DWLBC REPORT

McLaren Vale Prescribed Wells Area Groundwater Monitoring Status Report 2005

2006/04

Government of South Australia
Department of Water, Land and Biodiversity Conservation

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Report DWLBC 2006/04

Government of South Australia
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FOREWORD

South Australia's unique and precious natural resources are fundamental to the economic and social wellbeing of the State. It is critical that these resources are managed in a sustainable manner to safeguard them both for current users and for future generations.

The Department of Water, Land and Biodiversity Conservation (DWLBC) strives to ensure that our natural resources are managed so that they are available for all users, including the environment.

In order for us to best manage these natural resources it is imperative that we have a sound knowledge of their condition and how they are likely to respond to management changes. DWLBC scientific and technical staff continues to improve this knowledge through undertaking investigations, technical reviews and resource modelling.

Rob Freeman
CHIEF EXECUTIVE
DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

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1. INTRODUCTION

The Willunga observation well monitoring network provides critical water level and salinity information on the groundwater systems in the Willunga Basin, or what is now known as the McLaren Vale Prescribed Wells Area (PWA). This information will lead to an understanding of the hydrodynamics of the system, highlight possible impacts, and for the longer term, enable sustainable management of the resource within the PWA (Fig. 1).

The observation well network was established in the 1970s in response to a marked increase in the use of groundwater for irrigation purposes within the McLaren Vale PWA and has been managed by the Knowledge and Information Division within the Department of Water, Land and Biodiversity Conservation (DWLBC). The number of wells monitoring all aquifers on a monthly basis has increased to 133 in the current network (2005).

The monitoring information is used in conjunction with the McLaren Vale PWA Water Allocation Plan (WAP; OCWMB 2000), introduced in November 2000 to assess the:

- hydrogeological impacts of point of groundwater extraction changes
- water allocation transfer requests
- surface water injection requests for aquifer storage and recovery schemes, and
- potential impact on groundwater dependent ecosystems within the immediate area, and downgradient, of a transfer.

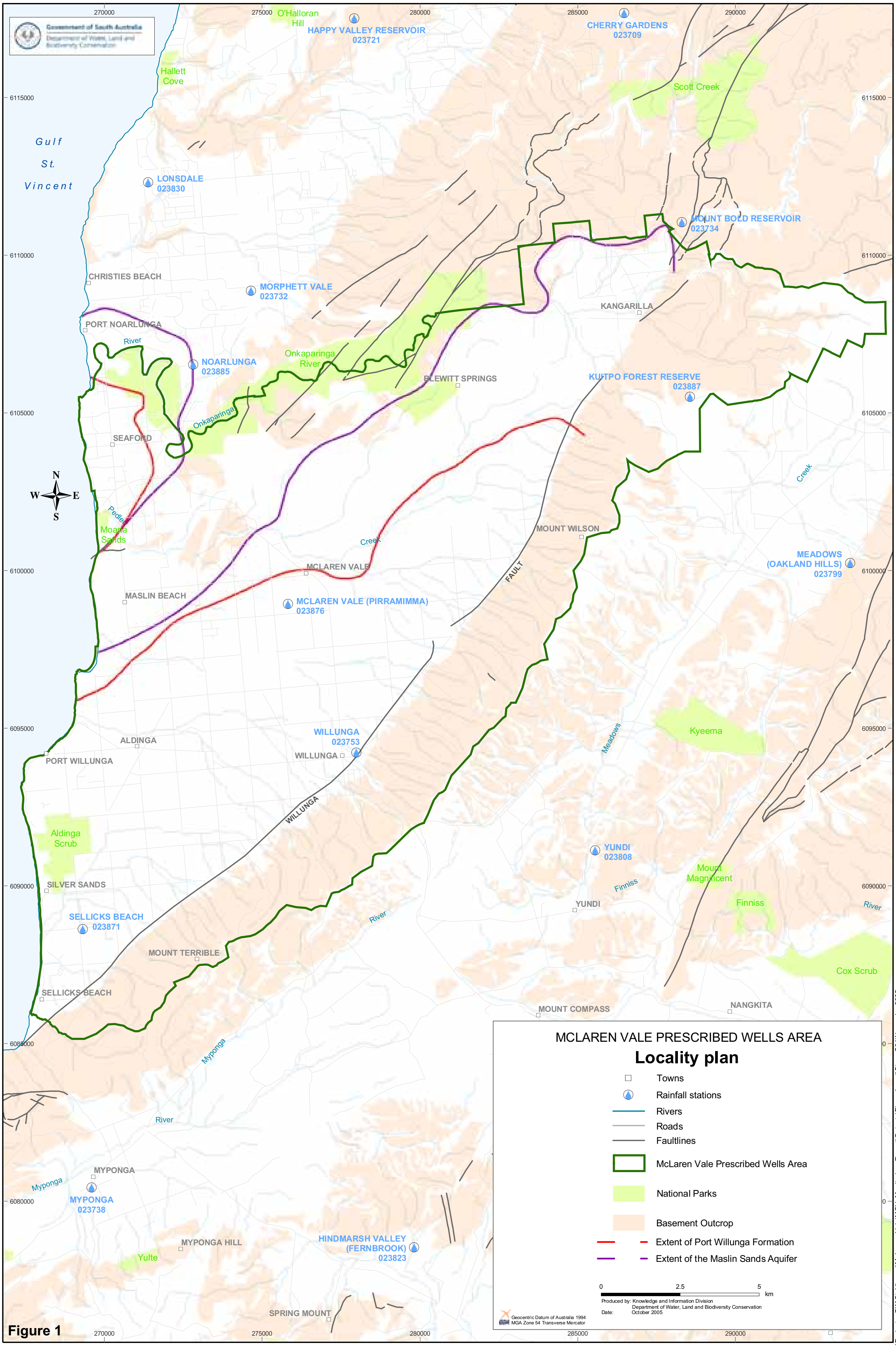
The introduction of external water sources, such as mains water, reclaimed water for irrigation and the injection of reclaimed water for aquifer storage and recovery schemes, may impact on the groundwater resources in the area. Consequently, the monitoring network should also serve to identify possible impacts on the hydrogeological environments from these types of activities.

The monitoring network is a primary resource management tool and endeavours to identify:

- regional water level changes
- regional changes in groundwater salinity
- sub-regions within an aquifer system that may become stressed as a result of concentrated pumping demand
- areas that may be at risk from salinisation.

This report provides a summary of the trends observed from the current monitoring data in relation to groundwater levels and groundwater quality in the McLaren Vale PWA for the period 1 October 2002 through 31 October 2005. The McLaren Vale WAP identifies a specific timeframe (three years) during which specified changes in groundwater levels (decline of an average rate of 1 m/y) or groundwater salinity (increase at an average rate of >100 mg/L/y) are considered unacceptable.

These management rules are some of the criteria against which transfer of water allocations are assessed. Transfers will not be granted into those areas within the McLaren Vale PWA where changes in groundwater quality or level exceed the identified criteria. A number of the figures presented in this report identify changes in groundwater levels and salinity over the specified planning timeframe.


MCLAREN VALE PRESCRIBED WELLS AREA
Locality plan
Towns
Rainfall stations
Rivers
Roads
Faultlines
McLaren Vale Prescribed Wells Area
National Parks
Basement Outcrop
Extent of Port Willunga Formation
Extent of the Maslin Sands Aquifer
Gulf St. Vincent
HAPPY VALLEY RESERVOIR 023721
CHERRY GARDENS 023709
LONSDALE 023830
MORPHETT VALE 023732
NOARLUNGA 023885
MOUNT BOLD RESERVOIR 023734
KUITPO FOREST RESERVE 023887
MCLAREN VALE (PIRRAMIMMA) 023876
MEADOWS (OAKLAND HILLS) 023799
WILLUNGA 023753
YUNDI 023808
SELLICKS BEACH 023871
MYPONGA 023738
HINDMARSH VALLEY (FERNBROOK) 023823
CHRISTIES BEACH
PORT NOARLUNGA
SEAFORD
MASLIN BEACH
MCLAREN VALE
KANGARILLA
BLEWITT SPRINGS
MOUNT WILSON
ALDINGA
PORT WILLUNGA
WILLUNGA
SILVER SANDS
MOUNT TERRIBLE
SELLICKS BEACH
YUNDI
MOUNT COMPASS
NANGKITA
MYPONGA
MYPONGA HILL
SPRING MOUNT
WILLUNGA FAULT
Figure 1
Produced by: Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation
Date: October 2005
Geocentric Datum of Australia 1994
MGA Zone 54 Transverse Mercator
Figure 1

2. CLIMATE

There is often a very strong relationship observed in shallow aquifer systems between changes in groundwater levels and rainfall, which occur as a result of rapid recharge to these systems from rainfall. Where a strong relationship exists, changes in groundwater level can be quite easily matched against the rainfall event.

In many aquifer systems, because groundwater levels are recharge controlled, years of above average rainfall will result in rising groundwater levels, while years of below average rainfall will result in declining groundwater levels.

In deeper confined aquifer systems, such as the Port Willunga Formation or Maslin Sands Aquifers, the majority of recharge typically occurs along the up-gradient aquifer margins. The observed response in these aquifers is a gradual rise in water level, which is a combination of aquifer recovery from summer pumping stresses and recharge.

Figure 2 shows the rainfall cumulative deviation from the monthly mean plotted against the monthly rainfall. The data, which ranges from 1939–2005, has been obtained from established meteorological stations closest to the potential recharge regions.

The rainfall gauging stations are managed by the Bureau of Meteorology (BoM). Location and their respective station numbers are identified in Figure 1:

- Clarendon Post Office — Station number 023710.
- McLaren Vale Post Office — Station number 023729.
- Willunga — Station number 023753.

Figure 2 illustrates that Clarendon, McLaren Vale and Willunga experienced above average rainfall over the periods 1939–1956 and 1968–75. Since then, rainfall has generally been below average as indicated by the declining trend in the cumulative deviation. Significant rainfall events occurred in 1986 and 1992. Below average rainfall in 2002 was present at all stations. Since 2000, rainfall has been generally above average, more notably in the Clarendon region.

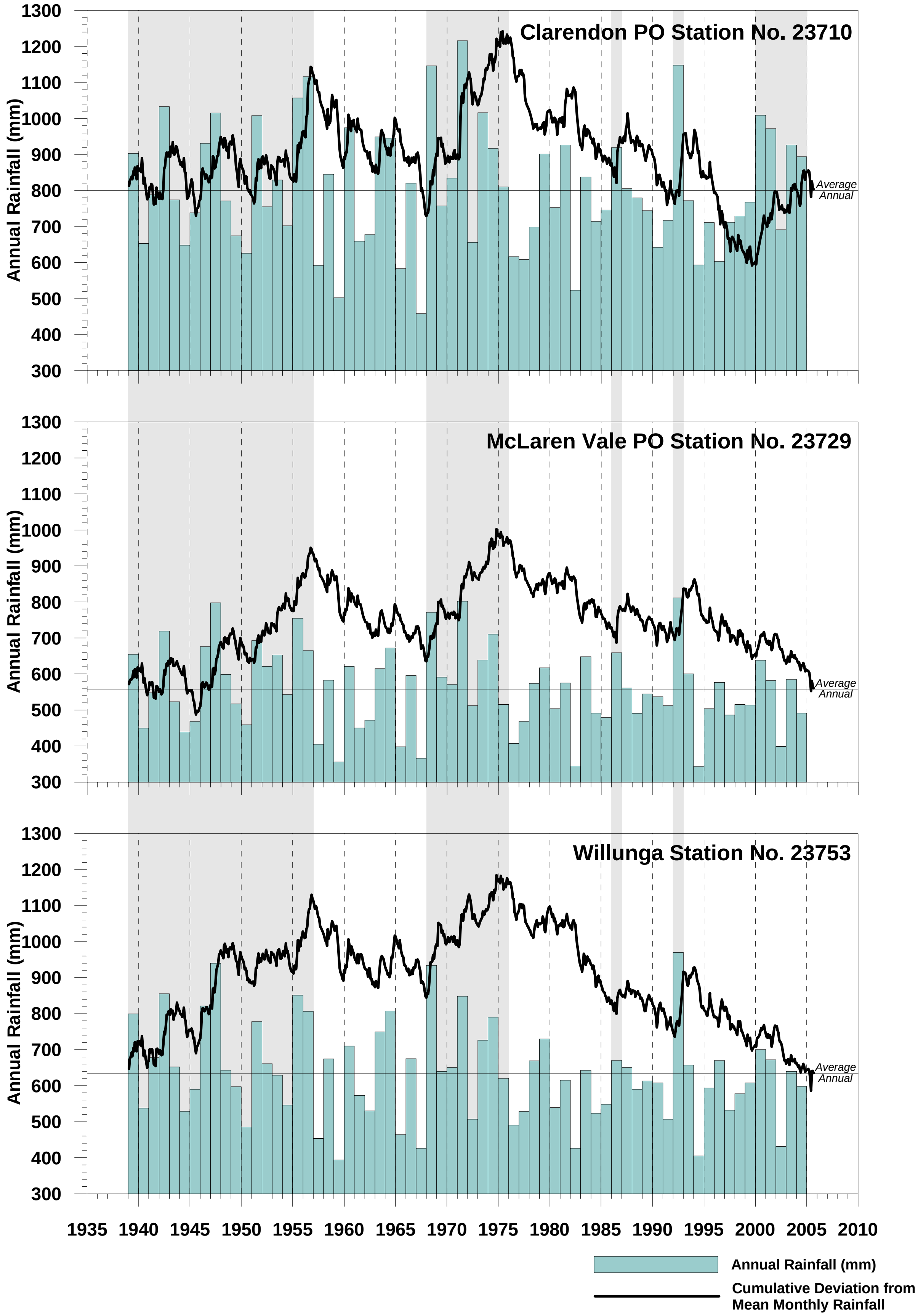


Figure 2. Annual rainfall and cumulative deviation from mean monthly rainfall

3. HYDROGEOLOGY

The detailed geology and hydrogeology of the McLaren Vale PWA have been outlined by Sereda and Martin (2001) and numerous Office of Minerals and Energy Resources reports (Table 1). In summary, the area (or basin) is a structurally controlled trough bounded in the south and east by the Willunga Fault and to the north by outcropping basement. The trough is formed by the southward tilt of a basement block below the basin, with the upper edge of the block exposed at the Onkaparinga Gorge. The depth of the basin increases to ~250 m deep near the Willunga Fault of Aldinga.

Groundwater occurs in four major aquifers:

- Quaternary Aquifer.
- Port Willunga Formation Aquifer.
- Maslin Sands Aquifer.
- Fractured Rock Aquifer.

Figure 3 illustrates a schematic cross-section detailing the extent of the aquifer systems throughout the McLaren Vale PWA.

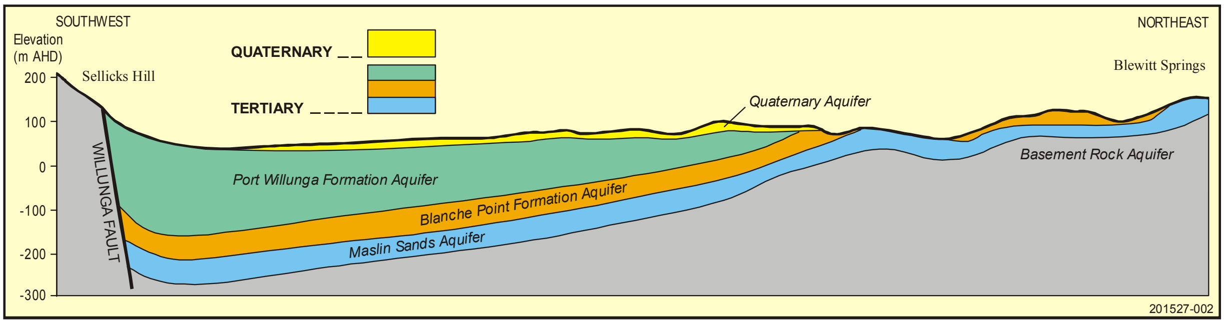


Figure 3. Schematic cross-section beneath the McLaren Vale PWA

3.1 QUATERNARY AQUIFER

The Quaternary Aquifer comprises watertable aquifers, formed where sands and interbedded clays exist, and a perched aquifer within the dune sand sediments in the Aldinga Scrub area. Recharge is predominantly derived from local rainfall and runoff provided by streams.

3.2 PORT WILLUNGA FORMATION AQUIFER

The Port Willunga Formation Aquifer comprises sand and limestone and is generally high yielding. It is unconfined near McLaren Vale and McLaren Flat in the centre of the PWA and confined by Quaternary sediments in the south and southwest regions. Recharge to this aquifer system principally occurs across the unconfined portion that is a narrow strip only some 2–3 km wide extending from the coast and slightly south of the McLaren Vale township up to McLaren Flat (Martin 1998). The aquifer sub-crops in the region to the northeast of McLaren Vale Flat.

Table 1. Stratigraphy and hydrostratigraphy of the Willunga Embayment

Stratigraphy										
		Cooper, 1979			May, 1992		Fairburn, 1998		Bowering, 1979	Aldam, 1990a, b
Quaternary	Holocene	(Not included as part of the investigation)			–		Modern alluvium, Semaphore Sand member and beach gravels		Confining bed over much of the basin. Thin shallow sandy and gravel unconfined and semi-confined aquifers.	Aquifers, confining beds.
					Waldeila Formation	Ngankipari Sand	(Not mapped)			
							Ngankipari Sand			
	Pleistocene	(Not included as part of the investigation)			Christies Beach Formation		Christies Beach Formation			Aquifers, confining beds.
					(Not present in coastal section)		Kurrajong Formation			
					Taringa Formation		Ngaltinga Formation			
					Ngaltinga Formation	Snapper Point Sand member				
						Neva Clay member		Pirramimma sandstone		
					Robinson Point Formation		Ochre Cove Formation			
					(Mapped as Robinson Point Formation)		Seaford Formation			
					Burnham Limestone		Burnham Limestone			
Tertiary	Pliocene	(Not included as part of the investigation)			Hallett Cove Sandstone		Hallett Cove Sandstone		?	?
	Eocene to Oligocene	Port Willunga Formation	–	Pirramimma Sand member	–		Port Willunga Formation		Confined aquifer in southern half of basin. Unconfined elsewhere.	(Aquifer T1) Port Willunga Formation Aquifer including Pirramimma sand, Aldinga and Ruwarung members.
			Ruwarung member							
			Aldinga member							
		Chinaman Gully Formation					Chinaman Gully Formation		Aquitard	Confining bed
		Blanche Point Formation	Gull Rock member				Undifferentiated (Blanche Point Formation and Tortachilla Limestone)		Confining bed over southern half of basin. Aquifer to aquitard elsewhere.	
		Tortachilla Limestone							Aquitard	
		Maslin Sands	South Maslin Sand member				Maslin Sands (undifferentiated South Maslin Sand and North Maslin Sand)		Confined aquifer over most of basin. Unconfined in northern most part of basin.	(Aquifer T2) Maslin Sands including South Maslin Sand and North Maslin Sand members.
			North Maslin Sand member							
Permian		Cape Jervis Formation			–		–		Varies from poor aquifer to aquitard.	?
Precambrian		Adelaide System			–		–		Almost entirely confined or semi-confined aquifer. Unconfined over a restricted area.	Basement aquifer, confining in places.

