked from the spatial distribution aspect, which suggests significantly poor coverage of some areas, in particular the Upper Aquifer sequence between Tanunda and Lyndoch (Figs 9 and 10).

The long-term water level trends, both for the Fractured Rock and Upper aquifers, show a general decline consistent with below average rainfall, while long-term monitoring of the Lower Aquifer shows neither increasing nor decreasing trends.

Ground water salinity in all aquifers is highly variable. A number of monitoring wells in the Fractured Rock Aquifer show a slight increase of ~ 10 mg/L/y, while the Lower and Upper aquifers show no dramatic increasing or decreasing trends.

8 REFERENCES

Brown, K.G., (in press). A Review of Barossa Basin Hydrostratigraphy. South Australia. Department of Water, Land and Biodiversity Conservation, Report DWLBC, 2002/18.

Zulfic, D. and Brown, K.G. Barossa Prescribed Water Resource Area groundwater monitoring status report 2002, South Australia. Department of Water, Land and Biodiversity Conservation, Report DWLBC, 2002/05.

9 APPENDIX A



STRATIGRAPHY AND HYDROSTRATIGRAPHY OF THE BAROSSA BASIN

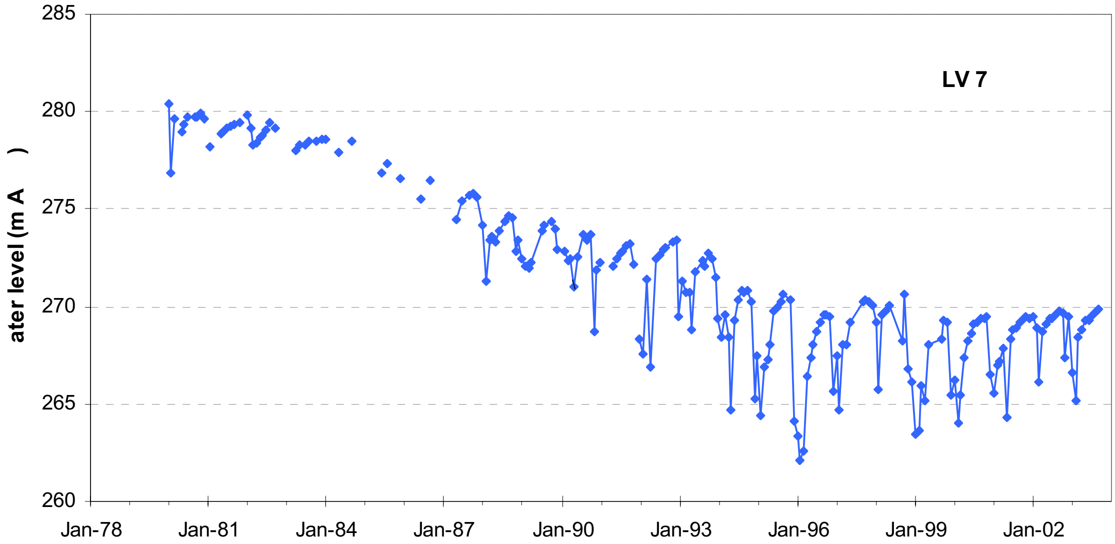
		ST AT AP Y		Y ST AT AP Y	
		nit	**Lithology**	**nit**	**escri tion**
Quaternary	Holocene	Undifferentiated Quaternary	Sands, gravels and silts of modern drainage channels	**er Aquifer**	Unconfined-confined aquifer, salinities from 500 to over 10 000 mg/L, used for irrigation and stock supplies
	Pleistocene	Pooraka Formation	Red-brown sandy clays with minor gravel lenses near ranges		
Tertiary	Miocene (early–late)	Rowland Flat Sand	Non-carbonaceous clays, gravels, sands and silts		
	Miocene (early) Oligocene (early)	Rowland Flat Sand	Carbonaceous (lignitic) clays, brown	**Aquitard**	Confining layer
			Carbonaceous clays, gravel, sands and silt	**Lo er Aquifer**	Confined aquifer, salinities 500-2500 mg/L, used extensively for irrigation
Cam rian		Kanmantoo – Normanville Groups	Metamorphosed greywacke, schist, marble	**Fractured ock Aquifer**	Confined-unconfined aquifer, supplies low, salinities highly variable - from 500 to over 3000 mg/L
Proterozoic		Adelaide System	Siltstones, shales, sandstones, quartzites		

