The Department of Water, Land and Biodiversity Conservation

South East Catchment Water Management Board groundwater monitoring status report 2002

Report DWLBC 2002/10

Government of South Australia

The Department of
Water, Land and
Biodiversity
Conservation

South East Catchment Water Management Board groundwater monitoring status report 2002

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Groundwater Assessment
Department of Water, Land and Biodiversity Conservation

October 2002

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of South Australia

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Rammers, N. and Stadter, F., 2002. South East Prescribed Wells Areas groundwater monitoring status reports 2002. *South Australia. Department of Water, Land and Biodiversity Conservation. Report,* DWLBC 2002/10.

Foreword

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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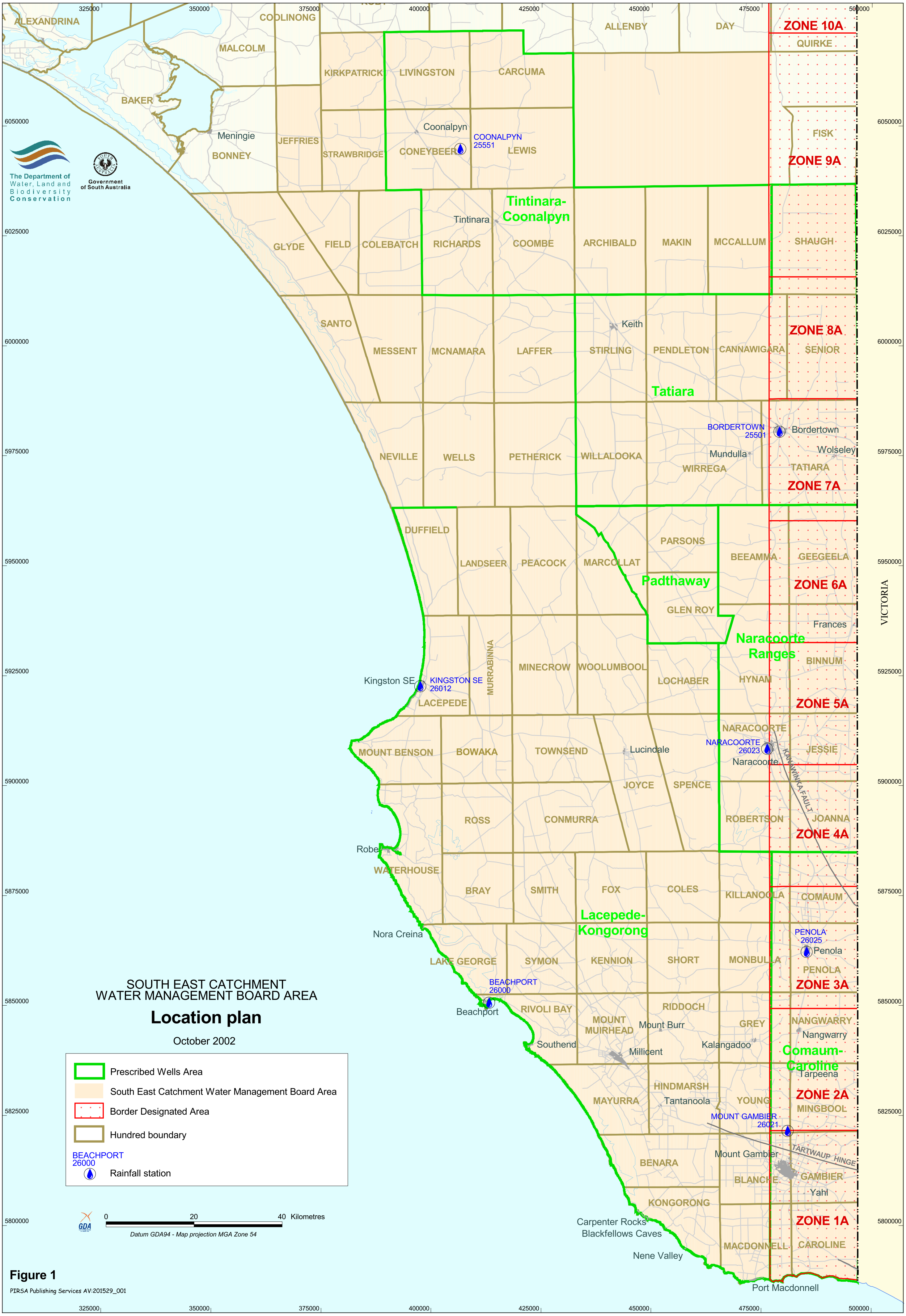
INTRODUCTION

The South Australian Government, through the Department of Water, Land and Biodiversity Conservation (DWLCB) is responsible for the management of the State's groundwater resources. As a part of its role, the DWLCB monitors and maintains an extensive statewide groundwater monitoring network.

Ground water monitoring has been undertaken in parts of the South East of South Australia for more than 30 years. The two main parameters used to measure the condition of the groundwater resources are water levels and salinity. Over time, a history of the condition of the aquifers has been established from this baseline information, enabling longer term and short-term changes to be identified and correlated with either natural (e.g. climatic) or man-induced changes (e.g. irrigation, development).

This report is compiled for the South East Catchment Water Management Board (SECWMB) and displays a snapshot of data collected for the South East region up until June 2002.

The South East catchment comprises five Prescribed Wells Areas (PWA), which cover an area of ~20 000 km^2. These groundwater management areas are referred to as the Padthaway, Tatiara, Comaum–Caroline, Naracoorte Ranges and Lacepede-Kongorong Prescribed Wells Areas. More recently a sixth management area identified as the Tintinara–Coonalpyn PWA has been included (Fig. 1).


SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA
Location plan
October 2002
Prescribed Wells Area
South East Catchment Water Management Board Area
Border Designated Area
Hundred boundary
BEACHPORT
26000
Rainfall station
0
20
40 Kilometres
Datum GDA94 - Map projection MGA Zone 54
The Department of Water, Land and Biodiversity Conservation
Government of South Australia
PIRSA Publishing Services AV:201529_001
VICTORIA
ZONE 10A
ZONE 9A
ZONE 8A
ZONE 7A
ZONE 6A
ZONE 5A
ZONE 4A
ZONE 3A
ZONE 2A
ZONE 1A
Tintinara-Coonalpyn
Tatiara
Padthaway
Naracoorte Ranges
Lacepede-Kongorong
Comaum-Caroline
ALEXANDRINA
COOLINONG
MALCOLM
BAKER
BONNEY
JEFFRIES
KIRKPATRICK
STRAWBRIDGE
LIVINGSTON
CARCUMA
CONEYBEER
LEWIS
ALLENBY
DAY
QUIRKE
FISK
SHAUGH
GLYDE
FIELD
COLEBATCH
RICHARDS
COOMBE
ARCHIBALD
MAKIN
MCCALLUM
SANTO
MESSENT
MCNAMARA
LAFFER
STIRLING
PENDLETON
CANNAWIGARA
SENIOR
NEVILLE
WELLS
PETHERICK
WILLALOOKA
WIRREGA
TATIARA
DUFFIELD
LANDSEER
PEACOCK
MARCOLLAT
PARSONS
BEEAMMA
GEEGEELA
GLEN ROY
MURRABINNA
MINECROW
WOOLUMBOOL
LOCHABER
HYNAM
BINNUM
LACEPEDE
MOUNT BENSON
BOWAKA
TOWNSEND
JOYCE
SPENCE
NARACOORTE
JESSIE
ROSS
CONMURRA
ROBERTSON
JOANNA
WATERHOUSE
BRAY
SMITH
FOX
COLES
KILLANOOLA
COMAUM
LAKE GEORGE
SYMON
KENNION
SHORT
MONBULLA
PENOLA
RIVOLI BAY
MOUNT MUIRHEAD
RIDDOCH
GREY
NANGWARRY
HINDMARSH
MAYURRA
YOUNG
MINGBOOL
BENARA
BLANCHE
GAMBIER
KONGORONG
MACDONNELL
CAROLINE
Meningie
Coonalpyn
COONALPYN
25551
Tintinara
Keith
BORDERTOWN
25501
Bordertown
Wolseley
Mundulla
Frances
Kingston SE
KINGSTON SE
26012
Lucindale
NARACOORTE
26023
Naracoorte
KANAWINKA FAULT
Robe
Nora Creina
PENOLA
26025
Penola
BEACHPORT
26000
Beachport
Southend
Mount Burr
Millicent
Kalangadoo
Nangwarry
Tarpeena
Tantanoola
MOUNT GAMBIER
26021
Mount Gambier
TARTWAUP HINGE
Yahl
Carpenter Rocks
Blackfellows Caves
Nene Valley
Port Macdonnell
325000
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375000
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Figure 1

REGIONAL HYDROGEOLOGY

Geologically, the South East region lies predominantly within the Gambier Embayment of the Otway Basin. The upper part of the South East catchment is located on the southwestern margin of the Murray Basin. The two basins are partially separated by an area of shallow or outcropping basement rocks known as the Padthaway Ridge Basement High (Fig. 2). The two basins display hydraulic connectivity.

There are no extensive supplies of good quality surface water flow in the South East. This excludes the Glenelg River, which predominantly lies over the State border in Victoria. Groundwater therefore is the main water resource in the region and is primarily used for irrigation. Other demands on groundwater include industrial, recreational, stock use and municipal water supplies.

The South East region is charaterised by several extensive low-lying flats, which are interspersed with a series of northwest-trending remnant sand dune ridges. East of Naracoorte the topography rises into higher inland plains, which extend into western Victoria.

In both the Murray and Gambier Basins, groundwater flows through two major aquifer systems: a regional unconfined limestone aquifer (Unconfined Aquifer) and an underlying confined sand aquifer (Confined Aquifer; Fig. 3). The Unconfined Aquifer consists mainly of calcareous sandstone and limestone deposited during the latter part of the Tertiary period through to the Quaternary (~30 million years ago). It incorporates the Gambier Limestone (referred to as the Murray Group Limestone in the Murray Basin) and the younger Coonmandook, Bridgewater and Padthaway Formations.

The Confined Aquifer consists of non-calcareous quartz-sands, interbedded with dark-brown carbonaceous clays. These units together make up the Dilwyn Formation in the South East; which are laterally equivalent to the Renmark Group in the Murray Basin. For groundwater management purposes, the Confined Aquifer is regarded regionally as one aquifer system, as there is insufficient data to describe the hydraulic interconnection of its various sub-units. In the northern region of the South East the Confined Aquifer is very thin to absent. Figure 4 shows the hydrostratigraphic units occurring in the South East region and how the units in the Murray Basin relate to those in the Gambier Basin.

The two aquifers are separated by low permeability aquitards, commonly a carbonaceous clay. The aquifers are believed to be hydraulically connected; however, the extent of this connection is poorly understood and is currently being assessed. The upper Unconfined Aquifer is more extensively used than the lower Confined Aquifer. Following the recent allocation of most of the available groundwater from the Unconfined Aquifer, there has been increased levels of interest in the groundwater resource of the Confined Aquifer.

Recharge of the Confined Aquifer is reliant on downward leakage from the overlying Unconfined Aquifer, and occurs on the eastern margin of the region. This recharge is a result of the potentiometric head difference between the aquifers, which allows for downward leakage. On the western side of the basin, the potentiometric head of the Confined Aquifer is above that of the unconfined, therefore there is the potential for upward movement of groundwater from the confined to the Unconfined Aquifer.

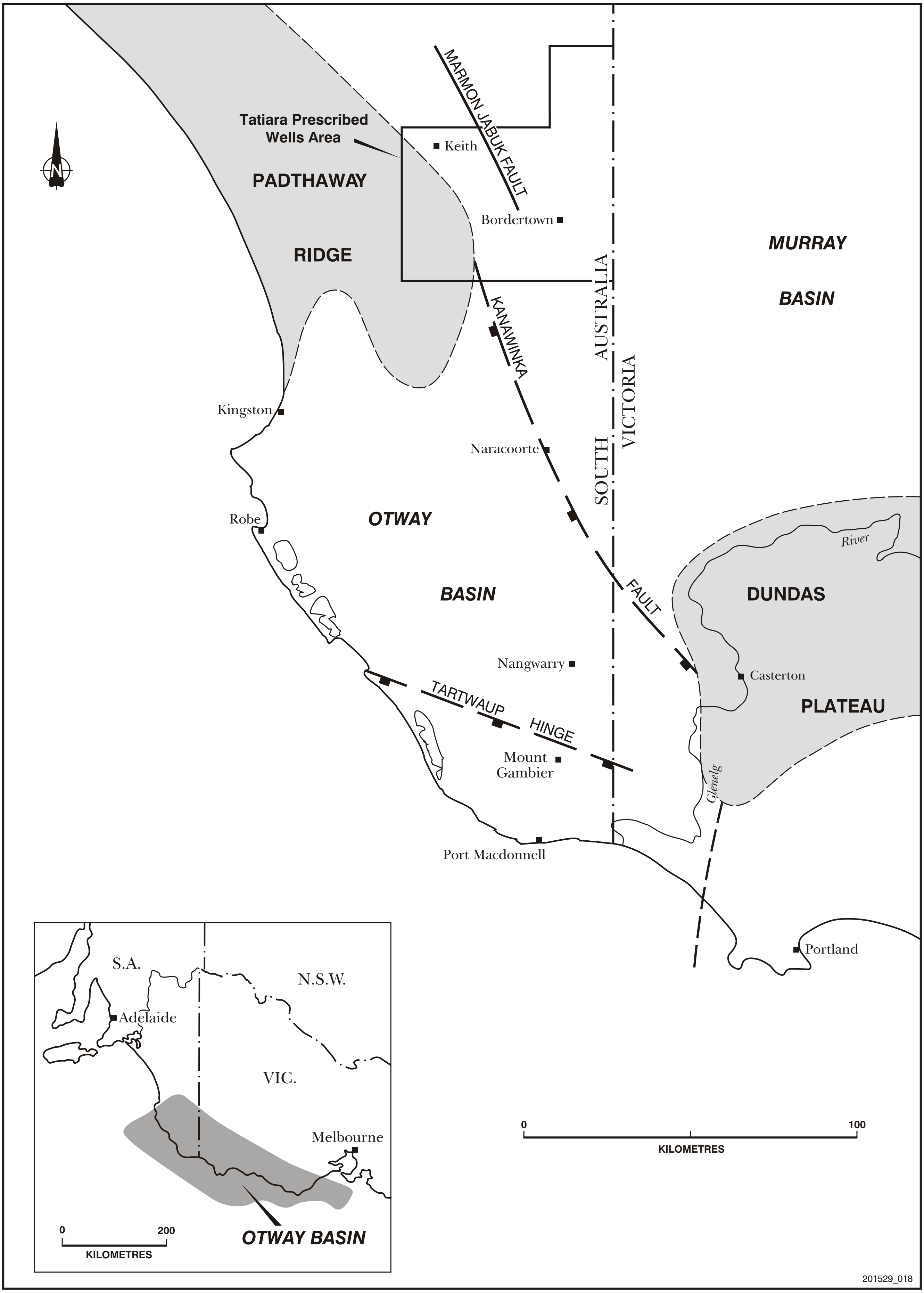


Figure 2 Geological provinces in the South East Region.

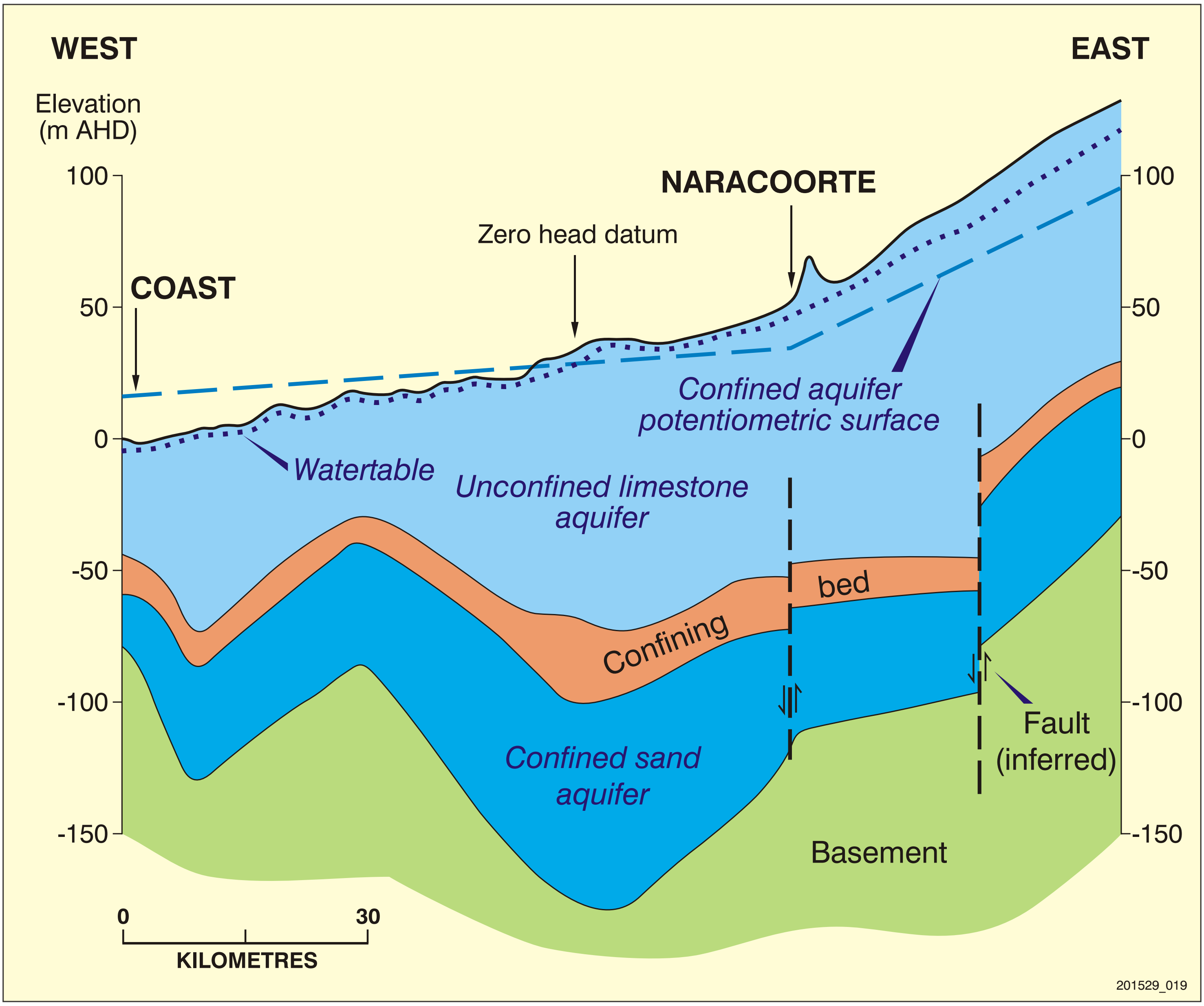


Figure 3 Schematic cross-section of southeast groundwater.

Groundwater flow for both the Confined and Unconfined Aquifers originates from the Dundas Plateau, a topographic high located in Victoria (Fig. 2). The rates at which groundwater moves vary depending on the hydrogeological properties of the aquifer. Groundwater tends to move faster within the Unconfined Aquifer, where secondary porosity (known as karstic features) has often developed. Karstic topography is more prominent south of the Tartwaup Hinge.

