MARNE SAUNDERS PWRA

GROUNDWATER LEVEL AND SALINITY STATUS REPORT

2011

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2011 SUMMARY

The Marne Saunders Prescribed Water Resources Area (PWRA) is located on the eastern side of the Mount Lofty Ranges about 60 km northeast of Adelaide. It is a regional scale resource for which surface water and groundwater is prescribed under South Australia's *Natural Resources Management Act 2004*. A Water Allocation Plan provides for sustainable management of the water resources.

The Marne Saunders PWRA is a tributary catchment for the River Murray which can be divided into two distinct groundwater regions: the Hills Zone and the Plains Zone. Overall, extractions for the whole PWRA totalled 1070 ML for 2010–11.

The Hills Zone comprises fractured rock aquifers of the Mount Lofty Ranges. Metered extractions from these aquifers have declined over recent years in response to better rainfall. The volume for 2010–11 was 137 ML which represents a decrease of 50% from the previous year. Lucerne was the largest user, accounting for 49% of the extraction and vines were the second largest user with 18% of the extraction. Extraction volumes are considered too low and dispersed to affect regional trends. Groundwater level monitoring shows a strong relationship with rainfall patterns.

In the Plains Zone irrigation supplies are obtained from the Murray Group Limestone aquifer, predominantly along the Marne River valley. Metered extractions for 2010–11 totalled 933 ML, a decrease of 40% from the previous year. Again, lucerne was the largest groundwater user accounting for 46%, followed by turf, pasture and intensive animal production accounting for 18%, 11% and 10% respectively.

Below average rainfall in the Hills Zone has resulted in very little streamflow and consequently little recharge to the limestone aquifer where it is unconfined downstream of Cambrai. The majority of groundwater levels on the Plains Zone along the river valley were at their lowest-ever recorded levels in November 2009. Above average rainfall during 2010 has resulted in some recent recovery of groundwater levels in some wells. Groundwater salinities in this aquifer are showing a gradual long term rise because of the lack of recharge from streamflow infiltration. There has been some decrease in salinity levels following above average streamflow during 2010.

There are no significant adverse trends in the fractured rock aquifer or the limestone aquifer where it is confined upstream of Cambrai.

ASSESSMENT OF STATUS

The Marne Saunders PWRA has been assigned a status of yellow "Adverse trends indicating low risk to the resource in the medium term" for the 2010–11 water use year. This status is supported by:

- a gradual decline in groundwater levels on the Plains Zone since 2006 due to lack of recharge from streamflow. These declines are not expected to affect access to the resource by groundwater users over the next 10–20 years.
- a gradual increase in some salinity levels since 2006 on the Plains Zone due to lack of recharge from streamflow. These increases are not expected to affect the current beneficial use of the resource by groundwater users over the next 10–20 years.

The observed trends highlight the importance of recharge from streamflow for the sustainable development of the groundwater resource on the Plains Zone. A prolonged period of limited or no streamflow could exacerbate the adverse trends.

There are no significant adverse trends in the fractured rock aquifer or the limestone aquifer where it is confined upstream of Cambrai.

2011 STATUS

 No adverse trends, indicating a stable or improving situation

Trends are either stable (no significant change), or improving (i.e. decreasing salinity or rising water levels).

 Adverse trends indicating low risk to the resource in the medium term

Observed adverse trends are gradual and if continued, will not lead to a change in the current beneficial uses of the groundwater resource for at least 15 years. Beneficial uses may be drinking water, irrigation or stock watering.

 Adverse trends indicating high risk to the resource eventuating in the short to medium term

Observed adverse trends are significant and if continued, will lead to a change in the current beneficial uses of the groundwater resource in about 10 years.

 Degradation of the resource compromising present use within the short term

Trends indicate degradation of the resource is occurring, or will occur within 5 years. Degradation will result in a change in the beneficial use (i.e. no longer suitable for drinking or irrigation purposes) and may take the form of increasing groundwater salinities, or a fall in the groundwater levels such that extractions from the aquifer may not be possible.

BACKGROUND

The Marne Saunders PWRA is located about 60 km northeast of Adelaide on the eastern side of the Mount Lofty Ranges (Fig. 1) and comprises a tributary catchment for the River Murray, which generates ephemeral flows in wet years. It is a regional-scale resource for which surface water and groundwater are prescribed under South Australia's *Natural Resources Management Act 2004*. A Water Allocation Plan, which was adopted in January 2010, provides for sustainable management of the resource.

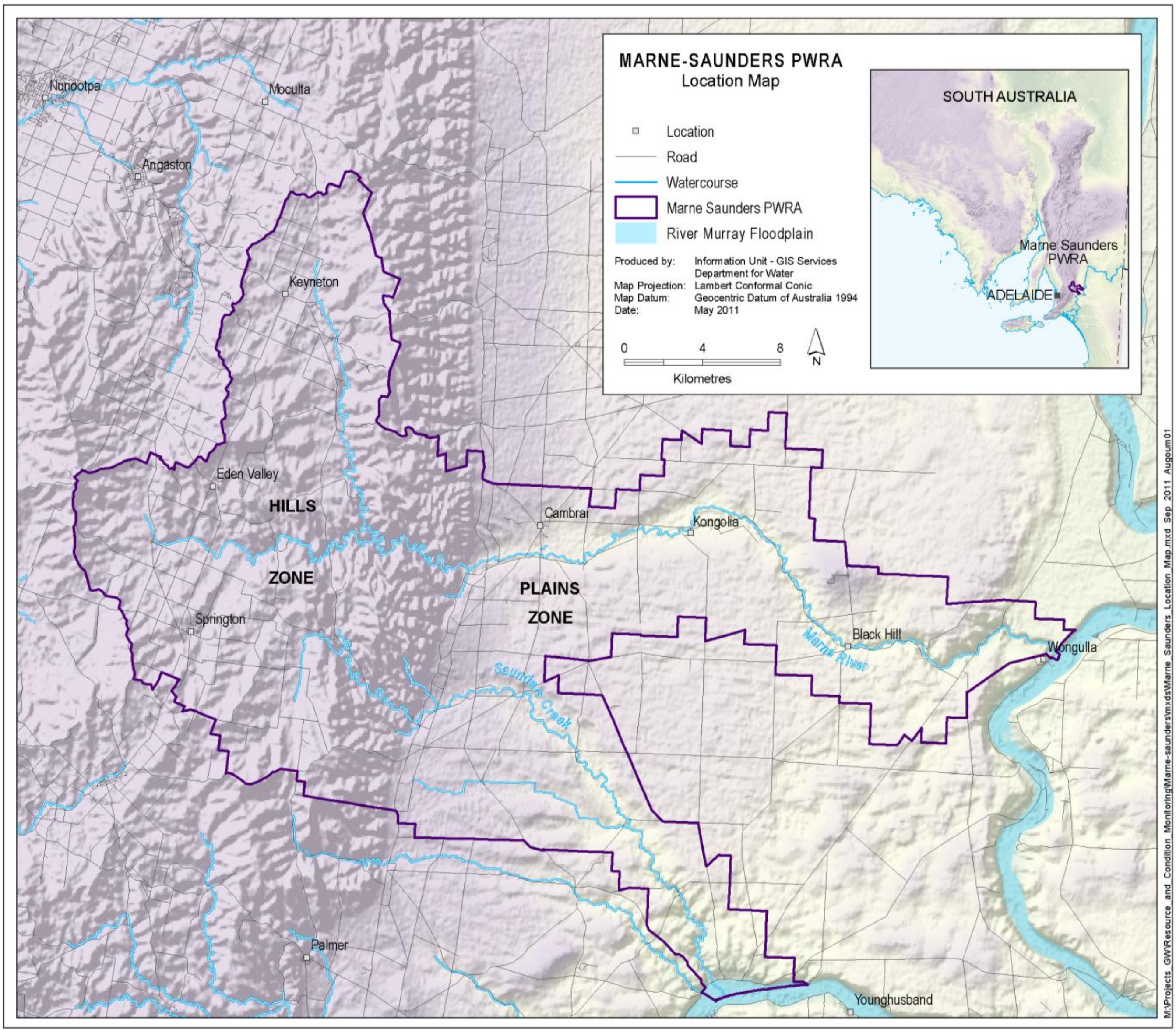

Figure 1. Location of the Marne Saunders PWRA

HYDROGEOLOGY

The Marne Saunders PWRA can be divided into two distinct groundwater regions; the Hills Zone and the Plains Zone. The Hills Zone comprises the consolidated basement rocks of the Mount Lofty Ranges, which form fractured rock aquifers (Table 1 and Fig. 2). Well yields are generally low (generally below 2 L/s). The Plains Zone is underlain by unconsolidated sediments of the Murray Basin (Table 1 and Fig. 2).

The main aquifer is the Murray Group Limestone, which is mostly developed along the Marne River for irrigation and is recharged mainly by infiltration of streamflow from the rivers as they flow out of the hills onto the plains. Groundwater level trends have shown a close correlation with streamflow and hence, rainfall in the Mount Lofty Ranges. Very little information is available about the underlying Renmark Group confined aquifer which comprises interbedded sands and lignitic (brown) clays, but yields are thought to be low.

Table 1. Hydrogeological units within the Marne Saunders PWRA

Aquifer	Lithology	Thickness (m)	Description
HILLS ZONE			
Fractured Rock Aquifer	Micaceous and feldspathic sandstones and siltstones		Fractured basement rock of the Mt Lofty Ranges. Lithology and connectivity of fractures is highly variable. Clayey weathering products may fill fractures and joints.
PLAINS ZONE			
Quaternary Sediments	Pooraka Formation; colluvial outwash of red-brown clays and minor gravels Alluvial sediments can be found in the river floodplains	0–60 m	Unconfined aquifer that increases in thickness towards the Hills Zone. Also forms confining layer for underlying limestone aquifer west of Cambrai
Murray Group Limestone	Yellow-brown to grey limestone, highly fossiliferous and sandy, with solution cavities present in some areas	20–25 m	Confined aquifer to the west of Cambrai and unconfined aquifer to the east.
Ettrick Formation	Grey-green sandy marls	10–20 m	Confining layer which is absent over most of the PWRA, occurs primarily in the northwest.
Renmark Group	Dark-brown, fine to medium-grained sands and interbedded carbonaceous clays and lignites	10– >50 m	Confined sedimentary aquifer comprising discontinuous deposits due to the undulating nature of the basement rock.