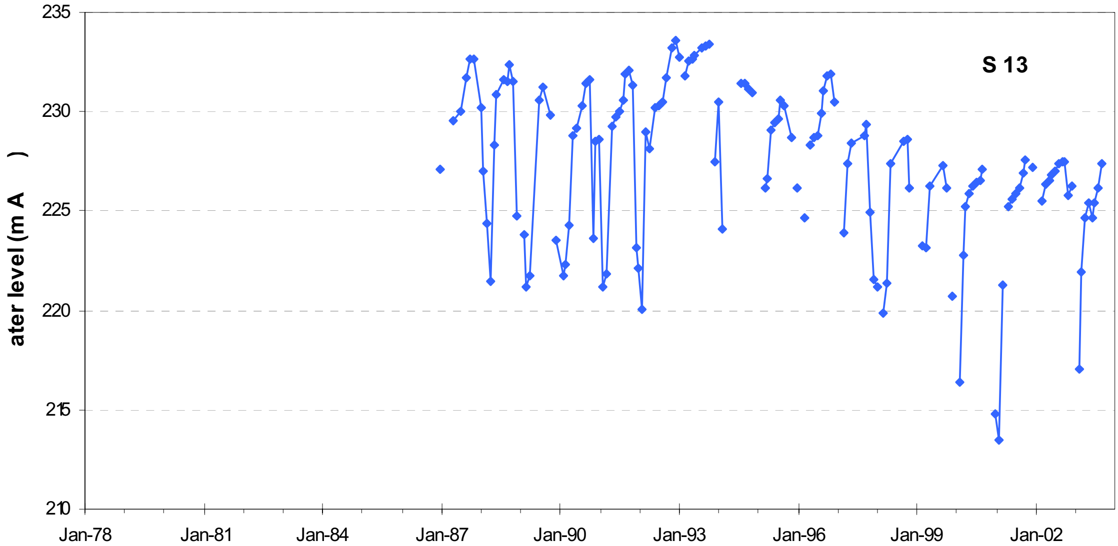
10 APPENDIX B

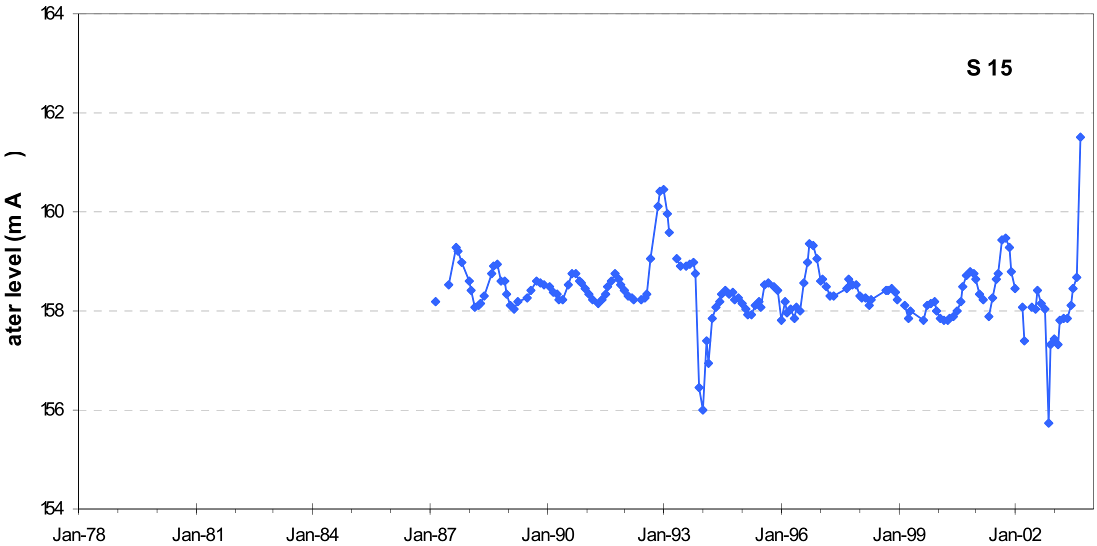
  

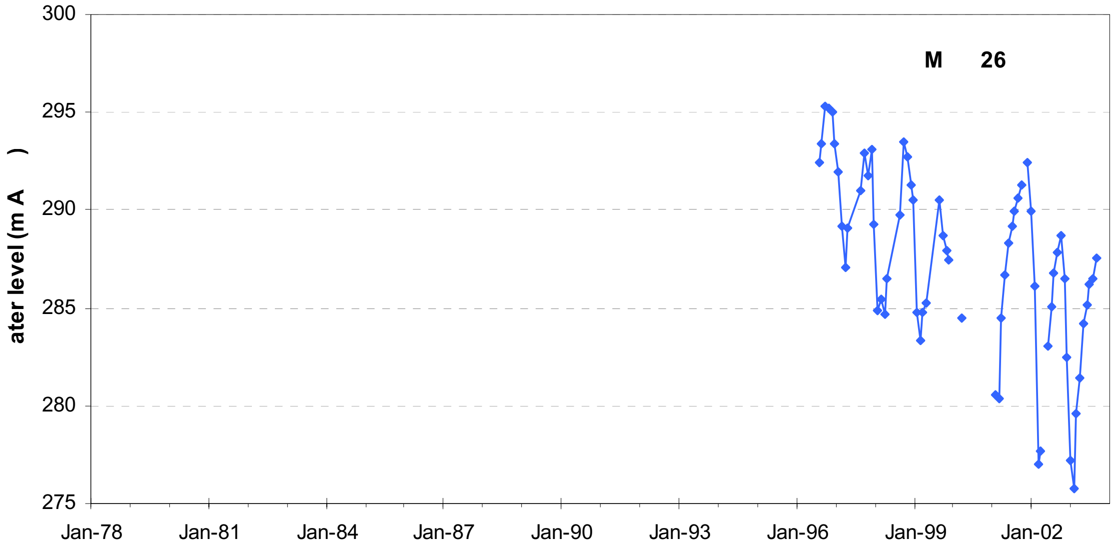
GROUNDWATER HYDROGRAPHS

Fractured ock Aquifer hydrogra hs





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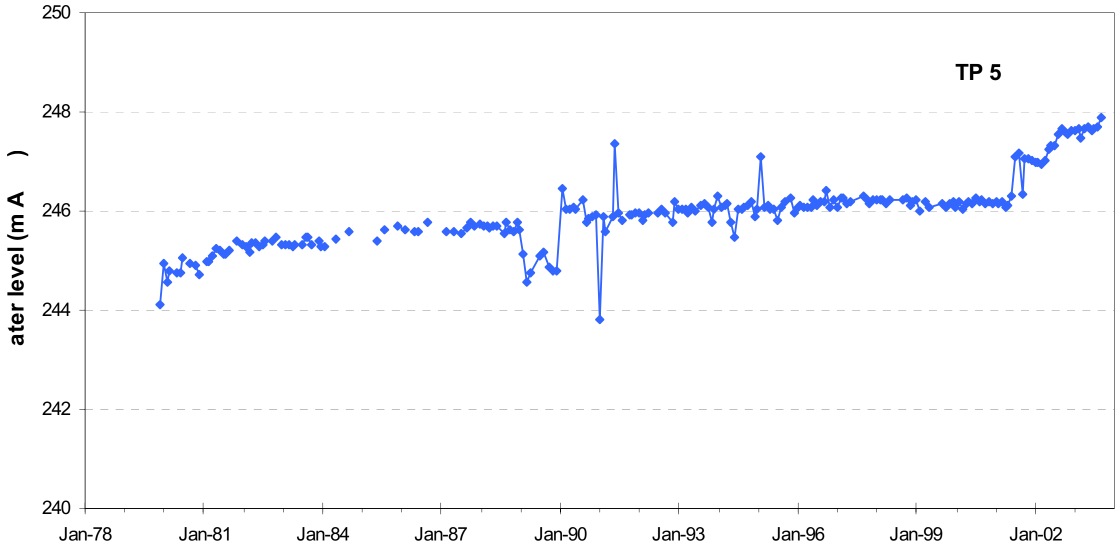
Jan-02


TP 5
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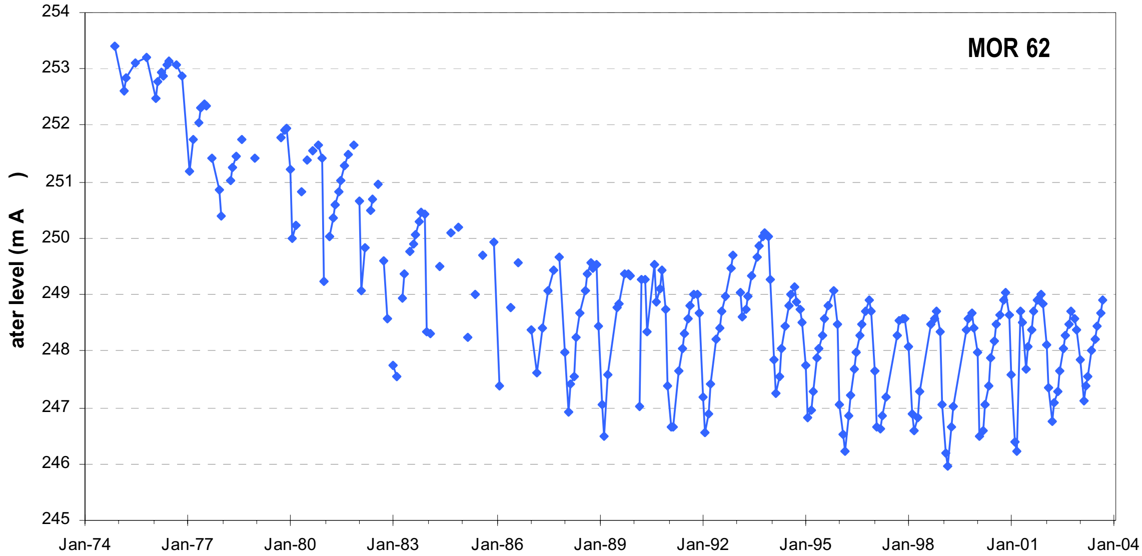
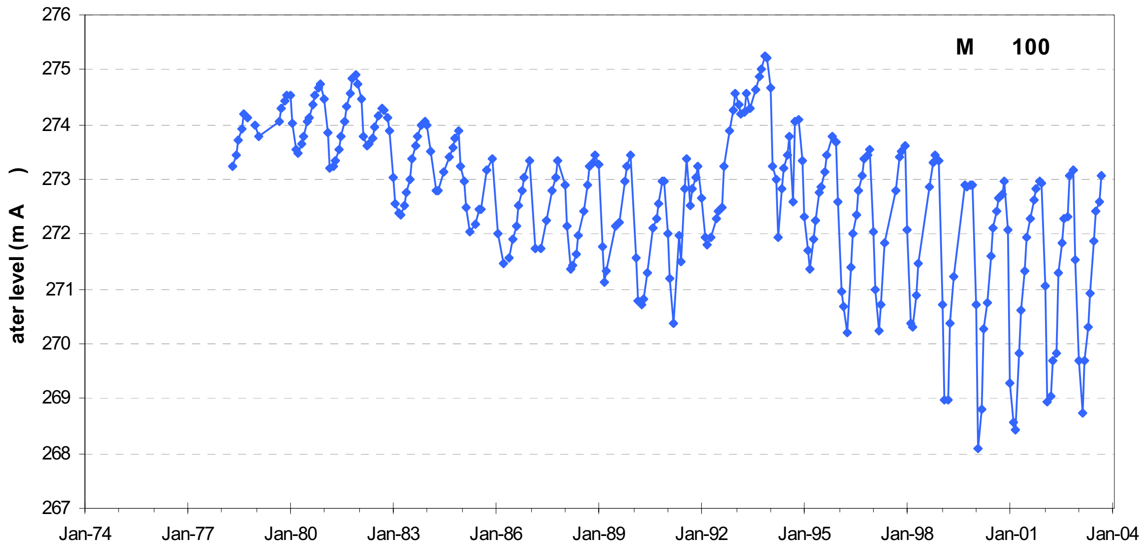
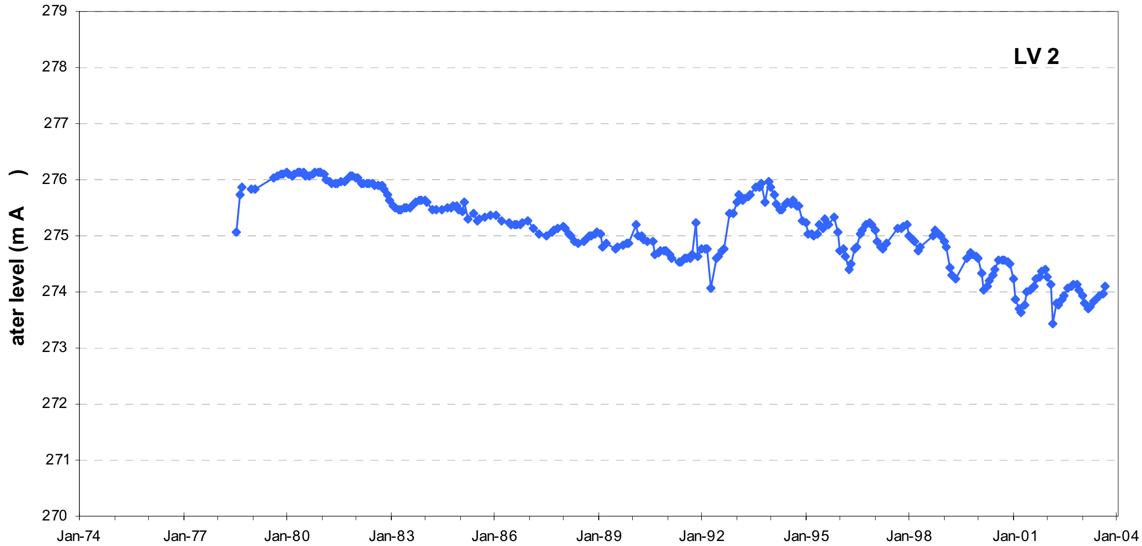
Jan-93
Jan-96
Jan-99
Jan-02