There are a number of major faults in the area. The two most prominent are the northwest-trending Kanawinka Fault and the west-northwest-trending Tartwaup Fault, referred to as the Tartwaup Hinge (Boult and Hibburt, 2002; Fig. 2). The Kanawinka Fault has a pronounced lineament and is down-thrown to the southwest. The Tartwaup Hinge is expressed as a monoclinal structure. The potentiometric surface of both aquifers indicates a significant steepening of slope immediately up-gradient of each fault.

The climate of the South East region is typified by hot, dry summers and cool, wet winters. Annual rainfall ranges from more than 800 mm in the south to ~450 mm in the north. Potential annual evapotranspiration increases from ~1400 mm in the south to ~1800 mm in the north. Rainfall recharge occurs to the Unconfined Aquifer when winter precipitation exceeds evapotranspiration, and this generally occurs between May and September (Waterhouse, 1975). However the amount of recharge varies considerably with land use, magnitude and timing of precipitation, topography, vegetation and the nature and structure of the soil through which recharge water percolates. Very little or no recharge occurs to the Unconfined Aquifer under pine and blue gum forests when full canopy closer exists (Dillon et al., 2001), while in other parts of the South East the recharge can range from 2 to 130 mm per year (Bradley et al., 1995). There is a general trend of increasing recharge to the south of the region corresponding to the increase in annual rainfall.

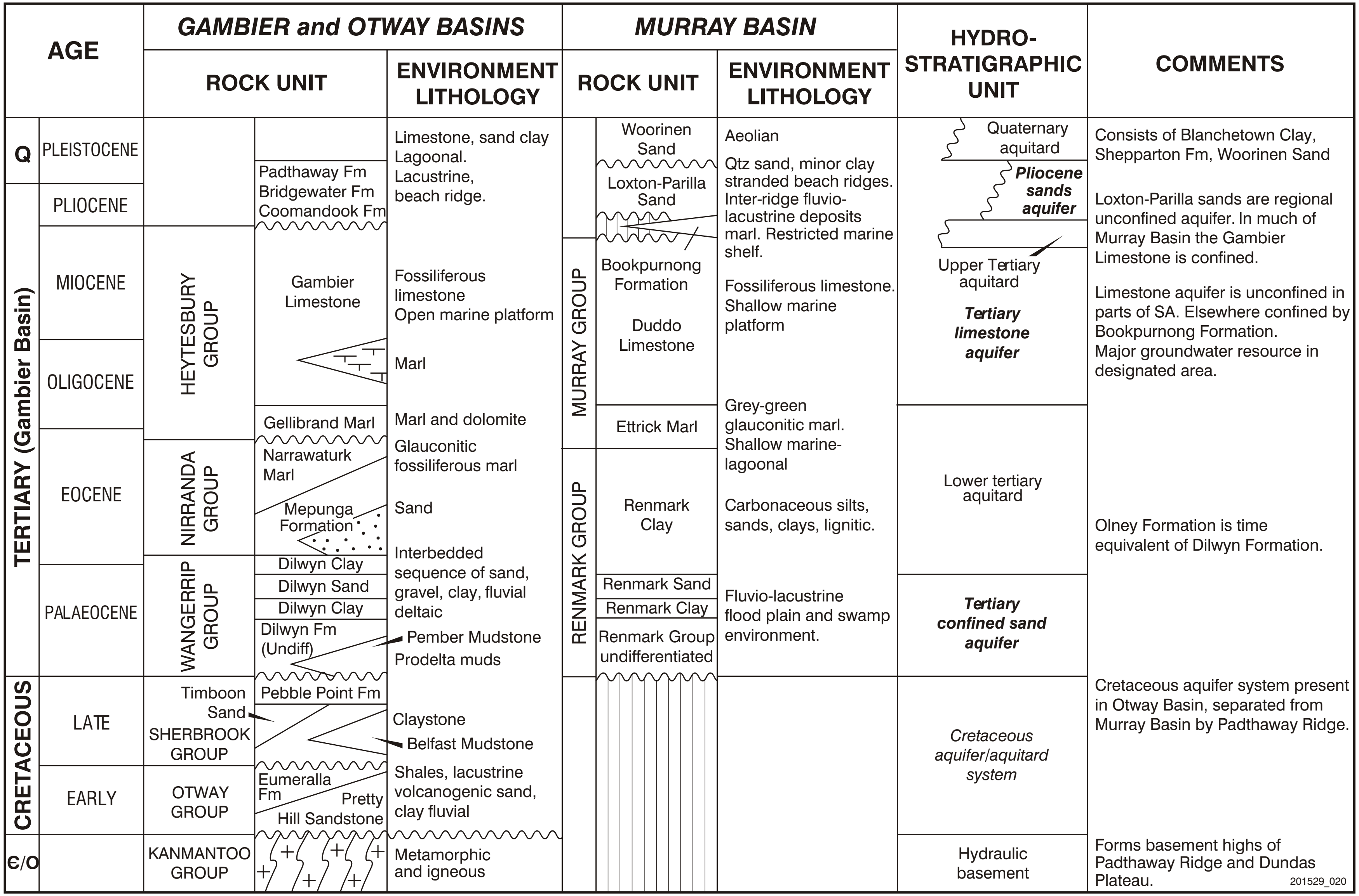


Figure 4 Stratigraphic and hydrostratigraphic units of the Otway and Murray Basins.

GROUNDWATER ALLOCATION METHOD (LICENSING SYSTEM)

Unconfined Aquifer

Groundwater from the Unconfined Aquifer has been generally allocated on the basis of the estimated average annual vertical recharge to the watertable. The underlying principle behind this approach is that the lateral throughflow is maintained in the aquifer, thereby allowing any accumulated salts to be flushed down-gradient.

Allocation of water for irrigation use is largely based on area and the irrigated crop water requirement relative to a reference crop (crop area ratio system). The area-based system does not incorporate additional quantities of groundwater extracted for the efficiencies of the various irrigation systems used or transport losses (e.g. leakage from channel delivery systems). It assumes that any excess water pumped from the aquifer that is not used by the crop or lost to evaporation percolates back down into the Unconfined Aquifer. All area-based allocations are to be converted to volumetric allocations by 2006.

Recent new allocations for irrigation use, since the introduction of pro-rata water allocations in 2000, have been issued volumetrically. Water allocated for industrial use has traditionally been issued on a volumetric basis. Domestic and stock water uses are exempt from licensing.

Confined Aquifer

Sustainable groundwater use limits for the Confined Aquifer have largely been based on groundwater modelling of this resource (Brown, 1998).

The water allocation system used for the Confined Aquifer is the same as that for the Unconfined Aquifer. However, excess irrigation water does not return to the Confined Aquifer, but rather to the Unconfined Aquifer. Therefore this method considerably underestimates the water use from this aquifer (Brown, 1998). As for the Unconfined Aquifer, all area-based allocations are to be converted to volumetric allocations by 2006.

MONITORING NETWORK

Unconfined Aquifer

There are currently 18 networks monitoring the Unconfined Aquifer within the SECWMB region, three of which are private irrigation well networks. Currently, there are 922 wells monitoring water levels and 506 wells monitoring salinity. Water levels and salinity are generally monitored on a three-monthly basis.

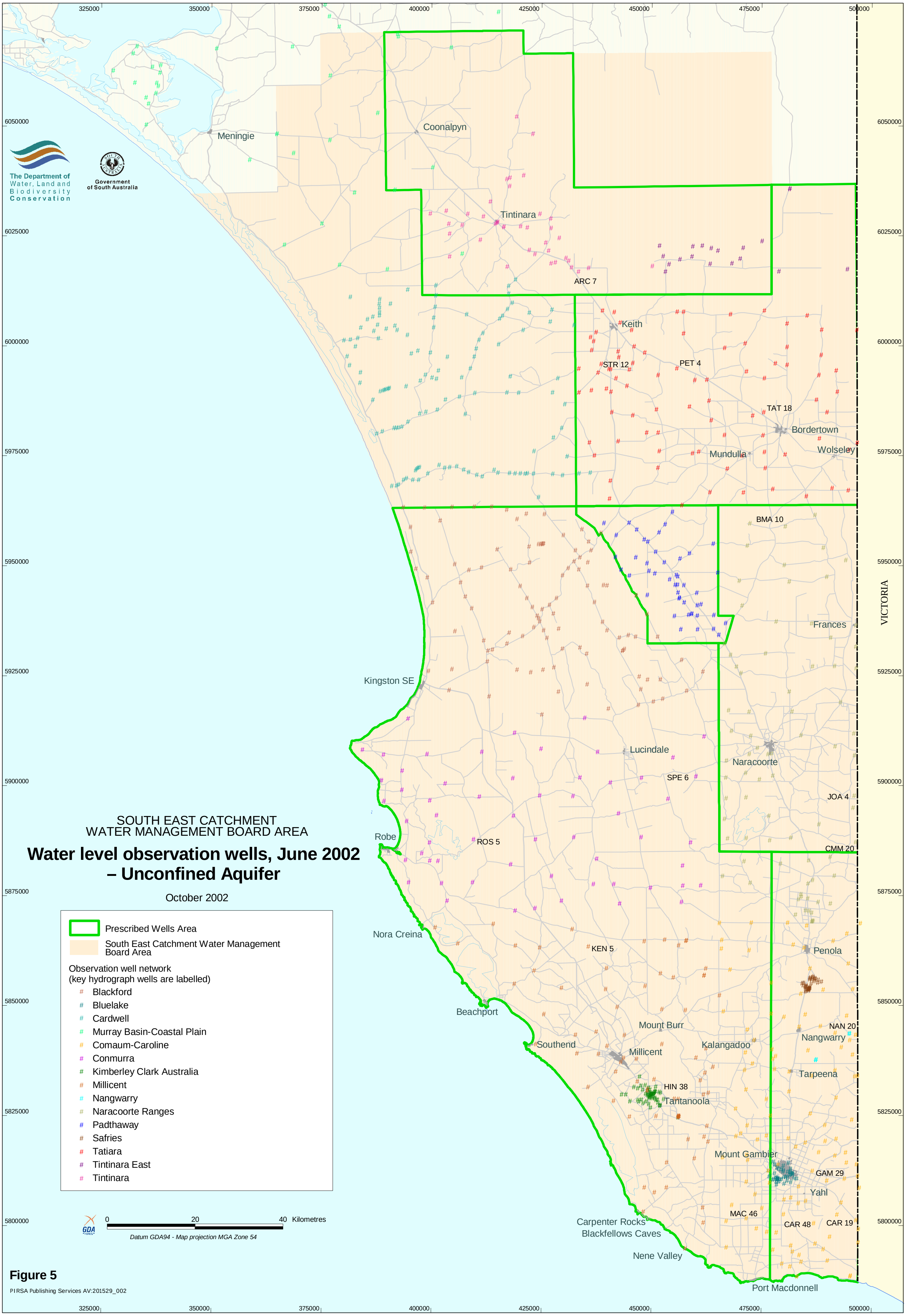
Water level monitoring well distribution is reasonably even on a regional scale. Denser networks occur in areas of more intense groundwater use such as Padthaway, Millicent (Snuggery) and Mount Gambier, or in the dryland salinity affected area west of Padthaway and Keith (Fig. 5).

The distribution of salinity monitoring wells is not as consistent as the water level network and is relatively sparse in some areas; however, this generally reflects the degree of groundwater use and the need to focus monitoring activity in areas of higher use. Monitoring concentrations occur at Padthaway, Keith, Millicent, Mount Benson and north of Glencoe (Fig. 6).

Confined Aquifer

There is currently one network which monitors the South East Confined Aquifer with 120 wells monitoring water levels and 49 monitoring salinity. Most of the current water level monitoring wells are concentrated around and southeast of Kingston SE, either side of the Princess Highway (Fig. 7). This reflects both the high level of groundwater use and the artesian nature of the aquifer in this area. Whilst the remaining spread of monitoring wells is significantly less dense, it is considered adequate for the current level of development for this aquifer. There are very few Confined Aquifer monitoring wells in the northern portion of the South East as the Dilwyn Formation Confined Aquifer is generally thin or absent.

Figure 8 shows the current salinity monitoring network. Although there are few observation wells monitoring salinity in the Confined Aquifer, the network is considered sufficient as there has been no real change in salinity since monitoring began.


SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA
Water level observation wells, June 2002
– Unconfined Aquifer
October 2002
Prescribed Wells Area
South East Catchment Water Management Board Area
Observation well network
(key hydrograph wells are labelled)
Blackford
Bluelake
Cardwell
Murray Basin-Coastal Plain
Comaum-Caroline
Conmurra
Kimberley Clark Australia
Millicent
Nangwarry
Naracoorte Ranges
Padthaway
Safries
Tatiara
Tintinara East
Tintinara
0
20
40 Kilometres
Datum GDA94 - Map projection MGA Zone 54
The Department of Water, Land and Biodiversity Conservation
Government of South Australia
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VICTORIA
Meningie
Coonalpyn
Tintinara
ARC 7
Keith
STR 12
PET 4
TAT 18
Bordertown
Wolseley
Mundulla
BMA 10
Frances
Kingston SE
Lucindale
Naracoorte
SPE 6
JOA 4
Robe
ROS 5
CMM 20
Nora Creina
KEN 5
Penola
Beachport
Mount Burr
Southend
Millicent
Kalangadoo
NAN 20
Nangwarry
Tarpeena
HIN 38
Tantanoola
Mount Gambier
GAM 29
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MAC 46
CAR 48
CAR 19
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Blackfellows Caves
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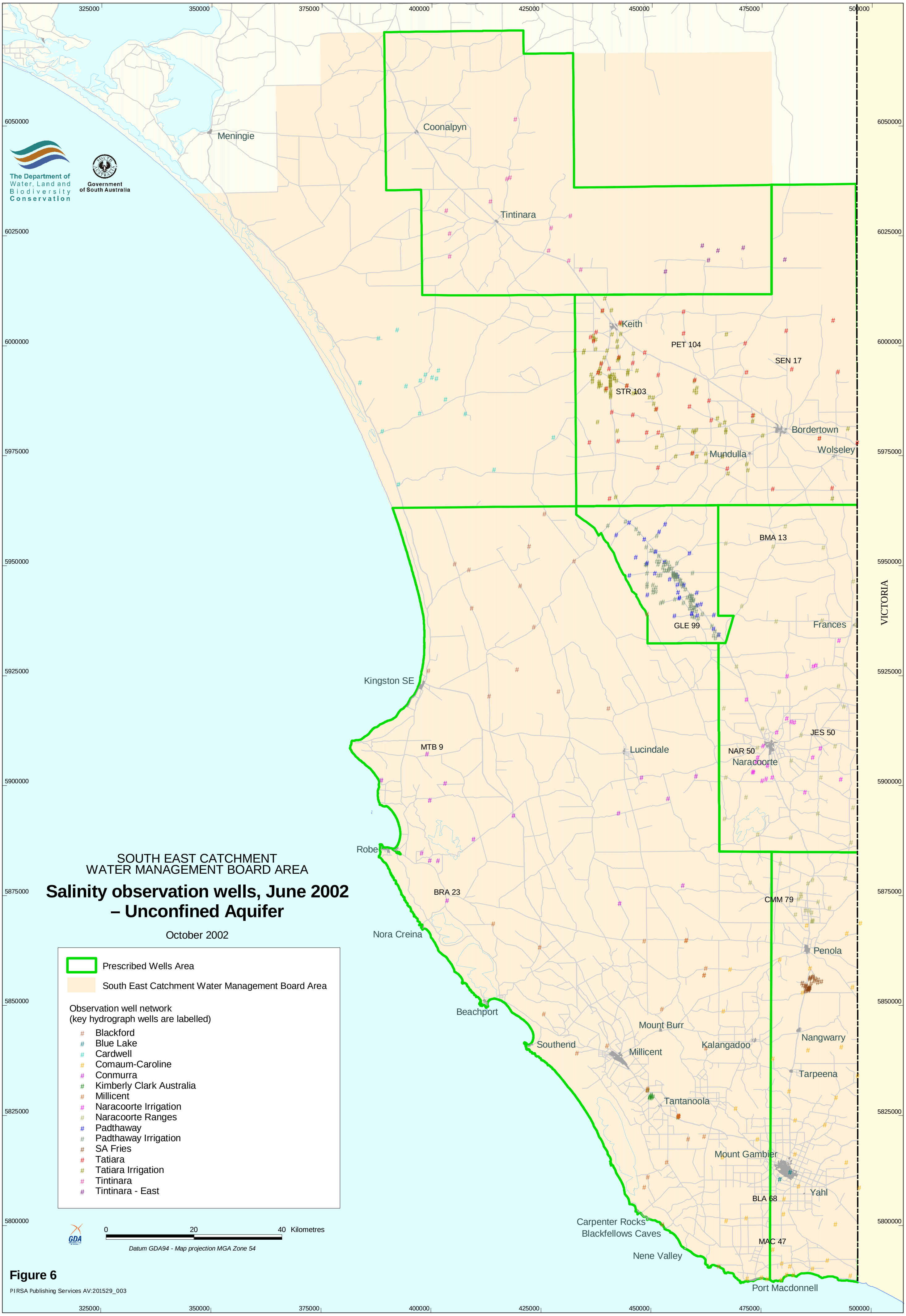
Figure 5



SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA
Salinity observation wells, June 2002
– Unconfined Aquifer
October 2002
Prescribed Wells Area
South East Catchment Water Management Board Area
Observation well network
(key hydrograph wells are labelled)
Blackford
Blue Lake
Cardwell
Comaum-Caroline
Conmurra
Kimberly Clark Australia
Millicent
Naracoorte Irrigation
Naracoorte Ranges
Padthaway
Padthaway Irrigation
SA Fries
Tatiara
Tatiara Irrigation
Tintinara
Tintinara - East
0 20 40 Kilometres
Datum GDA94 - Map projection MGA Zone 54
The Department of Water, Land and Biodiversity Conservation
Government of South Australia
Meningie
Coonalpyn
Tintinara
Keith
PET 104
SEN 17
STR 103
Bordertown
Wolseley
Mundulla
BMA 13
GLE 99
Frances
VICTORIA
Kingston SE
MTB 9
Lucindale
JES 50
NAR 50
Naracoorte
Robe
BRA 23
CMM 79
Nora Creina
Penola
Beachport
Mount Burr
Southend
Millicent
Kalangadoo
Nangwarry
Tarpeena
Tantanoola
Mount Gambier
BLA 68
Yahl
Carpenter Rocks
Blackfellows Caves
MAC 47
Nene Valley
Port Macdonnell
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Figure 6
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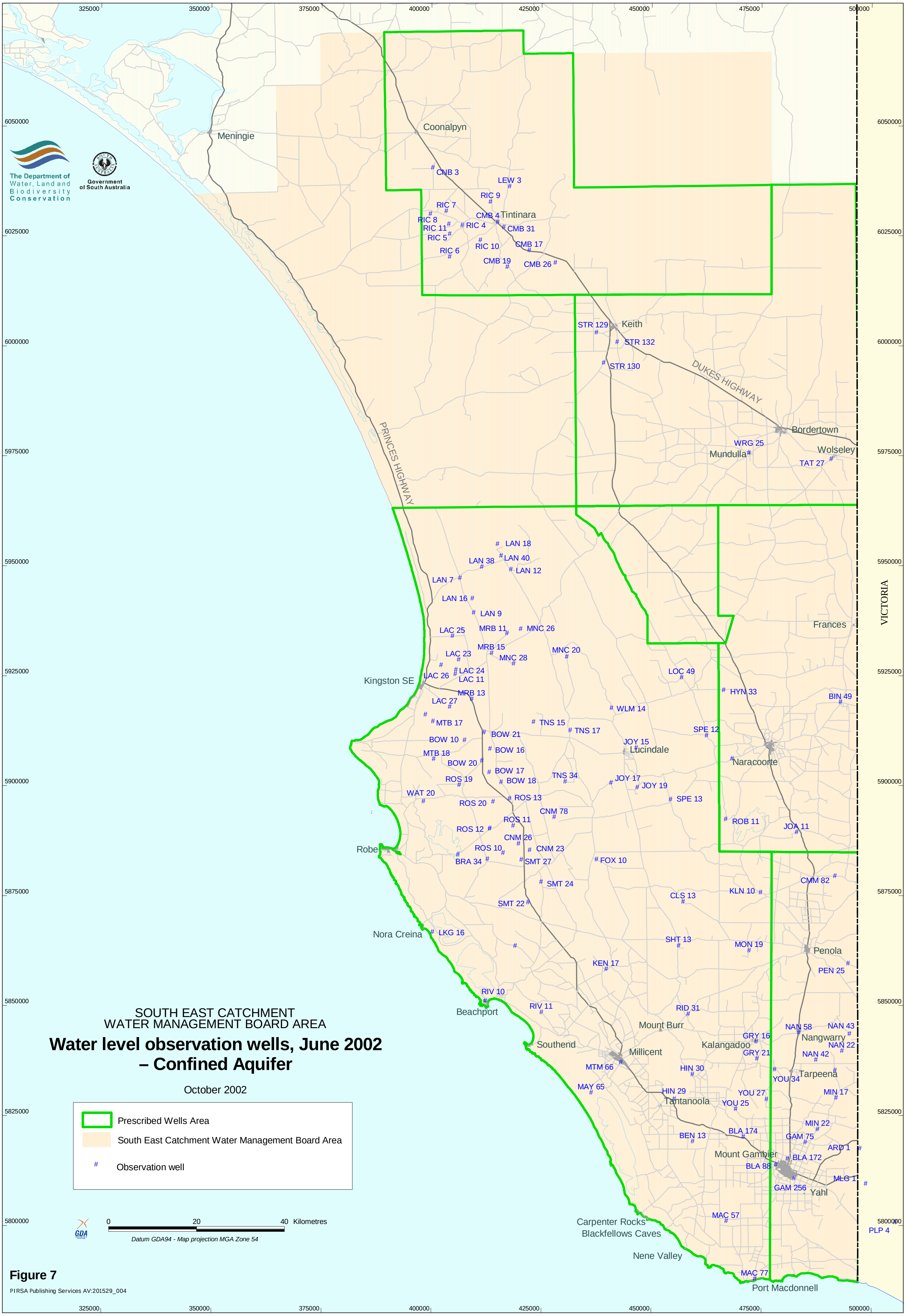
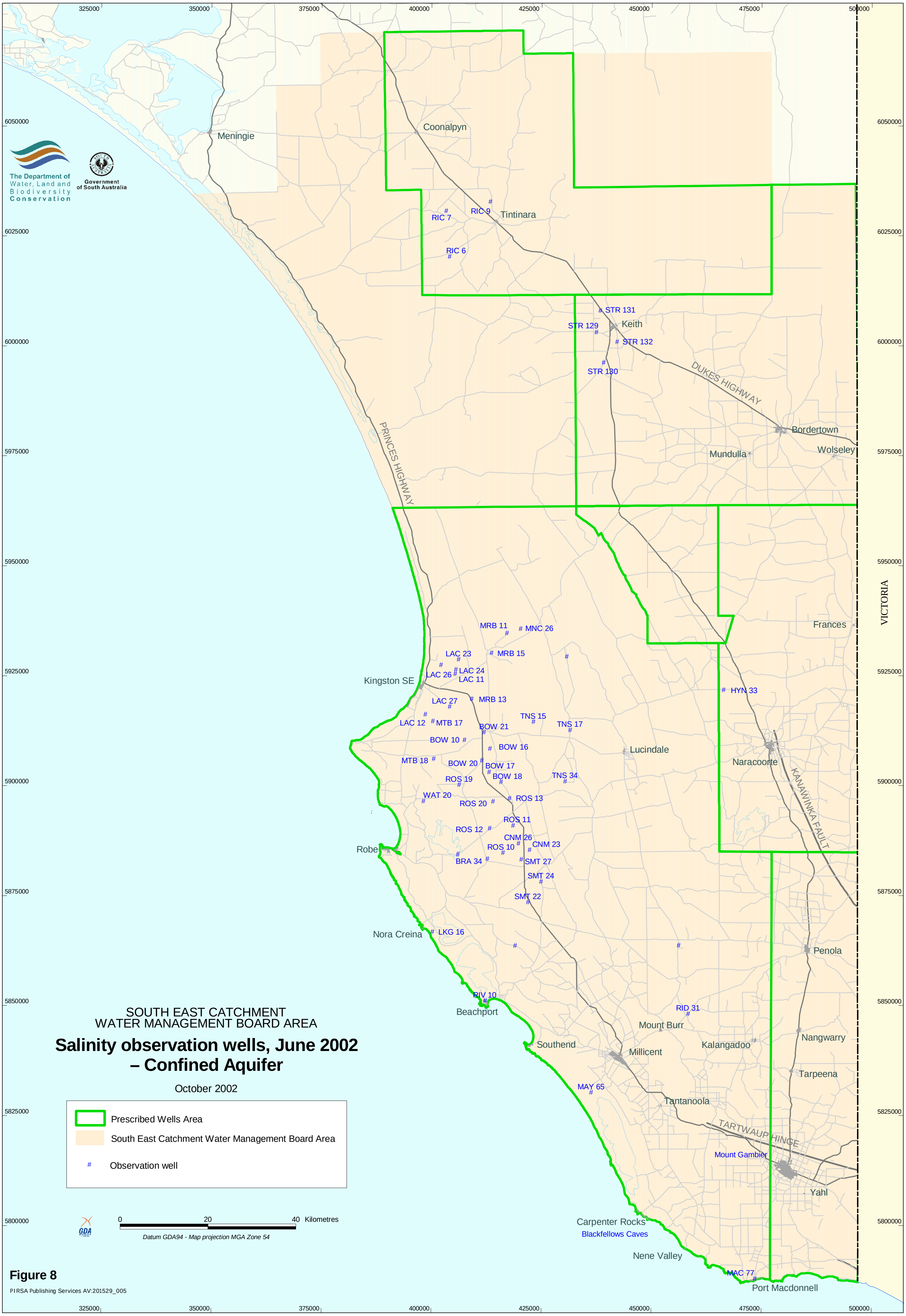


SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA

Water level observation wells, June 2002 – Confined Aquifer

October 2002

Figure 7


SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA
Salinity observation wells, June 2002 – Confined Aquifer
October 2002
Prescribed Wells Area
South East Catchment Water Management Board Area
Observation well
0
20
40 Kilometres
Datum GDA94 - Map projection MGA Zone 54
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Government of South Australia
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Meningie
Coonalpyn
Tintinara
RIC 7
RIC 9
RIC 6
STR 131
STR 129
STR 132
STR 130
Keith
DUKES HIGHWAY
Bordertown
Wolseley
Mundulla
PRINCES HIGHWAY
VICTORIA
Frances
MRB 11
MNC 26
LAC 23
MRB 15
LAC 26
LAC 24
LAC 11
Kingston SE
HYN 33
LAC 27
MRB 13
TNS 15
TNS 17
LAC 12
MTB 17
BOW 21
BOW 10
BOW 16
Lucindale
Naracoorte
KANAWINKA FAULT
MTB 18
BOW 20
BOW 17
BOW 18
TNS 34
ROS 19
WAT 20
ROS 20
ROS 13
ROS 11
ROS 12
CNM 26
CNM 23
ROS 10
Robe
BRA 34
SMT 27
SMT 24
SMT 22
Nora Creina
LKG 16
Penola
RIV 10
Beachport
RID 31
Mount Burr
Nangwarry
Southend
Millicent
Kalangadoo
Tarpeena
MAY 65
Tantanoola
TARTWAUP HINGE
Mount Gambier
Yahl
Carpenter Rocks
Blackfellows Caves
Nene Valley
MAC 77
Port Macdonnell
Figure 8

CURRENT WATER LEVEL ANALYSIS

Recent water level information has been presented in this report for two time periods: September–October 2001, which represents the pre-pumping and seasonally recovered water elevation, and March 2002, which represents the water elevation at the end of the pumping season. A comparison of the potentiometric surfaces for September–October 2001 and March 2002 enables an assessment to be made of the impacts of groundwater extraction through the irrigation season.

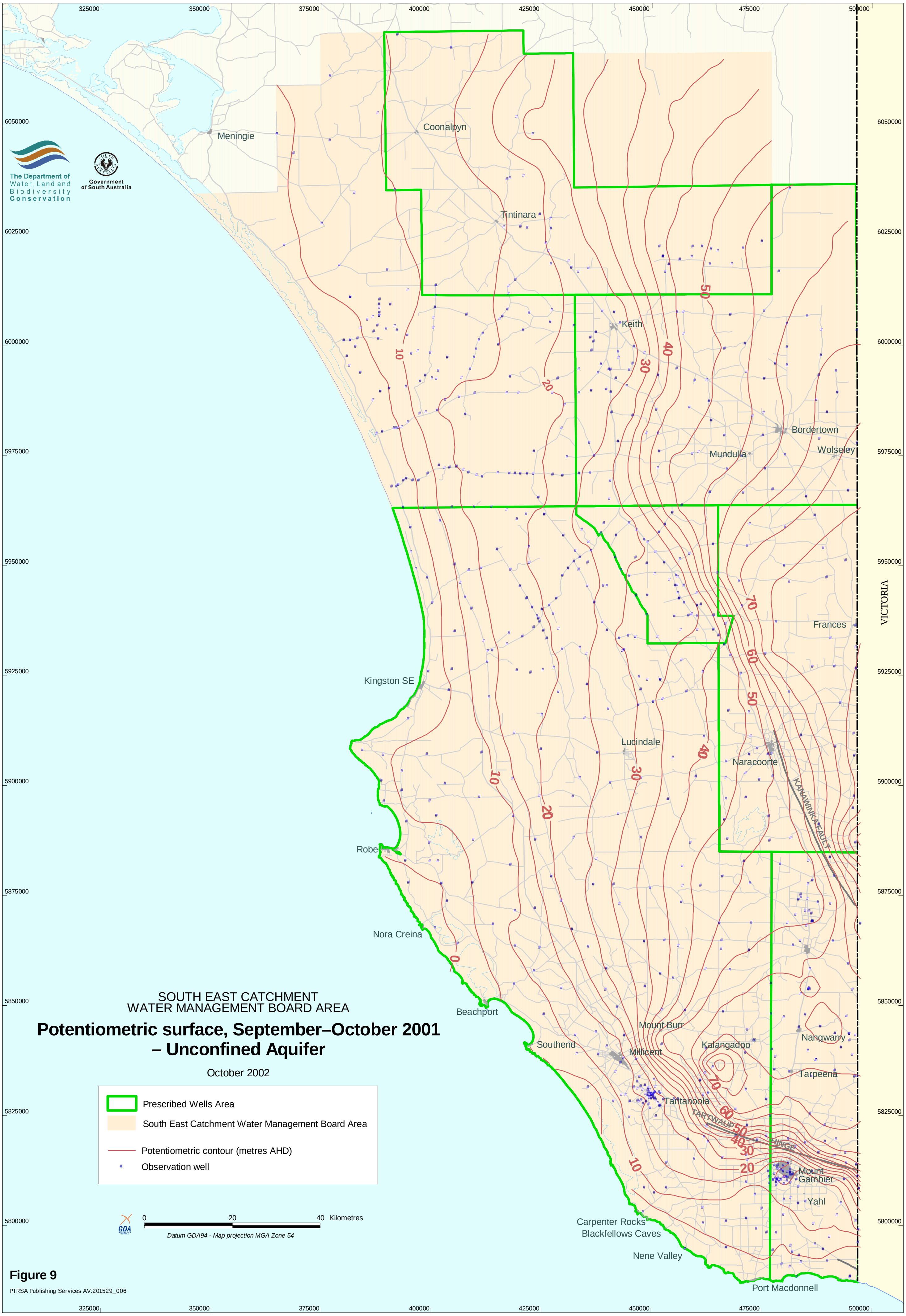
Unconfined Aquifer

Two plans were produced of the Unconfined Aquifer potentiometric surface at September–October 2001 (Fig. 9) and March 2002 (Fig. 10). Potentiometric surface contours indicate the direction and velocity of groundwater flow.

There are two distinct steep gradients of groundwater flow which coincide with the Tartwaup Hinge and Kanawinka Fault. The steepening of groundwater levels near the Tartwaup Hinge is caused by the hinge property of the fault. Beyond the Tartwaup Hinge moving southward to the sea, the Unconfined Aquifer ‘thickens out’, enabling groundwater levels to decrease contributed by the highly permeable karstic limestone. Near the hinge line and north, the unconfined limestone thins and has less karstic features and becomes more marl-clay dominant, and therefore less permeable. The Nangwarry–Tarpeena high that is associated with the Tartwaup Hinge dominates the groundwater flow pattern in the southern region of the South East. North of this region, groundwater flow direction is more uniform.

The groundwater hydraulic gradient is relatively steep up-gradient of the Kanawinka Fault indicative of either lower hydraulic conductivity in the Bridgewater Formation Aquifer or a change in the flow dynamics related to the fault. On the plain moving west from the fault the hydraulic gradient is much lower, reflecting the high transmissivity of the Padthaway and Bridgewater Formation sub-aquifers.

There is very little difference between the potentiometric heads for the Unconfined Aquifer for the two periods of time presented (Figs 9, 10), reflecting that even relatively intense groundwater use has no significant impact on water levels in the Unconfined Aquifer believed to be due to the significant volumes of water in storage.

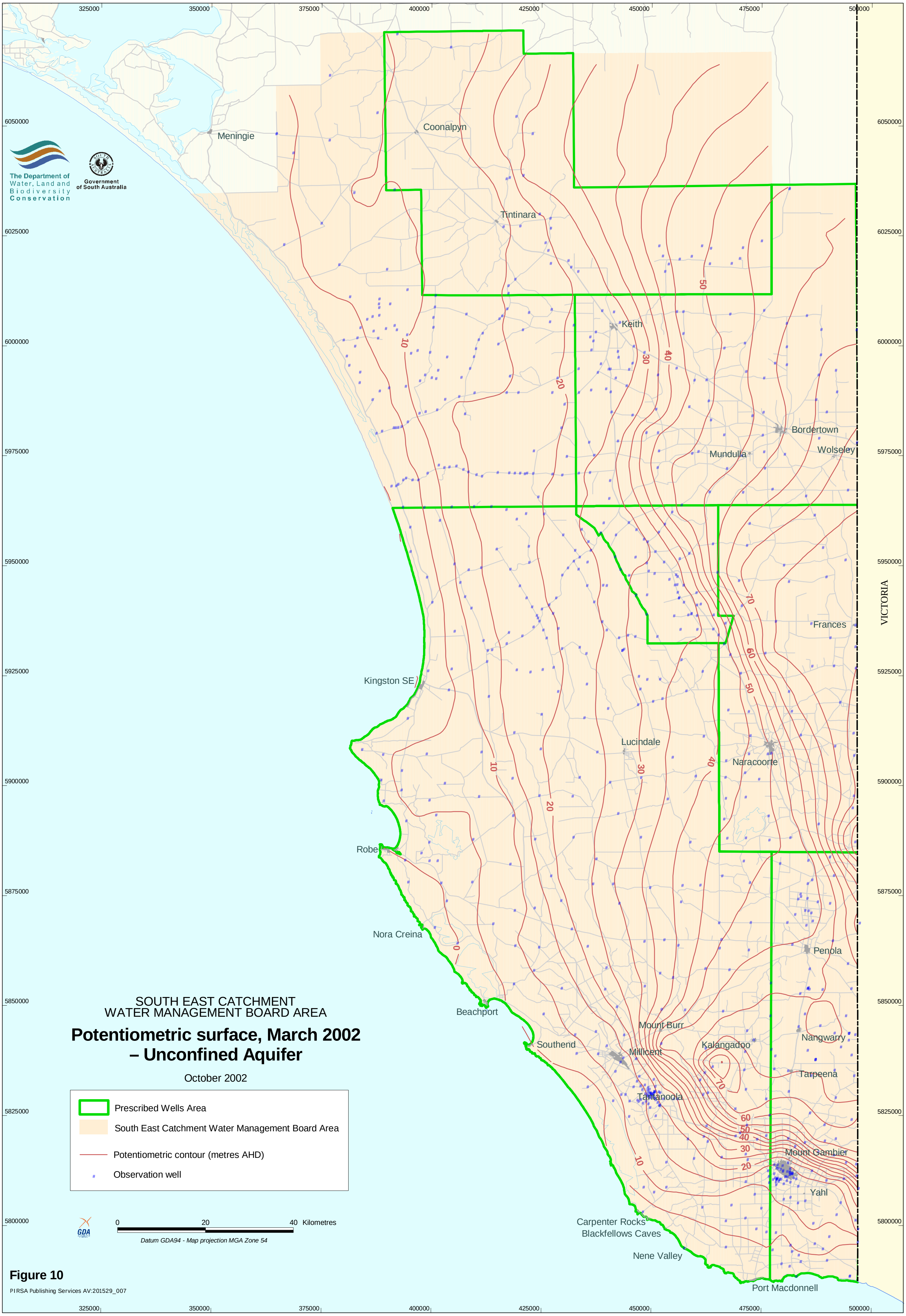


SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA

Potentiometric surface, September–October 2001 – Unconfined Aquifer

October 2002

Figure 9



SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA

Potentiometric surface, March 2002 – Unconfined Aquifer

October 2002

Figure 10

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TRENDS

The main water level trends evident in the South East region as illustrated by selected observation well hydrographs shown in Appendix A are:

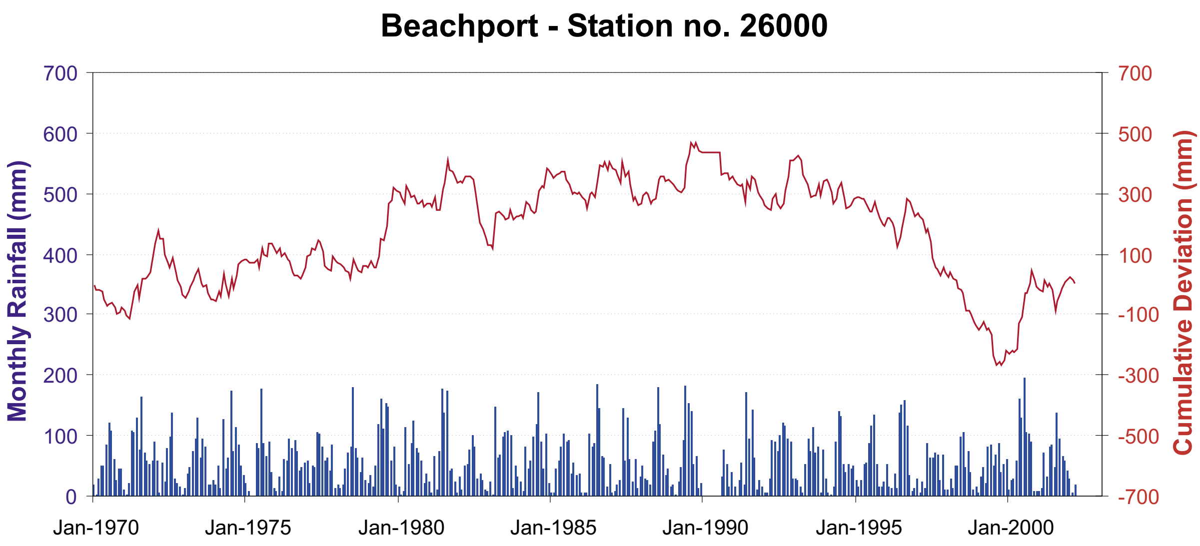
- A decline in water levels due to irrigation extraction in the area around Keith and possibly near Bordertown (observation wells ARC 7, STR 12 and TAT 18).
- Rising groundwater levels in the more elevated areas of the upper South East area, due to native vegetation clearance and loss of lucerne crops in the mid 1970s, which has resulted in increased recharge rates to the aquifer (observation wells BMA 10 and PAR 36).
- Relatively stable long-term water level trends, particularly in the area south of Lucindale, which is attributed in part to the long established drainage system, which removes excess surface water during the winter–spring period (ROS 5 and SPE 6).
- A distinct lowering of groundwater levels near Millicent (Snuggery) associated with the large groundwater extraction (~15 000 ML/y) for a paper mill, which has resulted in a localised cone of drawdown. The hydrograph for observation well HIN 38 illustrates this impact.
- A long-term decline in groundwater levels associated with areas of softwood plantations in parts of the lower South East (observation wells CAR 19 and CAR 48).
- A noticeable regional decline in groundwater levels over the last nine years associated with a period of below average rainfall and therefore reduced recharge to the Unconfined Aquifer (observation wells CMM 20, KEN 5, NAN 20, GAM 29, PET 4, JOA 4 and MAC 46).