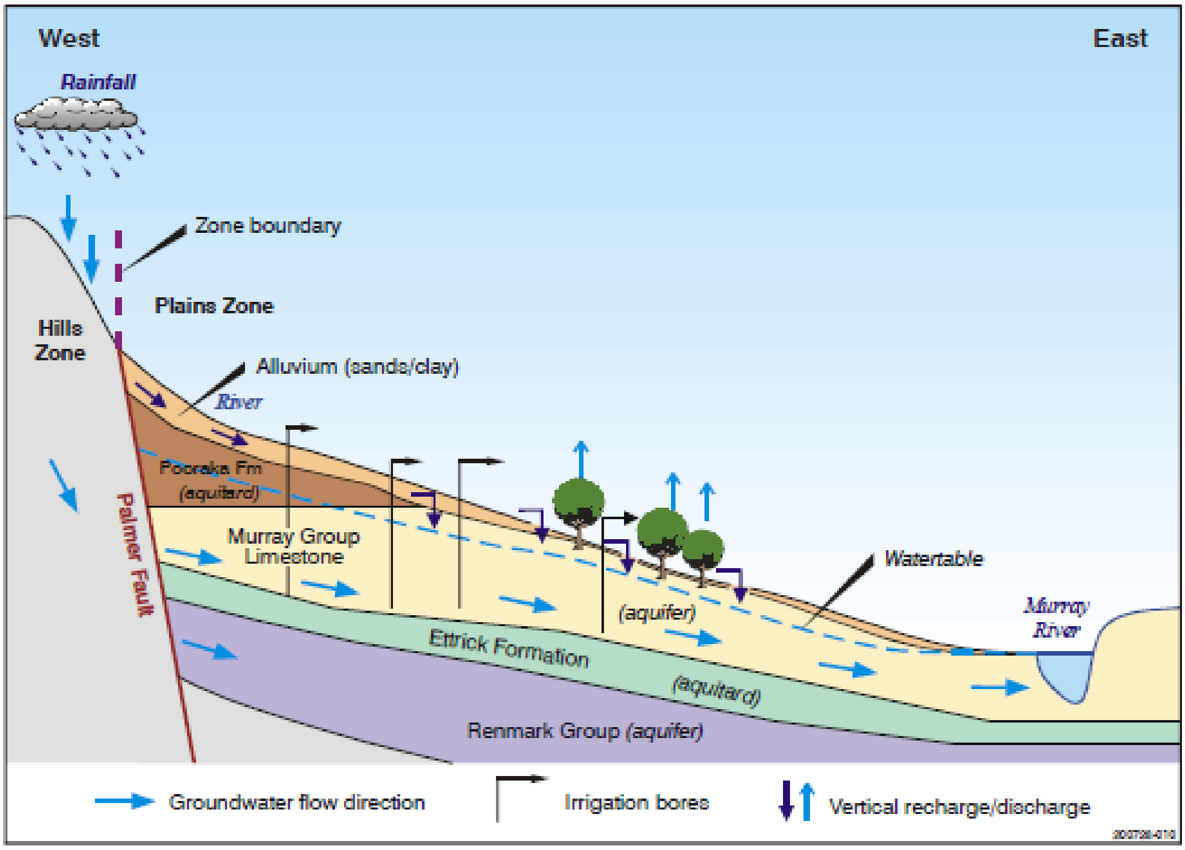

Figure 2. **Schematic cross section of the Marne Saunders PWRA**

GROUNDWATER FLOW AND SALINITY

Hills Zone

A groundwater level contour map for the fractured rock aquifer was not generated because of the highly variable ground elevations and limited coverage of observation wells. However, groundwater flow within the fractured rock aquifer in the Hills Zone generally follows topographic contours and flows from high points in the catchments to the low points where groundwater usually discharges to streams (Fig. 3). Groundwater also moves eastward from the Ranges, with discharge to the sedimentary aquifers on the Plains Zone. Salinities within the fractured rock aquifer are highly variable, with values ranging from 500 to 7000 mg/L.

Plains Zone

Figure 4 presents the water level elevation contours and salinity distribution for the Murray Group Limestone aquifer in the Plains Zone. Groundwater flow is generally in an easterly direction from the Hills Zone toward the River Murray in the Marne catchment, but tends toward a south-easterly direction in the Saunders catchment.

The salinity distribution reflects the source of recharge to the limestone aquifer. The low salinity zone adjacent to the faulted contact with the Hills Zone occurs where the limestone aquifer is confined by 60 m of clay (Pooraka Formation) as shown in Figure 2, and is unlikely to have received recharge by percolation from streamflow. Recharge by sub-flow from the fractured rock aquifers in the Hills Zone is more probable.

Further downstream to the east, a second low-salinity zone near Kongolia indicates where the clay layer has thinned out and allowed direct infiltration of streamflow, which has recharged the limestone aquifer.

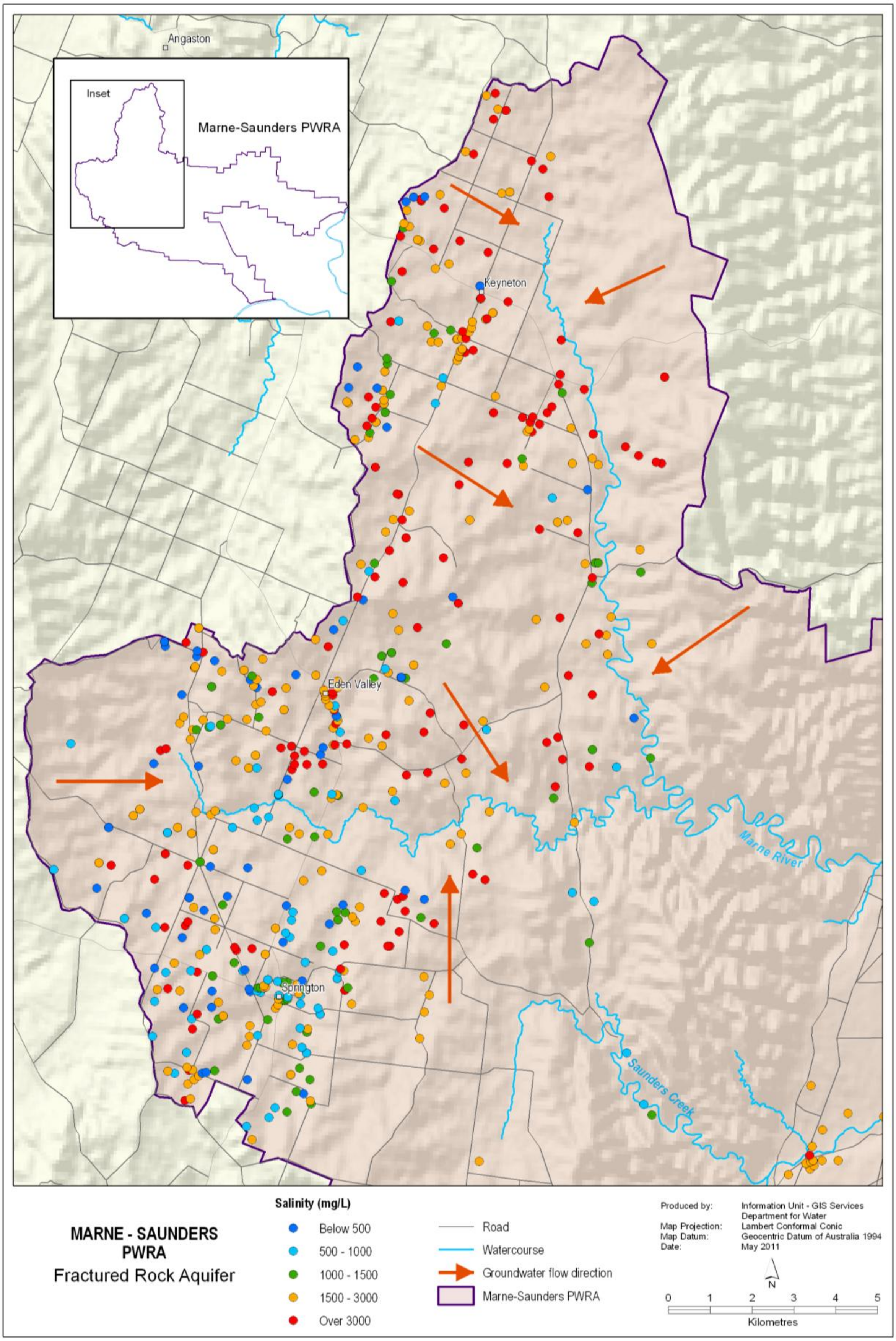

Figure 3. Groundwater flow and salinity distribution of the Hills Zone in the Marne Saunders PWRA