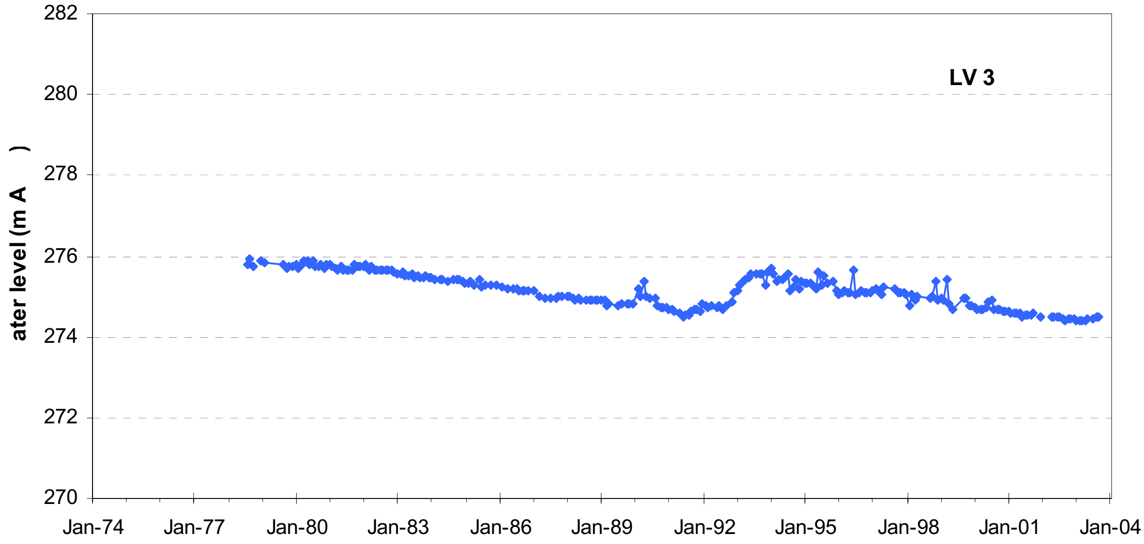
Lo er Aquifer hydrogra hs

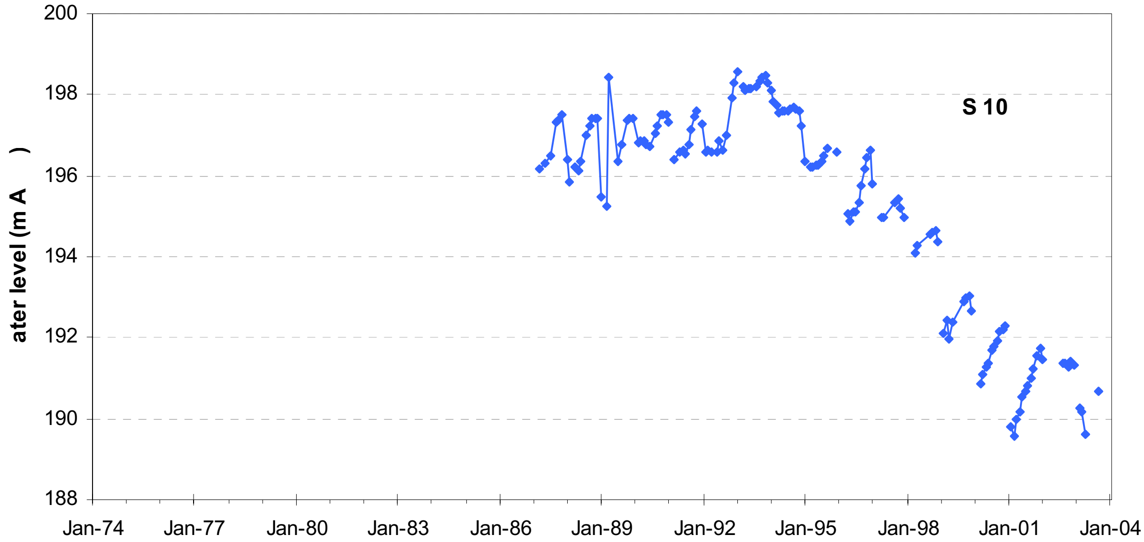


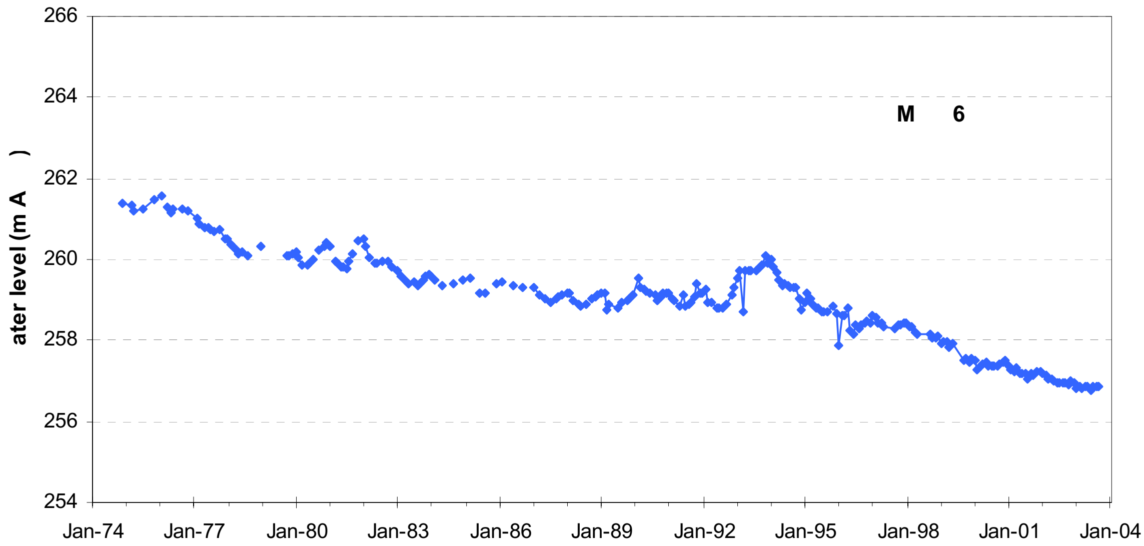




er Aquifer hydrogra hs







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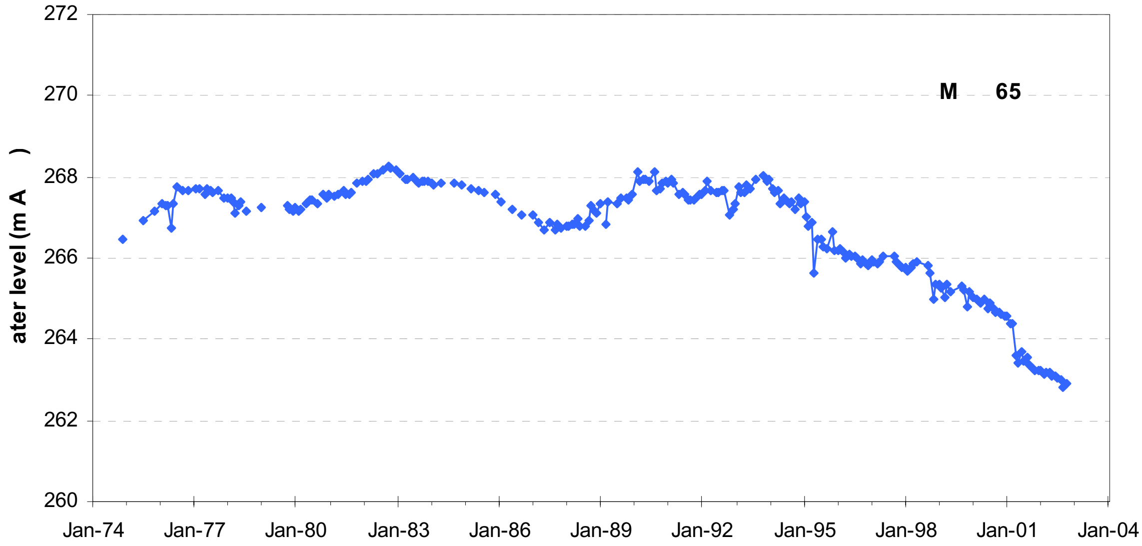
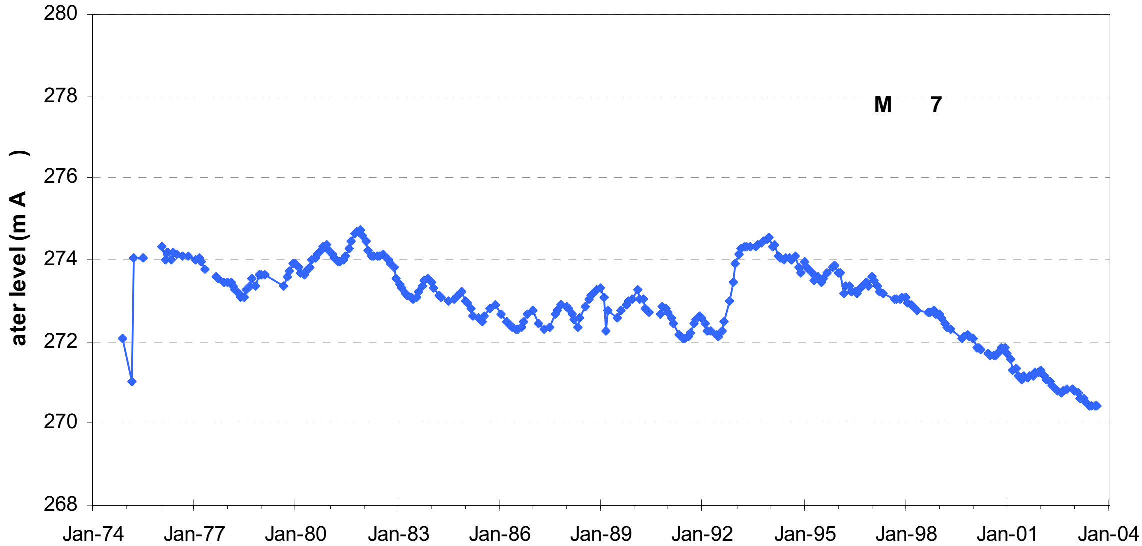
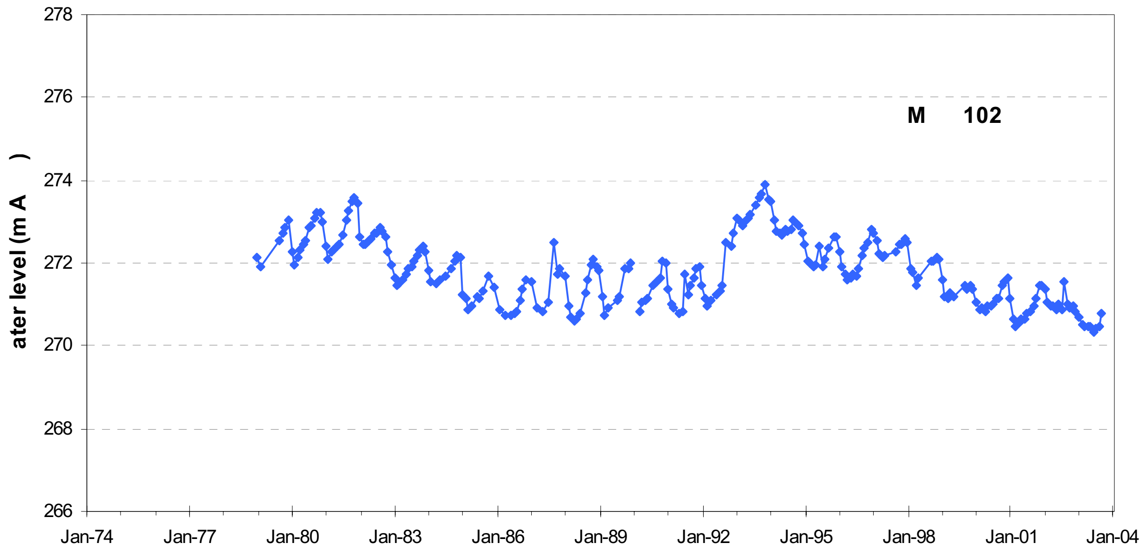

M 65
ater level (m A)
272
270