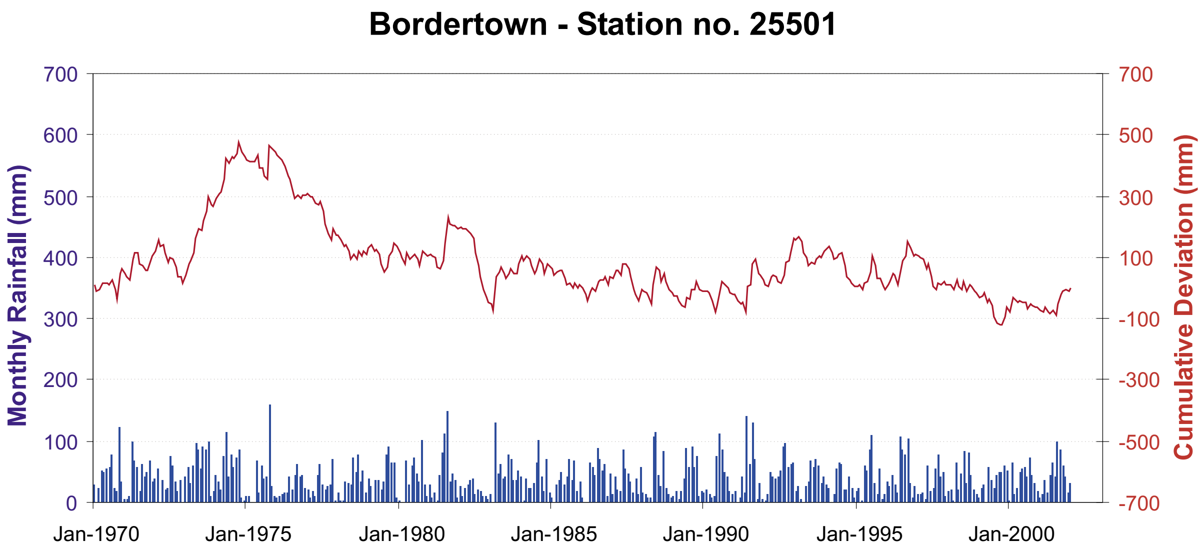
Seven rainfall stations were selected, shown on Figures 1 and 11(a–c). Cumulative deviation has been plotted in Figure 11 for these rainfall stations to identify extended periods where rainfall has been above or below the annual average, and these plots illustrate the below average rainfall experienced in the South East since 1992. The relationship between rainfall and the response of the Unconfined Aquifer is shown in Figure 12 where select hydrographs are plotted against cumulative deviation.

Confined Aquifer

The potentiometric heads for the Confined Aquifer for two selected time periods, September–October 2001 and March 2002, are shown in Figures 13 and 14. Flow direction is similar to the Unconfined Aquifer, being southerly in the region to the south of the Nangwarry–Tarpeena high, whereas above this region flow is more in a westerly direction.

The change in potentiometric head over the period September–October 2001 to March 2002 (Fig. 15) illustrates a noticeable seasonal decline in head inland from Kingston to Beachport (either side of Princess Highway) associated with the irrigation groundwater use in this area. The heads in the Confined Aquifer generally show a seasonal fluctuation ranging from 7 to 10 m annually as a result of these groundwater withdrawals. In the Tintinara–Coonalpyn region there is also notable fluctuation in groundwater levels which is also caused by pumping; this is further discussed in Barnett (2002).





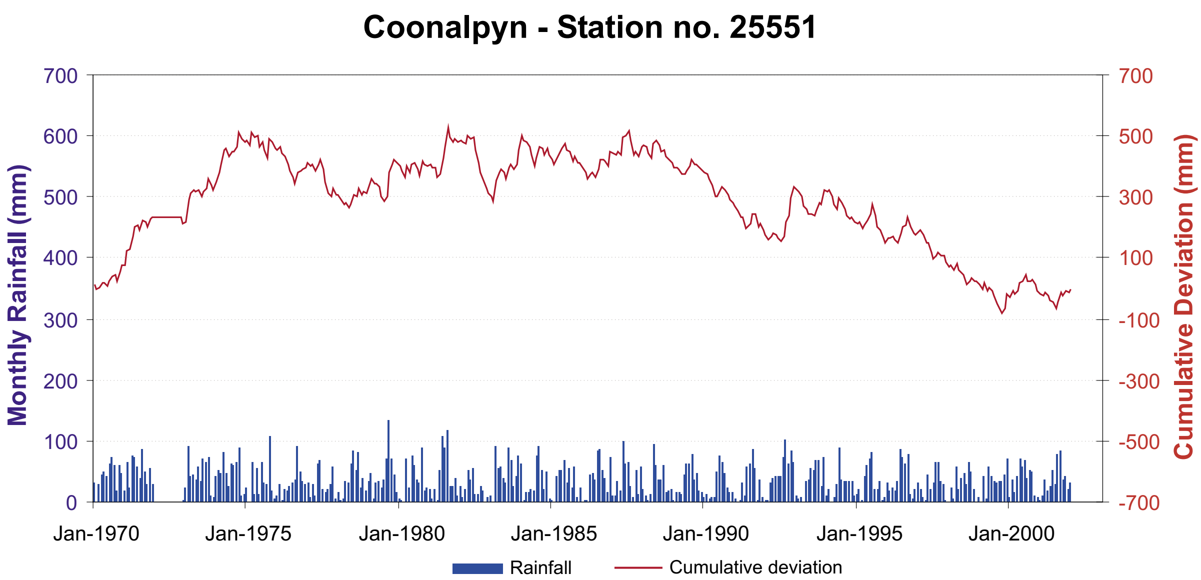


Figure 11(a) Monthly rainfall and cumulative deviation

201529_008

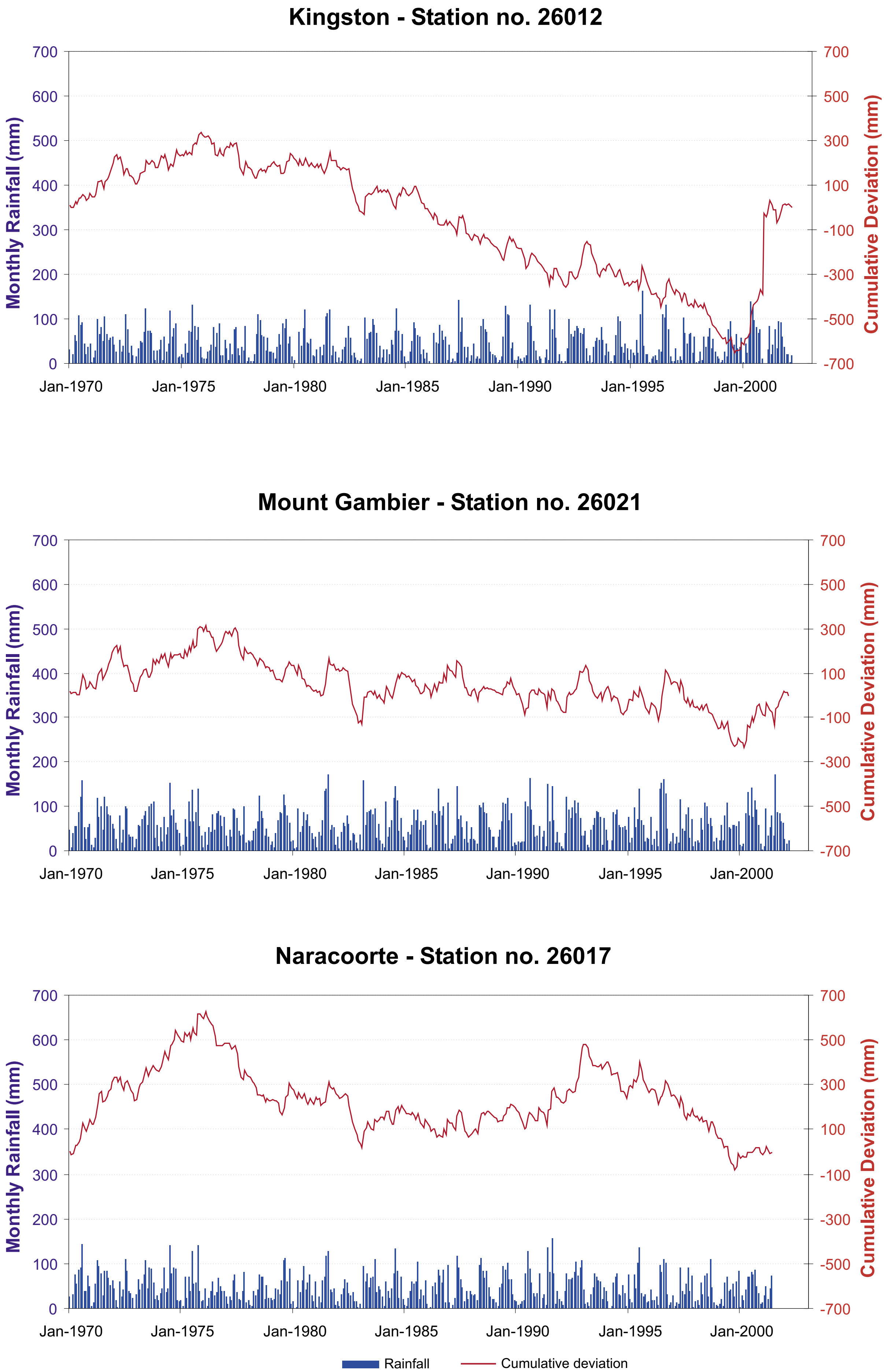


Figure 11(b) Monthly rainfall and cumulative deviation

201529_008

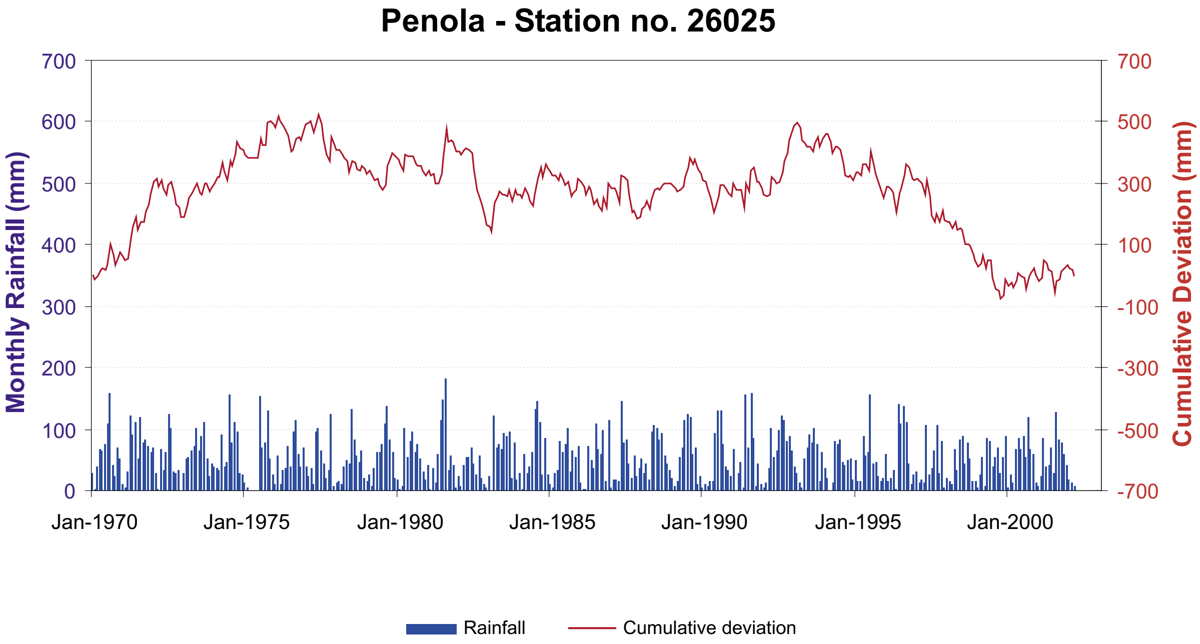


Figure 11(c) Monthly rainfall and cumulative deviation

201529_008

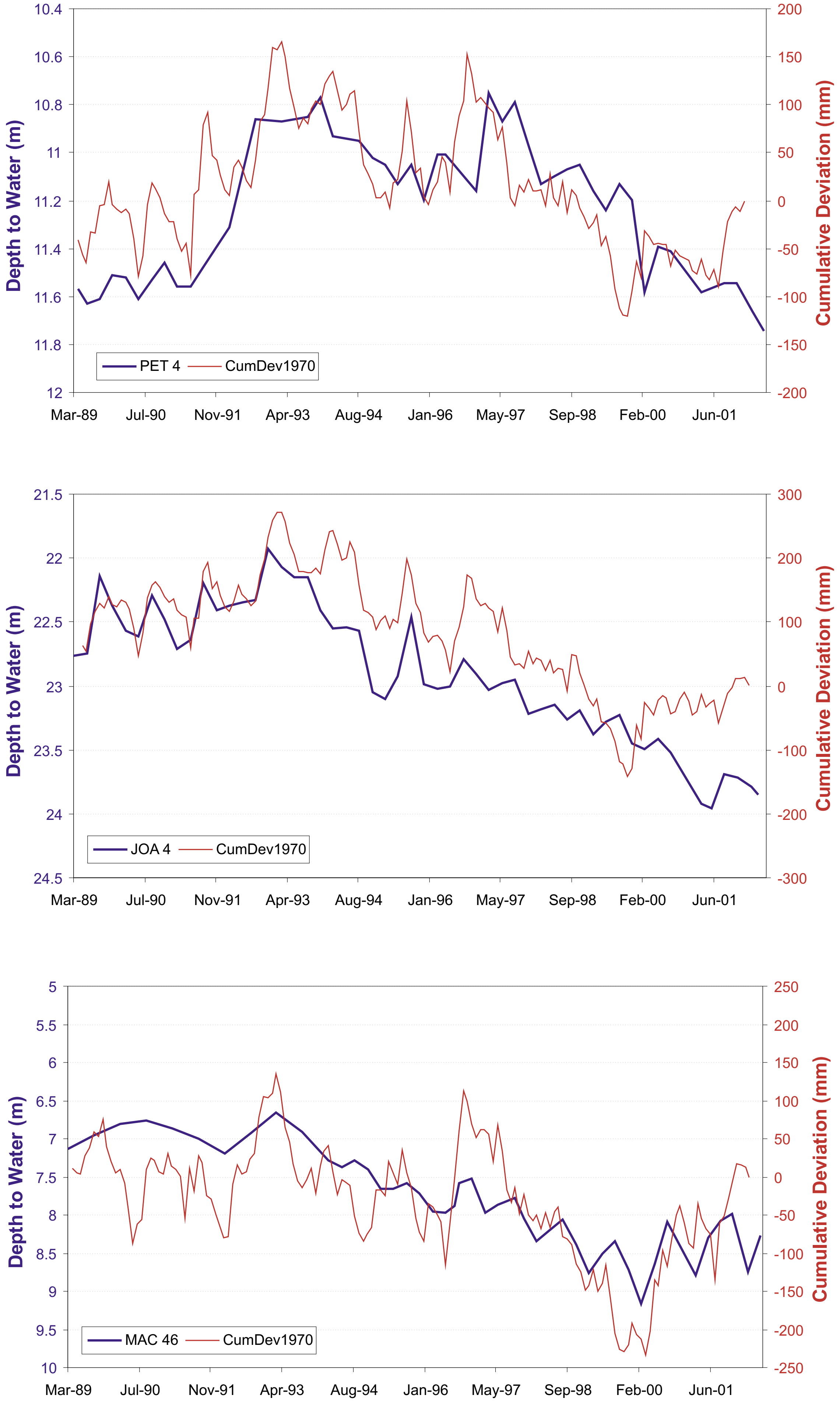
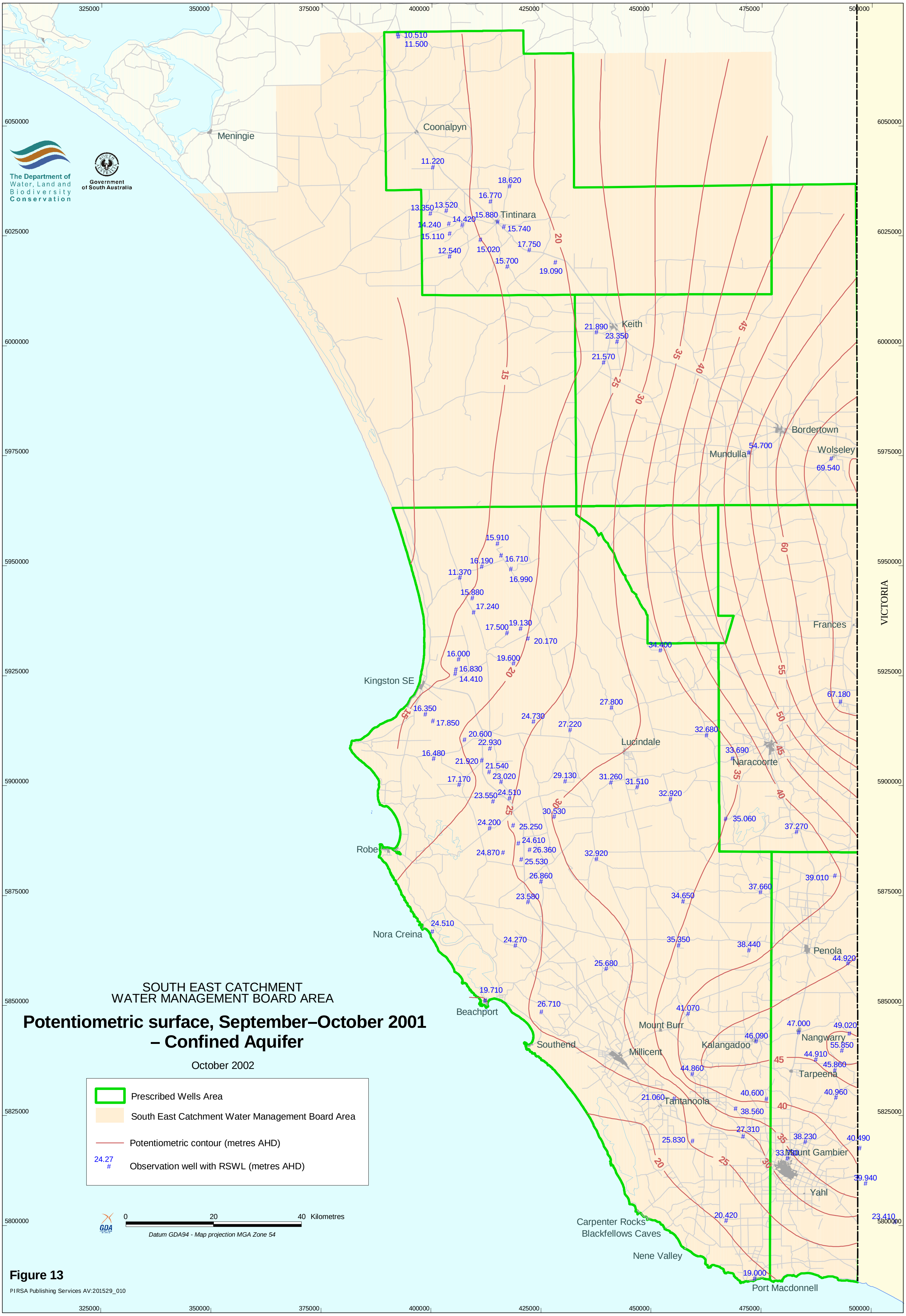