The Port Willunga Formation overlays the confining bed consisting of the Chinaman Gully Formation Aquitard, which lies over the Blanche Point Formation and Tortachilla Limestone. The Blanche Point Formation comprises low permeability marine mudstone, limestone and chert. All formations are poor yielding but there are several observation wells penetrating these formations to monitor any changes. This information may assist in determining the movement of groundwater between aquifers and the effects of water extraction on the confining layer from the surrounding aquifers.

3.3 MASLIN SANDS AQUIFER

The Maslin Sands Aquifer overlies the Fractured Rock Aquifer and comprises fine to coarse sands and clays. The aquifer is unconfined in the northeast of the PWA in the vicinity of Baker Gully, Blewitt Springs and north of McLaren Flat where the aquifer outcrops and receives local recharge.

South of Pedler Creek, the aquifer is confined by the Blanche Point Formation Aquitard, separating it from the Port Willunga Formation Aquifer.

3.4 FRACTURED ROCK AQUIFER

The Fractured Rock Aquifer outcrops east of the Willunga Fault and along the northern extent of the PWA along the Onkaparinga Gorge. Groundwater flows through fractures and fissures in the formation. The flow is variable and strongly influenced by the size, density and orientation of the fractures. This aquifer is recharged by rainfall in outcropping areas and the watertable is likely to reflect the surface topography.

4. MONITORING NETWORK

Groundwater level and salinity trends throughout the PWA are currently monitored via an observation well network of 133 private and government owned wells. Table 2 details the number of wells monitoring the different aquifers and aquitards.

From this observation well network, 131 wells are used to monitor depth to water (Fig. 4) and 61 wells are used to monitor salinity (Fig. 5). There are 59 observation wells used to monitor both water level and salinity. Most of the observation wells monitor the regional aquifers utilised for licensed groundwater extraction; however, a small number of wells monitor discrete aquifers within the regional confining beds.

Table 2. Count of current observation wells

Hydrogeological Unit	Aquifer or Aquitard	Water Level	Salinity
Quaternary	Aquifer	29	11
Port Willunga Formation	Aquifer	30	16
Chinaman Gully Formation	Aquitard	1	–
Chinaman Gully Formation and Blanche Point Formation	Aquitard	1	–
Blanche Point Formation	Aquitard	4	1
Tortachilla Limestone	Aquitard	–	–
Maslin Sands	Aquifer	32	22
Maslin Sands and Fractured Rock	Aquifer	3	–
Fractured Rock	Aquifer	29	9

The current observation well network is not comprehensive or monitored frequently enough to conclusively assess all the impacts of licensed extraction in all aquifer systems. A review of the observation well network is recommended to build up a comprehensive database of the hydrogeologic status of the McLaren Vale Prescribed Wells Area. Although there are 133 wells within the current network, the majority of the wells do not have sufficient data to produce three-year salinity or water level trends or longer-term trends.

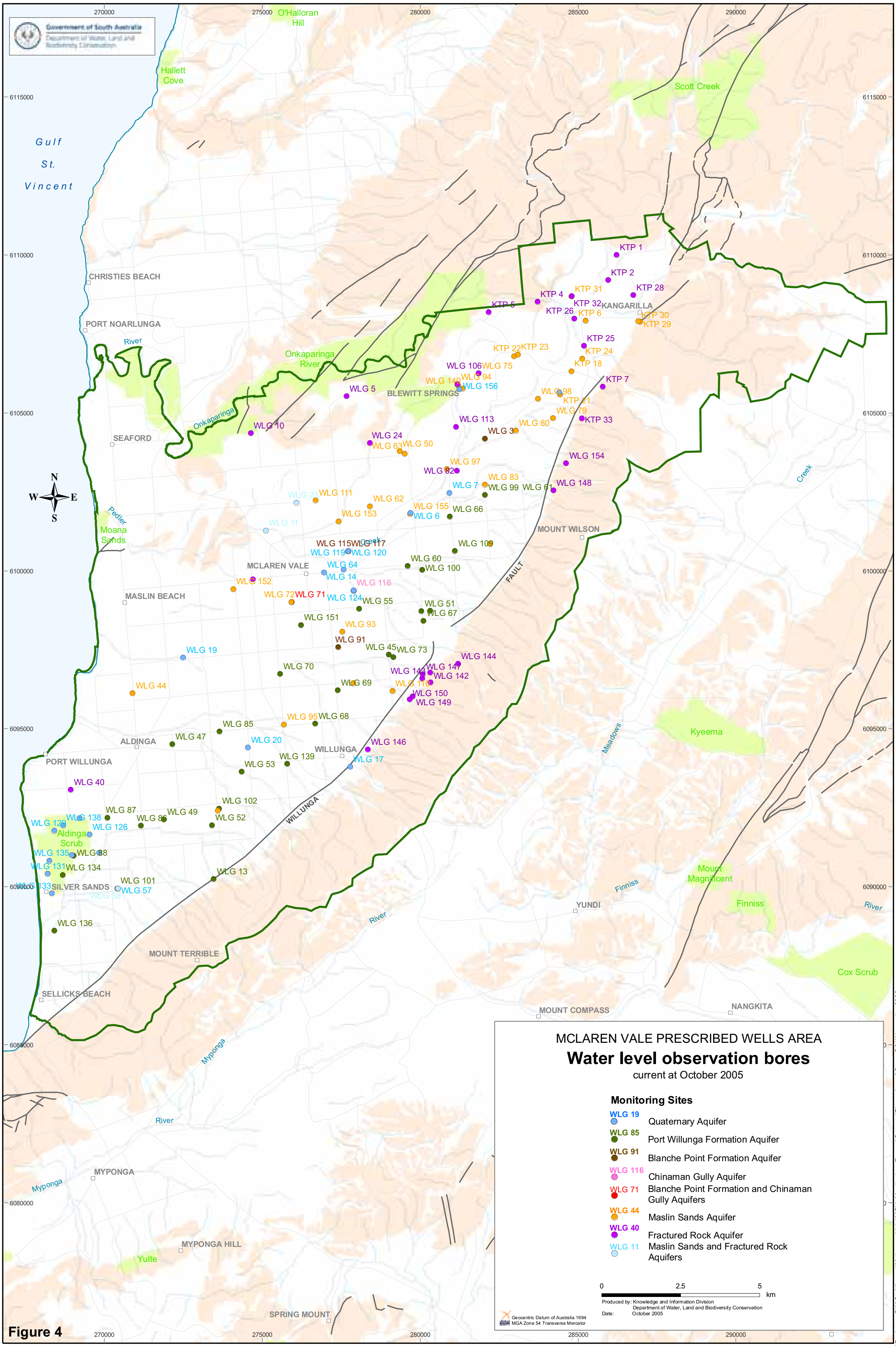

MCLAREN VALE PRESCRIBED WELLS AREA
Water level observation bores
current at October 2005
Monitoring Sites
WLG 19 Quaternary Aquifer
WLG 85 Port Willunga Formation Aquifer
WLG 91 Blanche Point Formation Aquifer
WLG 116 Chinaman Gully Aquifer
WLG 71 Blanche Point Formation and Chinaman Gully Aquifers
WLG 44 Maslin Sands Aquifer
WLG 40 Fractured Rock Aquifer
WLG 11 Maslin Sands and Fractured Rock Aquifers
0 2.5 5 km
Produced by: Knowledge and Information Division, Department of Water, Land and Biodiversity Conservation
Date: October 2005
Geocentric Datum of Australia 1994
MGA Zone 54 Transverse Mercator
Gulf St. Vincent
CHRISTIES BEACH
PORT NOARLUNGA
SEAFORD
MCLAREN VALE
MASLIN BEACH
ALDINGA
PORT WILLUNGA
WILLUNGA
SILVER SANDS
MOUNT TERRIBLE
SELLICKS BEACH
MOUNT COMPASS
NANGKITA
MYPONGA
MYPONGA HILL
SPRING MOUNT
YUNDI
MOUNT WILSON
BLEWITT SPRINGS
KANGARILLA
WILLUNGA FAULT
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Figure 4

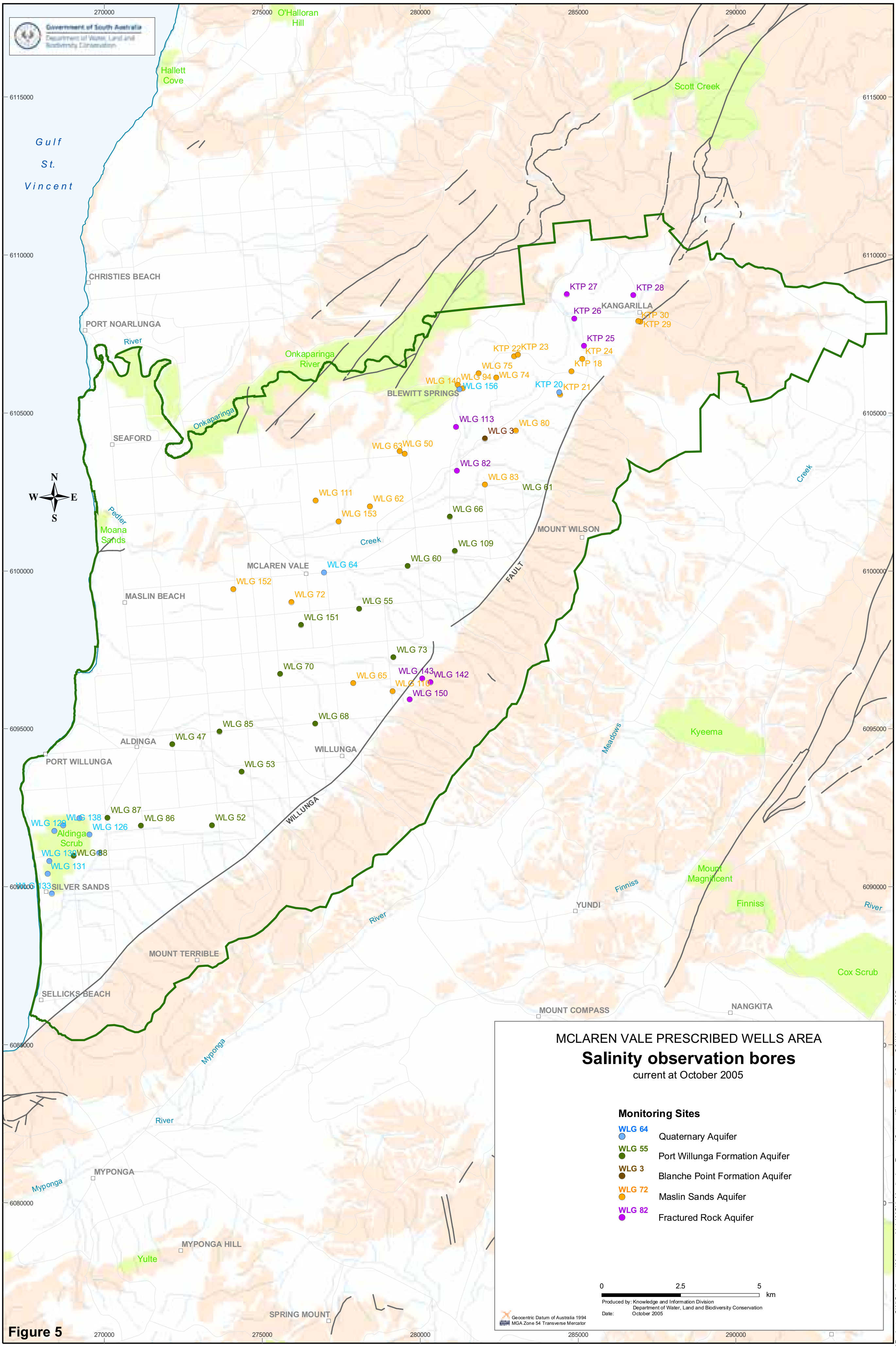

Figure 5

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5. WATER LEVEL ANALYSIS

Potentiometric contours represent a virtual surface defined by the level to which water in a confined aquifer rises in observation wells (called the watertable in an unconfined system) and are used to determine the groundwater flow direction from recharge to discharge zones. Changes in flow direction caused by groundwater extraction may result in the development of a cone of depression in over-stressed parts of the aquifer.

Two sets of contours have been prepared for the aquifer systems targeted for the majority of the licensed extraction. The October 2004 contours represent groundwater levels at peak recovery levels (i.e. after the winter season). The April 2005 contours represent the water levels at the end of the irrigation season. Changes or significant deflection in the position of these two sets of contours may indicate a redirection of groundwater flow towards areas that are becoming stressed due to a concentration in pumping demand for the 2004–05 irrigation season.

5.1 QUATERNARY AQUIFER

Historically, the Quaternary Aquifer has not been studied in detail and has only been monitored by a small number of observation wells. Consequently, it is not possible to construct reliable contours of the watertable surface for this aquifer system. With the introduction of new Quaternary Aquifer observation wells, more information will be collected and, with time, it will enable a more comprehensive representation of water levels.

Figure 6 identifies the changes in watertable from the recovery and irrigation season. The largest drawdowns are identified in WLG 6, 17, 19 and 118 with drawdown values of ~2 m. Observation wells WLG 14, 57, 64 and 133 show notable declines in the water table of ~1 m during the irrigation season.

5.2 PORT WILLUNGA FORMATION AQUIFER

Groundwater within the Port Willunga Formation Aquifer typically flows from the northeast part of the basin towards the coast and the potentiometric surface contours typically align northwest–southeast across the basin (Fig. 7).

There is a general gradient of between 0.3–0.4% over the majority of the aquifer. Between 15–30 mAHD contour intervals the gradient steepens to 1.0%. From the 15 mAHD contour towards the coast the gradient flattens out to between 0.1–0.5%. The steepening of the hydraulic gradient is assumed to be due to changes in aquifer properties and may suggest that the aquifer in this zone is less able to satisfy extraction demands. The shallowing of the gradient towards the coast may indicate an indirect connectivity between the aquifer and the seawater.

The slight deflection observed in the 5 and 10 m contour intervals may suggest localised pumping stresses. This is also evident between 40–45 m contour intervals. Alternative to this, these deflections may indicate zones of recharge. The consistent contour interval locations between summer and winter would exclude seasonal influences.

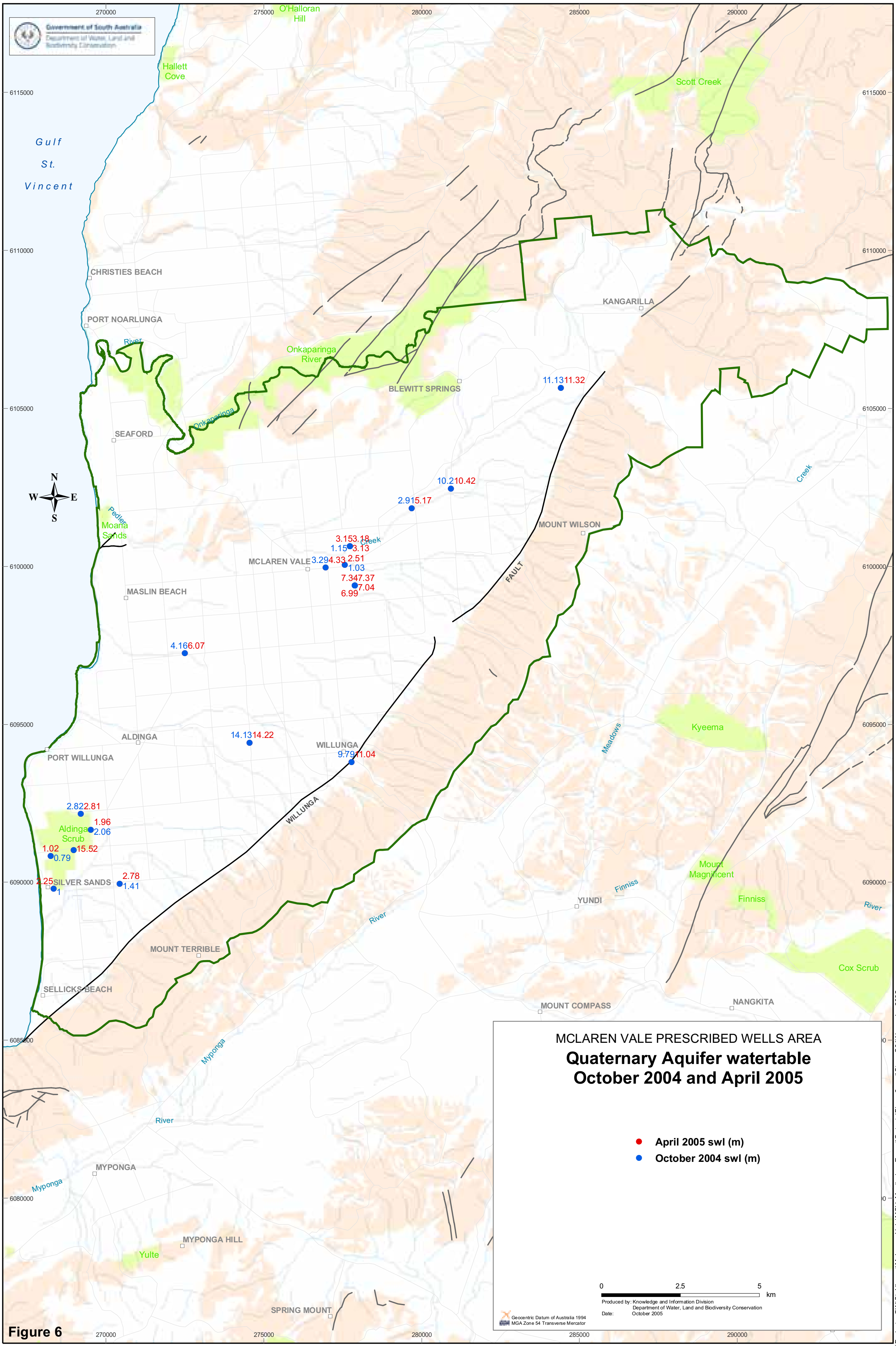

MCLAREN VALE PRESCRIBED WELLS AREA
Quaternary Aquifer watertable
October 2004 and April 2005
April 2005 swl (m)
October 2004 swl (m)
Gulf St. Vincent
CHRISTIES BEACH
PORT NOARLUNGA
SEAFORD
MASLIN BEACH
ALDINGA
PORT WILLUNGA
SILVER SANDS
MOUNT TERRIBLE
SELLICKS BEACH
MCLAREN VALE
BLEWITT SPRINGS
KANGARILLA
MOUNT WILSON
WILLUNGA
YUNDI
MOUNT COMPASS
NANGKITA
MYPONGA
MYPONGA HILL
SPRING MOUNT
WILLUNGA FAULT
Scott Creek
Kyeema
Aldinga Scrub
Cox Scrub
Finniss
Mount Magnificent
Onkaparinga River
Moana Sands
Hallett Cove
O'Halloran Hill
Yulte