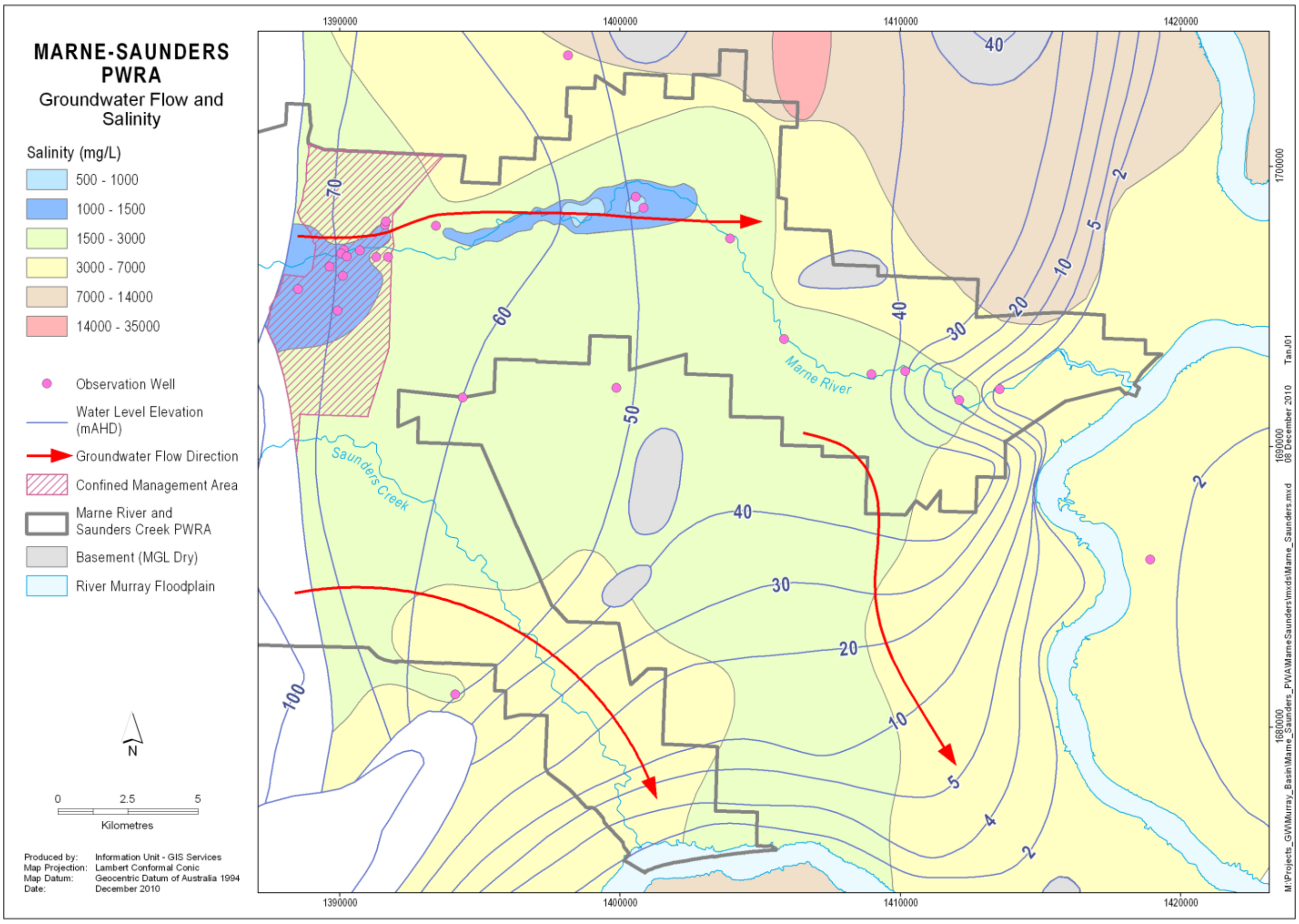

Figure 4. Groundwater flow direction and salinity distribution of the Murray Group Limestone in the Marne Saunders PWRA[1]

For further details on the hydrogeology of the Marne catchment, please see:
http://www.waterconnect.sa.gov.au/BusinessUnits/InformationUnit/Technical%20Publications/DWRREP200100009.pdf

For further details on the hydrogeology of the Saunders catchment, please see:
http://www.waterconnect.sa.gov.au/BusinessUnits/InformationUnit/Technical%20Publications/saunders_creek_2002_01.pdf

[1] Upon review of data for 2011, there were little discernable difference between the potentiometric surface and salinity from the previous year. As a consequence the figure has not been altered.

GROUNDWATER DEPENDENT ECOSYSTEMS

Whilst groundwater dependent ecosystems (GDEs) have not been used in the assessment of the status of the groundwater resource, it is important to note the presence and ecological characteristics of the GDEs in the Marne Saunders PWRA. Groundwater dependent ecosystems can be defined as ecosystems where groundwater provides all or part of the water quantity, chemistry or temperature requirements, either permanently, seasonally or intermittently. It is generally considered that shallow watertables less than 10 m below the surface are more likely to support GDEs than deeper watertables. The exception to this is stygofauna (animals that inhabit water filled spaces and pools below the ground), which can be found at greater depths.

Permanent pools exist throughout the upper watercourses that flow through the Marne Saunders PWRA, most of which are expected to be maintained through groundwater baseflow contributions from the fractured rock aquifer. These permanent aquatic habitats are important refugia for aquatic biota and are known to support diverse populations of aquatic plants, aquatic macroinvertebrates and fish.

On the Plains Zone, baseflow from the regional limestone aquifer provides a key water source in some localised areas where the river channels have been incised down to the level of the watertable close to the River Murray. This is particularly important in the Marne River downstream of Black Hill and in the Saunders Creek near Lenger Reserve. These pools support one of only four known remaining populations of River Blackfish in the South Australian Murray-Darling Basin. River Blackfish are protected under South Australia's *Fisheries Management Act 2007*.

Plants with a dependence on groundwater also exist along the watercourses within the PWRA and largely consist of River Red Gum (*Eucalyptus camaldulensis*). Other possible GDEs in the Marne Saunders PWRA include stygofauna.

RAINFALL

The climate of the Marne Saunders PWRA is characterised by hot, dry summers and cool to cold, wet winters. Rainfall is highest in the Hills Zone at the western edge of the PWRA. Rainfall declines rapidly towards the east in the rain shadow of the Mount Lofty Ranges, at the confluence of the Marne River and the River Murray (Fig. 5).

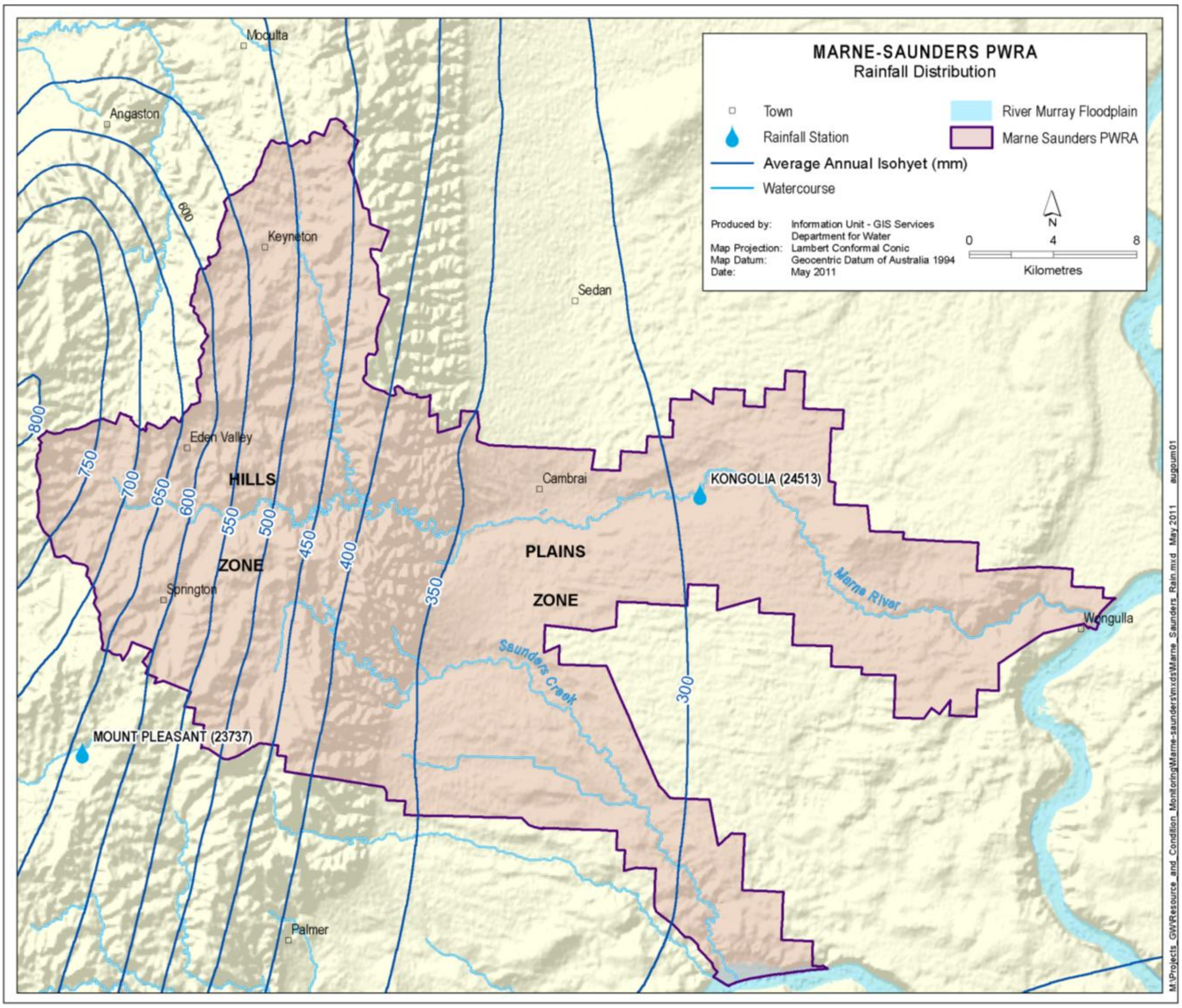

Figure 5. Rainfall distribution across the Marne Saunders PWRA

Figure 6 displays the annual rainfall recorded for Mount Pleasant (station 23737). For the period 1889 to 2011 the long term average annual rainfall is 665 mm, with the overall long-term rainfall trend decreasing.

The cumulative deviation from the average annual rainfall for Mount Pleasant (station 23737) is graphed in orange in Figure 6 to identify periods where annual rainfall trends are above or below average. An upward slope indicates a period where the rainfall is greater than the average, while a downward slope indicates a period where the rainfall is below the average. The results for Mount Pleasant (station 23737) show alternating above and below average trends lasting between 15 and 25 years. Since 1975, significant periods of below average rainfall have been recorded, with the exception of very wet years in 1981 and 1992. While above average years have been recorded since 1975 (e.g. in 2005 and 2010) the magnitude has typically been less than has occurred historically. This would have a very strong impact on streamflow and hence recharge to the aquifer on the Plains Zone.