Figure 12 Unconfined aquifer hydrographs compared to cumulative deviation (taken from data collected in 1970)

201529_009



SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA

Potentiometric surface, September–October 2001 – Confined Aquifer

October 2002

Figure 13

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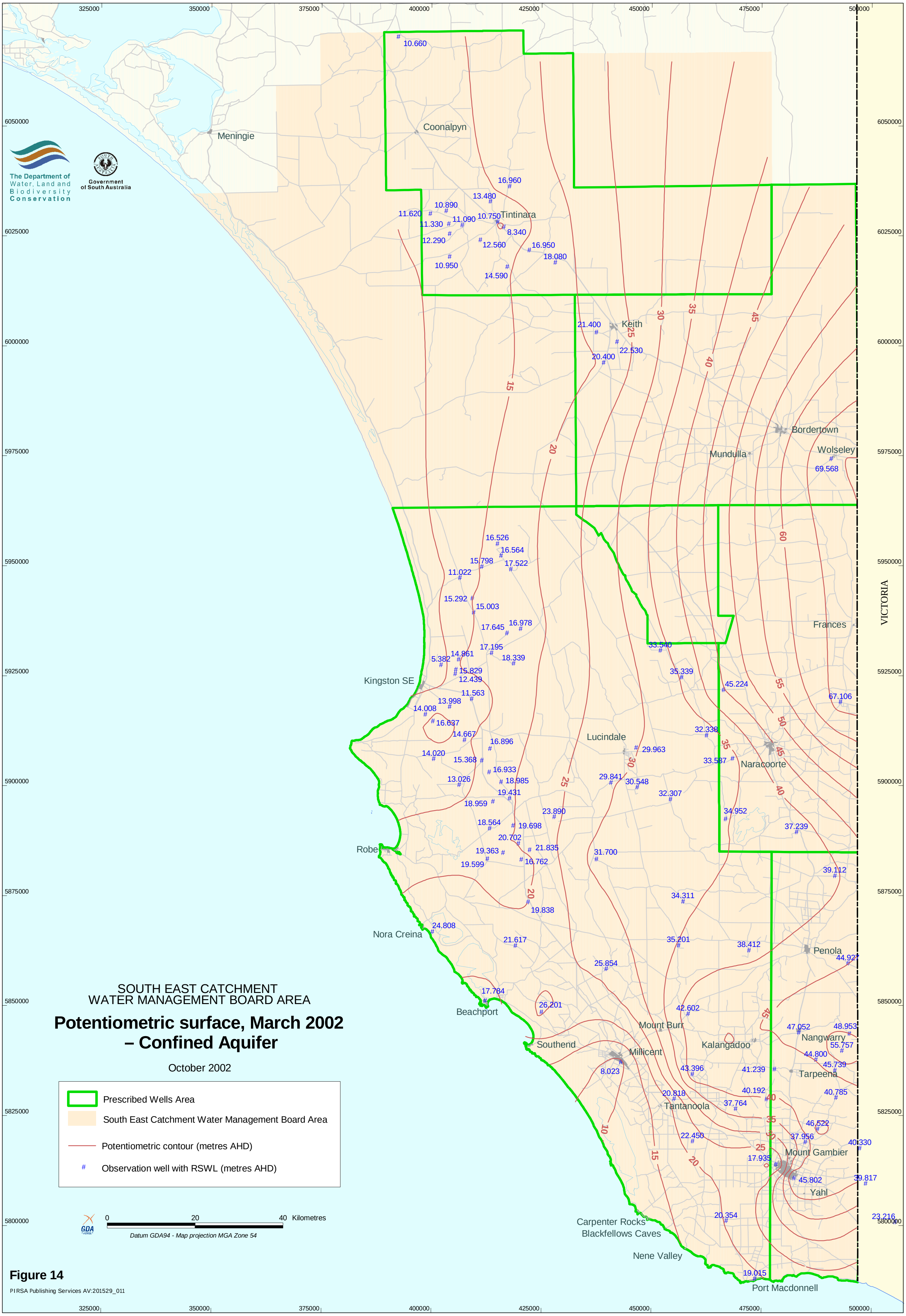

SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA

Potentiometric surface, March 2002 – Confined Aquifer

October 2002

Figure 14

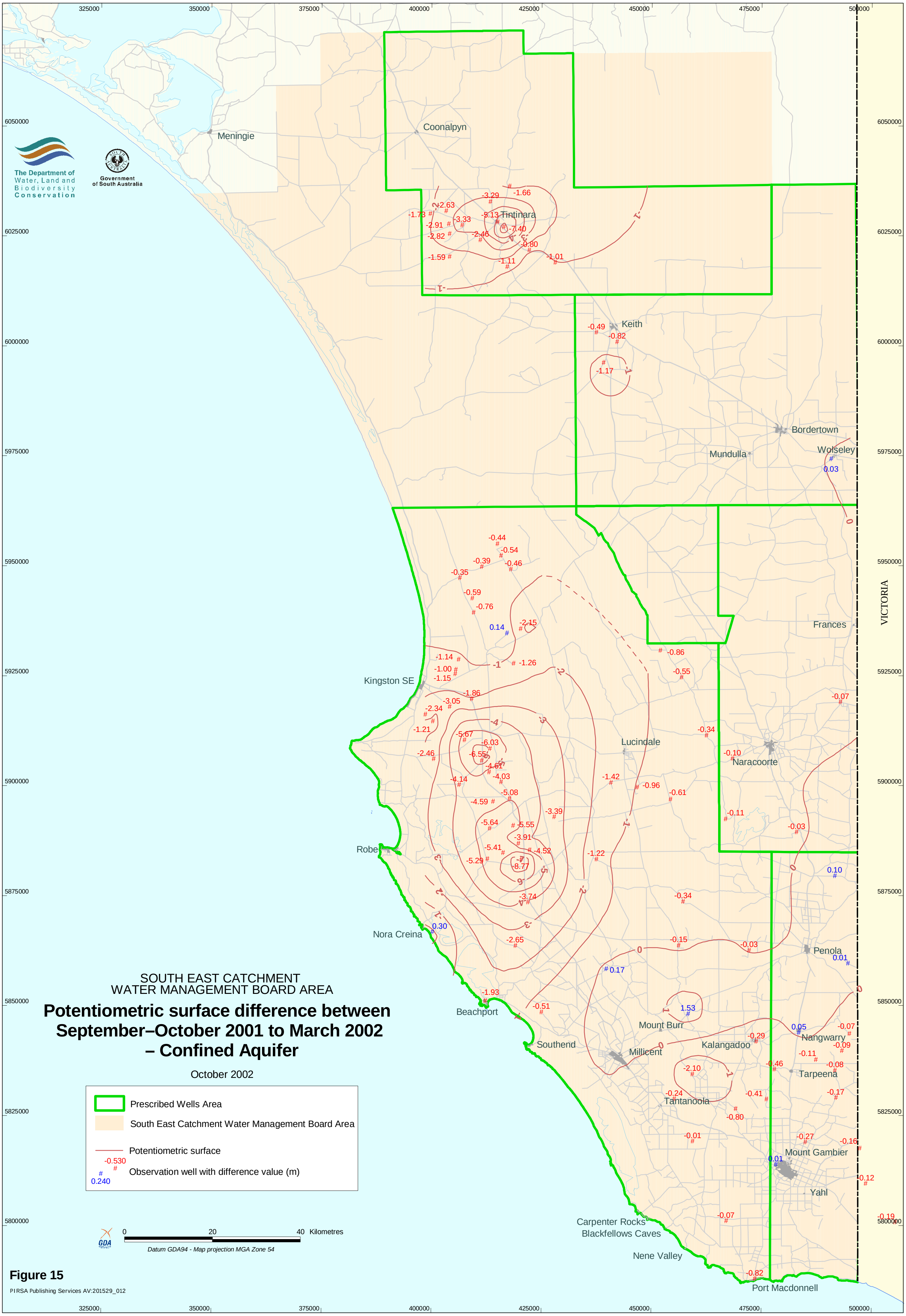

Figure 15

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TRENDS

The hydrographs for Confined Aquifer observation wells in the central artesian area (inland of Kingston to Beachport) show significant fluctuations between seasons due to the high levels of irrigation use as discussed previously. The overall trends are mainly stable showing that intensive extraction in this part of the region has not greatly stressed the resource (Appendix B for observation wells ROS 10, BOW 18 and JOY 15).

Away from the Kingston–Beachport area, water levels tend to be relatively stable until 1993, after which declining trends are evident; illustrated in Appendix B for observation wells ARD 1, HIN 30, PEN 25 and MAC 57. This downward trend is believed to be a result of the below average rainfall over the last nine years (Fig. 12). The decline in water levels in the Confined Aquifer is attributed to a decrease in overburden pressure associated with the decrease in recharge rates over the same period in the Unconfined Aquifer (Brown et al., 2001).

CURRENT SALINITY ANALYSIS

Unconfined Aquifer

The distribution of salinity observation wells monitoring the Unconfined Aquifer is shown in Figure 7. In general, groundwater salinity increases from less than 500 mg/L in the south to greater than 4000 mg/L in the north, reflecting largely the reduction in annual rainfall and therefore recharge to the north (Fig. 16).

The aquifer shows distinct vertical and short-range lateral variations in salinity, which cannot be characterised by the regional spread of the monitoring wells. Patches of high salinity occur near intensive irrigation areas. This can be seen near Padthaway and Keith.

TRENDS

Appendix C shows key salinity graphs in the South East region.

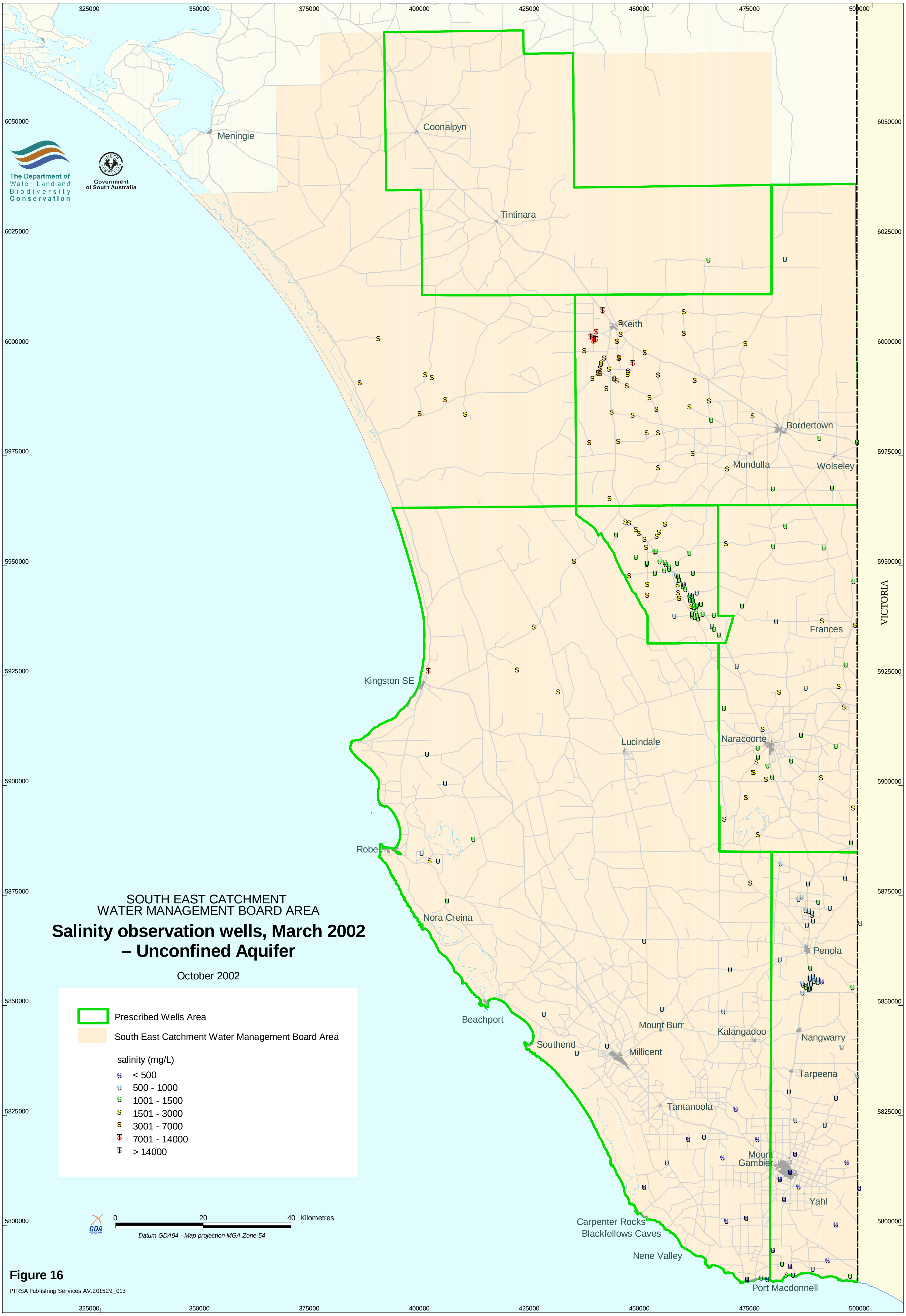
Increasing salinity trends are evident in areas that are intensively irrigated, particularly the Padthaway (GLE 99), Keith (STR 103), Coonawarra (CMM 79) and Naracoorte (JES 50, NAR 50) regions.

In the upper parts of the South East region (Naracoorte–Bodertown district), increasing salinity trends are evident due to the mobilisation of soil accumulated salts resulting from the increased recharge rates associated with native vegetation clearance and loss of lucerne crops as discussed previously (SEN 17, BMA 13, PET 104).

In other parts of the South East region, no discernible long-term salinity trends are evident (BLA 68, MTB 9, BRA 23 and MAC 47).

Confined Aquifer

Groundwater salinity in the Confined Aquifer is quite uniform and less than 1000 mg/L over the southern area of the South East (Fig. 17). In the upper parts of the South East, the Confined Aquifer's salinity increases rapidly as the aquifer thins and groundwater circulation becomes restricted near the Padthaway ridge. Salinity monitoring has revealed no discernible salinity trend.