268
266
264
262
260
Jan-74
Jan-77
Jan-80
Jan-83
Jan-86
Jan-89
Jan-92
Jan-95
Jan-98
Jan-01
Jan-04


M 7
ater level (m A)
280
278
276
274
272
270
268
Jan-74
Jan-77
Jan-80
Jan-83
Jan-86
Jan-89
Jan-92
Jan-95
Jan-98
Jan-01
Jan-04

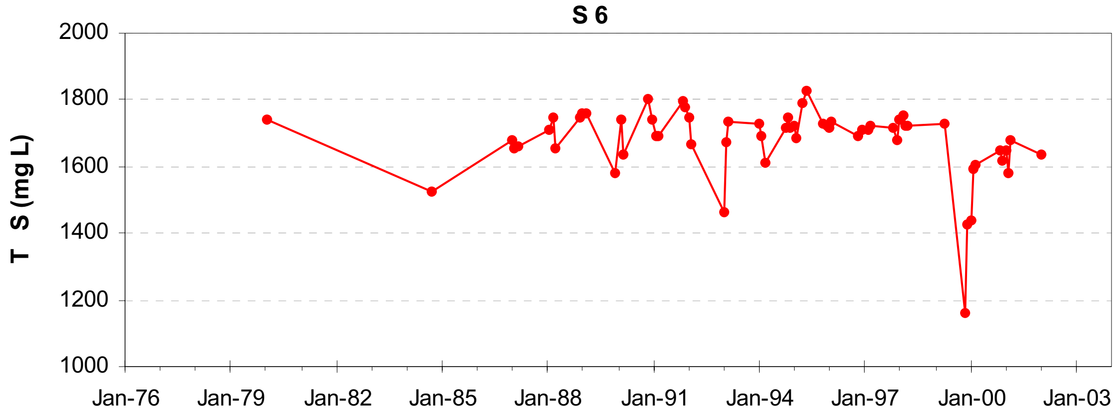

M 102
ater level (m A)
278
276
274
272
270
268
266
Jan-74
Jan-77
Jan-80
Jan-83
Jan-86
Jan-89
Jan-92
Jan-95
Jan-98
Jan-01
Jan-04