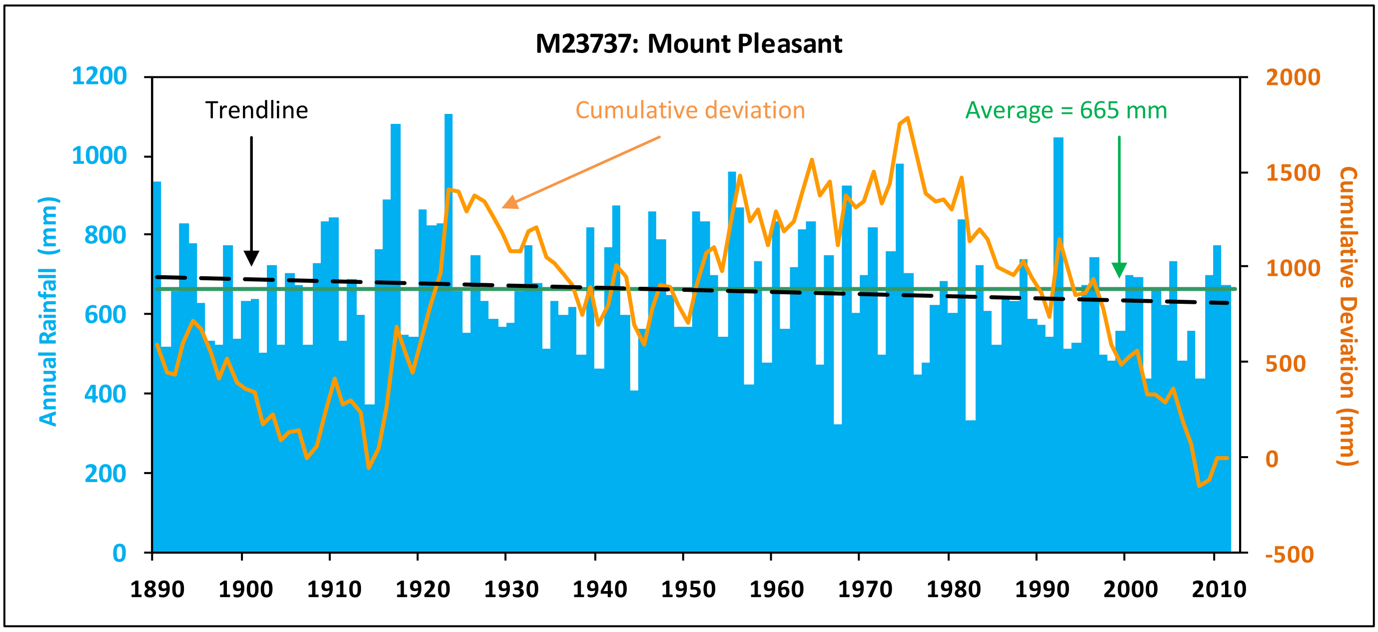

Figure 6. Annual rainfall and cumulative deviation from average annual rainfall for the Mount Pleasant station adjacent the Marne Saunders PWRA

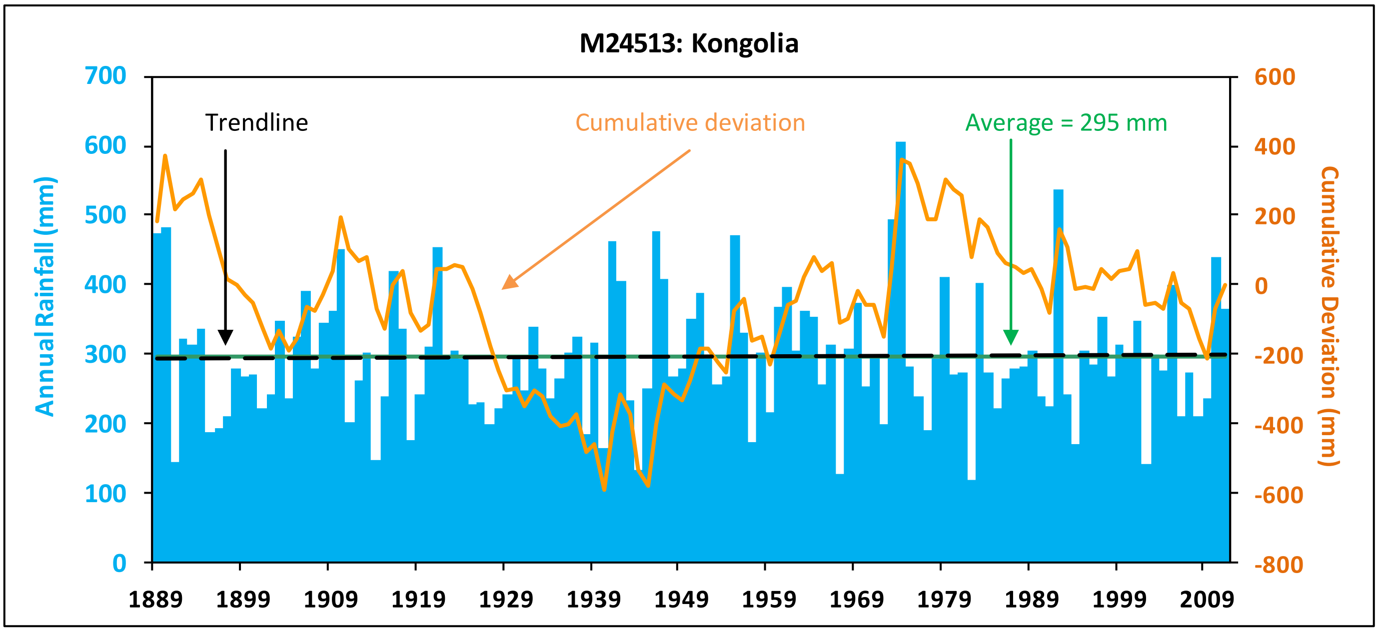

Figure 7. Annual rainfall and cumulative deviation from average annual rainfall for Kongolia station in the Marne Saunders PWRA

The rainfall data for Kongolia (station 24513) located on the Plains Zone (Fig. 7) shows a much lower and more consistent rainfall over the past 40 years than recorded at Mount Pleasant. The long term average annual rainfall recorded at Kongolia (station 24513) for the period 1889 to 2011 is 295 mm, with a stable long term rainfall trend. The cumulative deviation from the average annual rainfall for Kongolia displays an overall decreasing trend from 1975 to 2009, followed by a recent increasing trend following above average rainfall in 2010 of 439 mm. This rainfall has only a slight impact on groundwater levels beneath the Plains Zone, away from the influence of infiltration from the Marne River.

GROUNDWATER USE

Meters have been installed on all irrigation wells in the Marne Saunders PWRA since 2002 in response to the prescription of the water resources. The metered groundwater extraction for the PWRA totalled 1070 ML for 2010–11 and is divided into the two aquifer categories (Fig. 8). Extractions from the fractured rock aquifer in the Hills Zone have declined over recent years since the 2006 drought in response to better rainfall. Extractions from the sedimentary (limestone) aquifer in the Plains Zone have steadily declined following 2008–09 and have recorded the lowest level of extraction since metering commenced.

Actual values for 2010–11 were 137 ML for the fractured rock aquifer (a decrease of 50% from the previous year) and 933 ML for the sedimentary (limestone) aquifer (a decrease of 40% from the previous year).

Extraction volumes from both aquifers are well below the extraction limits as shown in Figure 8.

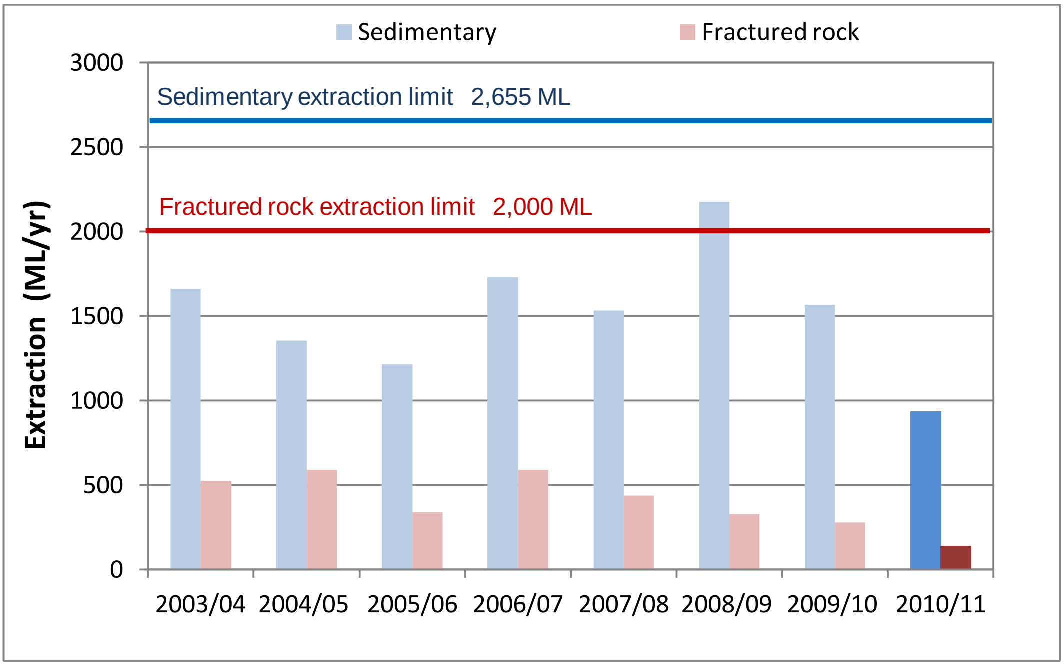

Figure 8. Historical licensed groundwater use in the Marne Saunders PWRA

Figures 9 and 10 show the volume applied to the various purposes of use in 2010–11 for the two aquifers types. Lucerne accounted for 49% and 46% respectively of the total volume extracted in both Hills and Plains Zones. Vines are the second largest user in the Hills Zone, while turf is the second largest in the Plains Zone. It should be noted that purpose of use is not recorded for all licensees and consequently, these figures should be used as a guide only.