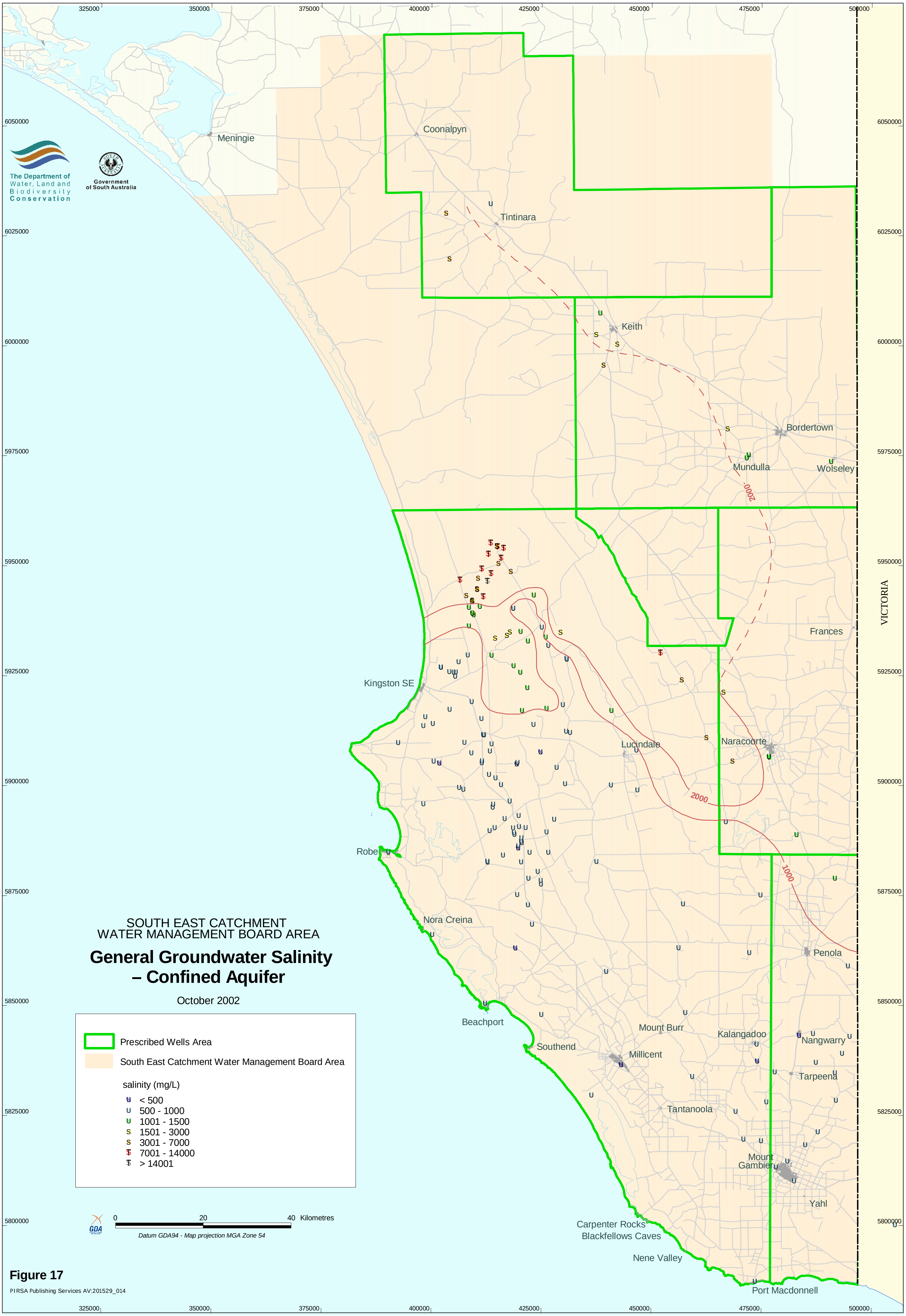


SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA

Salinity observation wells, March 2002 – Unconfined Aquifer

October 2002

Figure 16



SOUTH EAST CATCHMENT
WATER MANAGEMENT BOARD AREA
General Groundwater Salinity
– Confined Aquifer
October 2002
Prescribed Wells Area
South East Catchment Water Management Board Area
salinity (mg/L)
< 500
500 - 1000
1001 - 1500
1501 - 3000
3001 - 7000
7001 - 14000
> 14001
0
20
40
Kilometres
Datum GDA94 - Map projection MGA Zone 54
The Department of Water, Land and Biodiversity Conservation
Government of South Australia
Meningie
Coonalpyn
Tintinara
Keith
Bordertown
Mundulla
Wolseley
Frances
Kingston SE
Lucindale
Naracoorte
Robe
Nora Creina
Beachport
Southend
Mount Burr
Millicent
Kalangadoo
Nangwarry
Penola
Tarpeena
Tantanoola
Mount Gambier
Yahl
Carpenter Rocks
Blackfellows Caves
Nene Valley
Port Macdonnell
VICTORIA
2000
1000
325000
350000
375000
400000
425000
450000
475000
500000
6050000
6025000
6000000
5975000
5950000
5925000
5900000
5875000
5850000
5825000
5800000
PIRSA Publishing Services AV:201529_014

Figure 17

SHORTENED FORMS

Measurement

Name of unit	Symbol	Definition in terms of other metric units	
Gram	g		Mass
Kilometre	km	10^3 m	Length
Litre	L	10^{-3} m^3	Volume
Metre	m		Length
Milligram	mg	10^{-3} g	Mass
Milligrams per litre	mg/L		
Megalitre	ML	10^{-6} m^3	Volume
Megalitres per year	ML/y		
Millimetre	mm	10^{-3} m	Length

General

Shortened form	Description
AHD	Australian height datum
DWLBC	Department of Water, Land and Biodiversity Conservation
PWA	prescribed wells area
RSWL	reduced standing water level
SECWMB	South East Catchment Water Management Board
TDS	total dissolved solids

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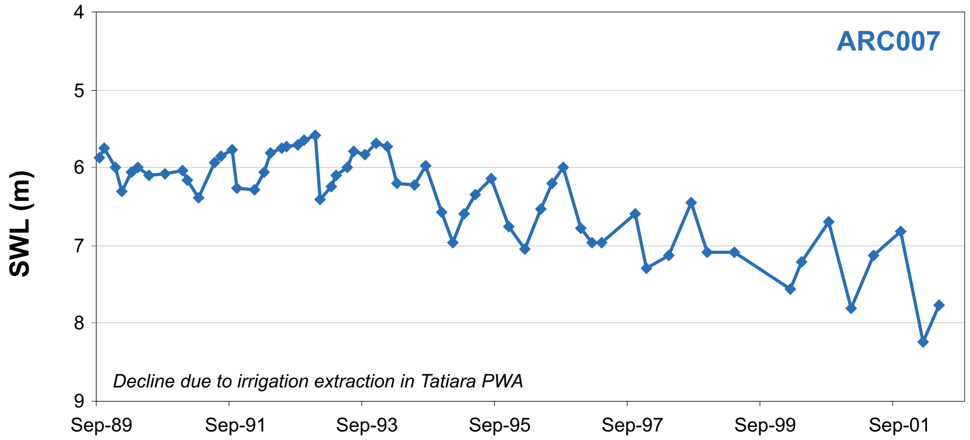
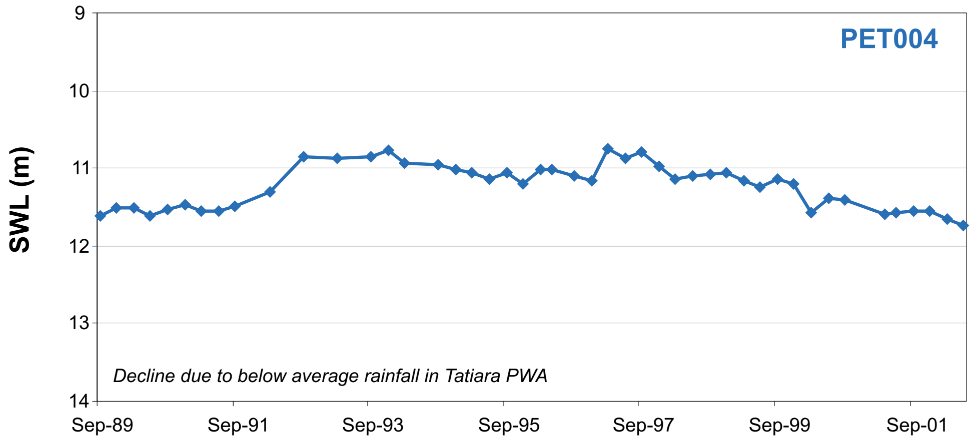
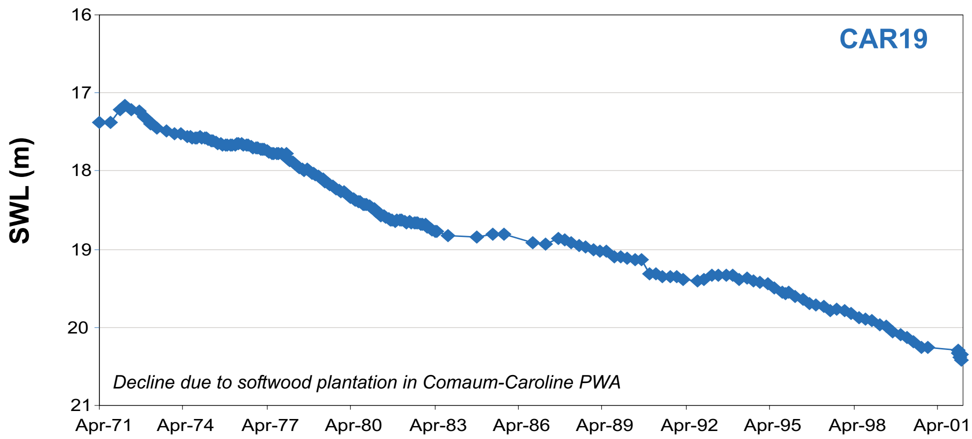
Dillon, P., Benyon, R., Cook, P., Hatton, T., Marvanek, S. and Gillooly, J., 2001. Review of research on plantation forest water requirements in relation to groundwater resources in the South East of South Australia. *South Australia. Centre for Groundwater Studies. Report,* 99.

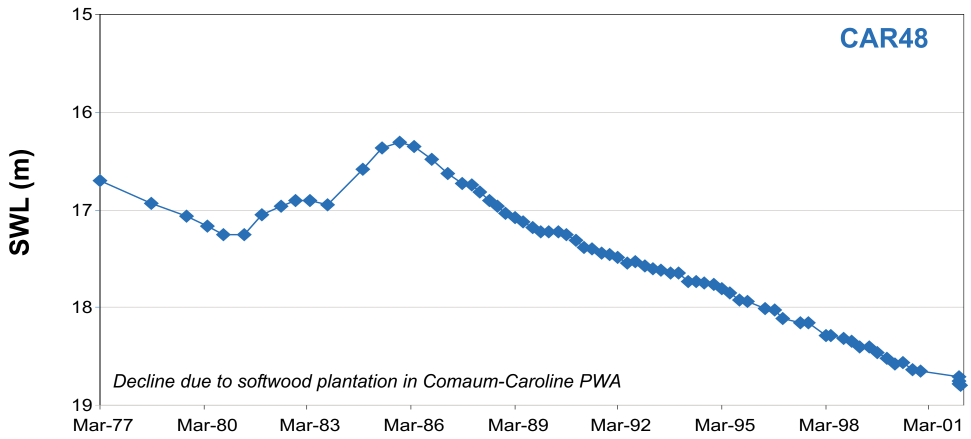
Waterhouse, J.D., 1975. The hydrogeology of the Mount Gambier area, South Eastern South Australia. *South Australia. Department of Mines. Report Book,* 75/82.

APPENDIX A
Unconfined Aquifer hydrographs









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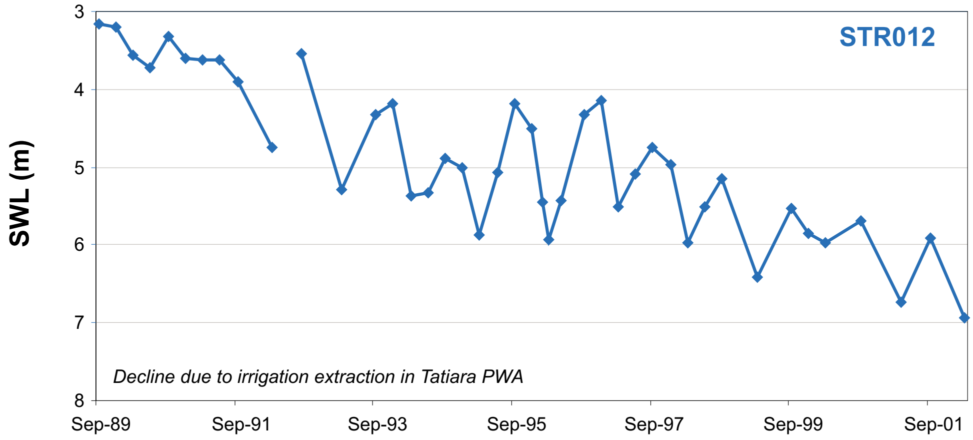
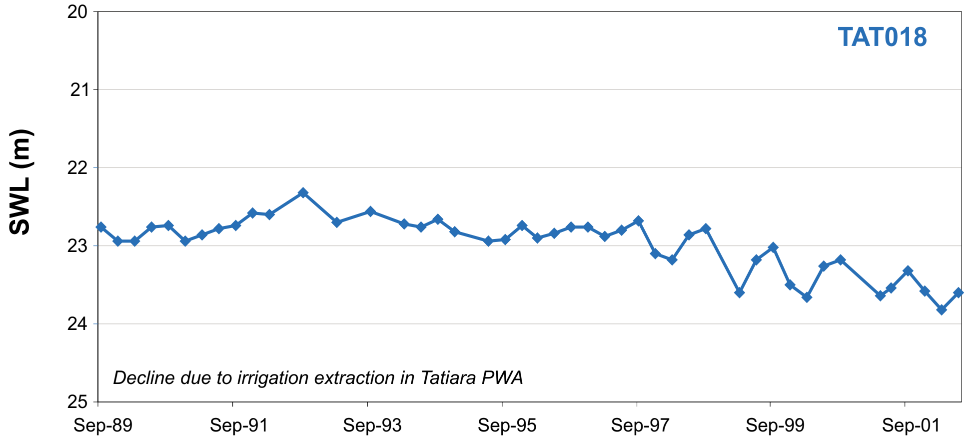
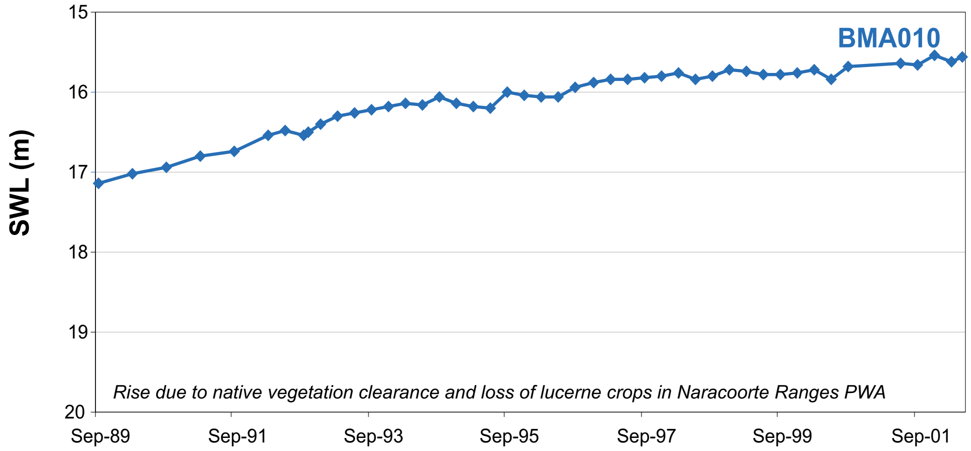
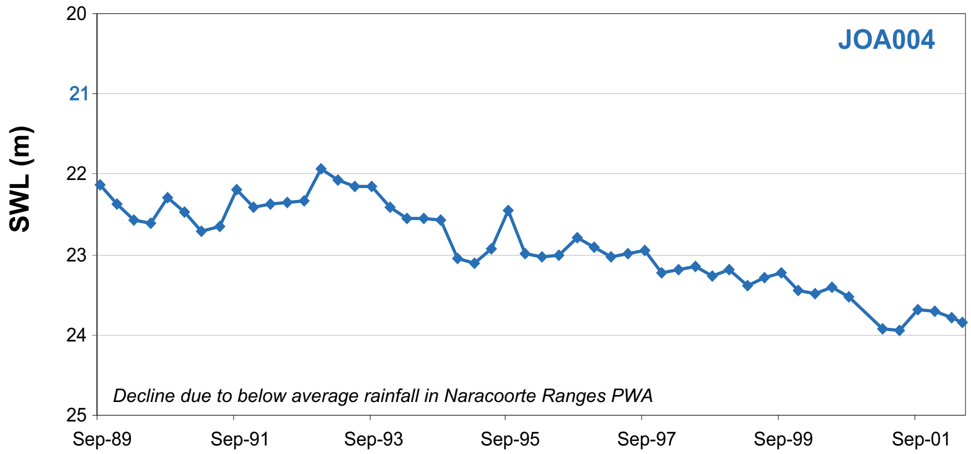
APPENDIX A (continued)









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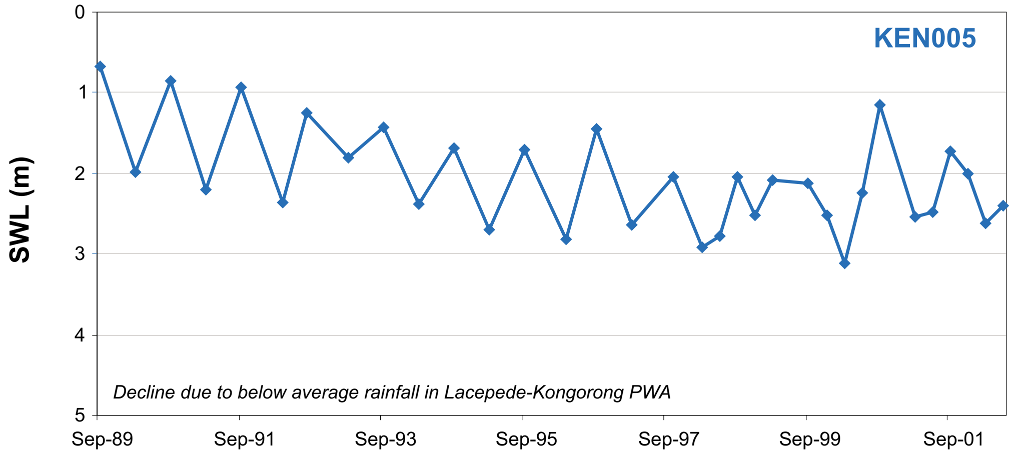