Figure 6

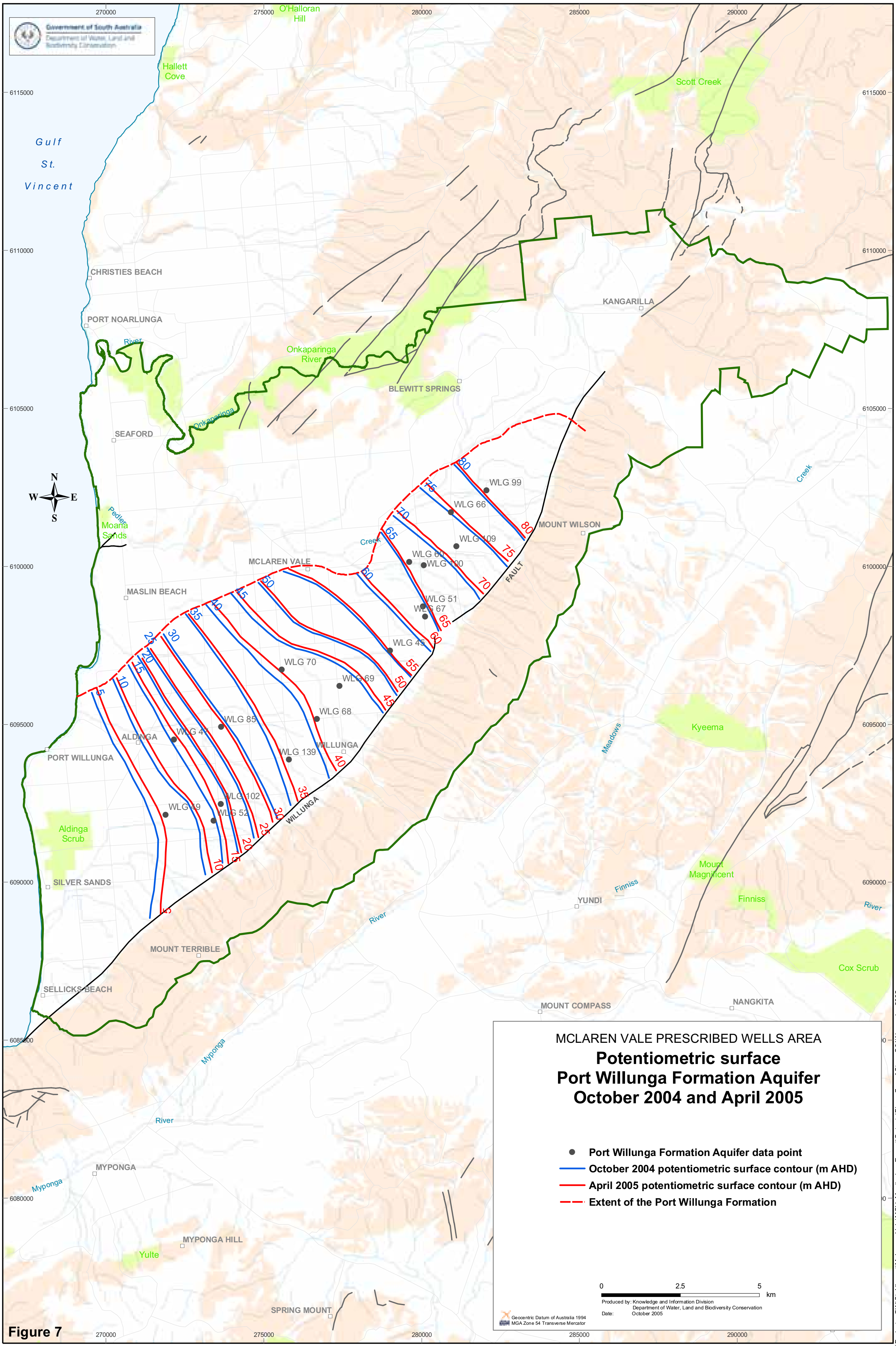

MCLAREN VALE PRESCRIBED WELLS AREA
Potentiometric surface
Port Willunga Formation Aquifer
October 2004 and April 2005
Port Willunga Formation Aquifer data point
October 2004 potentiometric surface contour (m AHD)
April 2005 potentiometric surface contour (m AHD)
Extent of the Port Willunga Formation
Government of South Australia
Department of Water, Land and Biodiversity Conservation
Gulf St. Vincent
N
W
E
S
O'Halloran Hill
Hallett Cove
Scott Creek
CHRISTIES BEACH
PORT NOARLUNGA
KANGARILLA
Onkaparinga River
BLEWITT SPRINGS
SEAFORD
Moana Sands
MCLAREN VALE
MASLIN BEACH
MOUNT WILSON
WLG 99
WLG 66
WLG 109
WLG 60
WLG 100
WLG 51
WLG 67
WLG 45
WLG 70
WLG 69
WLG 68
WLG 85
WLG 47
WLG 139
WLG 102
WLG 52
WLG 49
ALDINGA
PORT WILLUNGA
WILLUNGA
WILLUNGA FAULT
Aldinga Scrub
SILVER SANDS
MOUNT TERRIBLE
SELLICKS BEACH
Kyeema
Mount Magnificent
Finniss
YUNDI
Cox Scrub
NANGKITA
MOUNT COMPASS
MYPONGA
MYPONGA HILL
Yulte
SPRING MOUNT
Produced by: Knowledge and Information Division, Department of Water, Land and Biodiversity Conservation
Date: October 2005
Geocentric Datum of Australia 1994
MGA Zone 54 Transverse Mercator
0 2.5 5 km

Figure 7

It has been noted that the existing observation wells used to define the potentiometric surface between 40–45 mAHD contour intervals are completed in the lower part of the Port Willunga Formation Aquifer, which has slightly different hydraulic properties than the upper Port Willunga Formation Aquifer at this location. Further assessment and review of completion depths for both the irrigation wells and monitoring wells in this area should be undertaken.

5.3 MASLIN SANDS AQUIFER

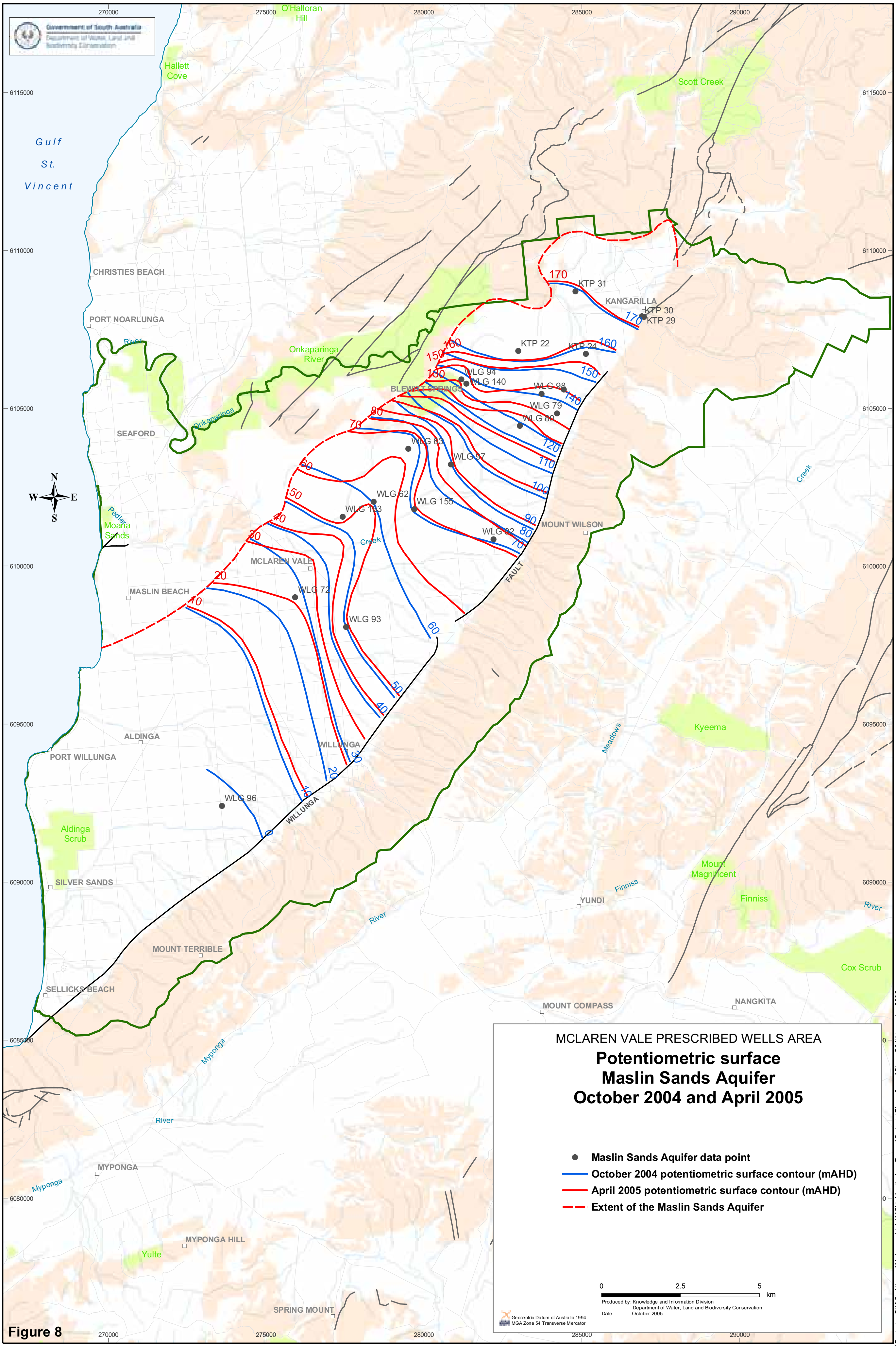
The potentiometric surface for the Maslin Sands Aquifer are presented (Fig. 8) as the best appropriate representation of groundwater levels, as there are only a few observation wells in the central and southern section of the area to construct contour intervals.

The potentiometric surface indicates that groundwater flows from the northeast towards the southwest. The distribution of the contour intervals suggest that this aquifer may be receiving recharge between 50–70 mAHD and above the 160 mAHD contour intervals where groundwater gradients are below 0.7%. The shallowing of the groundwater gradient below the 10 mAHD contour interval is interpreted to be where the hydraulics of the Maslin Sands Aquifer is influenced by the body of seawater.

The low transmissivity of the Maslin Sands Aquifer sediment (typically 35–50 m/d) results in considerable drawdowns in pumping wells during the main irrigation season. The derived contours of water levels (Fig. 8) show that the summer potentiometric surface is lower and receded to the northeast due to pumping, with some drawdown centres developing (particularly the 50–70 and 130–150 mAHD contour intervals). However, in some cases the deflection in the watertable elevation may be due to variation in hydraulic properties of the discrete sub-aquifers within the Maslin Sands unit and more detailed investigations should be undertaken to confirm this.

5.4 FRACTURED ROCK AQUIFER

The limited number of monitoring wells completed within the Fractured Rock Aquifer make it difficult to construct accurate contour intervals to represent the potentiometric surface for this aquifer system. It should be noted that the complex topography in the northeastern corner of the PWA inhibits the construction of reliable potentiometric contours in this area, as local topographic relief may dominate groundwater flow direction over regional trends. Therefore, the contours in Figure 9 should be regarded as the best approximation for the available data.


Government of South Australia
Department of Water, Land and Biodiversity Conservation
Gulf St. Vincent
MCLAREN VALE PRESCRIBED WELLS AREA
Potentiometric surface
Maslin Sands Aquifer
October 2004 and April 2005
Maslin Sands Aquifer data point
October 2004 potentiometric surface contour (mAHD)
April 2005 potentiometric surface contour (mAHD)
Extent of the Maslin Sands Aquifer
Produced by: Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation
Date: October 2005
Geocentric Datum of Australia 1994
MGA Zone 54 Transverse Mercator
WILLUNGA FAULT
MCLAREN VALE
WILLUNGA
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MYPONGA HILL
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Figure 8

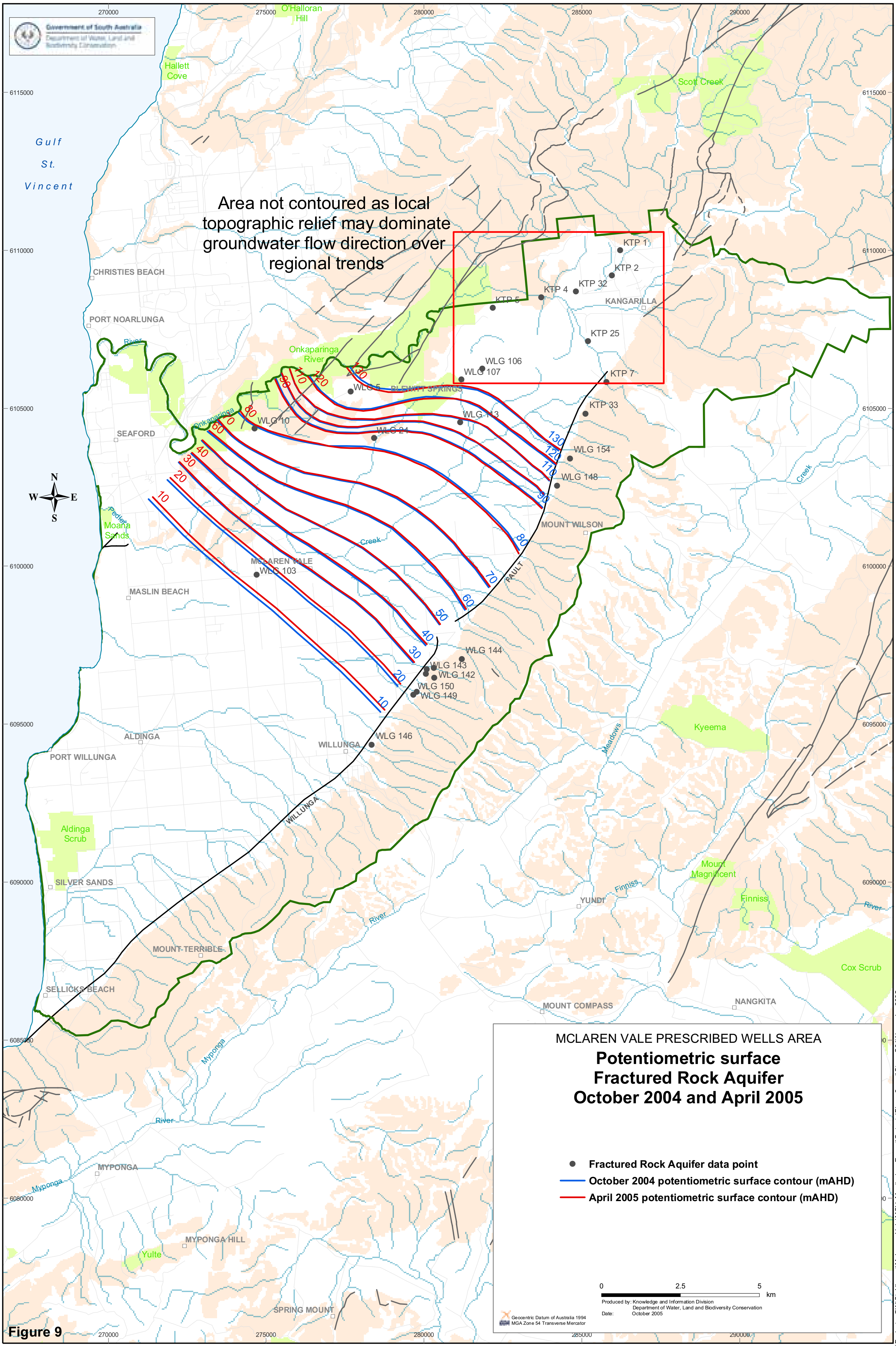

Figure 9

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The potentiometric surface indicates that groundwater generally flows from the northeast to the southwest. The distribution of the contour intervals above 90 mAHD suggest a possible reduction in aquifer transmissivity. It is uncertain how the Willunga Fault influences this aquifer, as data is limited.

Little variation can be observed between the October 2004 and April 2005 contours. There is a slight deflection of the 80–130 m contour intervals, which may be due to concentrated use or may indicate the influence of the Fractured Rock Aquifer exposure to the Onkaparinga River and unconfined conditions. However, hydraulic properties of the Fractured Rock Aquifer are very complex and to achieve a better understanding of trends in groundwater, especially localised drawdowns, more observation wells are required, particularly in areas that have a high density of irrigation wells.

There are 12 additional observation wells located east of the Willunga fault. These data points have not been included in the construction of the fractured rock potentiometric surface as the eastern side of the fault is not thought to be in direct connection with the western side of the fault. These bores were established to investigate the degree of connectivity across the fault.

6. WATER LEVEL TRENDS

The three-year (1 October 2002 to 31 October 2005) and the long-term (1 October 1998 to 31 October 2005) water level trends have been analysed for each aquifer. Water level data prior to 1998 was not included in calculating the long-term water level trends in the basin as irrigation demand over the past seven years has been more consistent with the estimated sustainable yield for the McLaren Vale PWA of 6000 ML per annum (OCWMB, 2000).

6.1 THREE-YEAR WATER LEVEL TRENDS

The three-year water level trends have been analysed to assess whether there are any 'stressed areas' as defined in the WAP (OCWMB 2000, sec. 6, clause 4b). An area where water level has declined at a rate of at least 1 m over the previous three years is considered stressed.

Hydrographs of selected wells in the various aquifers can be observed in Figures 10–13.

6.1.1 QUATERNARY AQUIFER

Groundwater level declines are evident in approximately half of the observation wells monitoring this aquifer system for the period 1 October 2002 through to 31 October 2005 (Fig. 14). The declines are relatively small, ranging between 0.04–0.20 m/y. The level of rise in groundwater has also been relatively minor (0.01–0.09 m/y). The well indicating the highest groundwater rise (WLG 133) is present in the Aldinga Scrub area and is intercepting the Semaphore Sand Member. The formation is only 1–6 m thick; however, it is underlain by a 15 m thick low permeability clay layer (preventing deep infiltration), thus resulting in a perched water table that is not laterally extensive. As the sand layer is quite permeable it has a high infiltration rate, thus limiting potential evaporation. In the winter the sand layer is saturated; this water is stored and utilised during summer.

WLG 20, which displayed an increasing water level trend during the period June 1999 to June 2002 (Clarke 2002), demonstrated a decline in groundwater level (0.19 m/y) over the 1 October 2002 to 31 October 2005 period.

The information reviewed from the current observation well network for the Quaternary Aquifer system indicates there are no apparent areas of groundwater stress as defined by the McLaren Vale WAP.

Because there is little use of the Quaternary Aquifer system to meet irrigation demand, the existing observation network is most likely sufficient to monitor the impacts to groundwater from this demand. However, if a primary aim of the monitoring network is to assist in assessing the needs of various groundwater dependent ecosystems throughout the McLaren Vale PWA, it is likely that some consideration may need to be given to the expansion of this network.