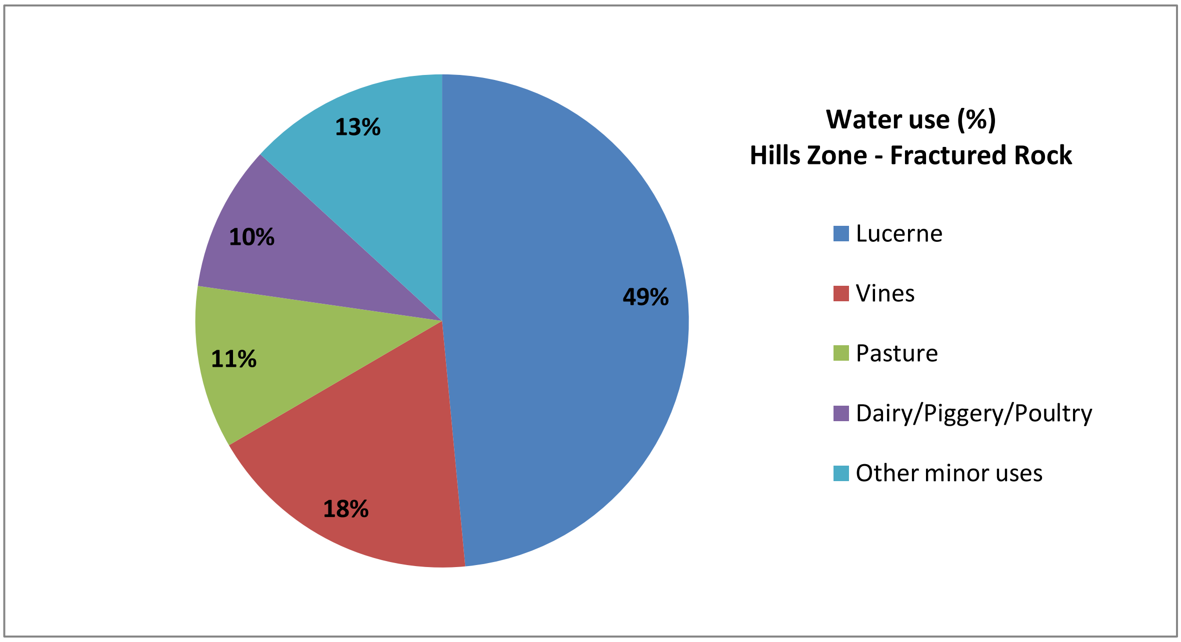

Figure 9. Groundwater proportions extracted per type of use in the fractured rock aquifer of the Marne Saunders PWRA for 2010–11

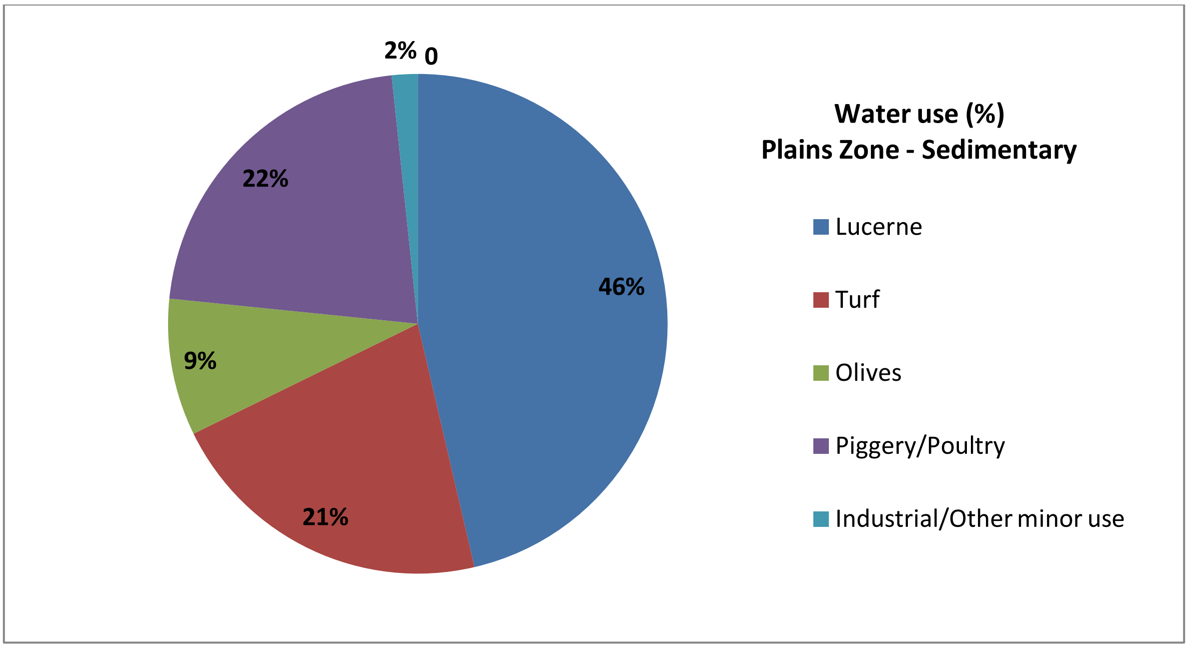

Figure 10. Groundwater proportions extracted per type of use in the sedimentary aquifer of the Marne Saunders PWRA for 2010–11

GROUNDWATER OBSERVATION NETWORKS

WATER LEVEL NETWORK

The groundwater level observation network for the Marne Saunders PWRA is shown below in Figure 11. Although monitoring commenced in 1980 with 11 wells, there are currently 54 wells being monitored as described in Table 2. The limited extraction in other parts of the PWRA has meant that most of the monitoring effort is concentrated on the limestone aquifer on the Plains Zone with a two-monthly frequency.

Table 2. Groundwater level observation network for the Marne Saunders PWRA

Aquifer	Number of wells
Quaternary	4
Murray Group Limestone	22
Renmark Group	1
Fractured rock aquifer	27

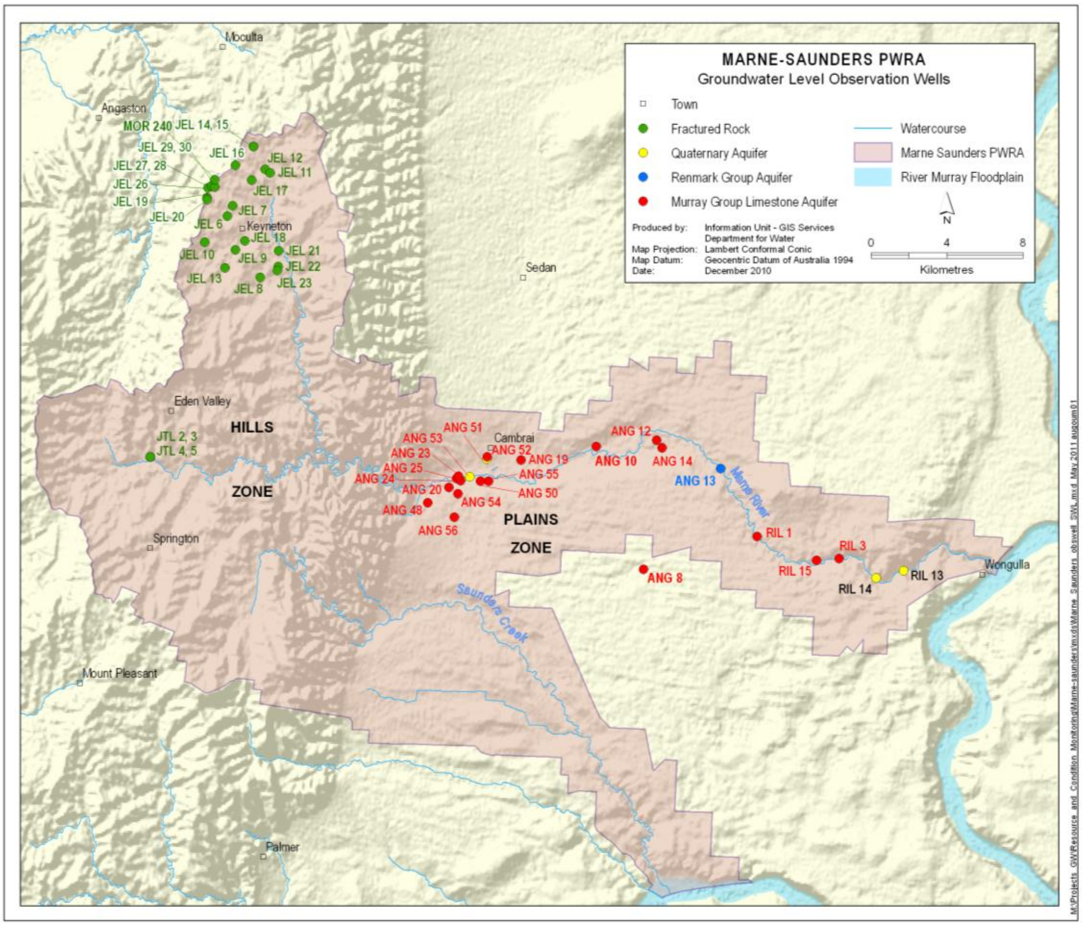

Figure 11. Location of groundwater level observation wells in the Marne Saunders PWRA

SALINITY NETWORK

The groundwater salinity observation network for the Marne Saunders PWRA is shown below in Figure 12. The limited extraction in other parts of the PWRA has meant that most of the monitoring effort is concentrated on the limestone aquifer on the Plains Zone. Monitoring commenced in 1990, with eight wells monitored on a six monthly basis (Table 3).