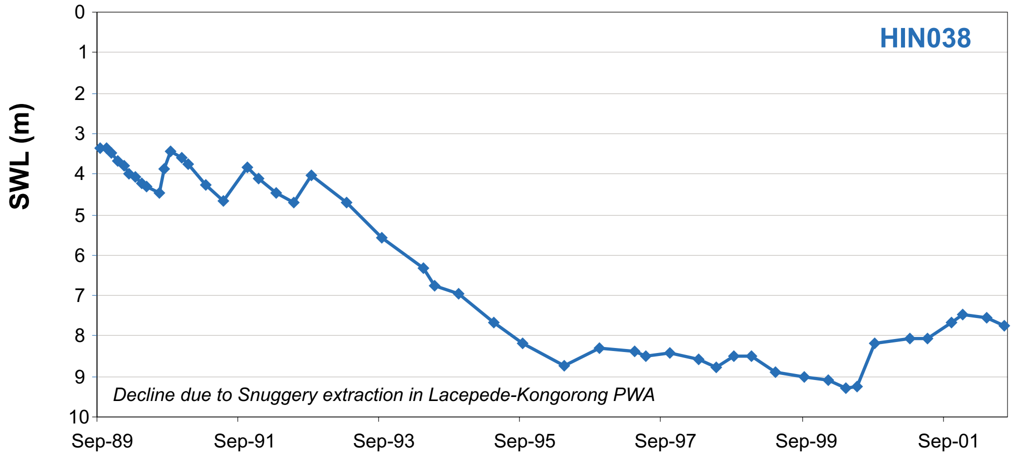

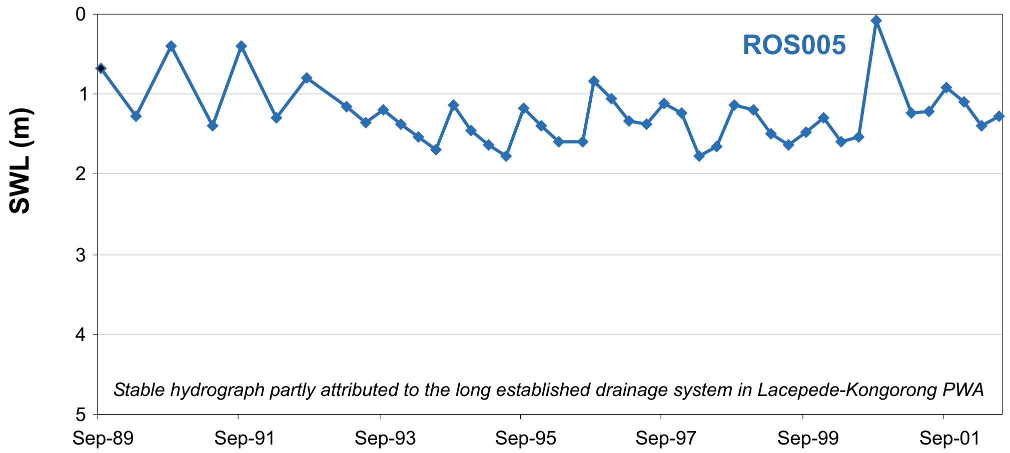

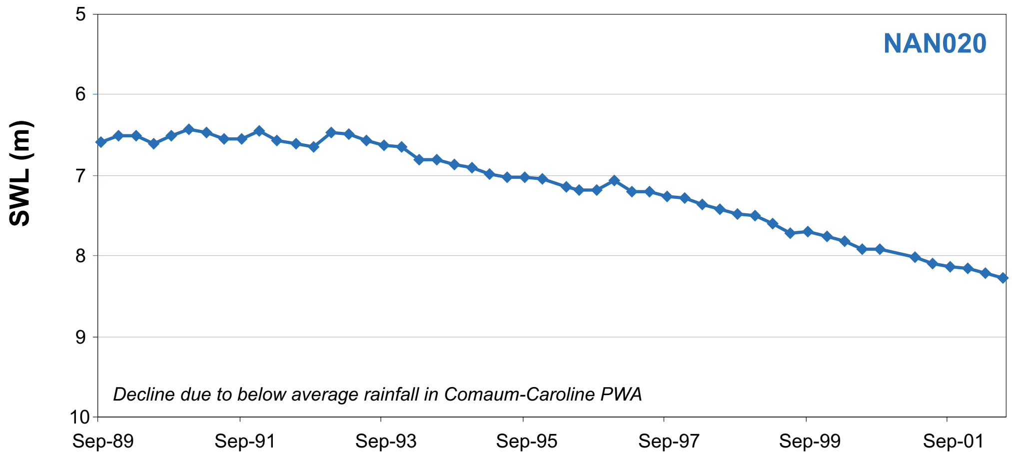

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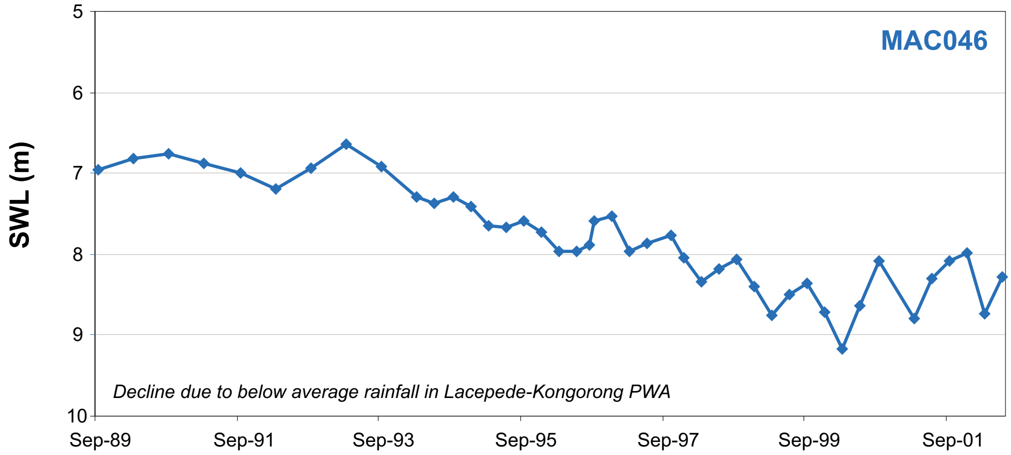

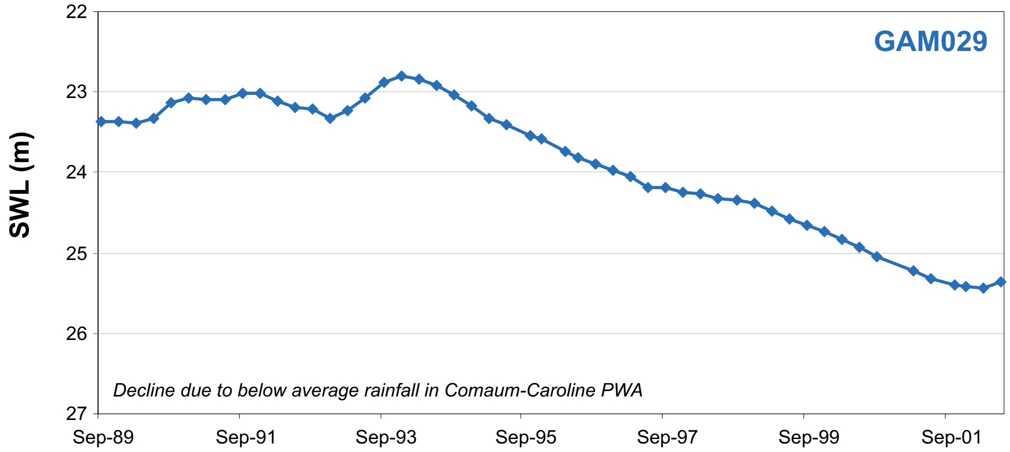

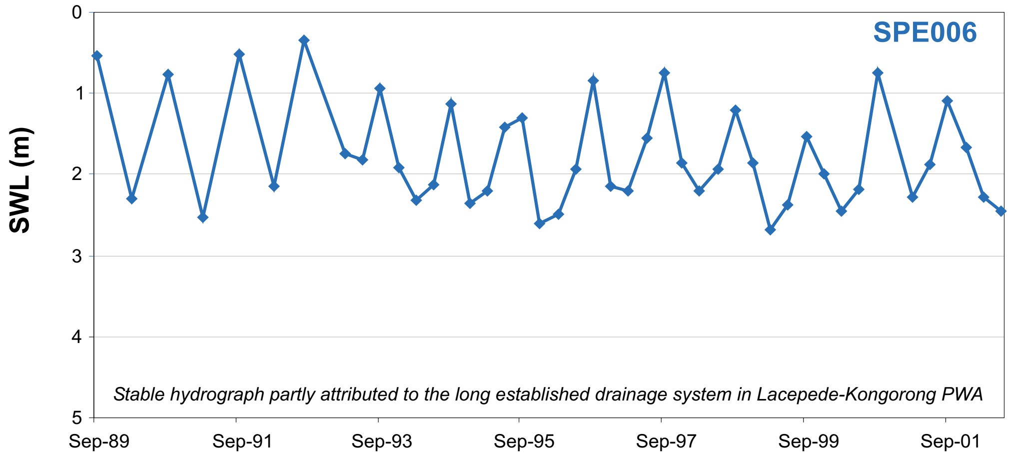

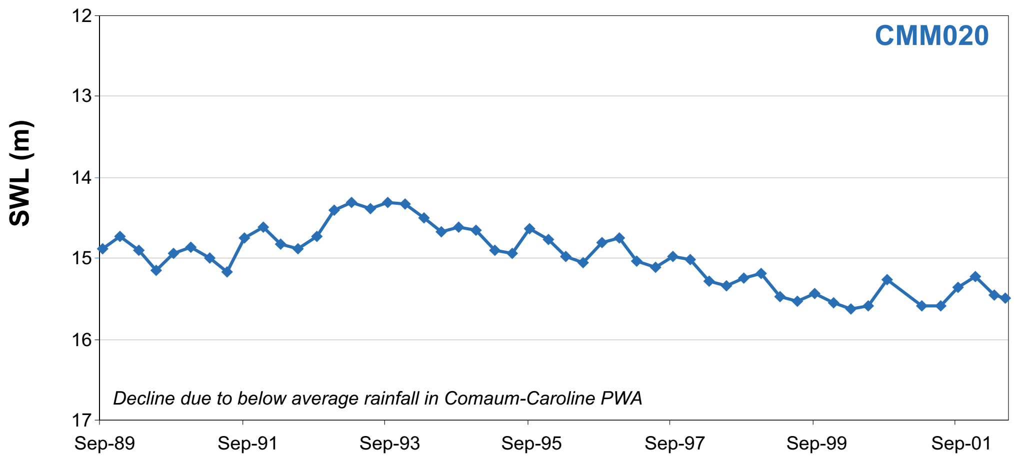

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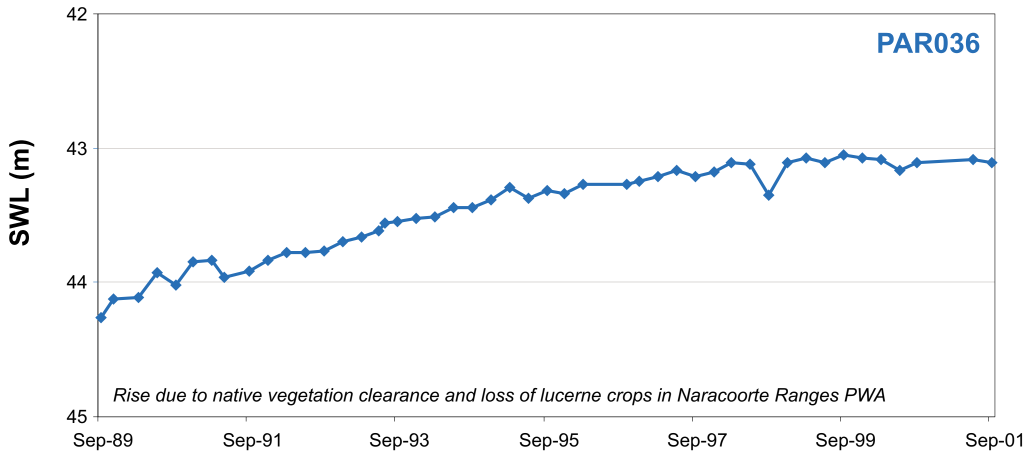
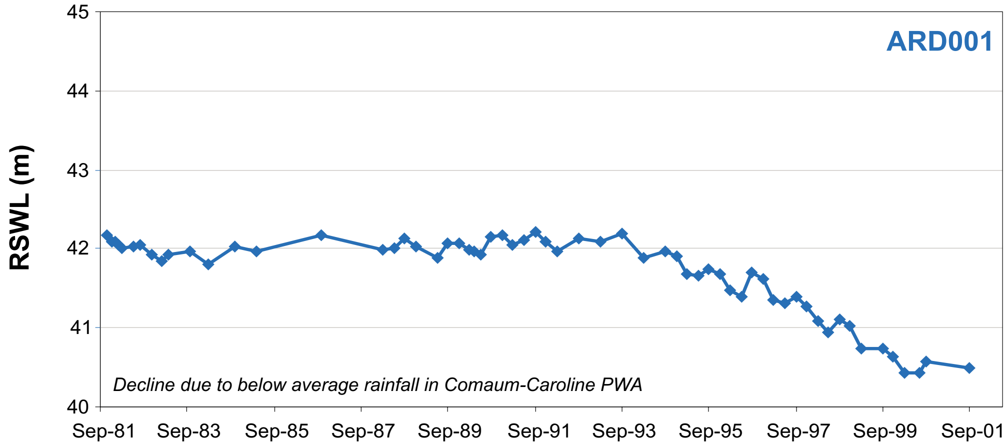
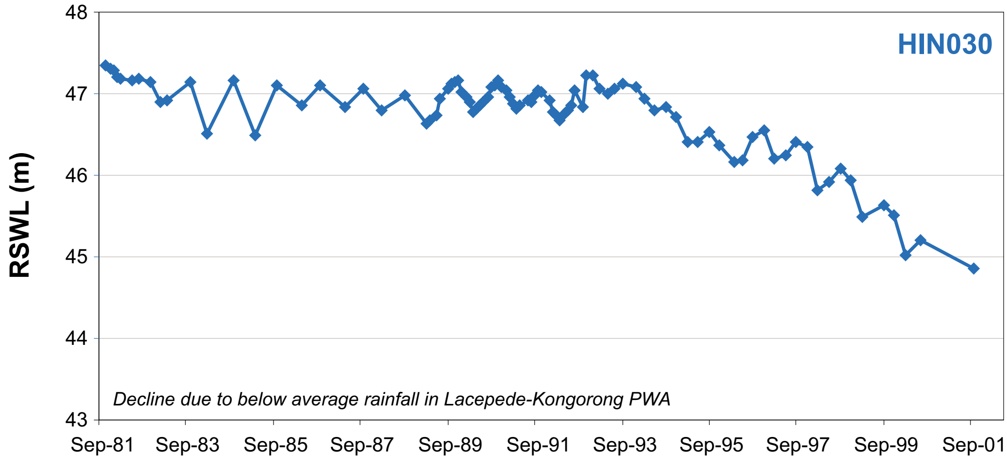
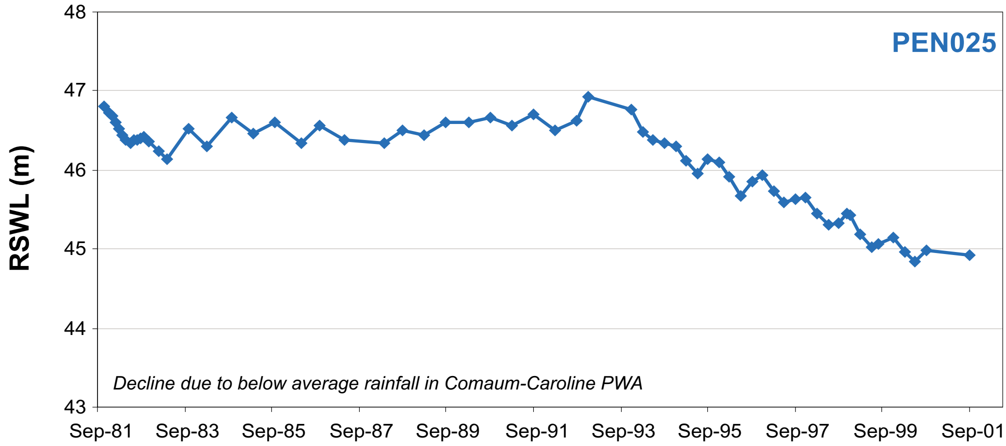
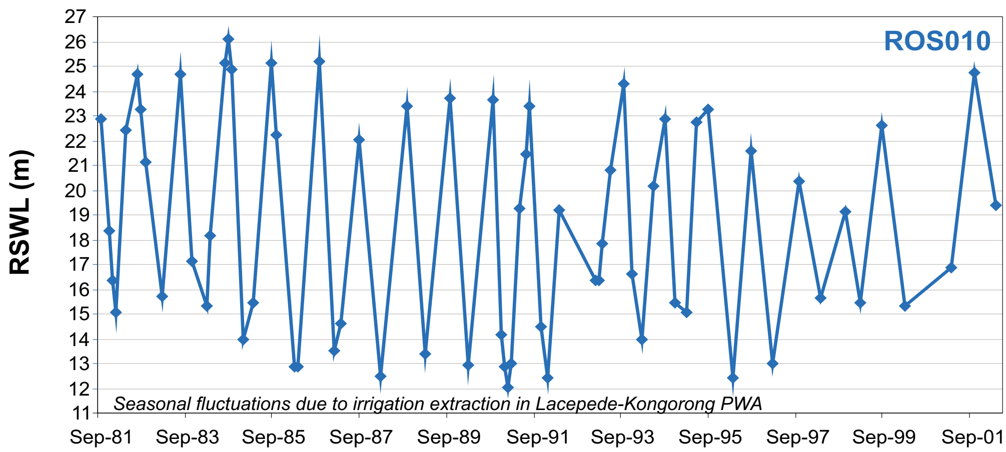


APPENDIX B
Confined Aquifer hydrographs









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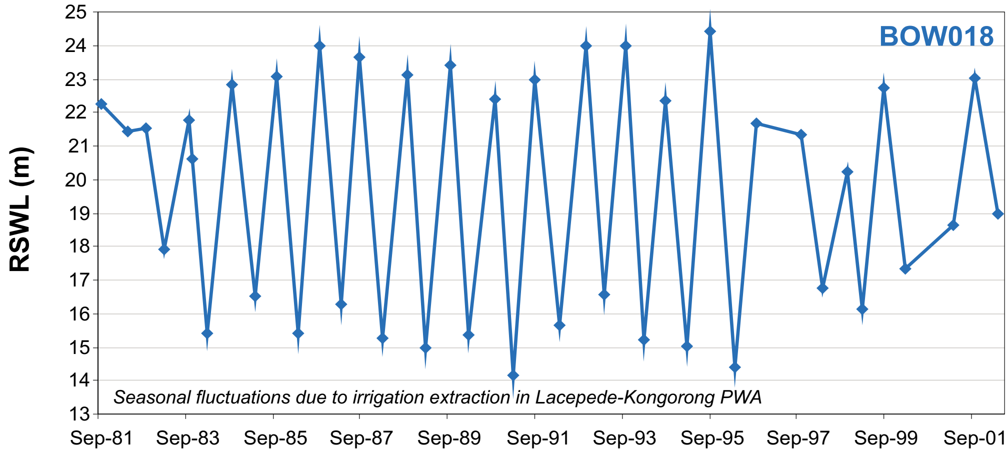