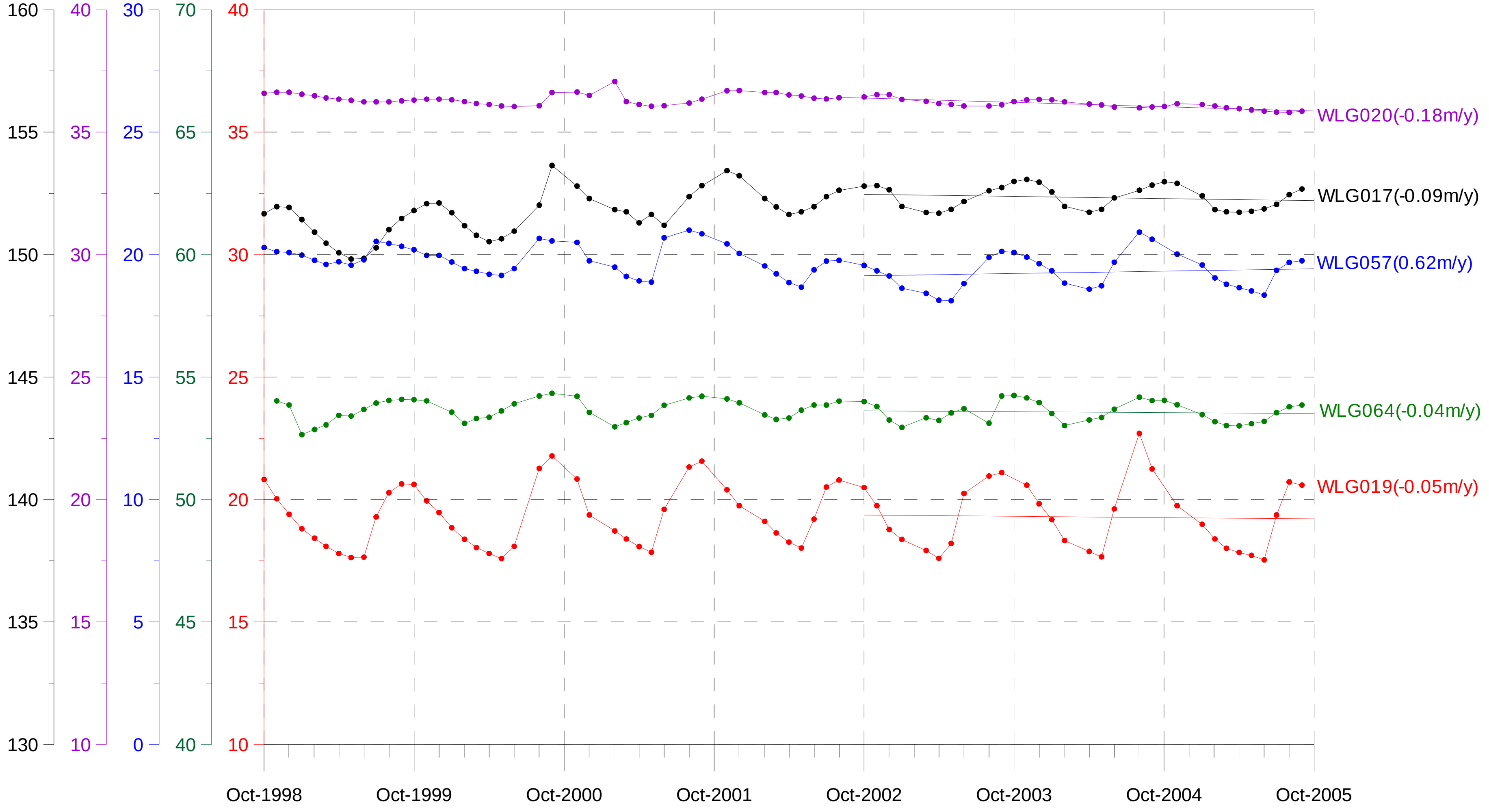

Figure 10. Quaternary Aquifer hydrographs

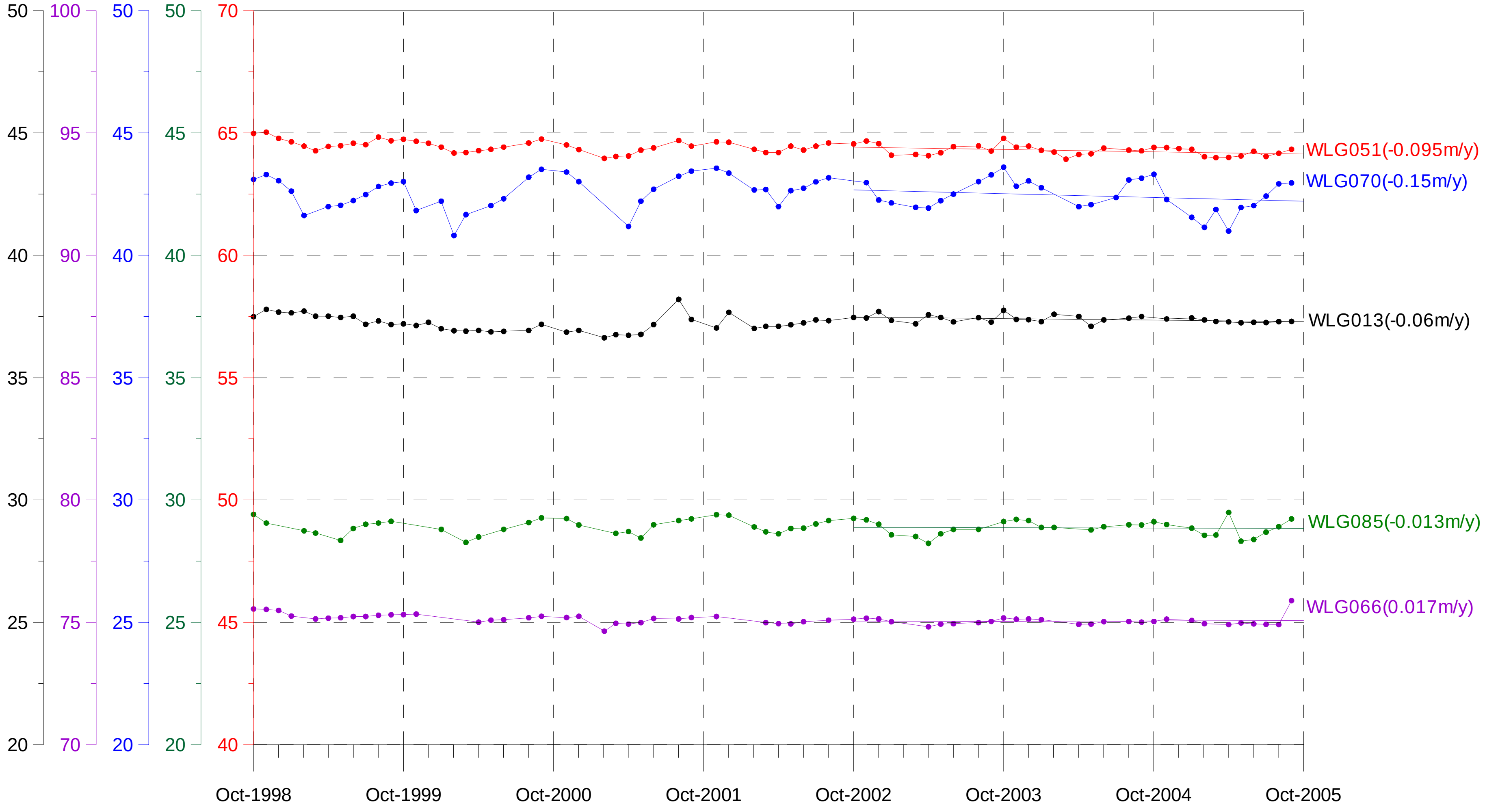

Figure 11. Port Willunga Formation Aquifer hydrograph

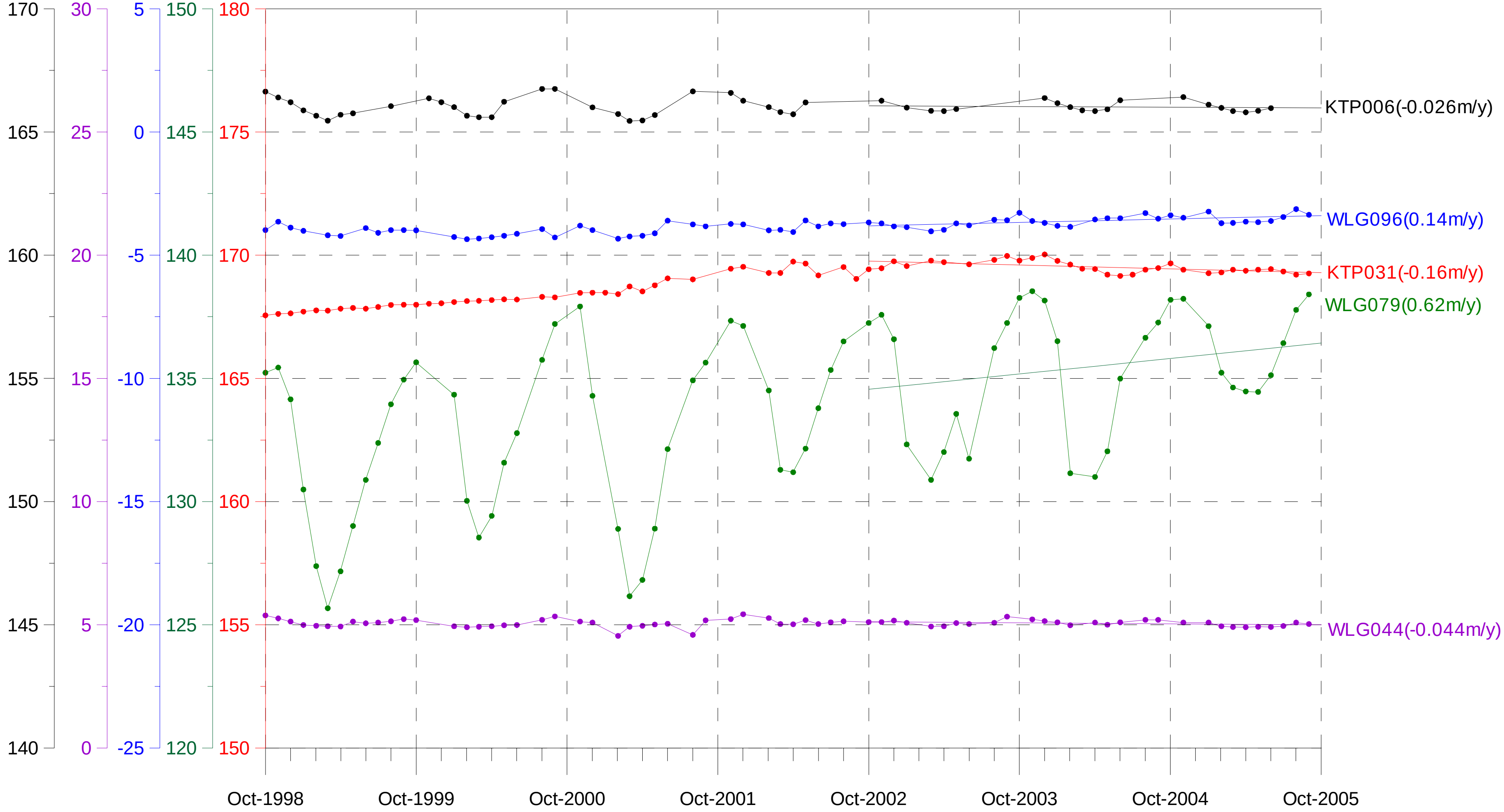

Figure 12. Maslin Sands Aquifer hydrograph

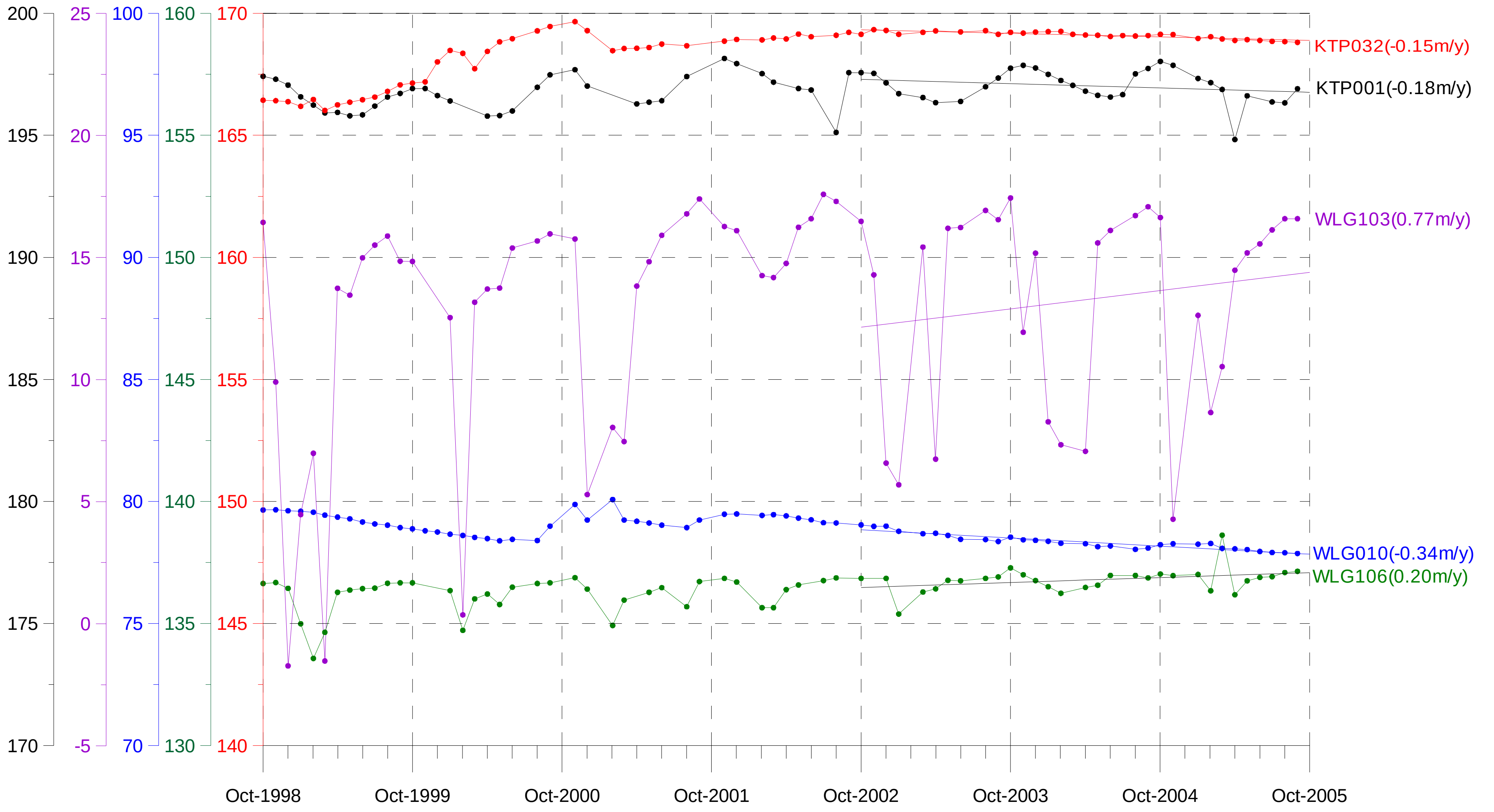

Figure 13. Fractured Rock Aquifer hydrographs

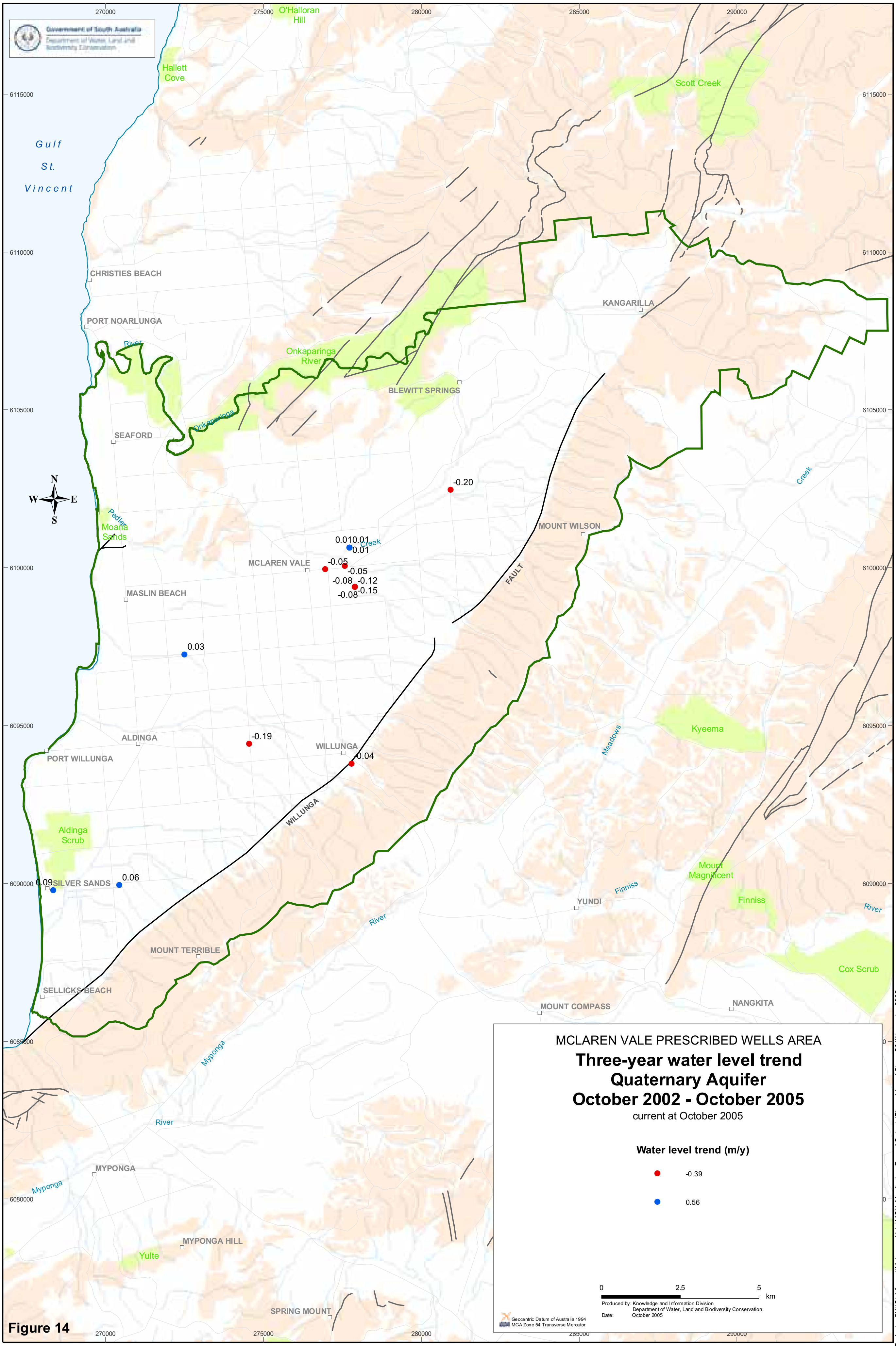

Figure 14

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6.1.2 PORT WILLUNGA FORMATION AQUIFER

For the monitoring period 1 October 2002 through to 31 October 2005, all but two wells present in the Port Willunga Formation indicate decreasing water levels (Fig. 15). Comparison of the results with the 1999–2002 trends show the water levels throughout the aquifer have generally decreased, with the exception of WLG 66 and WLG 87, which showed decreasing trends in 1999–2002 and currently display increasing water level trends (0.01 and 0.25 m/yr). The 1999–2002 data indicates the central area of the basin was experiencing groundwater rise; this area is now currently experiencing a groundwater decline.

Decreasing groundwater trends vary throughout the basin from 0.01 to 0.18 m/y, thus no areas within the Port Willunga Formation Aquifer have been identified as 'stressed areas' as defined by the McLaren Vale WAP (OCWMB 2000) for the period assessed.

6.1.3 MASLIN SANDS AQUIFER

For the monitoring period 1 October 2002 through to 31 October 2005, two areas of decreasing water level trends and one area of groundwater rise have been identified (Fig. 16). The level of decline in groundwater has been relatively minor (0.01–0.27 m/y). The areas of decline are concentrated in the upper reaches of the basin near Kangarilla and in the central area just south of Blewitt Springs.