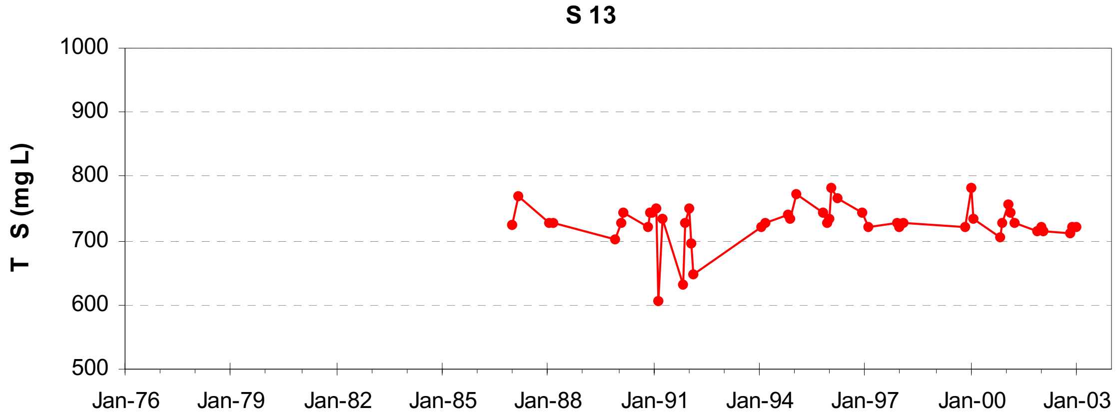
11 APPENDIX C

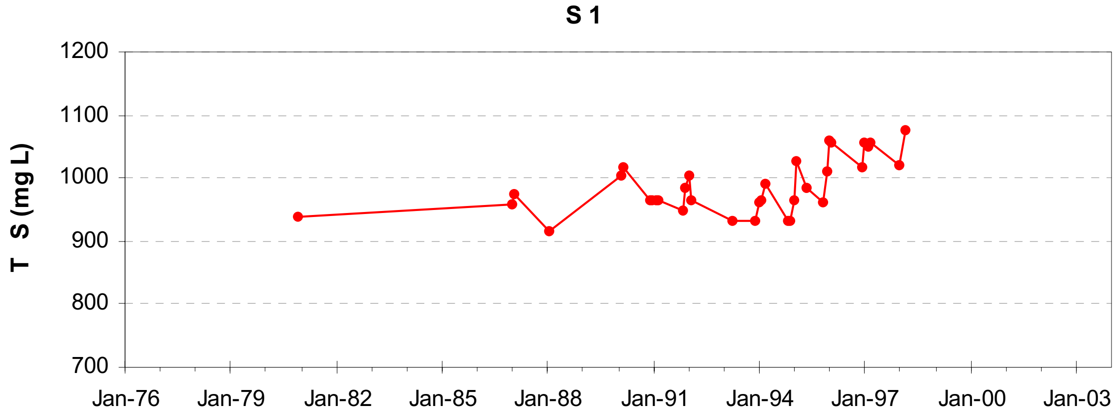


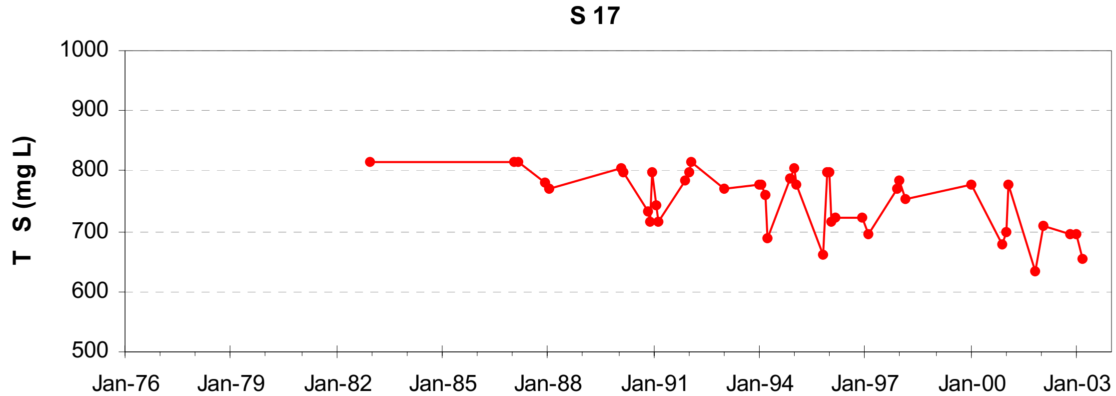
SALINITY GRAPHS

Fractured ock Aquifer

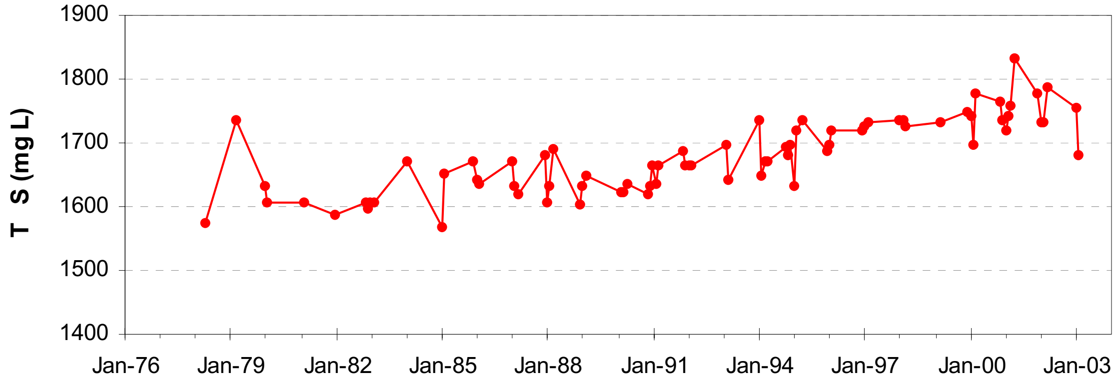




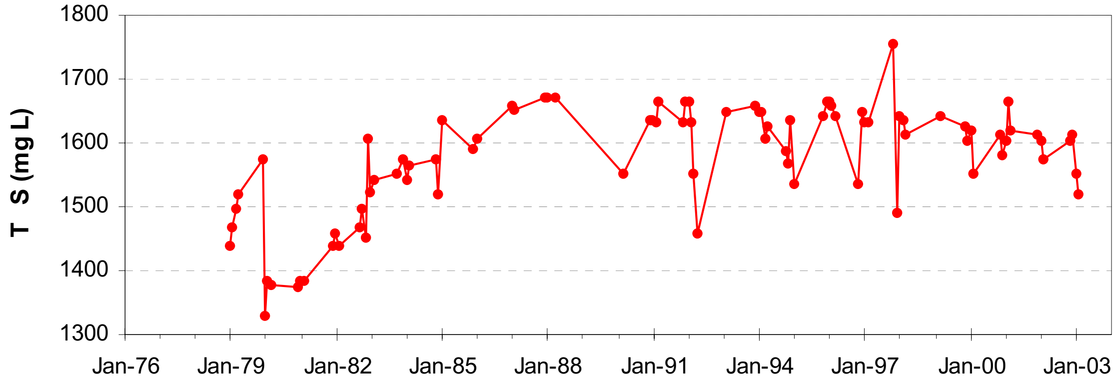




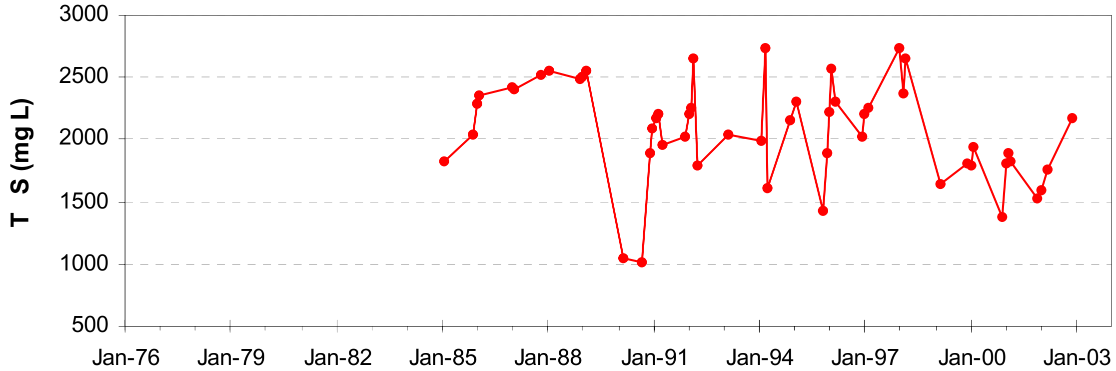
M 163



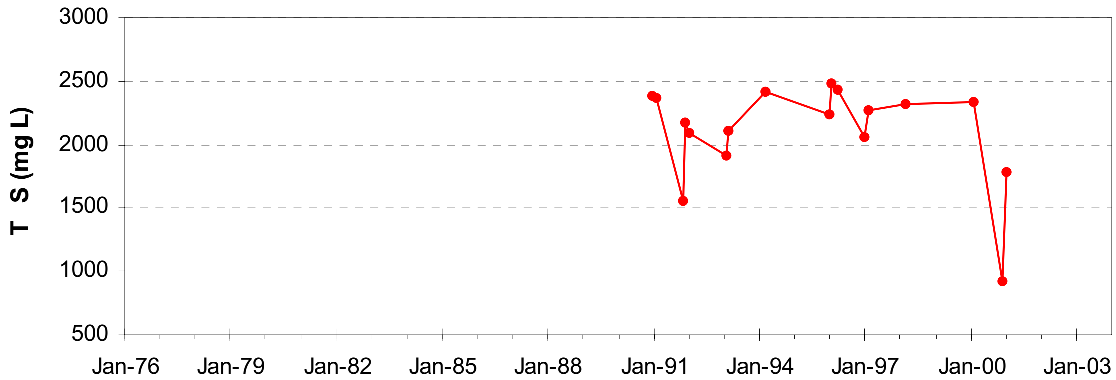
M 16

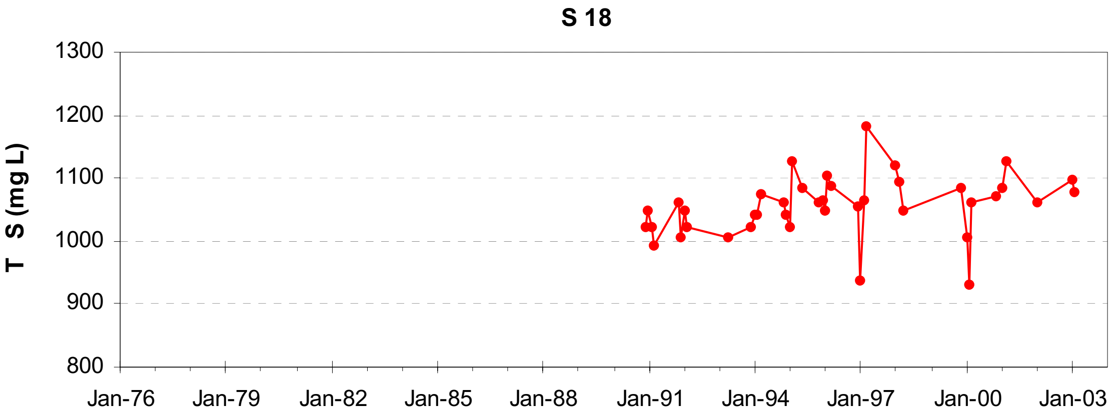


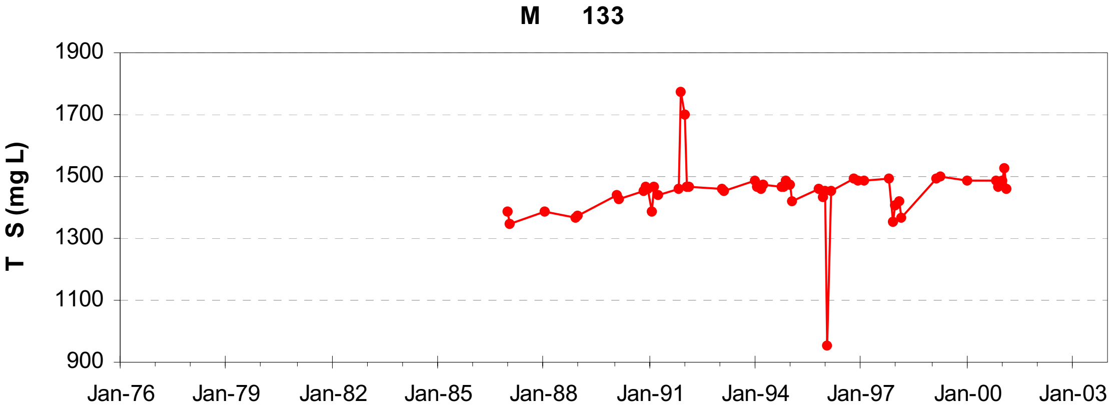
M 192

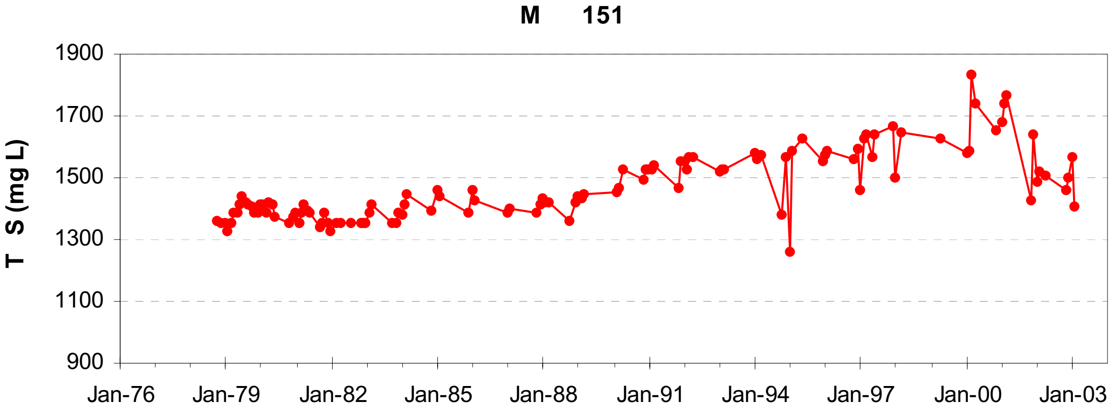