Table 3. Groundwater salinity observation network for the Marne Saunders PWRA

Aquifer	Number of wells
Quaternary	2
Murray Group Limestone	8

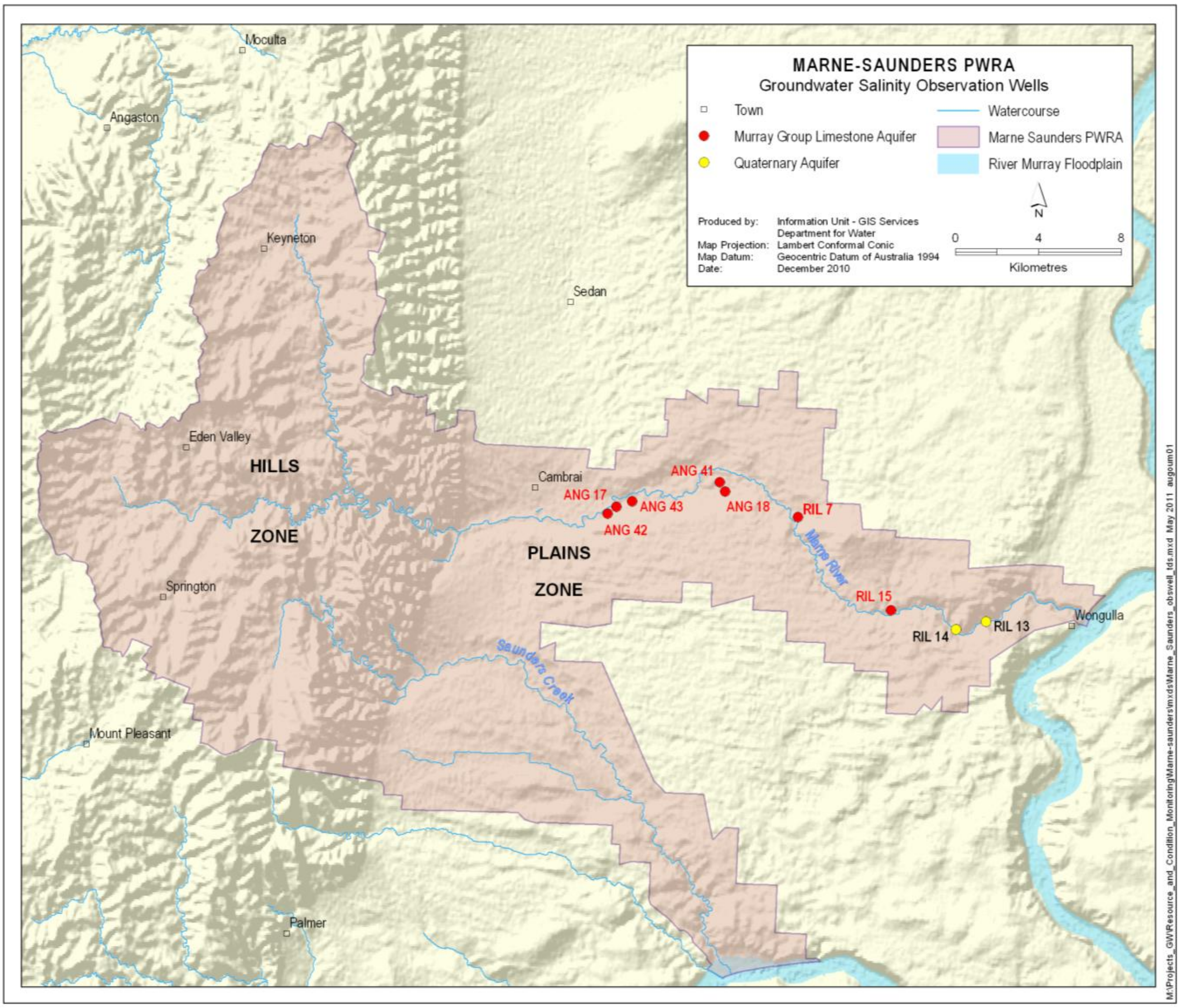

Figure 12. Location of groundwater salinity observation wells in the Marne Saunders PWRA

STREAMFLOW TRENDS

The majority of streamflow is generated in the Hills Zone where rainfall is highest, with very little contribution from runoff in the Plains Zone. Flows vary considerably from year to year, as a result of the high variability in annual rainfall. Over the period 1973 to 2011, measured annual flows at the Marne Gorge streamflow gauging station (A4260605) ranged from over 33 500 ML in 1974 down to 80 ML in 1982 for years with flow records which are shown in red in Figure 13. The pink values are modelled streamflow results obtained from a catchment surface water model. During these years there was no stream gauging information available. The location of the Marne Gorge streamflow gauging station is displayed in Figure 13.

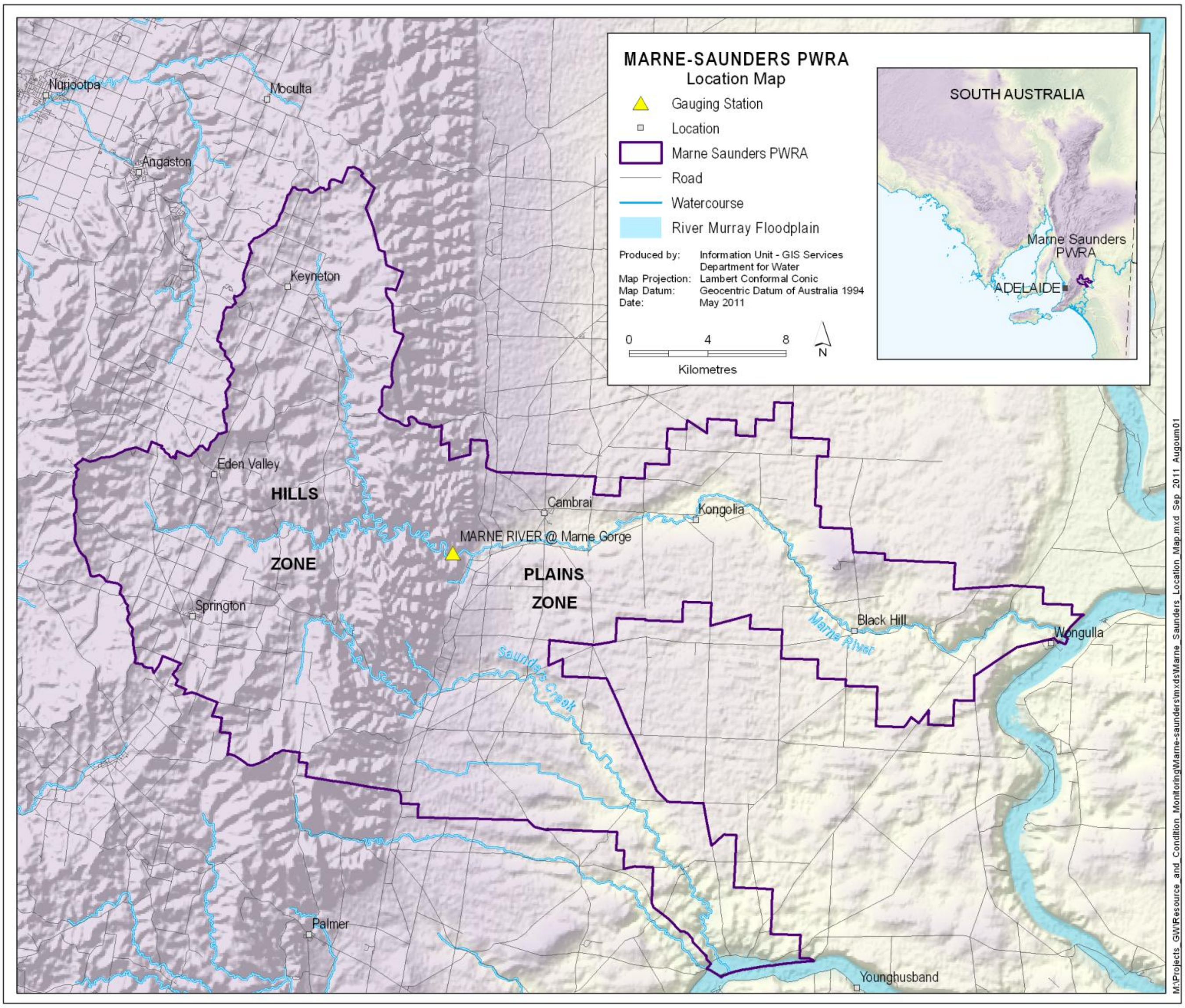

Figure 13. Location of Marne Gorge streamflow gauging station (A4260605) in the Marne Saunders PWRA

Figure 13 shows that very little stream flow has occurred between 2005 and 2009. A large proportion of the streamflow flowing out onto the Plains Zone infiltrates through the streambed and recharges the underlying sedimentary limestone aquifer and therefore, the resultant lack of recharge will have significant impacts on groundwater levels and salinity. During 2010, annual streamflow was recorded as

7650 ML, which is above the average of 6129 ML/y for the period 1973 to 2011. Streamflow recorded during 2011 was well below the average and recorded only 1040 ML.

It should be noted that for the 2011 year, there were 98 days of missing data from the annual record. This was over the summer to autumn period where streamflow is typically negligible. Consequently, it is not expected to have a significant impact on the overall recorded annual streamflow volume.