The level of groundwater rise has also been relatively minor (0.0–0.13 m/y) with the exception of four wells located in the upper reaches of the PWA near the Willunga Fault (KTP 21, WLG 79, WLG 80 and WLG 98), which display significant rises in the groundwater level (0.3–0.62 m/y).

For the period 1 October 2002 through to 31 October 2005 there is no region located in the basin within the Maslin Sands Aquifer currently experiencing stress as defined by the McLaren Vale WAP (OCWMB 2000).

6.1.4 FRACTURED ROCK AQUIFER

For the period 1 October 2002 through to 31 October 2005, eight wells show a rise in groundwater level of 0.02 to 0.28 m/y. However, the remaining five wells located in the Fractured Rock Aquifer show a decrease in groundwater trend of 0.11 m/y up to a maximum of 0.51 m/y (Fig. 17).

The variability in water level recovery within the Fractured Rock Aquifer is typical as these same systems also experience the greatest drawdowns (sometimes in excess of 20 m) under pumping stress. Two wells (WLG 10 and WLG 40) show declines in groundwater levels (0.39 and 0.51 m/y respectively) that exceed the intended definition of a stressed area as defined in the McLaren Vale PWA WAP (OCWMB 2000). Transfers to areas in the immediate vicinity of these wells should be limited.

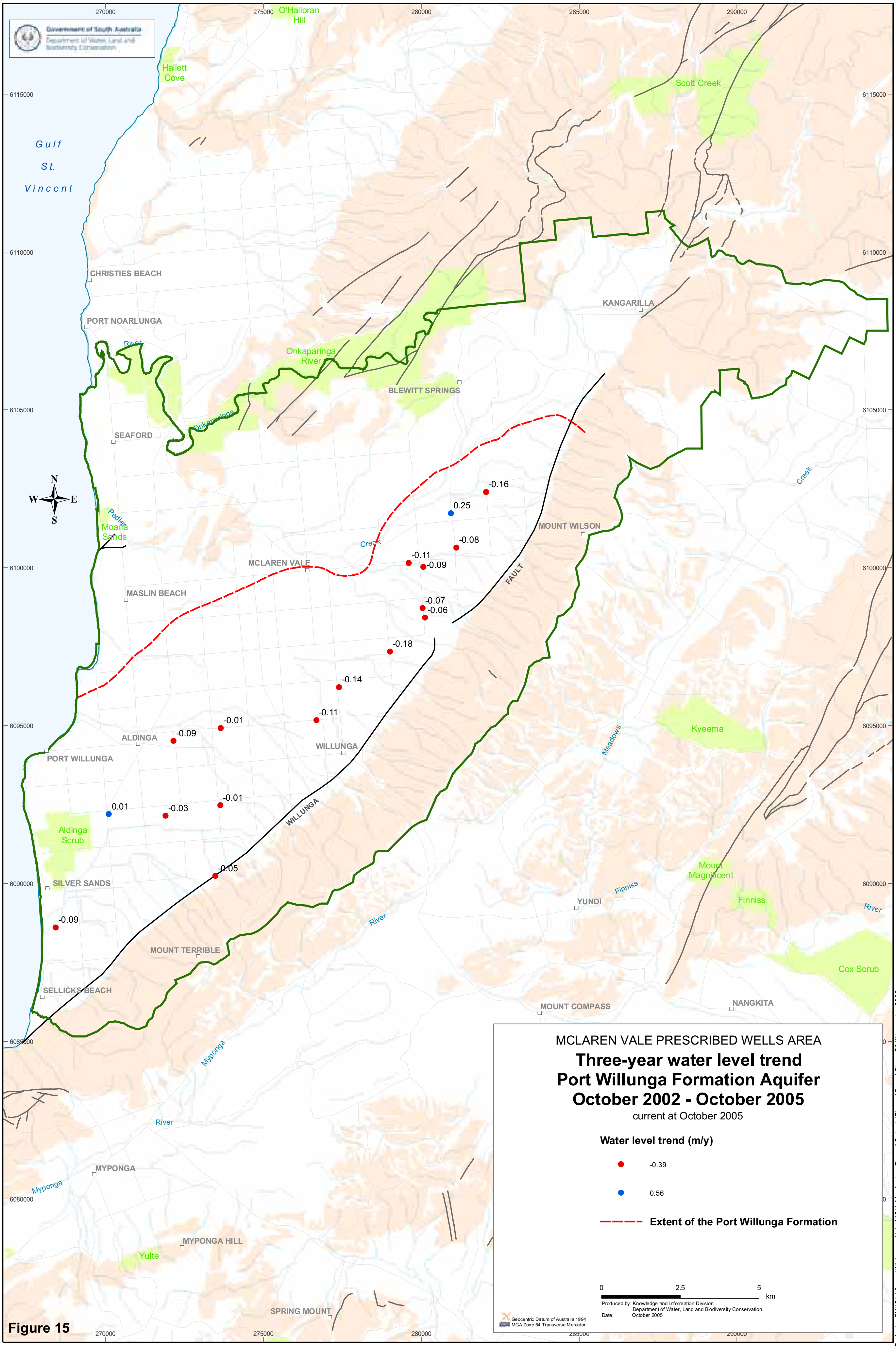

Figure 15

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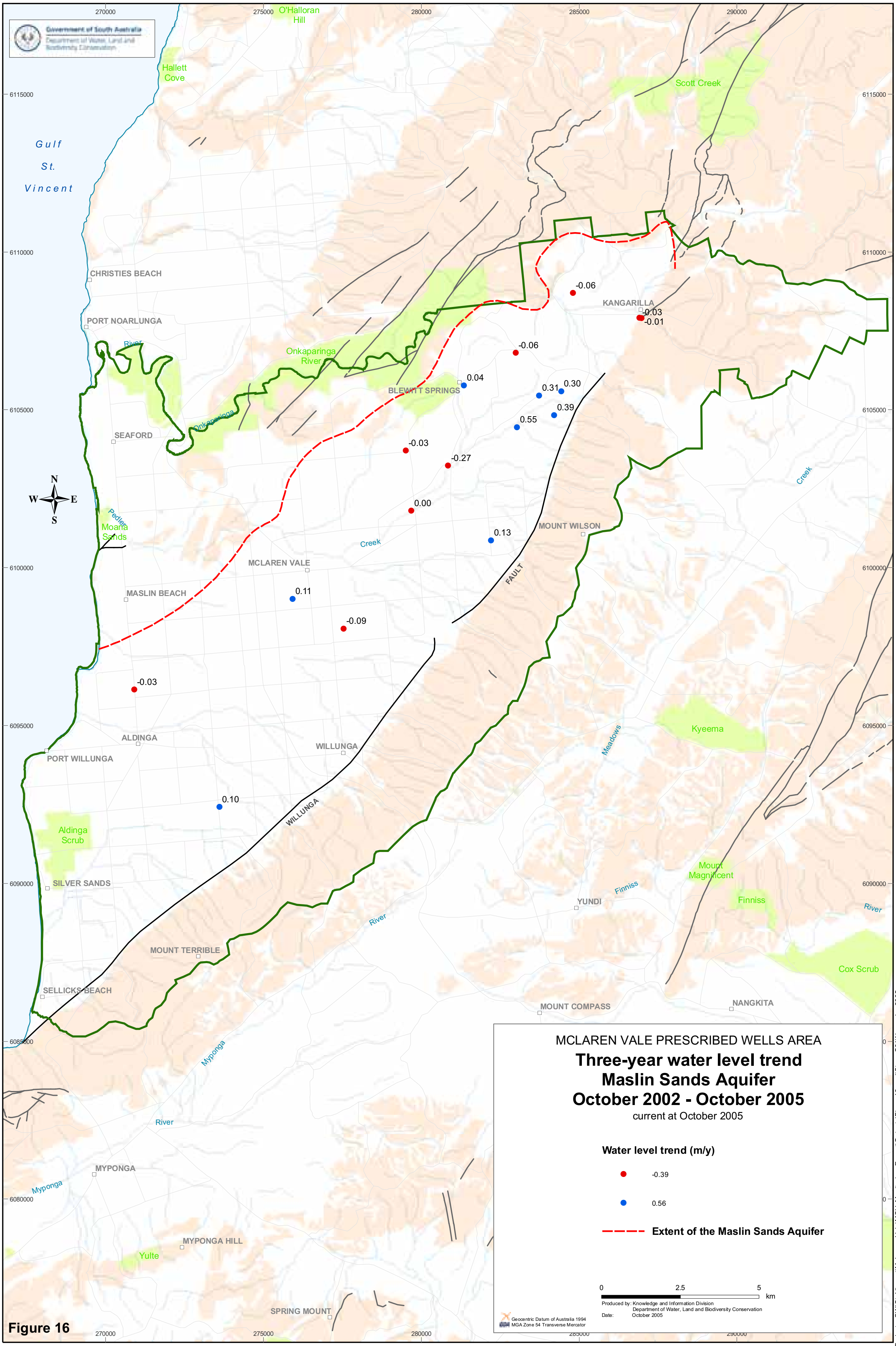

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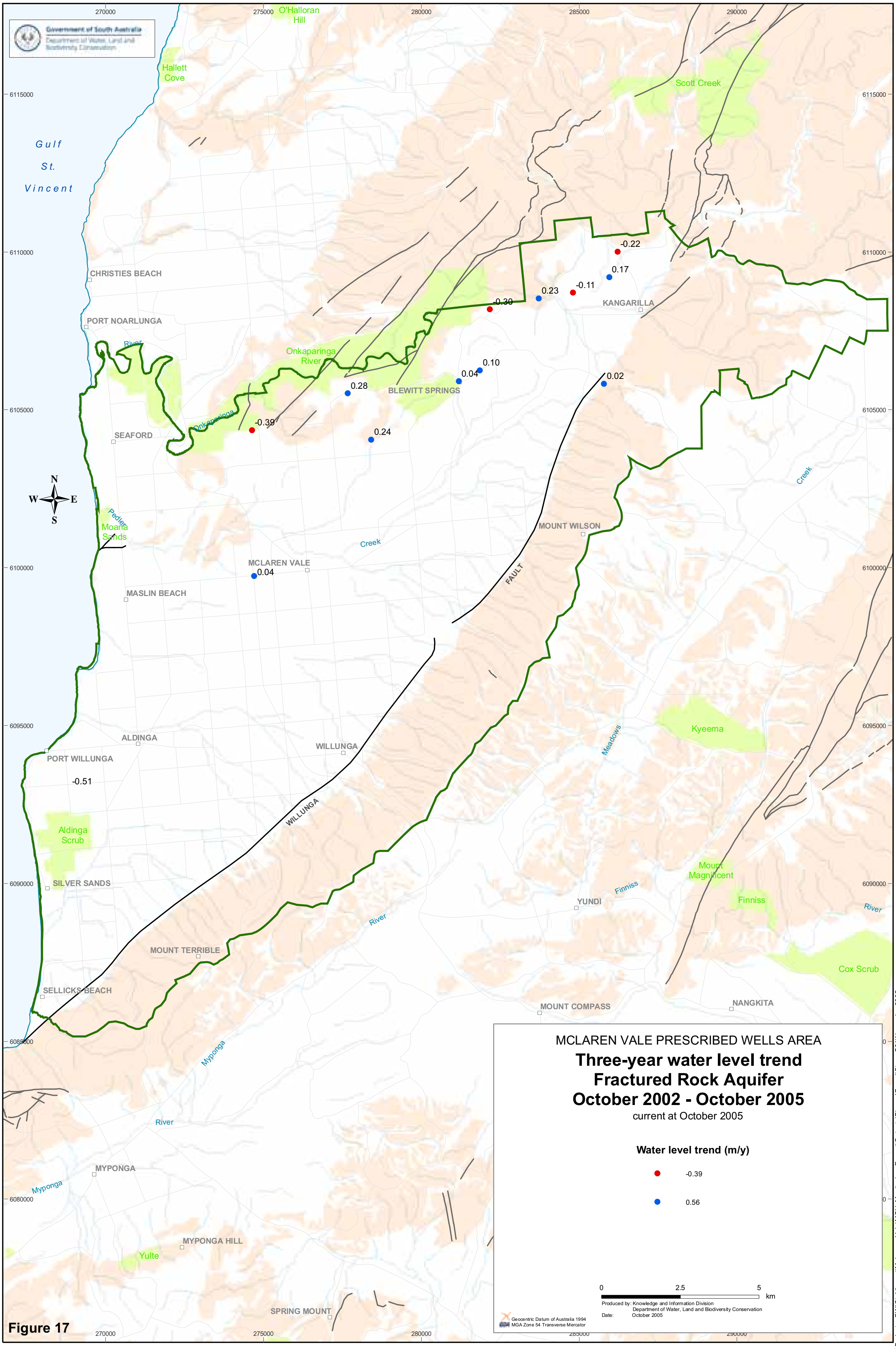

Figure 17

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6.2 LONG-TERM WATER LEVEL TRENDS

Water level trends have also been assessed over the period 1 October 1998 through 31 October 2005 (Figs 10–13) in an effort to provide a longer-term assessment of water level changes outside the period identified in the McLaren Vale WAP. This period also represents an interval where groundwater demand has approximated the estimated sustainable yield for the groundwater system of 6000 ML per annum (OCWMB 2000).

6.2.1 QUATERNARY AQUIFER

Changes in observed water levels over the period 1 October 1998 through 31 October 2005 (Fig. 18) are generally consistent with the changes reported on for the past three years, with the exception of WLG 19 which displays an increasing trend of 0.87 m/y over the long-term period compared to 0.03 m/y over the three-year period.

6.2.2 PORT WILLUNGA FORMATION AQUIFER

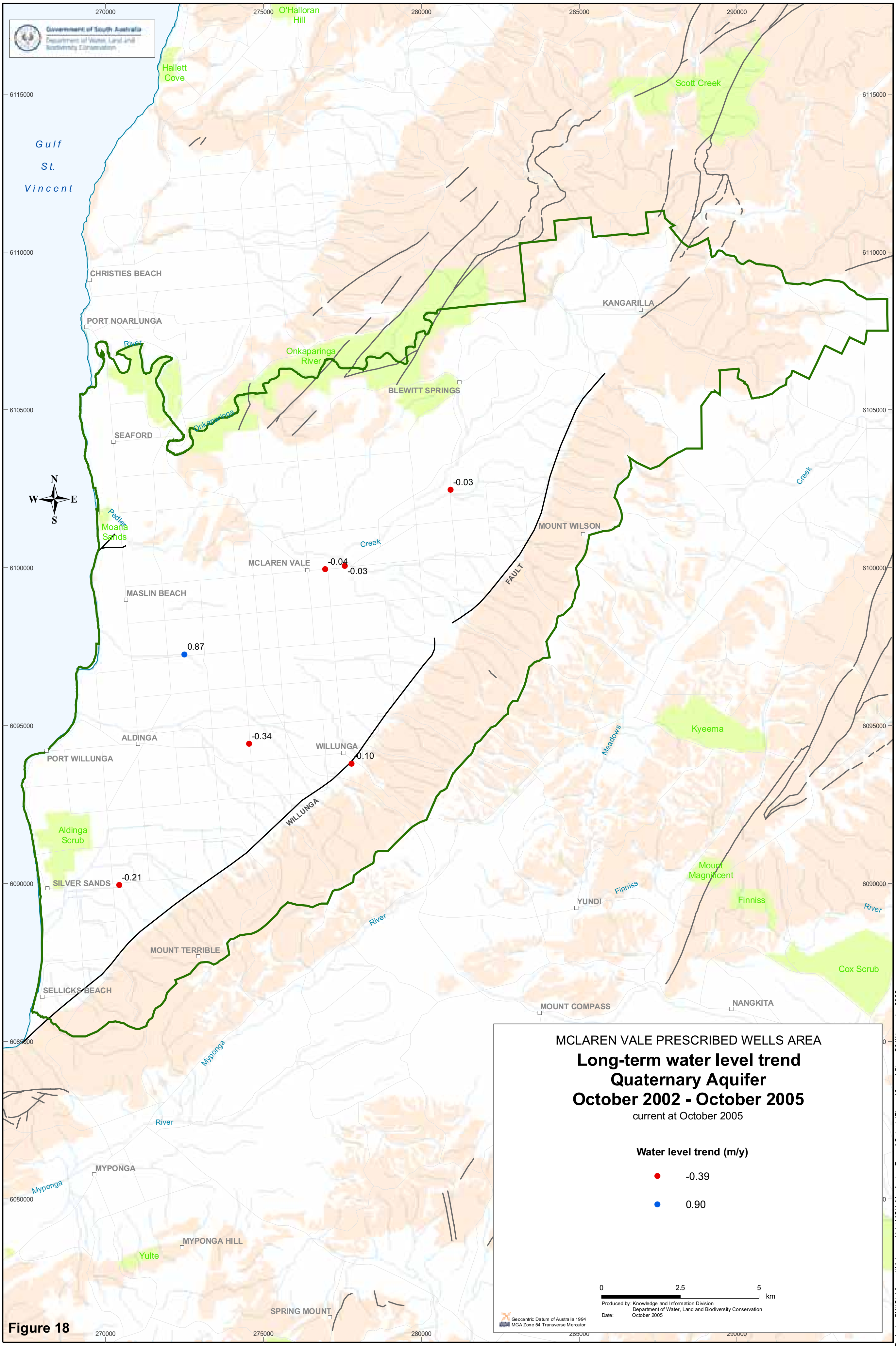
Within the Port Willunga Formation Aquifer system, changes in water levels have generally risen when compared to the three-year period (1 October 2002 through 31 October 2005). Decreasing water level trends in six wells are minimal, ranging from 0.01 to 0.09 m/y. The remaining eight wells indicating a rise in the water table are not concentrated in one area but are evident across the aquifer, with trends ranging from 0.02 to 0.45 m/y (Fig. 19). WLG 68, which indicated a decreasing trend of 0.11 m/y in the three-year analysis, now indicates a long-term rise in the water table with a trend of 0.45 m/y.

6.2.3 MASLIN SANDS AQUIFER

Over the period 1 October 1998 through 31 October 2005 (Fig. 20) changes in observed groundwater levels are consistent with those changes over the period 1 October 2002 through 31 October 2005. However, there are three wells (WLG 93, WLG 98 and KTP 31), which show long-term trends, which are significantly different to the three-year trends.

6.2.4 FRACTURED ROCK AQUIFER

Changes in groundwater levels over the period 1 October 1998 through 31 October 2005 (Fig. 21) are also consistent with those changes observed over the past three years. Groundwater level declines range from 0.05 to 0.29 m/y and groundwater rise varies from 0.03 to 0.34 m/y.