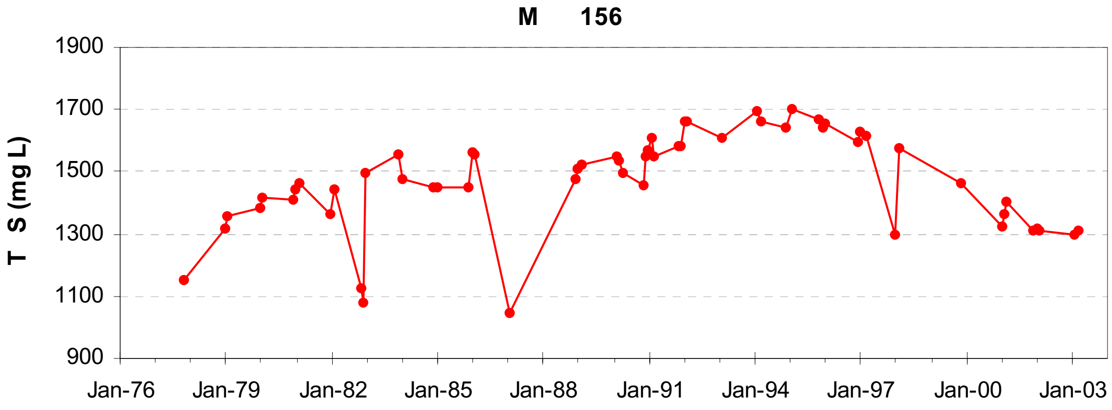
M 210



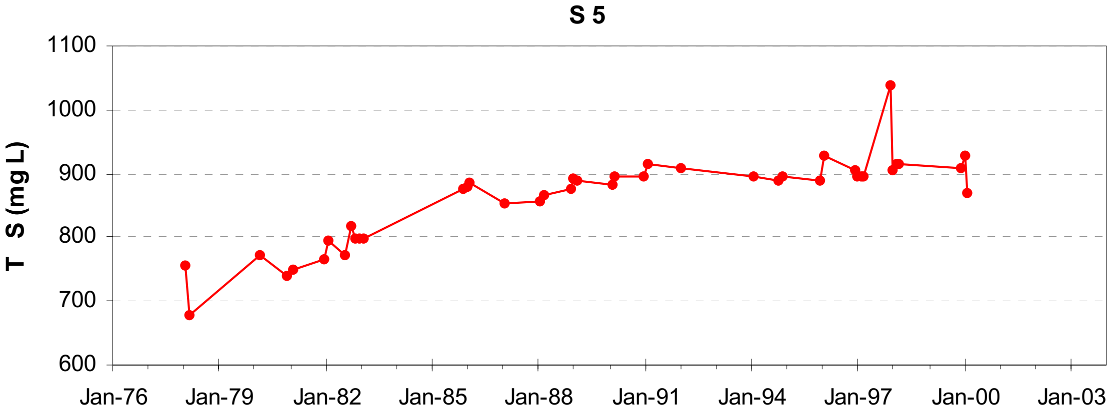

S 18
T S (mg L)
1300
1200
1100
1000
900
800
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03

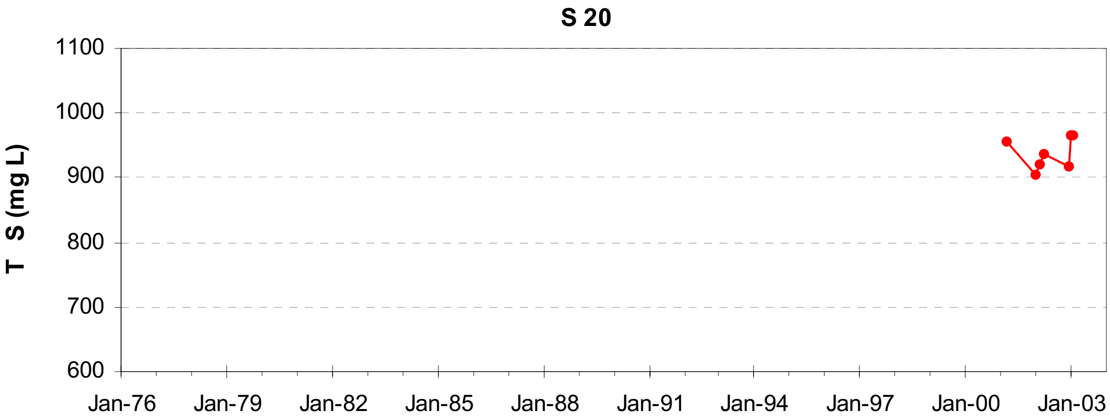

M 133
T S (mg L)
1900
1700
1500
1300
1100
900
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03

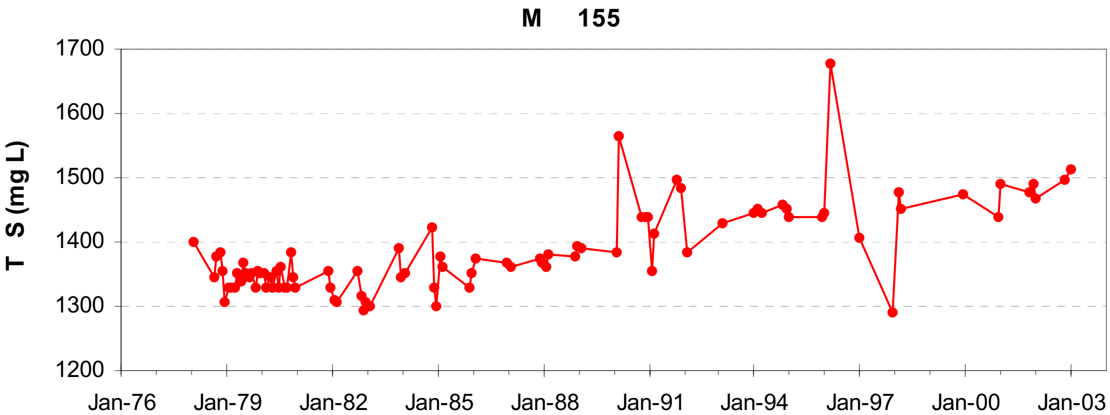

M 151
T S (mg L)
1900
1700
1500
1300
1100
900
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03