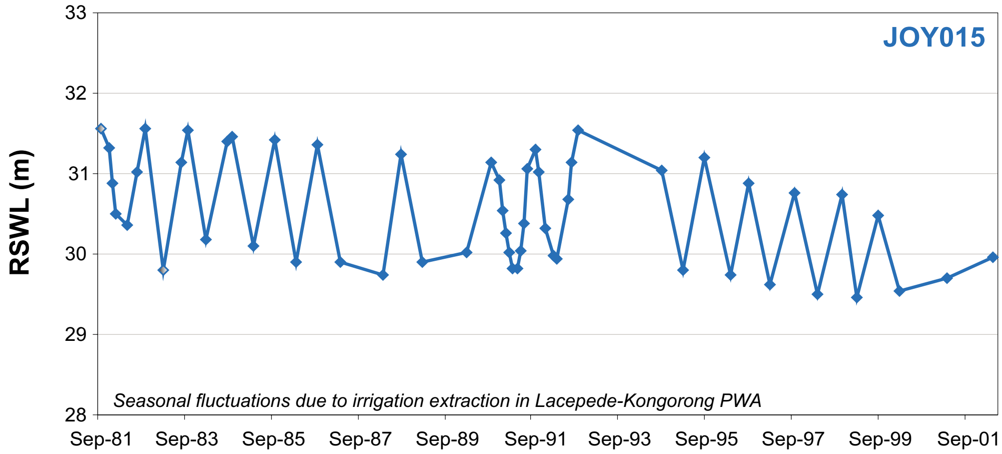

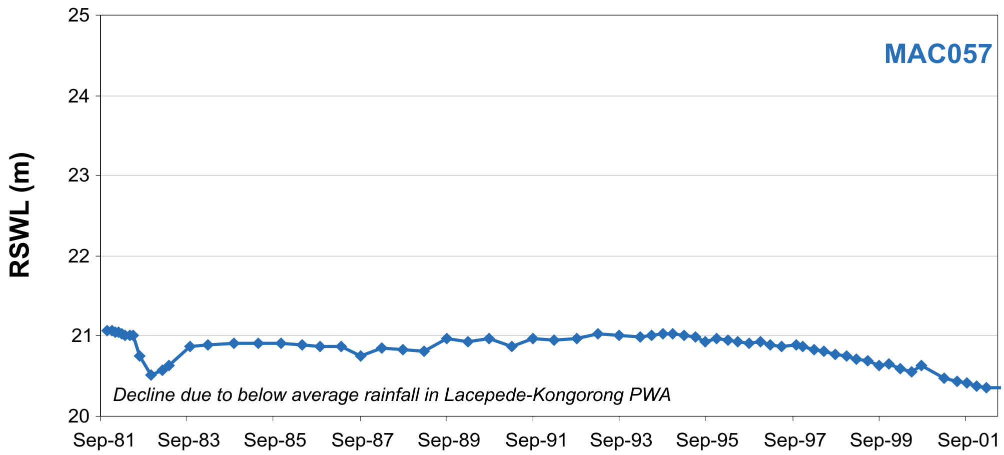

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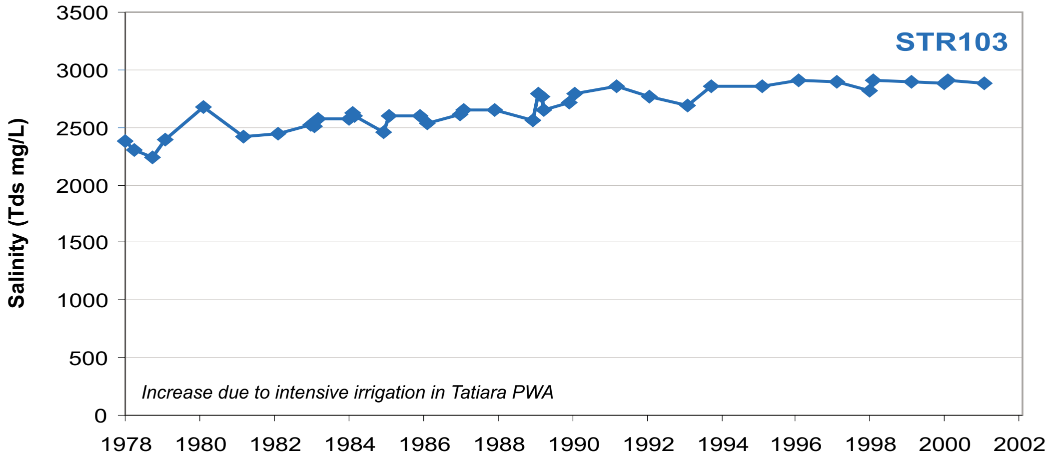
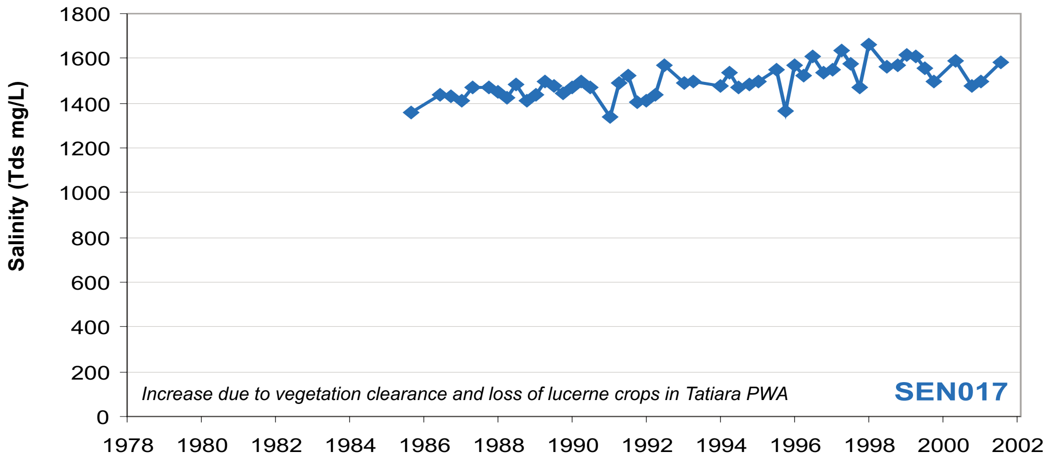
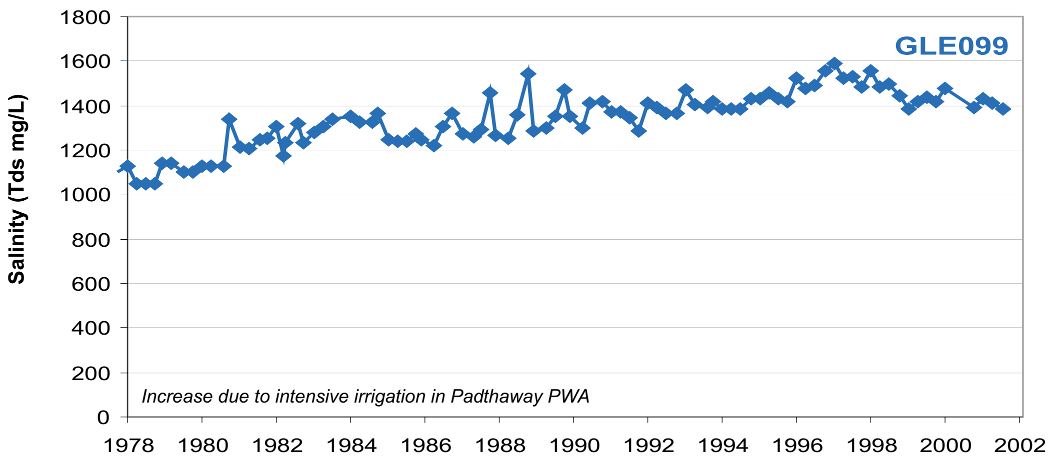
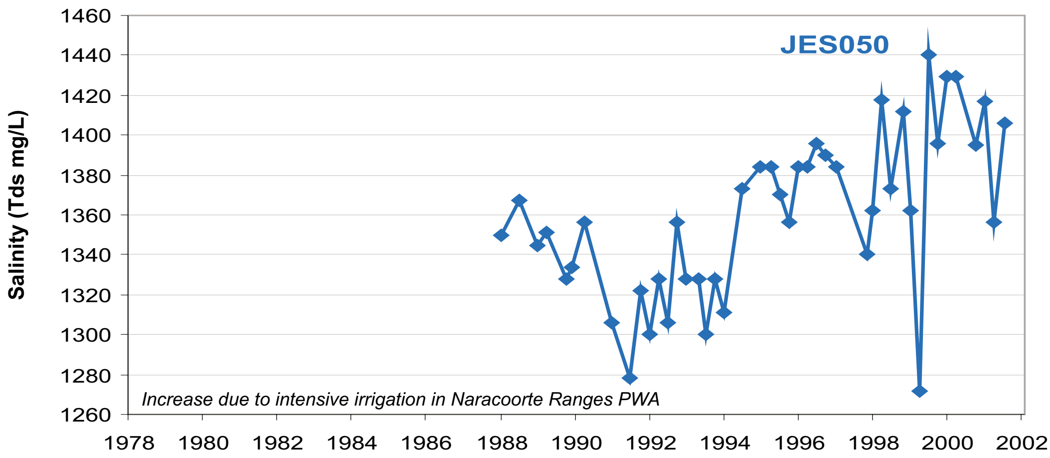
APPENDIX C
Unconfined Aquifer salinity hydrographs









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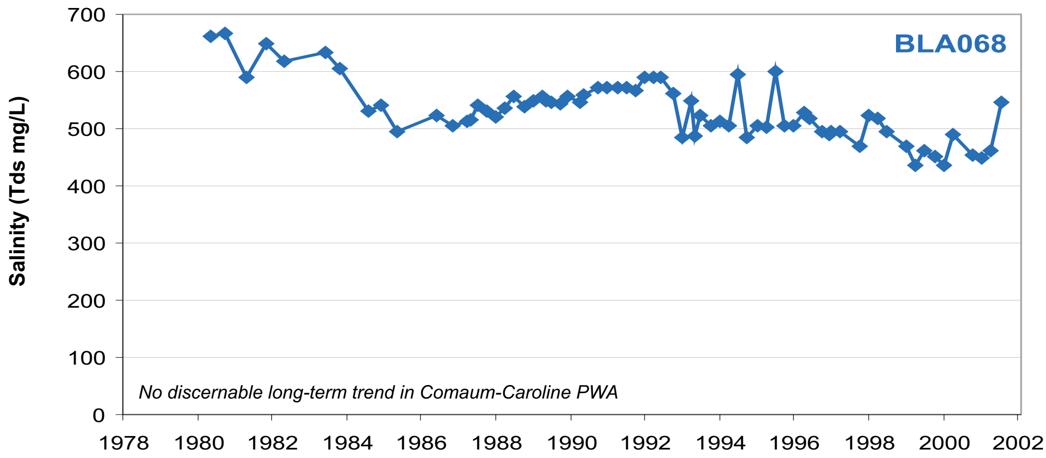
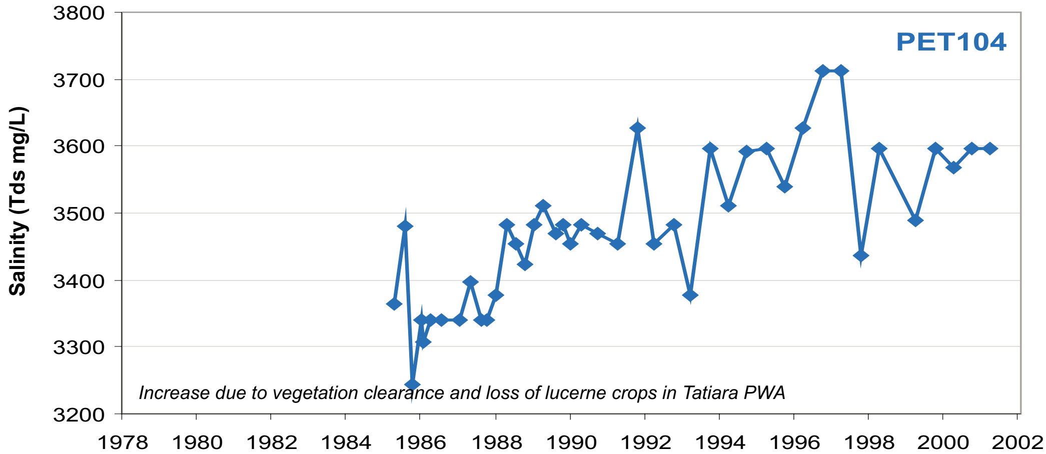
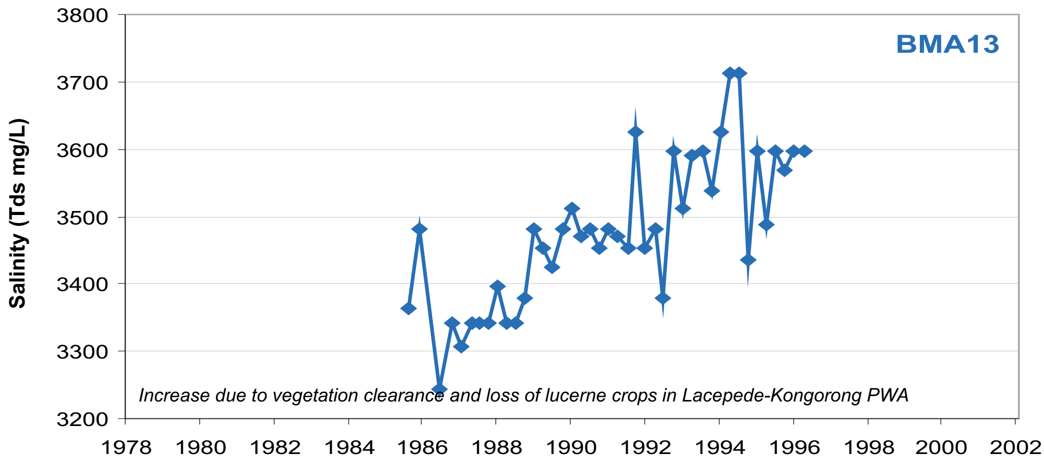
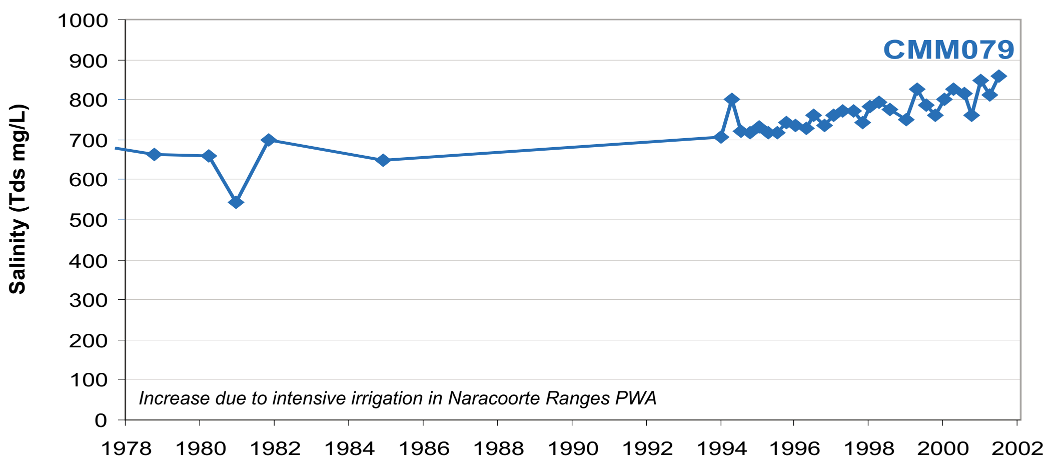
APPENDIX C (continued)









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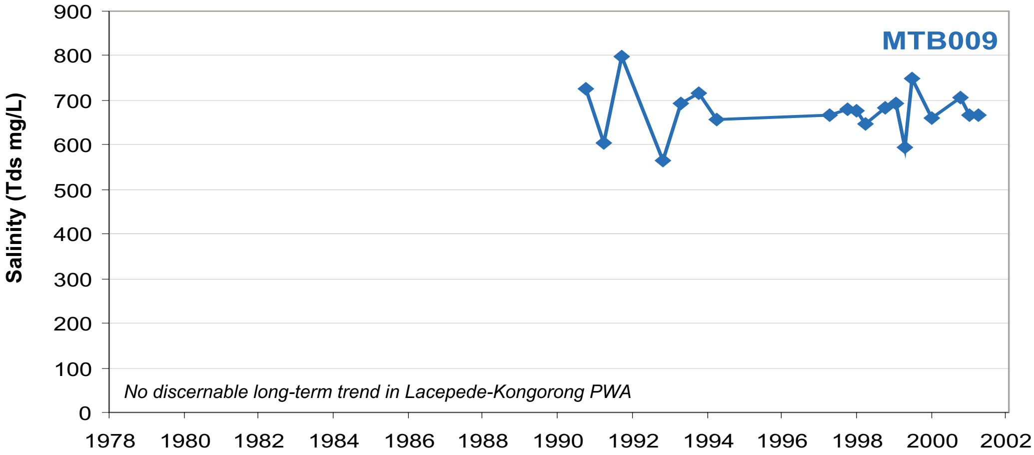
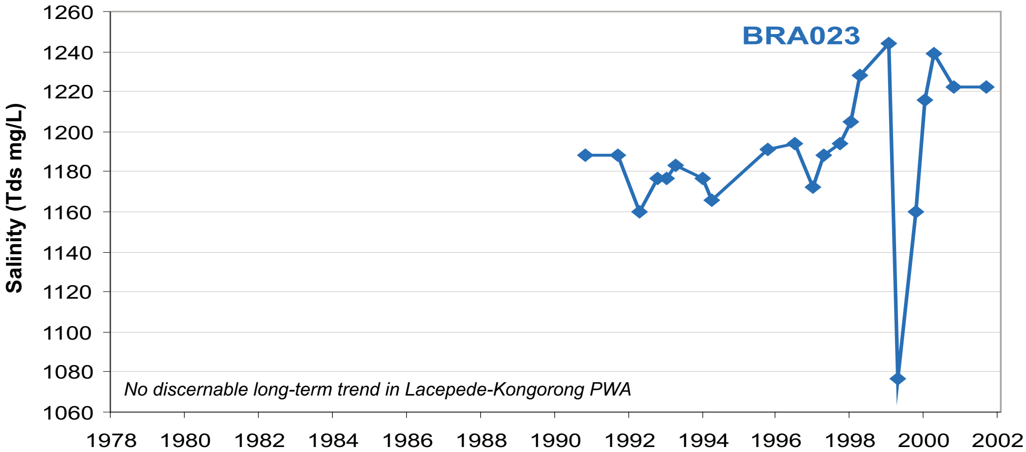
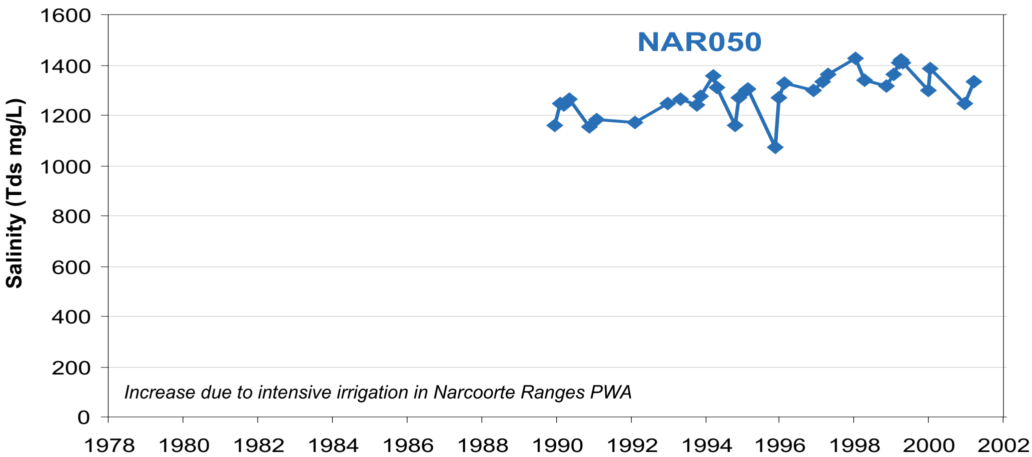
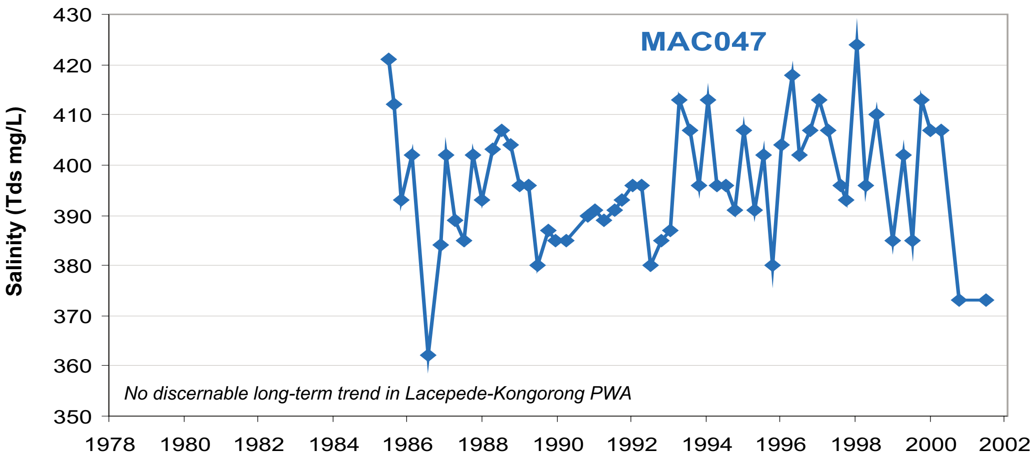
APPENDIX C (continued)









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