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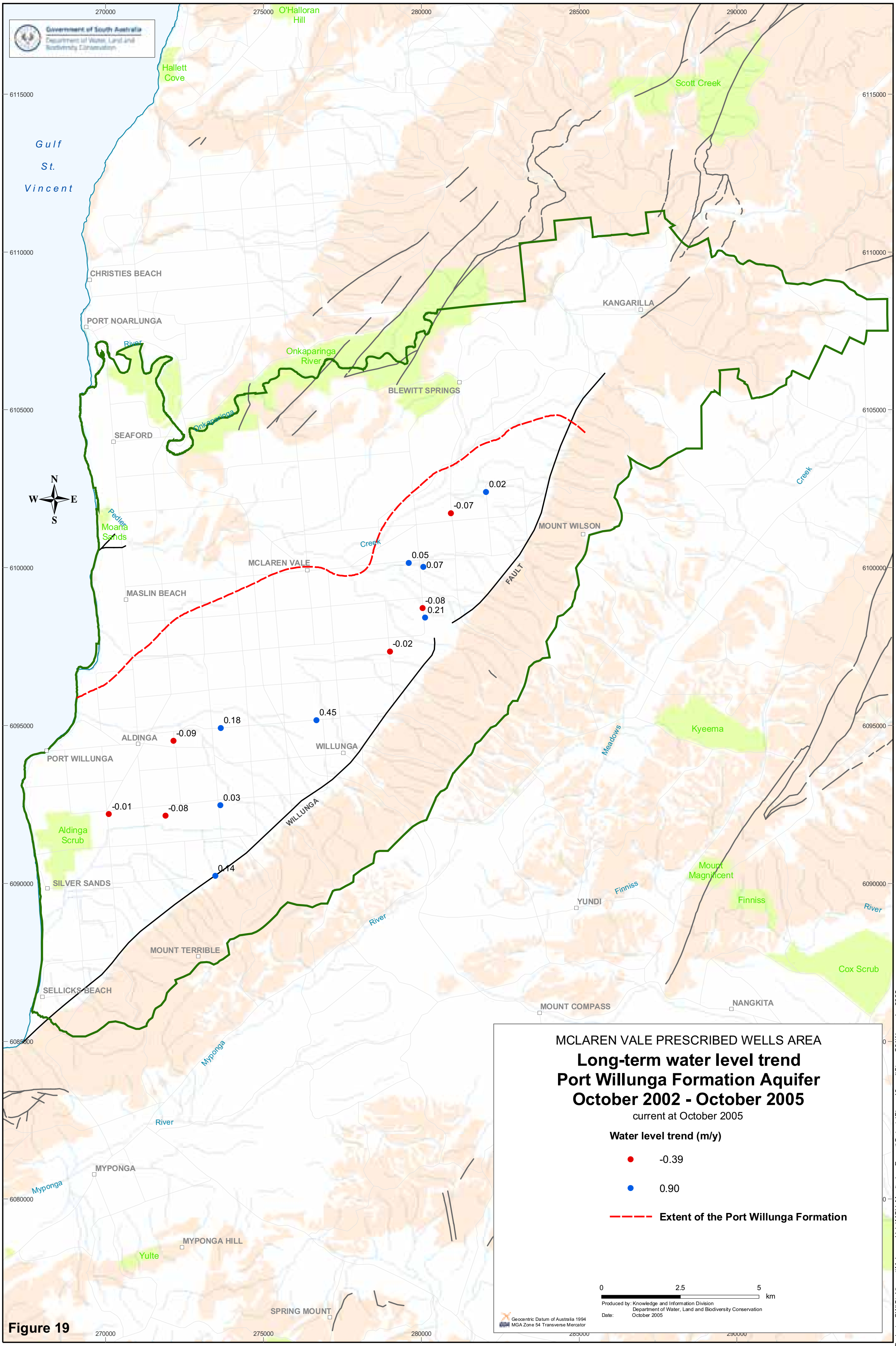

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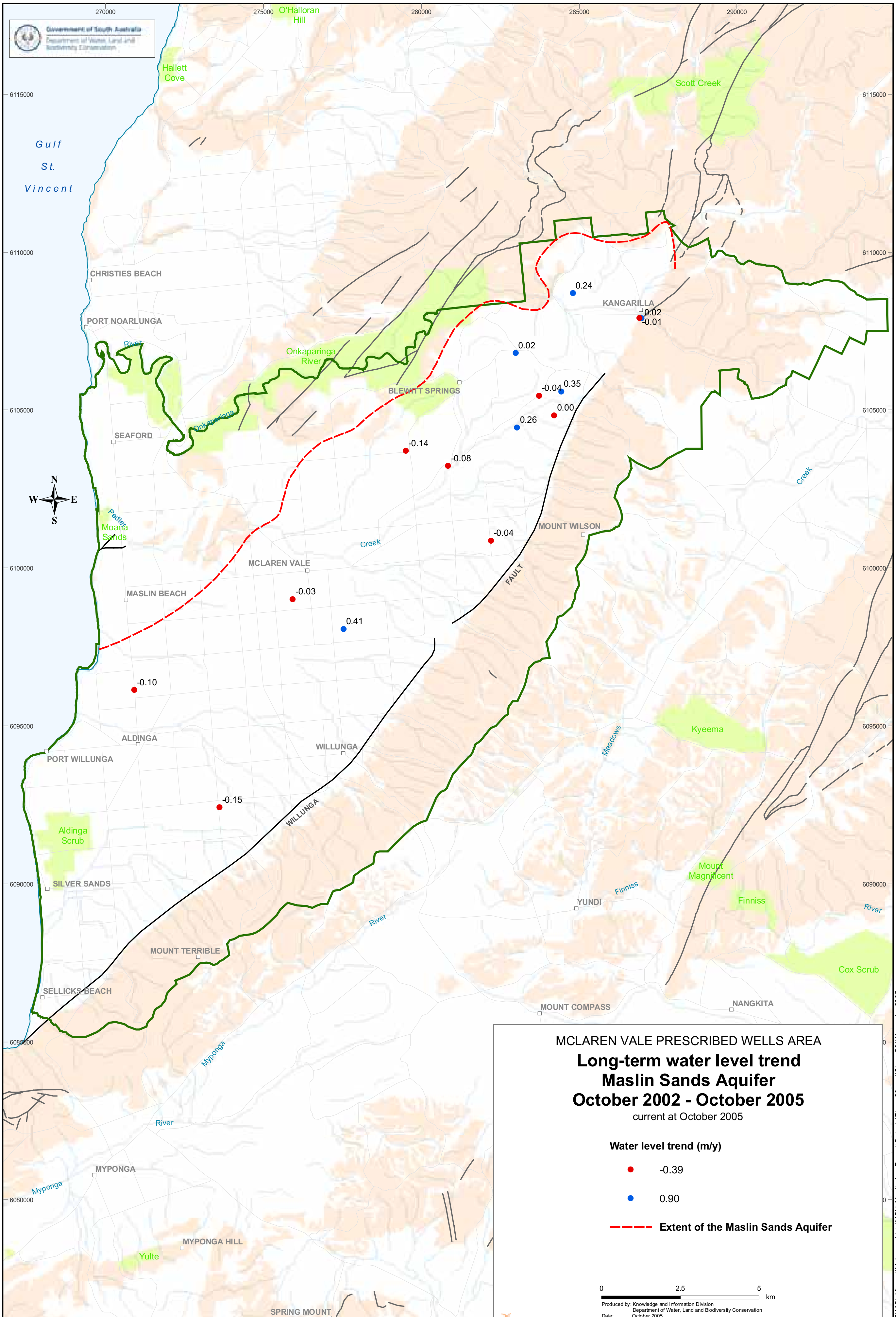

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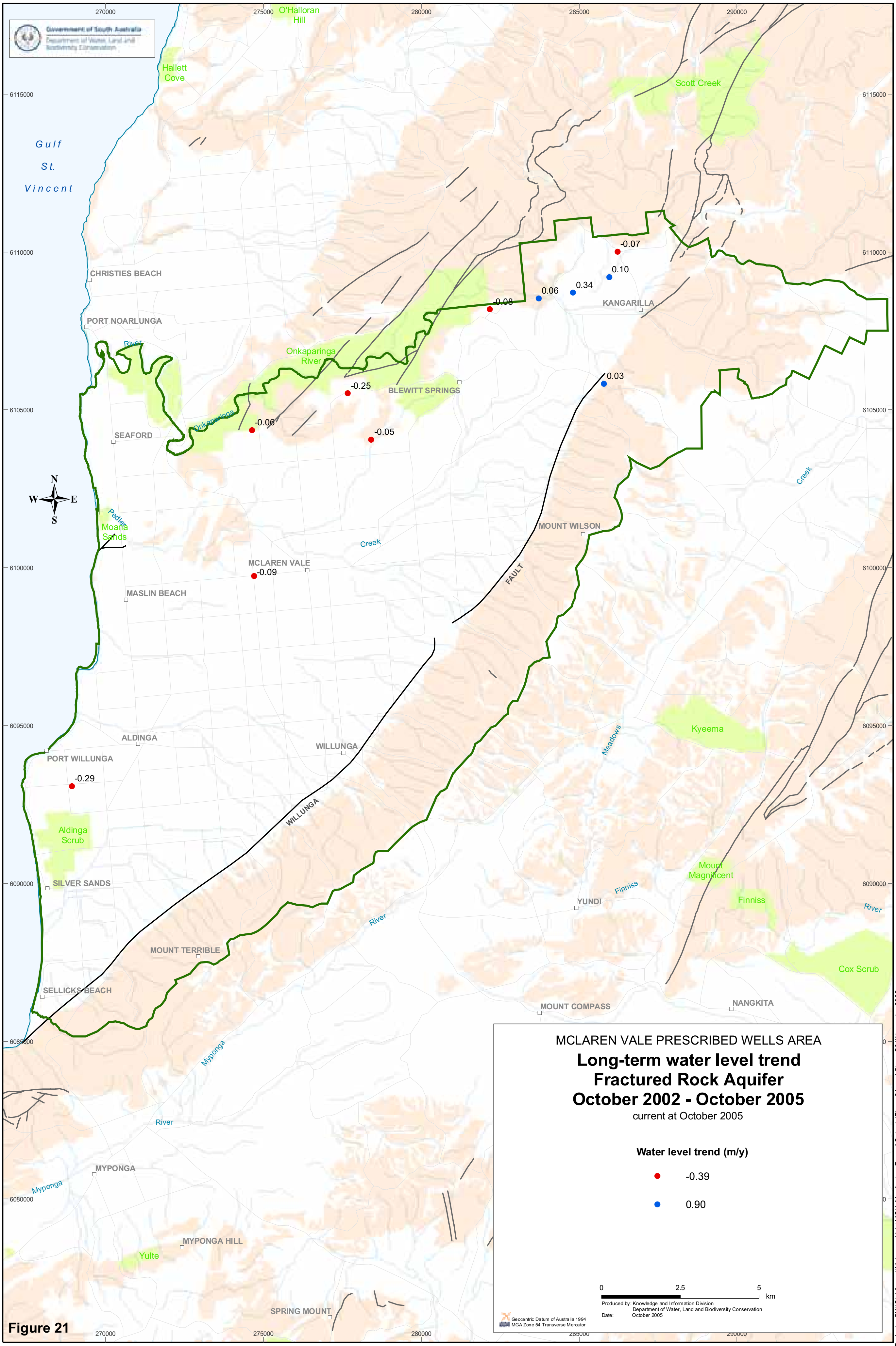

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7. SALINITY

The distribution of the latest salinity (post June 2005) sampled through the Observation Well Network is shown in Figures 22–25 for the different aquifer systems.

For the Quaternary Aquifer only two wells have been recently sampled (KTP 20 (567 mg/L) and WLG 156 (4199 mg/L) located near Blewitt Springs). It is noted that the salinity of the Quaternary Aquifer (prior to 1 July 2004) is very high in the Aldinga Scrub area where the aquifer is perched. This may be due to concentration of salts in the profile from evaporation.

Groundwater salinity increases towards the coast in the Port Willunga Formation Aquifer. This increase of salinity down hydraulic gradient suggests that recharge to this aquifer is limited along the groundwater flow path.

The salinity of the Maslin Sands Aquifer is generally similar to that of the Port Willunga Formation Aquifer. A region located between McLaren Vale and Blewitt Springs displays higher salinities than the remainder of the aquifer. This area coincides with a deflection in the potentiometric surface for the aquifer, thus the influence of this area's intense groundwater extraction should be closely monitored.

The salinity in the Fractured Rock Aquifer is variable, but generally fresh.

7.1 SALINITY TRENDS IN AQUIFERS

The three-year salinity trends (between 1 October 2002 and 31 October 2005) have been analysed for the Port Willunga Formation, Maslin Sands and Fractured Rock Aquifers. There is some discontinuity in the salinity data due to problems obtaining water samples from some of the private irrigation wells; thus, a limited number of wells were used to calculate salinity trends. There is limited water quality information to comment on changes in the Quaternary Aquifer.

Long-term and short-term spatial salinity trends can be observed in Figures 26–27. Long-term salinity time series, displaying three-year trends for all the wells in the PWA with sufficient data, can be seen in Figures 28–31.

The three-year salinity trends have been analysed to identify any stressed areas as defined in the WAP (OCWMB 2000, sec. 6, clause 4b). An area where groundwater salinity has increased at an average rate of 100 mg/L (total dissolved solids, TDS) over the previous three years is considered a 'stressed area'.

7.1.1 PORT WILLUNGA FORMATION AND BLANCHE POINT FORMATION AQUIFERS

A number of wells in the Port Willunga Formation are displaying a negative trend, indicating the salinity value is decreasing (-95.99 to -26.28 mg/L/y). Positive trends, indicating an increase in groundwater salinity, vary from 2.90 to 78.84 mg/L/y (Fig. 29).

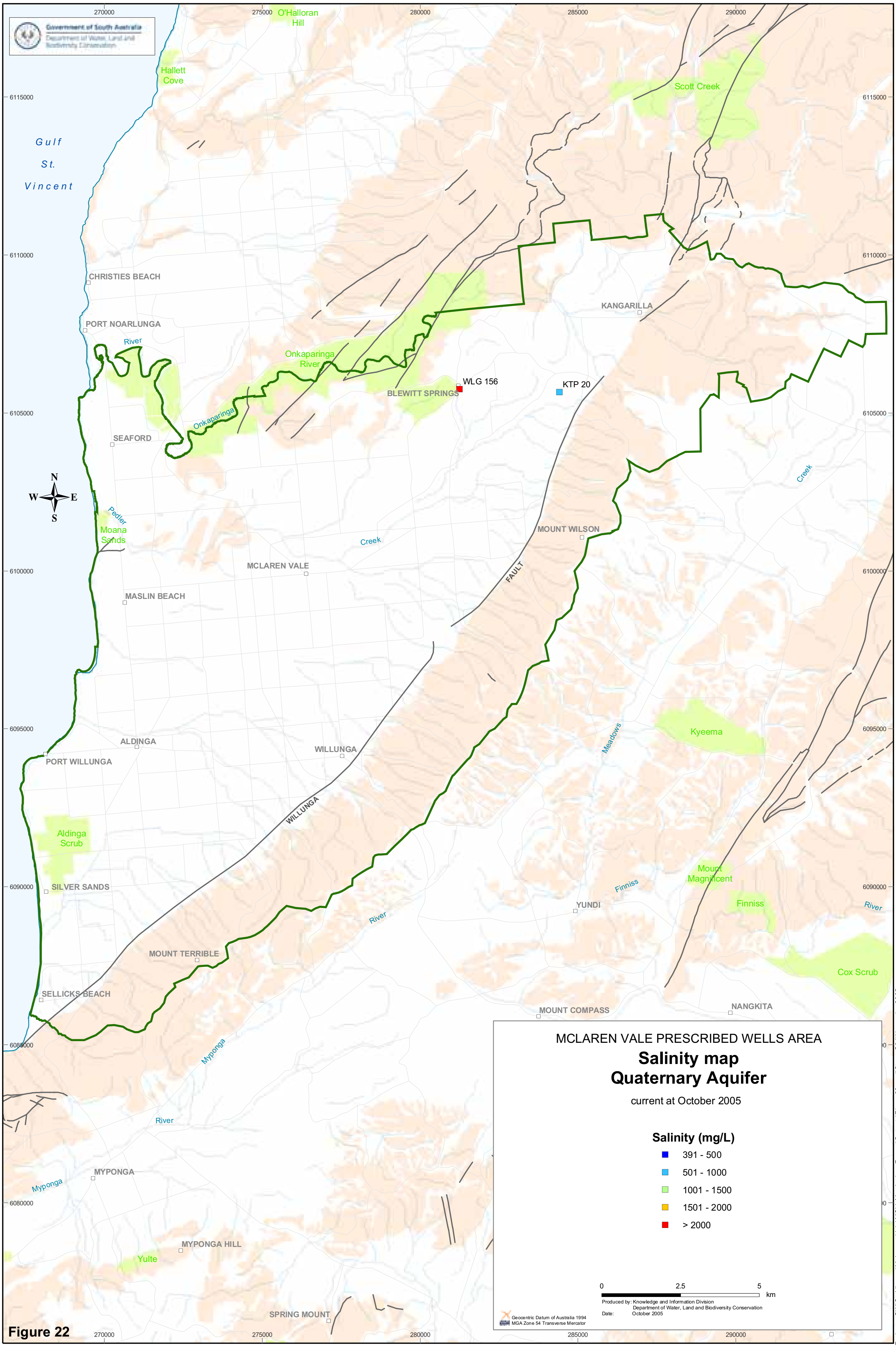

Figure 22

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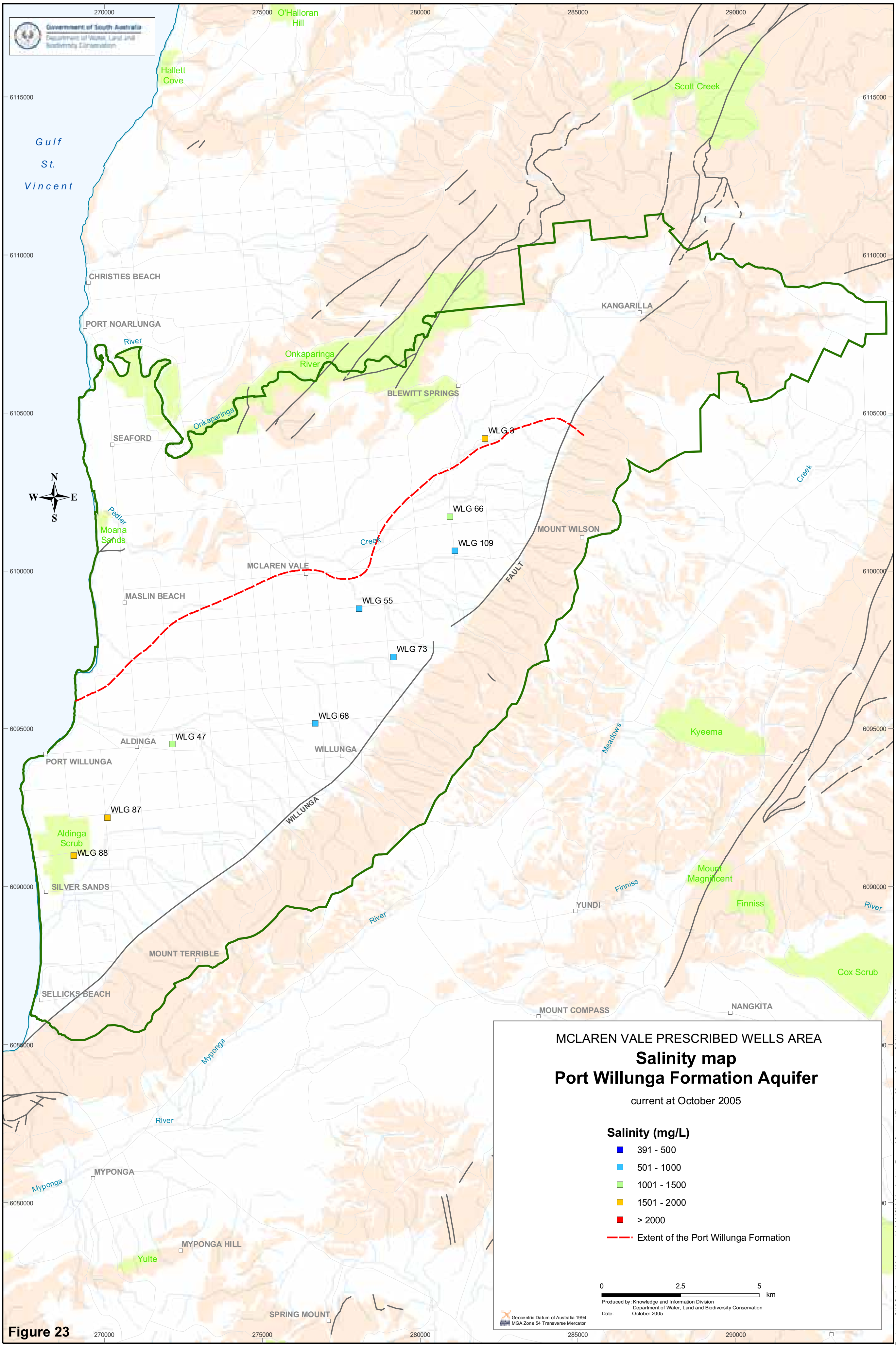