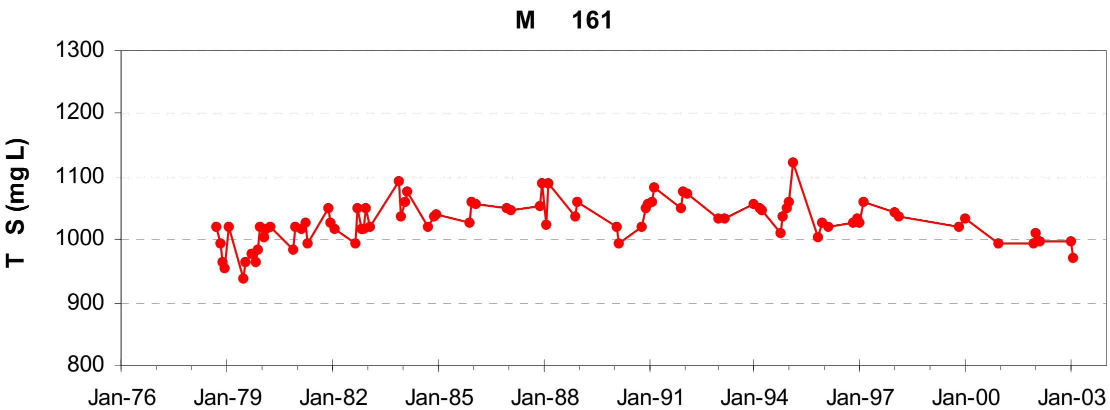

M 156
T S (mg L)
1900
1700
1500
1300
1100
900
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03

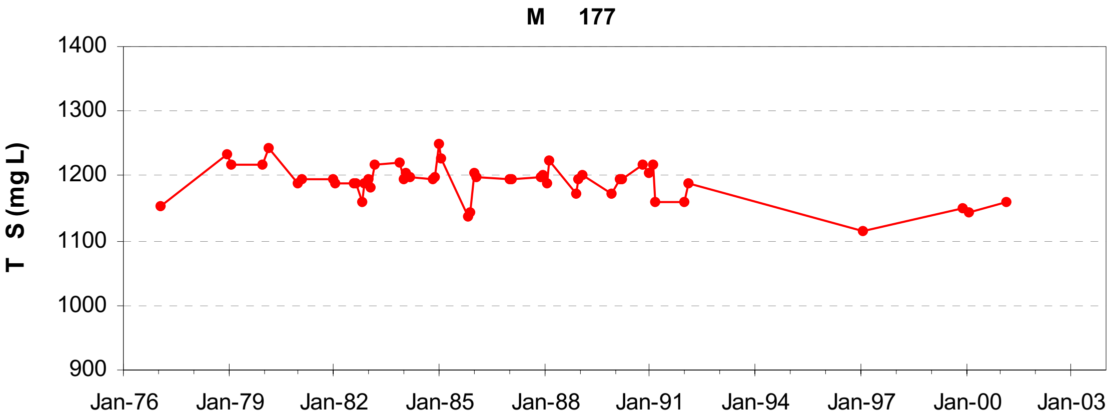
Lo er Aquifer

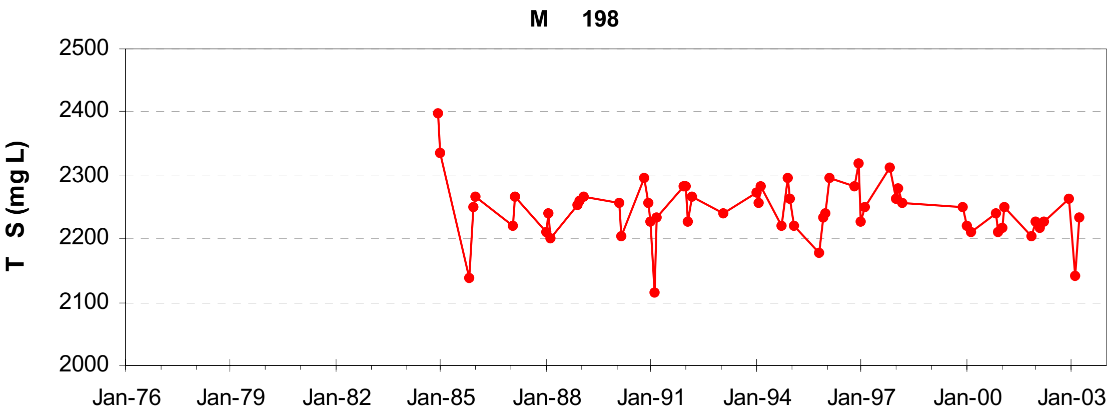












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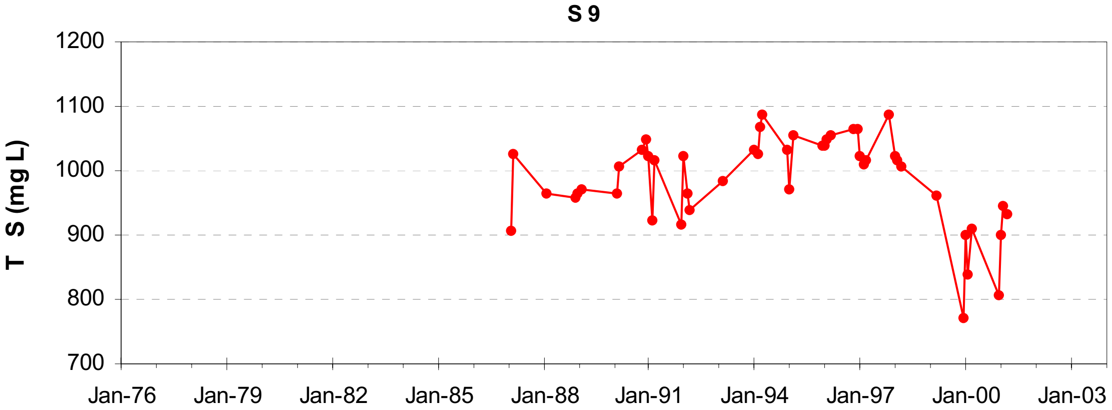
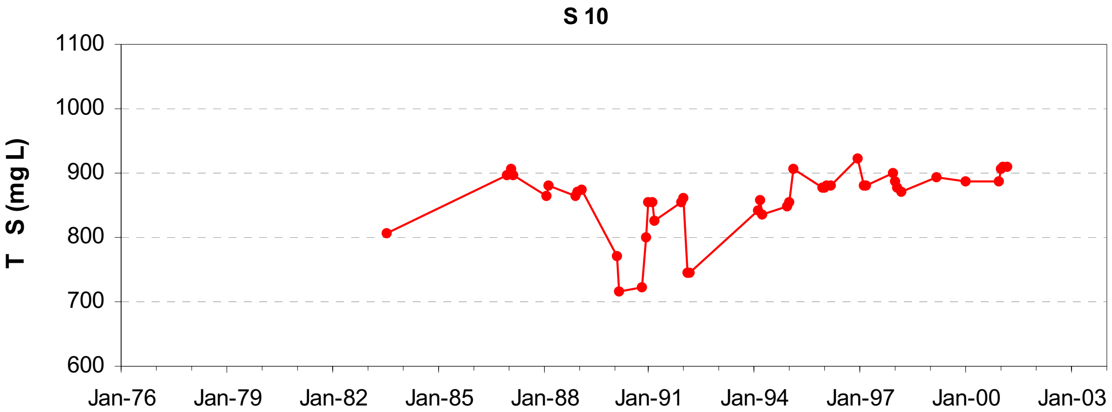
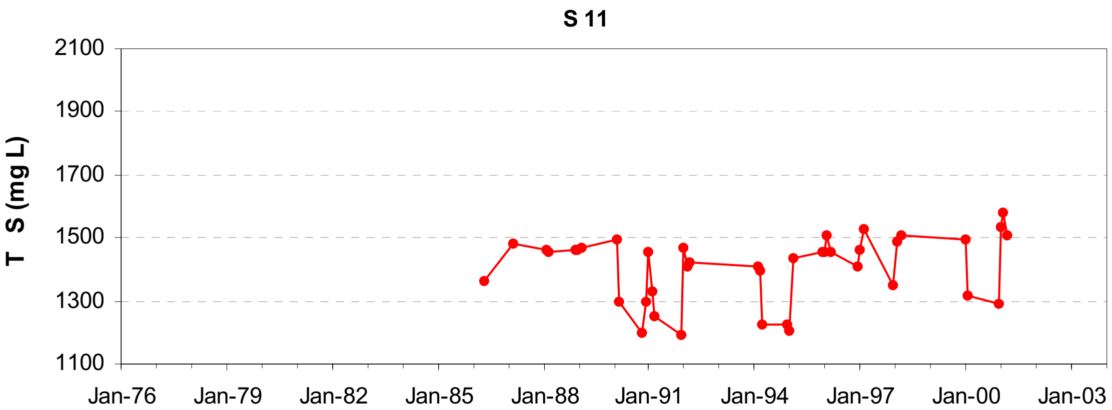
er Aquifer