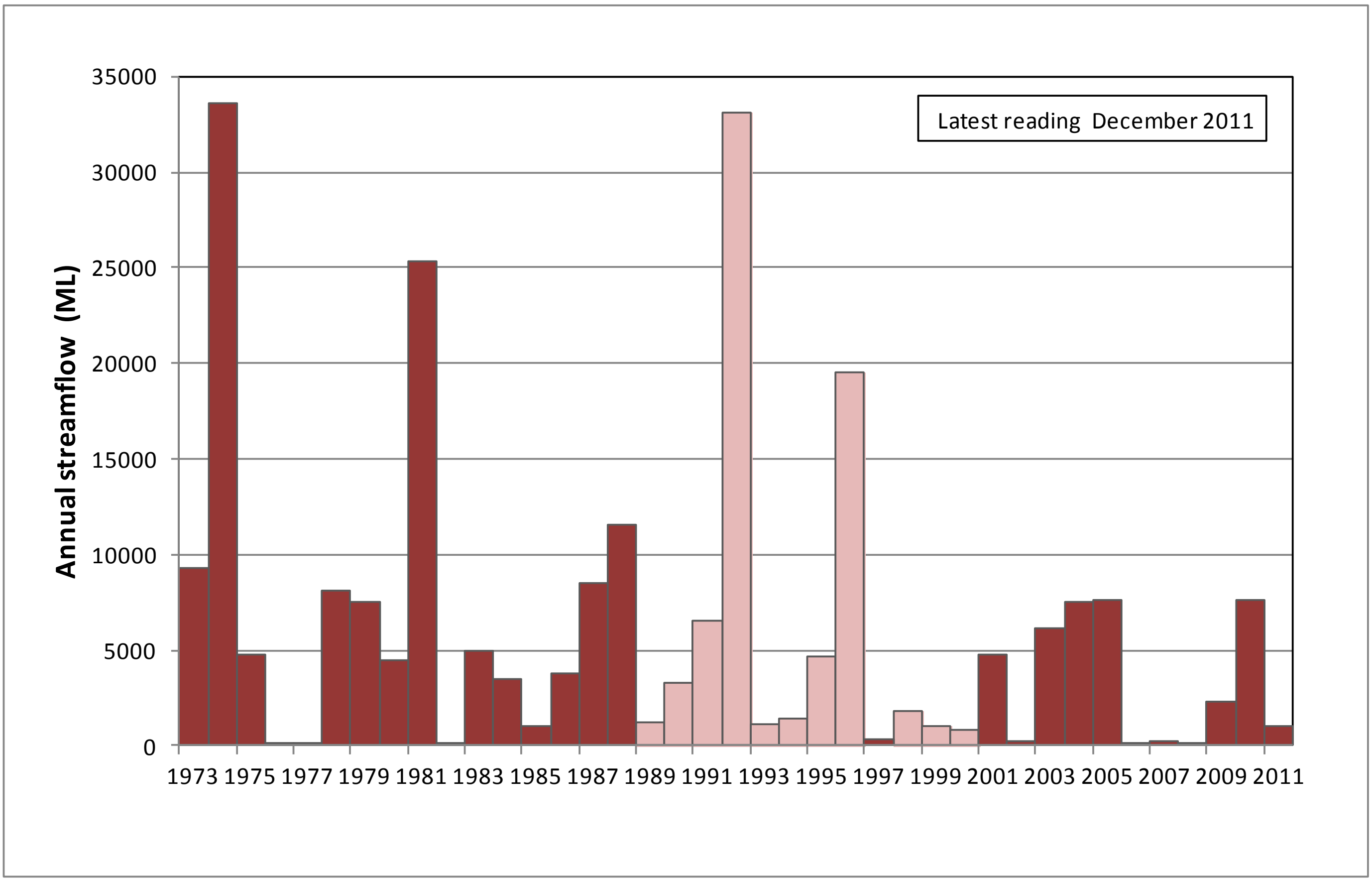

Figure 13. **Annual streamflow at the Marne Gorge streamflow gauging station (A4260605) in the Marne Saunders PWRA**

QUATERNARY AQUIFER

In 2001, several shallow observation wells were installed in the river alluvium downstream of Black Hill to monitor groundwater levels and salinity and their potential impacts on vegetation health and the sustainability of permanent pools (waterholes) that occur in the lower Marne valley.

There are two trends being observed in Figure 14. RIL 14 is located upstream of a shallow basement outcrop exposed in the river valley. This outcrop concentrates regional groundwater discharge into the valley and acts as an underground 'dam' which maintains groundwater levels at a reasonably constant level. RIL013 is located downstream of this flow barrier and is showing a decreasing trend which reflects the low streamflow (and reduced recharge) up to 2010. Following the above average streamflow year in 2010, RIL013 is displaying a recovery in water level.

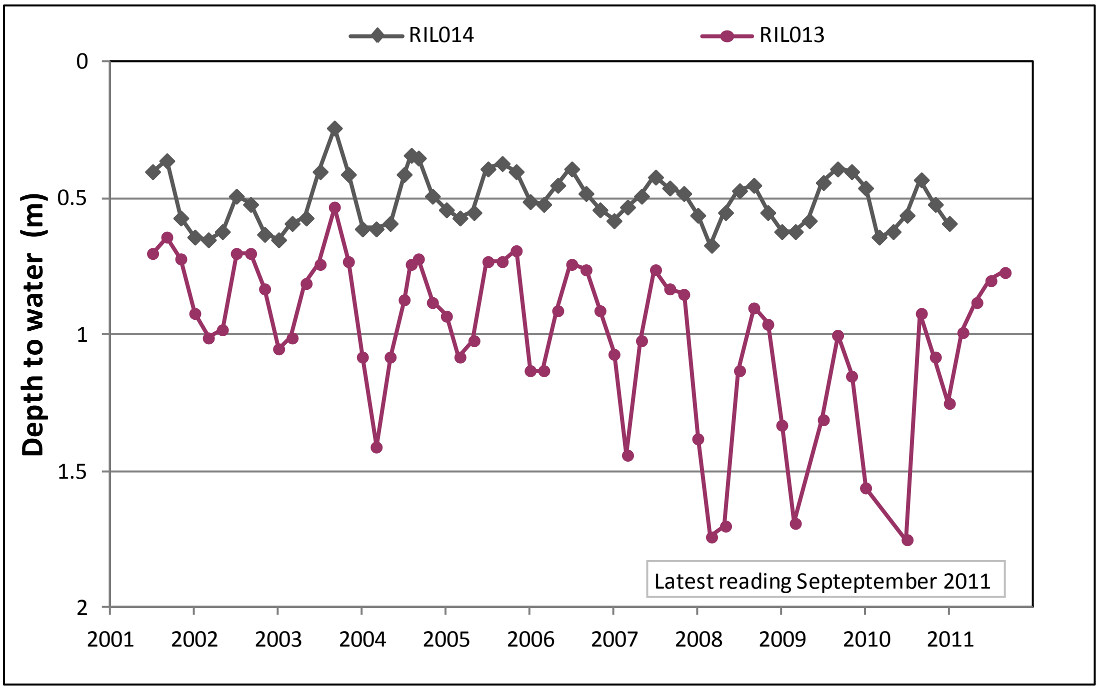

Figure 14. Groundwater level trends of the Quaternary alluvium aquifer in the Marne Saunders PWRA

MURRAY GROUP LIMESTONE AQUIFER

The Murray Group Limestone aquifer can be divided into two areas, a confined area between the Hills Zone and Cambrai and an unconfined area east of Cambrai where the confining Pooraka Formation thins (Figs 1 and 2). The water level trends are very different in these areas. Drawdowns in the confined portion of the aquifer occur more quickly and are greater than drawdowns in the unconfined portion because they are an instant pressure response to pumping. In an unconfined aquifer, drawdowns or rises due to recharge only occur when water physically drains into or out of the sediments, which is a much slower process.

Confined

Water level hydrographs in the confined limestone aquifer are shown below in Figure 15. ANG 25 is located near intensive irrigation and shows consistent seasonal drawdowns during the irrigation season of about 16 m. There is a slight downward trend in the recovered water level over the period 1988 to 2010. Insufficient data is available to assess whether or not the downward trend is continuing or whether a new equilibrium is being reached. Water pressure levels in ANG 25 almost completely recovered during winter 2010 to the 2009 winter level.

The other wells, ANG 54 and ANG 56, are located 800 m and 2 km south of ANG 25 respectively and show decreasing amplitude of seasonal drawdown with increasing distance from the irrigation extractions.

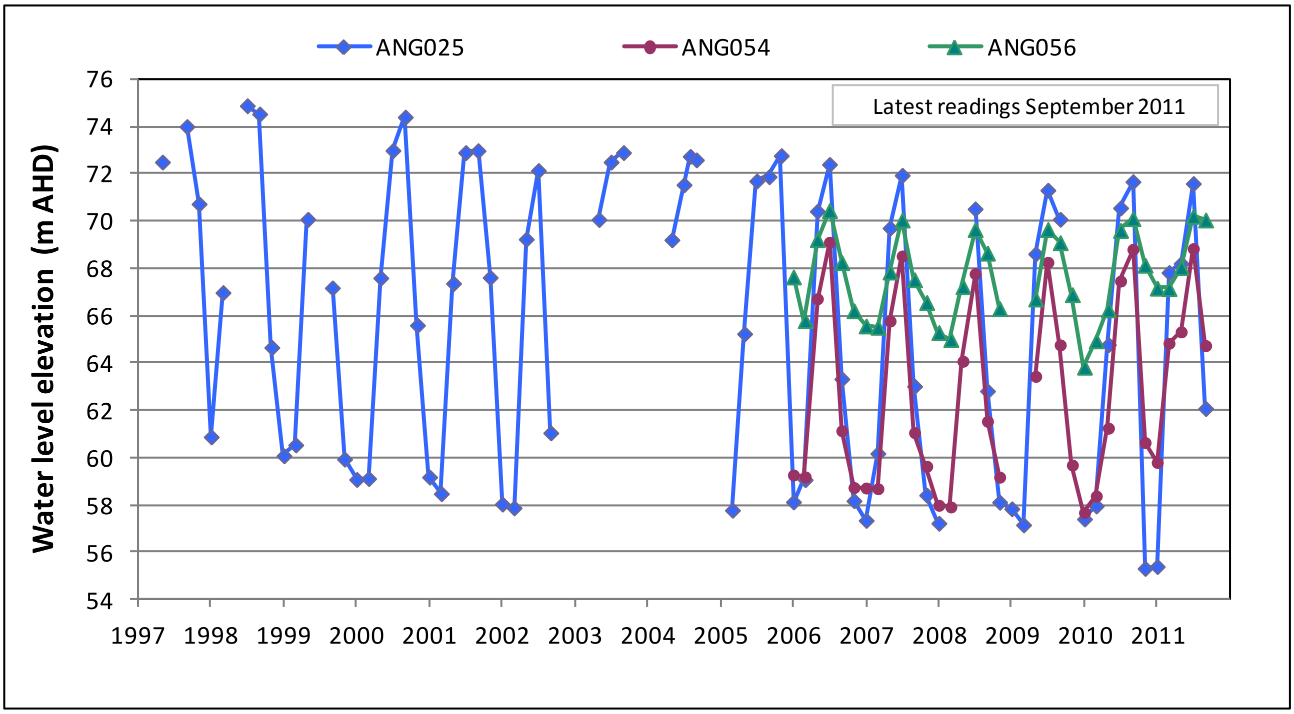

Figure 15. Groundwater level trends of the confined limestone aquifer in the Marne Saunders PWRA

Unconfined

In the unconfined aquifer a strong relationship between groundwater levels and streamflow is evident (Fig. 16). The timing and quantity of streamflow is controlled by the rainfall in the upper Marne catchment in the Hills Zone and consequently, the groundwater levels in the Plains Zone close to the Marne River are also controlled by rainfall in the Hills Zone.