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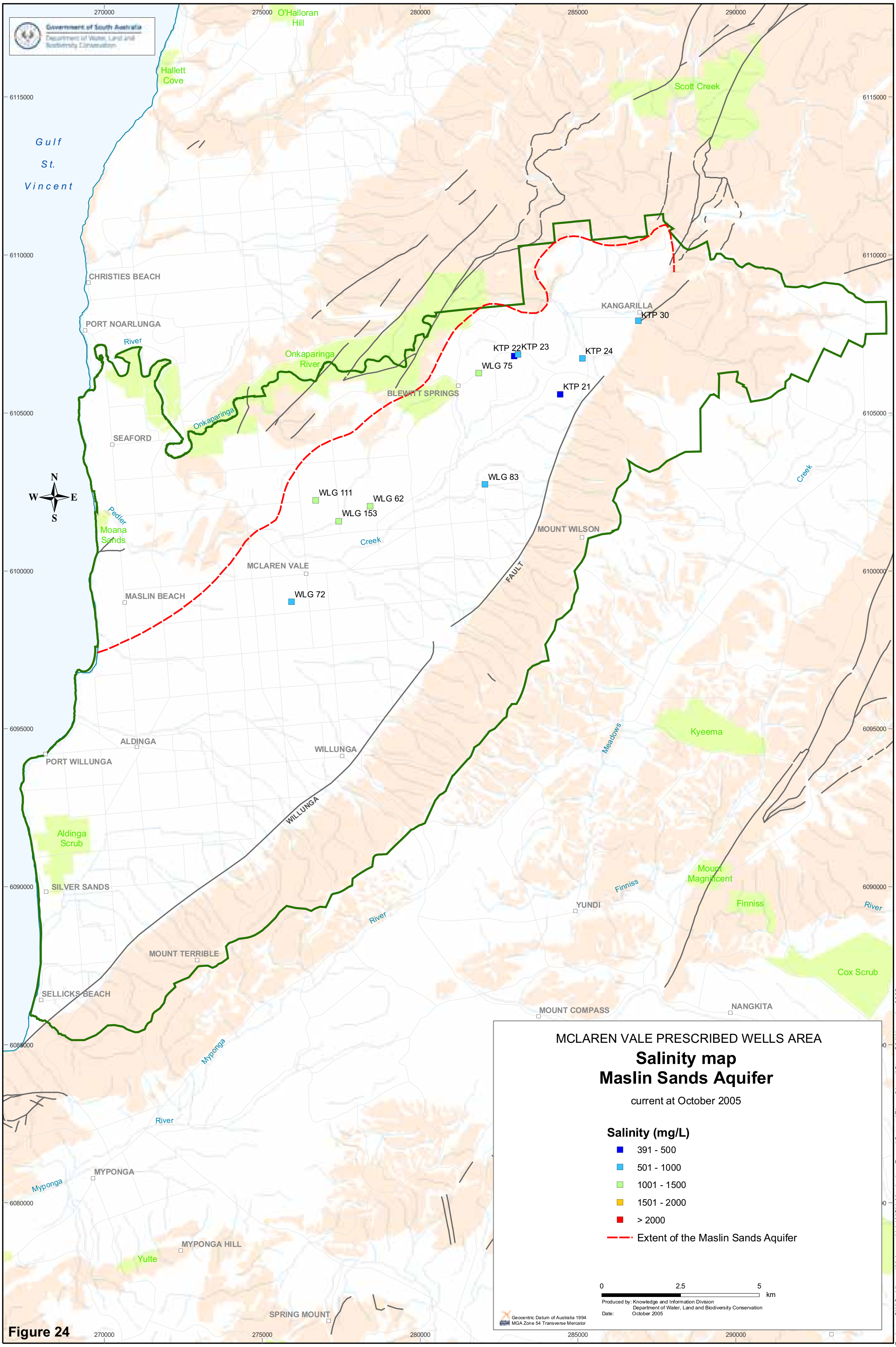

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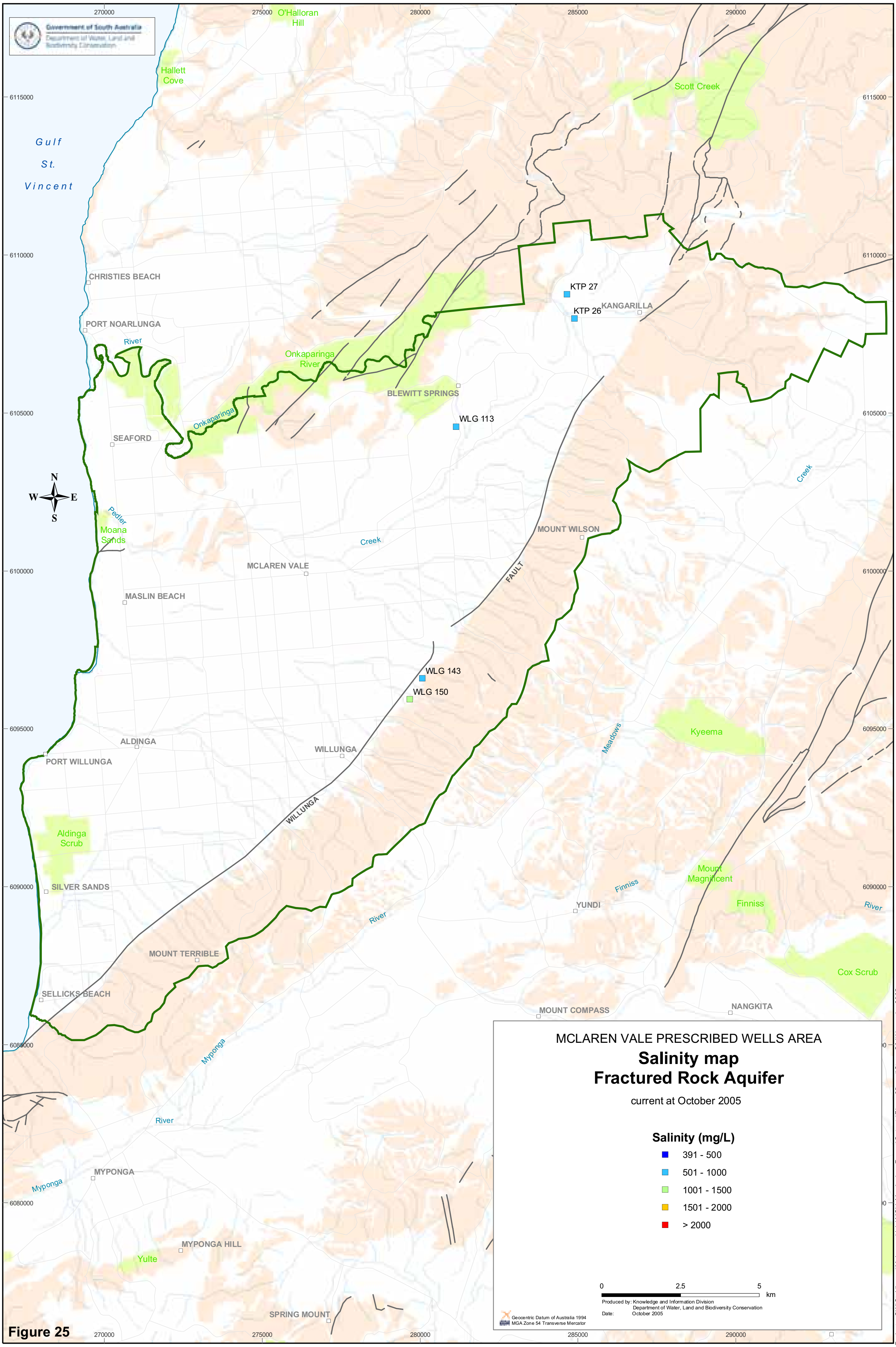

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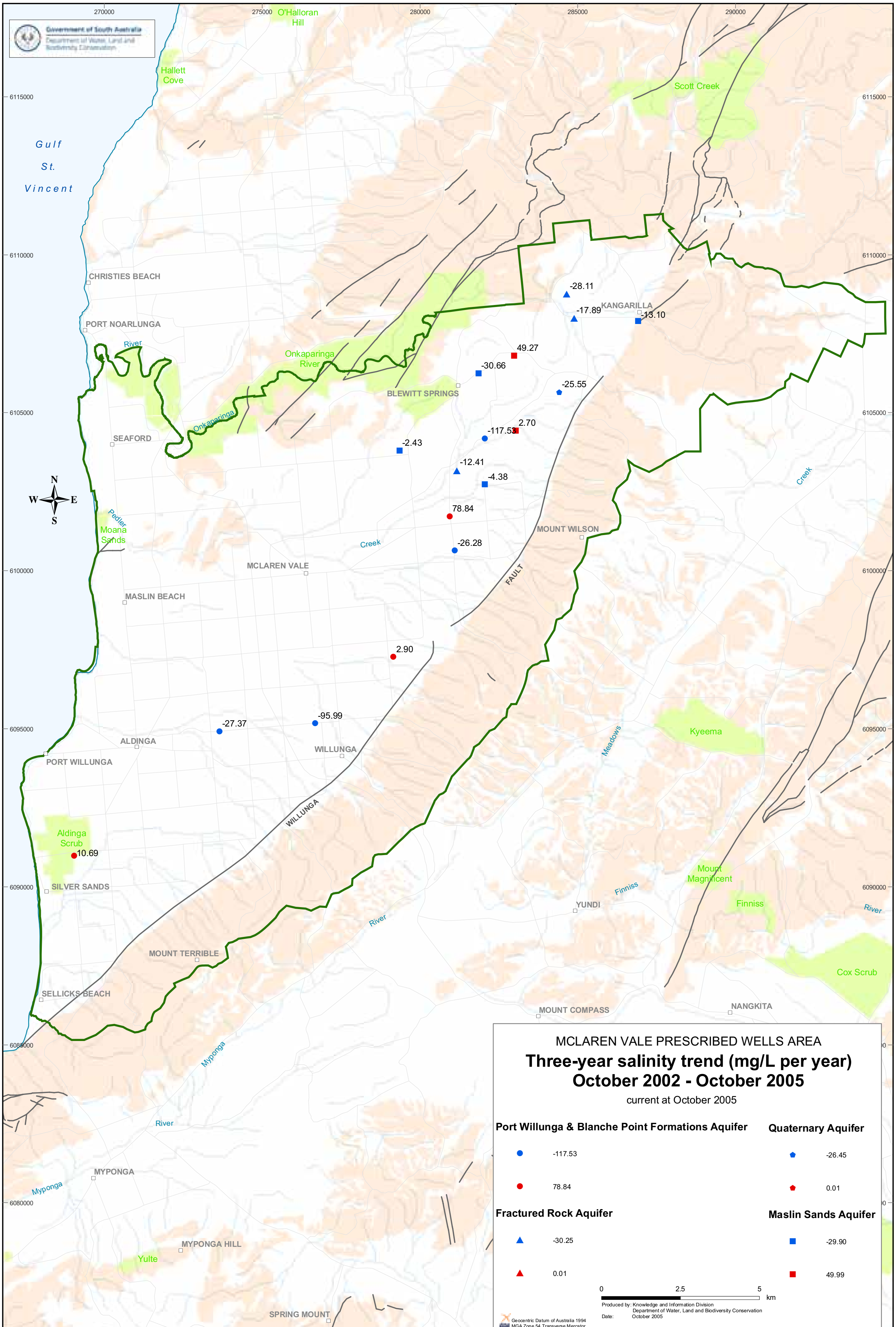

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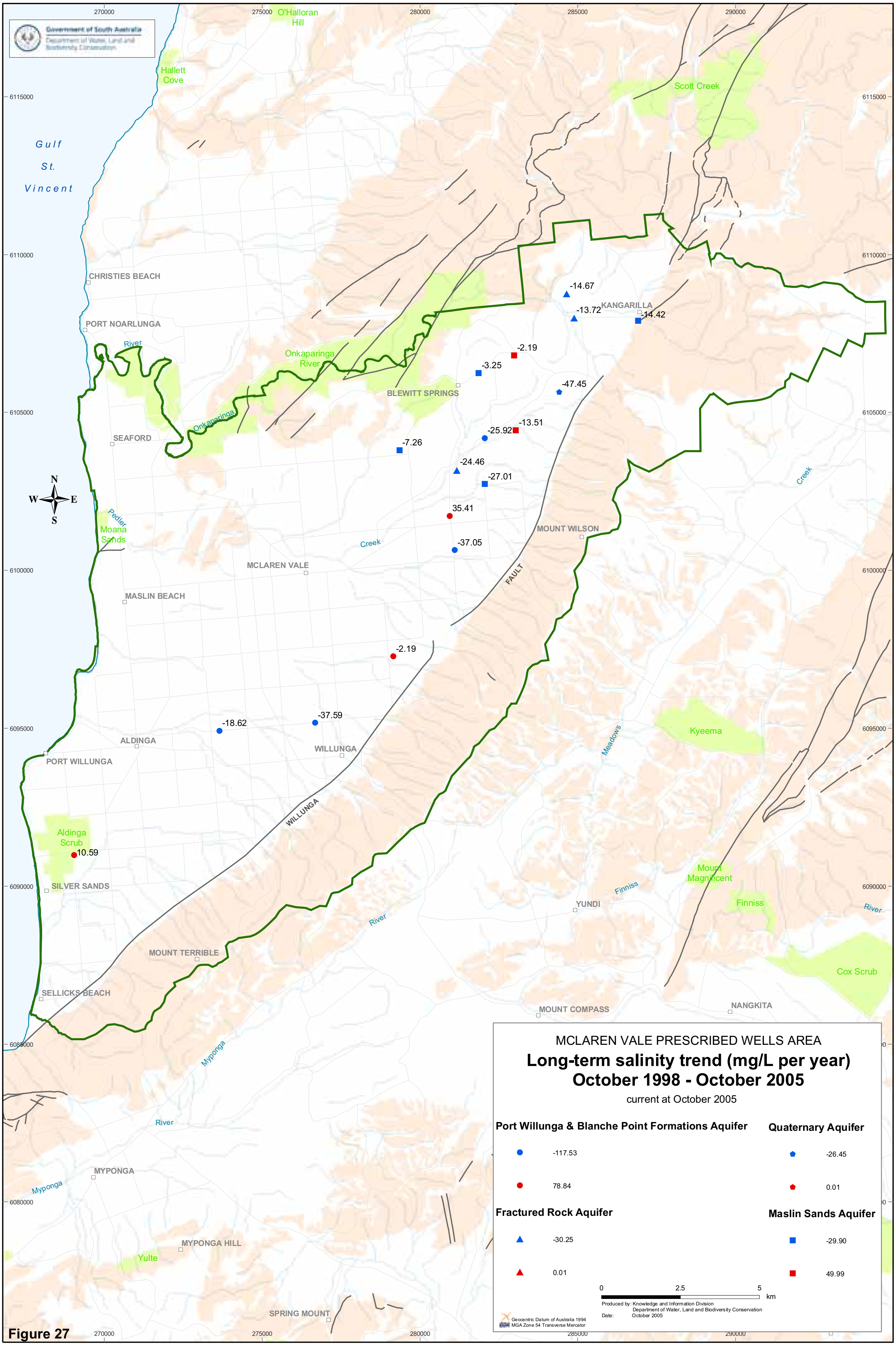

Figure 27

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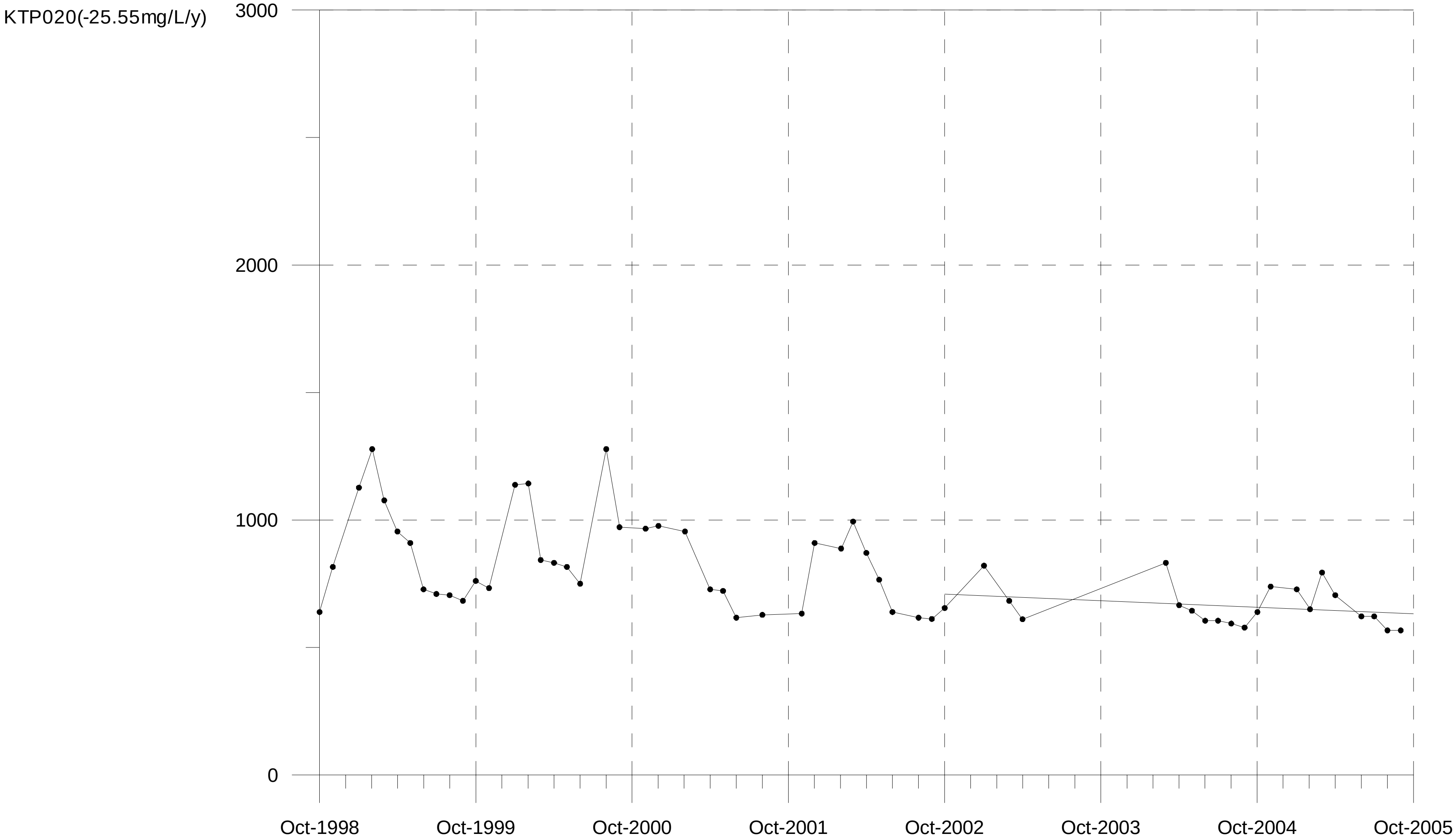