S 9
T S (mg L)
1200
1100
1000
900
800
700
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03


S 10
T S (mg L)
1100
1000
900
800
700
600
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03


S 11
T S (mg L)
2100
1900
1700
1500
1300
1100
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
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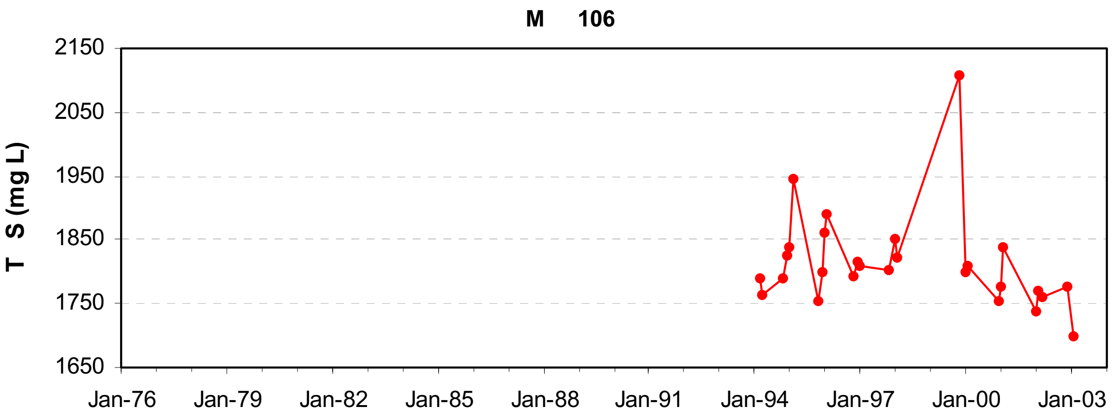
Jan-97
Jan-00
Jan-03


M 106
T S (mg L)
2150
2050
1950
1850
1750
1650
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Jan-79
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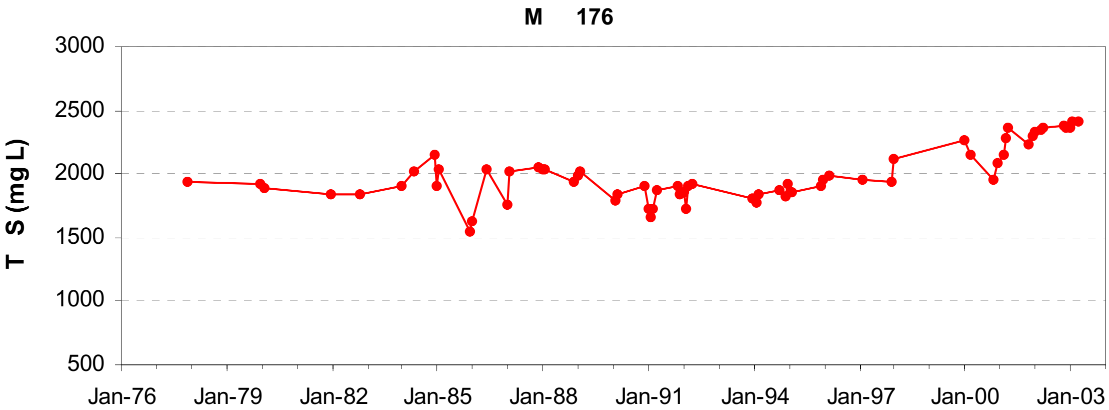
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03


M 176
T S (mg L)
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2500
2000
1500
1000
500
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Jan-79
Jan-82
Jan-85
Jan-88
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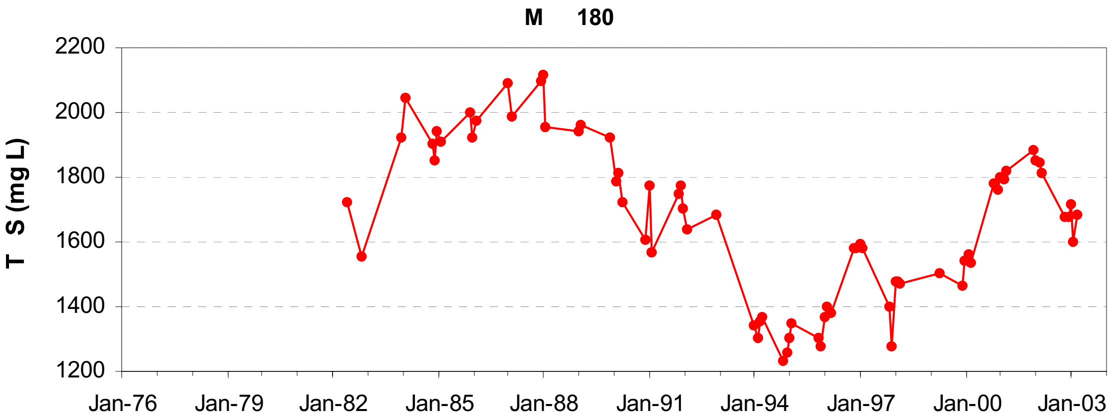
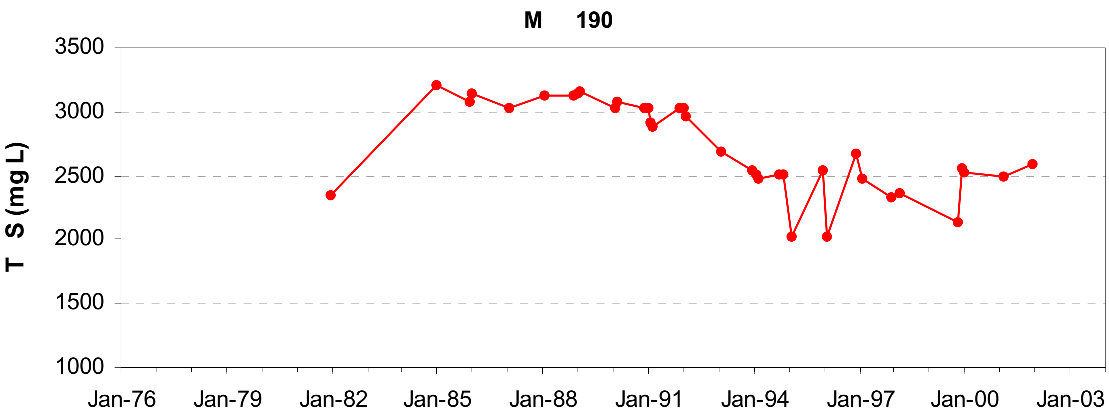
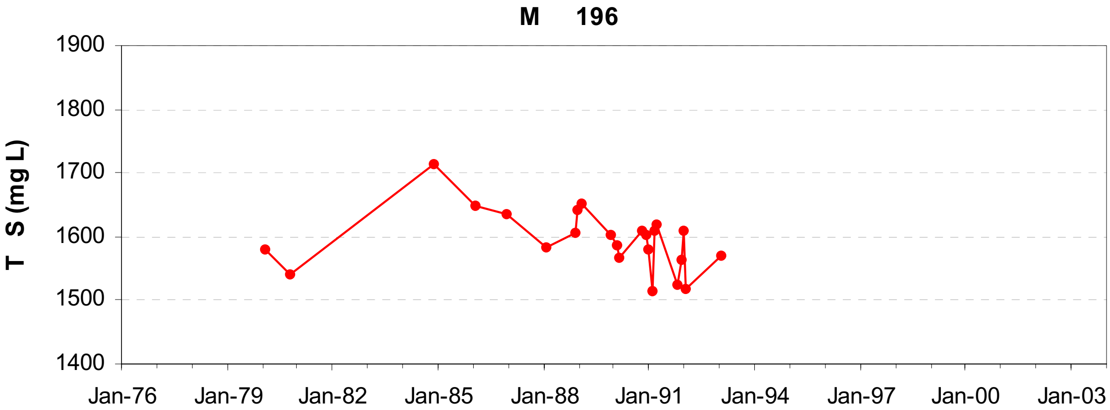
Jan-97
Jan-00
Jan-03


M 180
T S (mg L)
2200
2000
1800
1600
1400
1200
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03


M 190
T S (mg L)
3500
3000
2500
2000
1500
1000
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03


M 196
T S (mg L)
1900
1800
1700
1600
1500
1400
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03