Figure 28. Quaternary Aquifer salinity trends

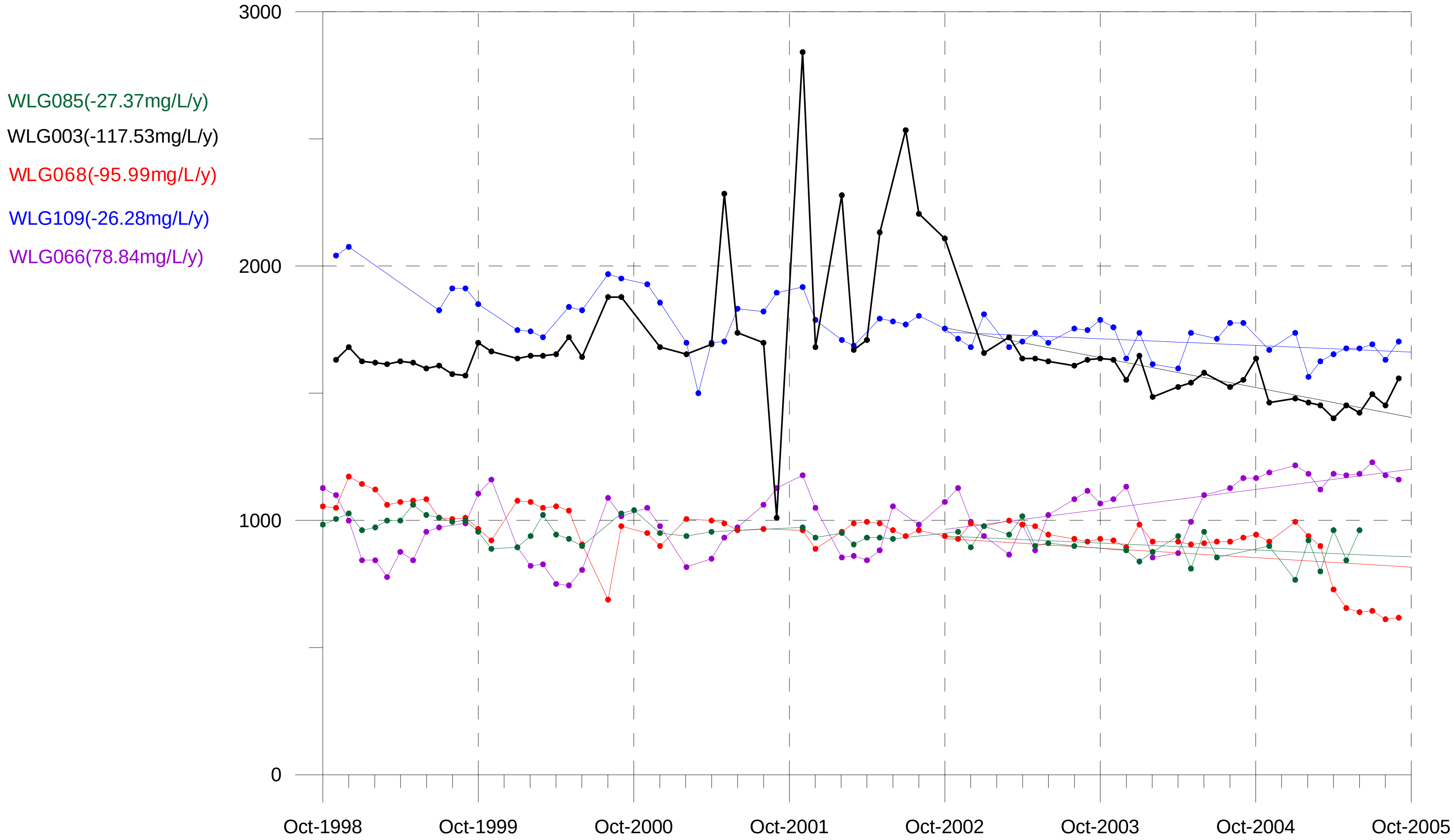

Figure 29. Port Willunga Formation and Blanche Point Formation Aquifer salinity trends

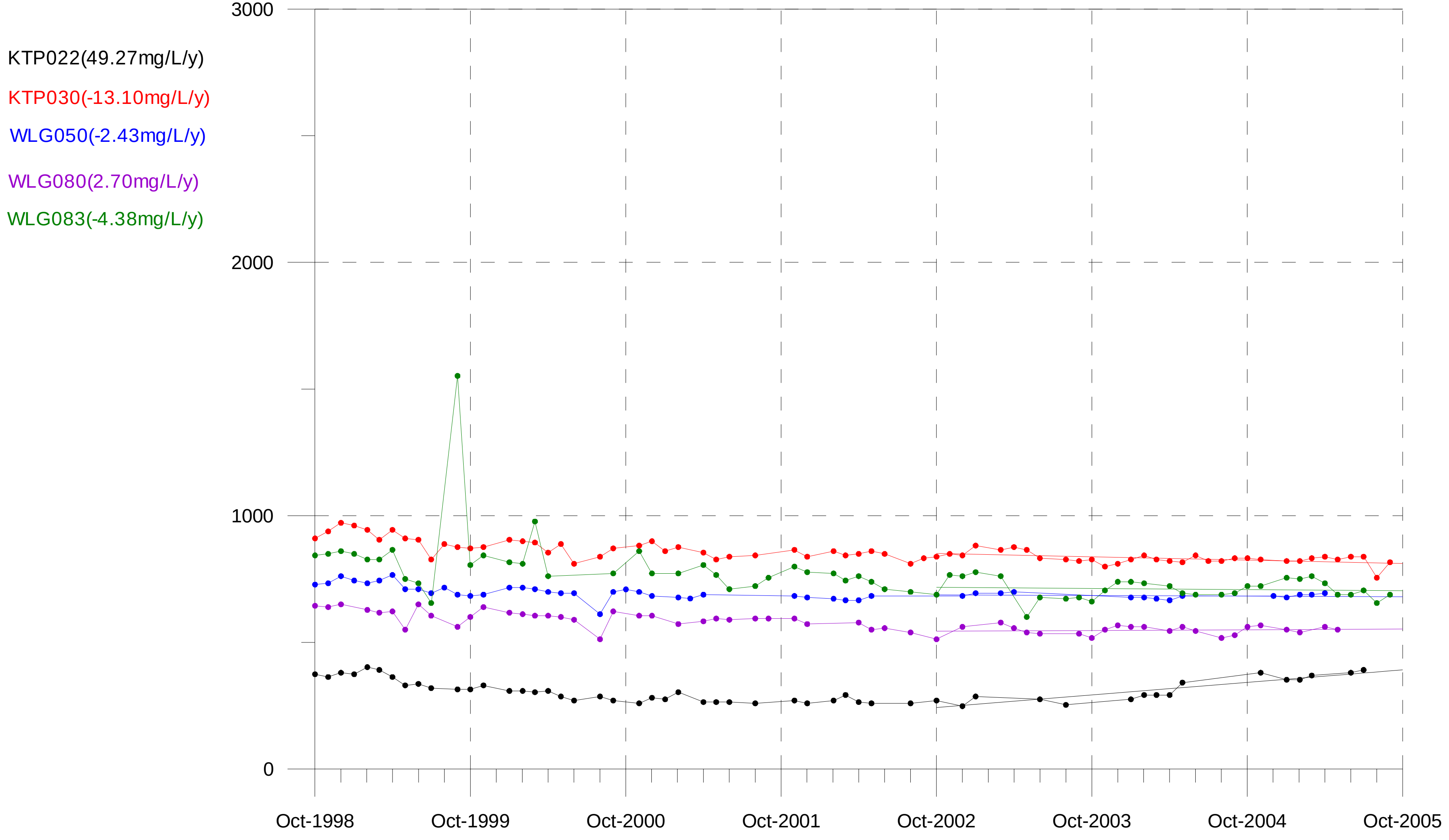

Figure 30. Maslin Sands Aquifer salinity trends

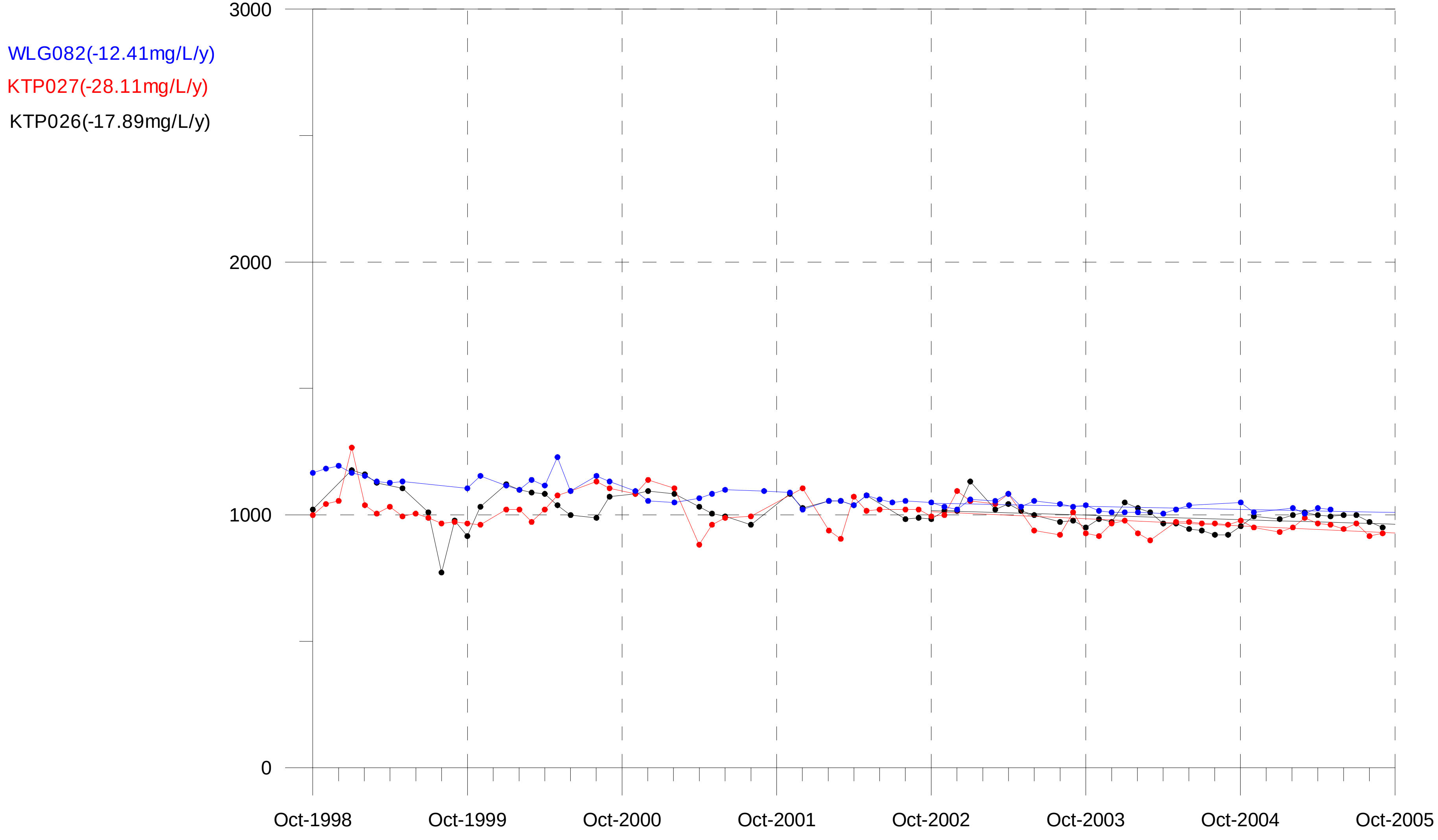

Figure 31. Fractured Rock Aquifer salinity trends

WLG 66, located in the central area of the basin, has a positive trend of 78.84 mg/L/y. This equates to an increase in salinity of 236.52 mg/L/y over the previous three years, and thus is defined as a ‘stressed area’ as stated in the McLaren Vale PWA WAP (OCWMB 2000). Licences wishing to transfer water allocations into this area to draw from the Port Willunga Formation Aquifer will be restricted.

WLG 3, located in the Blanche Point Formation Aquifer, indicates a significant decline in groundwater salinity over the previous three years (352.59 mg/L).

7.1.2 MASLIN SANDS AQUIFER

The majority of wells in the Maslin Sands Aquifer are displaying a negative or slight positive trend (-30.66 to 2.70 mg/L/y) indicating that salinity values have been decreasing (Fig. 30). However, there is one well with a notable salinity rise — KTP 22 (49.27 mg/L/y); the well does not appear to be located in an area of intense irrigation. KTP 22 exceeds the intended definition of a stressed area as defined in the McLaren Vale PWA WAP (OCWMB 2000). Licences wishing to transfer water allocations into this area to draw from the Maslin Sands Aquifer will be restricted.

7.1.3 FRACTURED ROCK AQUIFER

All wells located in the Fractured Rock Aquifer are displaying a decreasing salinity trend (Fig. 31). Trends vary from 12.41 to 28.11 mg/L/y.

8. SUMMARY

Generally, the water level trends in the McLaren Vale PWA have been relatively stable over the last three years. Comparisons made with the 1999–2002 water level trends documented by Clarke (2002) show that there has been a slight decrease in groundwater levels in all aquifers, especially in the Port Willunga Formation.

Since 2001, the cumulative deviation from the mean monthly rainfall has shown a decreasing trend (Station 23729 and 23753) indicating below average rainfall. The annual rainfall in 2002 was below average; the observed decrease in groundwater levels in the unconfined aquifer system may be attributed to this.

Two stressed areas have been identified in the Fractured Rock Aquifer (near WLG 10 and WLG 40), in the north of the PWA near the Onkaparinga River and around Port Willunga. Requests to transfer water allocations into these areas will be restricted.

If a primary aim of the monitoring network of the Quaternary Aquifer system is to assist in assessing the needs of various groundwater dependent ecosystems within the McLaren Vale PWA, it is likely that some consideration may need to be given to the expansion of this network to meet this objective.

Generally, the Port Willunga Formation, Maslin Sands and Fractured Rock Aquifers are stable or displaying negative salinity trends over the last three years. However, requests to transfer water allocation will be restricted in two areas, near WLG 66 in the Port Willunga Formation Aquifer and KTP 22 in the Maslin Sands Aquifer because they are identified as stressed areas.

UNITS OF MEASUREMENT

Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
gigalitre	GL	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	µg	10^{-6} g	mass
microlitre	µL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	365 or 366 days	time interval

EC	electrical conductivity (µS/cm)
ppm	parts per million
ppb	parts per billion
TDS	total dissolved solids (mg/L)

GLOSSARY

Aquifer. An underground layer of rock or sediment which holds water and allows water to percolate through.

Aquifer, confined. Aquifer in which the upper surface is impervious and the water is held at greater than atmospheric pressure. Water in a penetrating well will rise above the surface of the aquifer.

Aquifer, unconfined. Aquifer in which the upper surface has free connection to the ground surface and the water surface is at atmospheric pressure.

Aquitard. A layer in the geological profile that separates two aquifers and restricts the flow between them.

Australian Height Datum (AHD). The datum used for the determination of elevations in Australia. The determination set mean sea level as zero elevation.

Basin. The area drained by a major river and its tributaries.

Bore. *See well.*

Catchment. A catchment is that area of land determined by topographic features within which rainfall will contribute to runoff at a particular point.

Catchment water management board. A statutory body established under Part 6, Division 3, s. 53 of the Act whose prime function under Division 2, s. 61 is to implement a catchment water management plan for its area.

Cone of depression. An inverted cone-shaped space within an aquifer caused by a rate of groundwater extraction which exceeds the rate of recharge. Continuing extraction of water can extend the area and may affect the viability of adjacent wells, due to declining water levels or water quality.

CWMB. Catchment Water Management Board.

Datum. The reference point from which elevations are measured. Given the value of zero mAHD.

Depth to Water (DTW). The distance from the reference point to the water surface (that is not affected by pumping). Usually measured in metres.

DWLBC. Department of Water, Land and Biodiversity Conservation. Government of South Australia.

Evapotranspiration. The total loss of water as a result of transpiration from plants and evaporation from land, and surface waterbodies.

Groundwater. *See underground water.*

Hydrogeology. The study of groundwater, which includes its occurrence, recharge and discharge processes and the properties of aquifers. *(See hydrology.)*

Hydrology. The study of the characteristics, occurrence, movement and utilisation of water on and below the earth's surface and within its atmosphere. *(See hydrogeology.)*

Irrigation. Watering land by any means for the purpose of growing plants.

Irrigation season. The period in which major irrigation diversions occur, usually starting in August–September and ending in April–May.

Natural recharge. The infiltration of water into an aquifer from the surface (rainfall, streamflow, irrigation etc.) *(See recharge area, artificial recharge.)*

Potentiometric head. The potentiometric head or surface is the level to which water rises in a well due to water pressure in the aquifer.

Prescribed water resource. A water resource declared by the Governor to be prescribed under the Act, and includes underground water to which access is obtained by prescribed wells. Prescription of a water resource requires that future management of the resource be regulated via a licensing system.

PWA. Prescribed Wells Area.

Recharge area. The area of land from which water from the surface (rainfall, streamflow, irrigation, etc.) infiltrates into an aquifer. *(See artificial recharge, natural recharge.)*

Reduced Standing Water Level (RSWL). The elevation of the water level, typically measured in mAHD. It is calculated by subtracting the depth to water from the reference elevation.

Standing Water Level (SWL). The distance from the natural ground surface (natural surface) to the water surface. Usually measured in metres.

Total Dissolved Solids (TDS). The total amount of solids (milligrams per liter, mg/L) remaining when a water sample is evaporated to dryness.

Transfer. A transfer of a licence (including its water allocation) to another person, or the whole or part of the water allocation of a licence to another licensee or the Minister under Part 5, Division 3, s. 38 of the Act. The transfer may be absolute or for a limited period.

Underground water (groundwater). Water occurring naturally below ground level or water pumped, diverted or released into a well for storage underground.

Water allocation. (a) in respect of a water licence means the quantity of water that the licensee is entitled to take and use pursuant to the licence; (b) in respect of water taken pursuant to an authorisation under s. 11 means the maximum quantity of water that can be taken and used pursuant to the authorisation.

Water allocation plan (WAP). A plan prepared by a CWMB or water resources planning committee and adopted by the Minister in accordance with Division 3 of Part 7 of the Act.

Well. (a) an opening in the ground excavated for the purpose of obtaining access to underground water; (b) an opening in the ground excavated for some other purpose but that gives access to underground water; (c) a natural opening in the ground that gives access to underground water.

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