The amount of recharge from streamflow decreases with distance downstream and also with distance laterally away from the Marne River. This is illustrated by Figure 16, which shows the water level response for ANG 10 (3 km downstream from where recharge commences) is greater than ANG 14 (7.5 km downstream) and RIL 1 (15 km downstream). Below average rainfall in the Hills Zone area has resulted in very little streamflow and consequently little recharge to the aquifer. Groundwater levels on the Plains Zone along the river valley were consequently at their lowest ever recorded levels up to January 2010. Following above average rainfall in the Hills Zone (Fig. 6) and streamflow during 2010 (Fig. 16) there has been some recovery in water levels nearest the recharge zone.

ANG 8 is located 6 km south of the Marne River and shows no response to streamflow, but reflects changes in diffuse recharge from rainfall. The gradual decline in the water level is due to previous below average rainfall (2006 to 2009). While both 2010 and 2011 recorded above average rainfall (Fig. 7), responses in water level are not yet evident in ANG 8. Well RIL 1 appears to be displaying slight recovery during 2011.

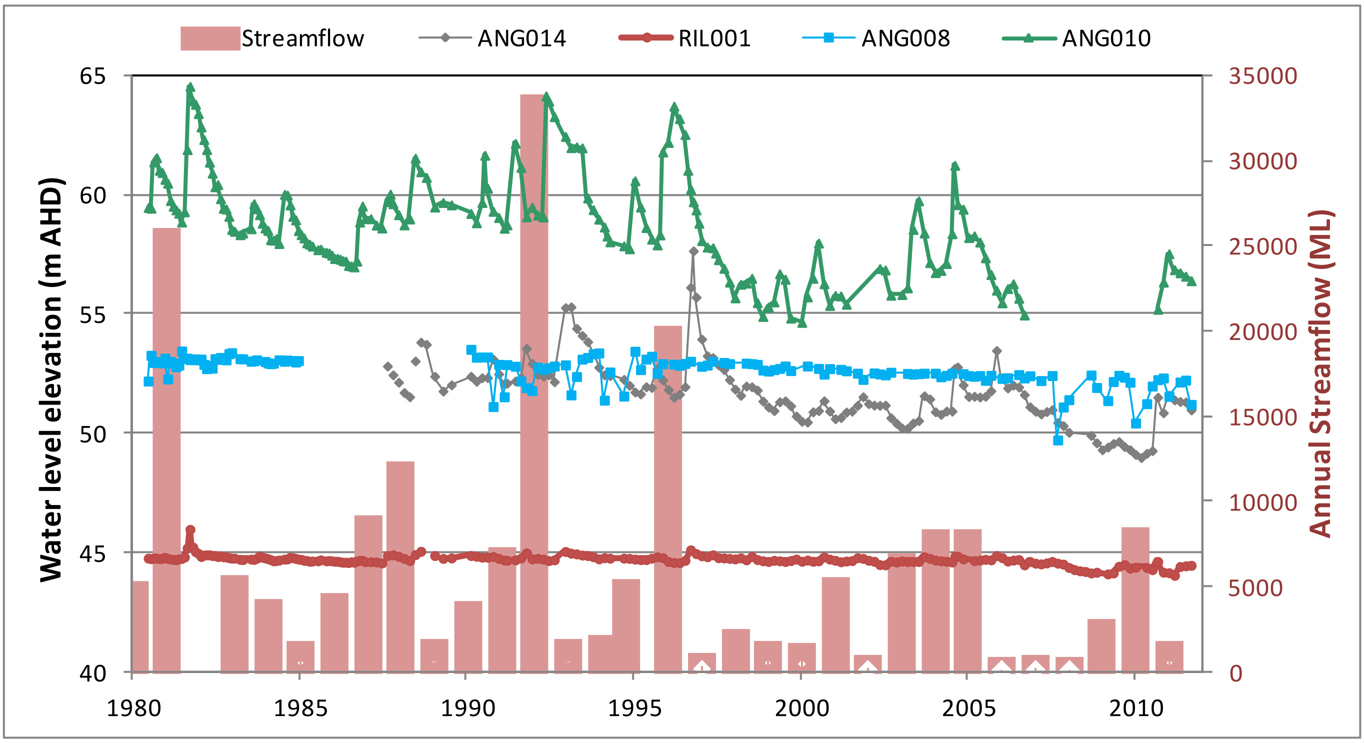

Figure 16. Groundwater level trends of the unconfined limestone aquifer and annual streamflow at the Marne Gorge streamflow gauging station (A4260605) in the Marne Saunders PWRA

FRACTURED ROCK AQUIFER

Regional trends in the fractured rock aquifer in the Hills Zone generally reflect rainfall trends, with Figure 17 showing groundwater level declines in drier than average years such as 1995 – and recoveries in wetter than average years such as 2005. The orange line indicates the cumulative deviation from the average rainfall. Below average rainfall between 2006 and 2008 resulted in a declining trend, however recent improvement in rainfall has led to recovery of water levels. Extraction volumes are relatively small and too dispersed to affect regional trends.

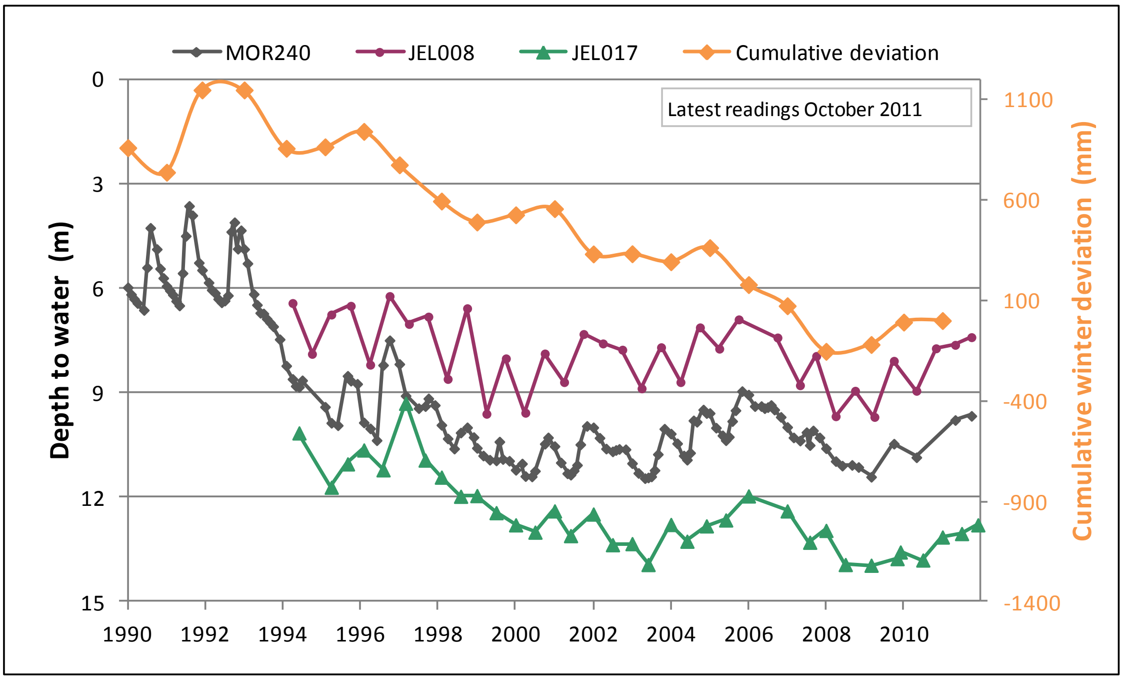

Figure 17. Groundwater level trends of the fractured rock aquifer in the Marne Saunders PWRA

GROUNDWATER SALINITY TRENDS

The groundwater salinity readings recorded from irrigation wells in the Plains Zone are quite variable as can be seen in Figures 18 and 19, with two trends emerging — rising and stable.

Wells showing rising trends

A number of wells show a rising trend but the pattern is not consistent. In Figure 19, ANG042 is showing a reasonably consistent rising trend of about 18 mg/L/y (for the period 1995-2011). On closer examination, this increasing trend only really becomes apparent after 2002. This is consistent with RIL007 which also shows an increase in salinity after 2002. This is likely due to generally below average rainfall experienced from 2002 to 2009, with the exception of 2003 and 2005.

Other wells have shown a stable trend for 10–20 years before showing a rising trend after 2006 (ANG043 in Fig. 18 and ANG017 in Fig. 19).

This process occurs as irrigation water is drawn up through the root system, with most of the dissolved salt accumulating in the root zone and not being taken up by the plant. This salt then percolates back down into the aquifer during subsequent irrigation applications or from rainfall recharge, resulting in a continuous cycle of increasing groundwater salinity.

Wells showing stable trends

ANG043 (Fig. 18) displays a near stable trend for the period 1995–2011). ANG041 (Fig. 18) has also shown a generally stable trend however, since 2010 salinity has increased marginally The most interesting trend is from ANG018 which was rising at about 60 mg/L/y up until 2004. This well is situated in an irrigation area on the floodplain with a depth to the watertable of about 10 m. This rise could have been attributed to the recycling of irrigation water. However since then, the trend has stabilised with a marked seasonal variation which could reflect a change in irrigation practice.

Effects of Flood Events

Figures 18 and 19 both show evidence that most wells experienced a marked salinity decrease immediately after the 1996 and 2010 flood events, with an equally sudden rise afterwards. It is understood that this occurred due to the rapid recharge of low salinity river water, causing a simultaneous rise in the watertable and a reduction in groundwater salinity. As the flood receded, any surface water on the floodplain drained slowly down to the watertable and flushed down salt which had been accumulating in the unsaturated zone.

Figure 14 shows that the last significant flows that would have recharged the aquifer occurred in 2004 and 2005. As no significant recharge has occurred since then (with the exception of 2010), it is not surprising that salinities have increased as the more saline regional groundwater has moved in to replace the lower salinity recharged water as it is pumped out.

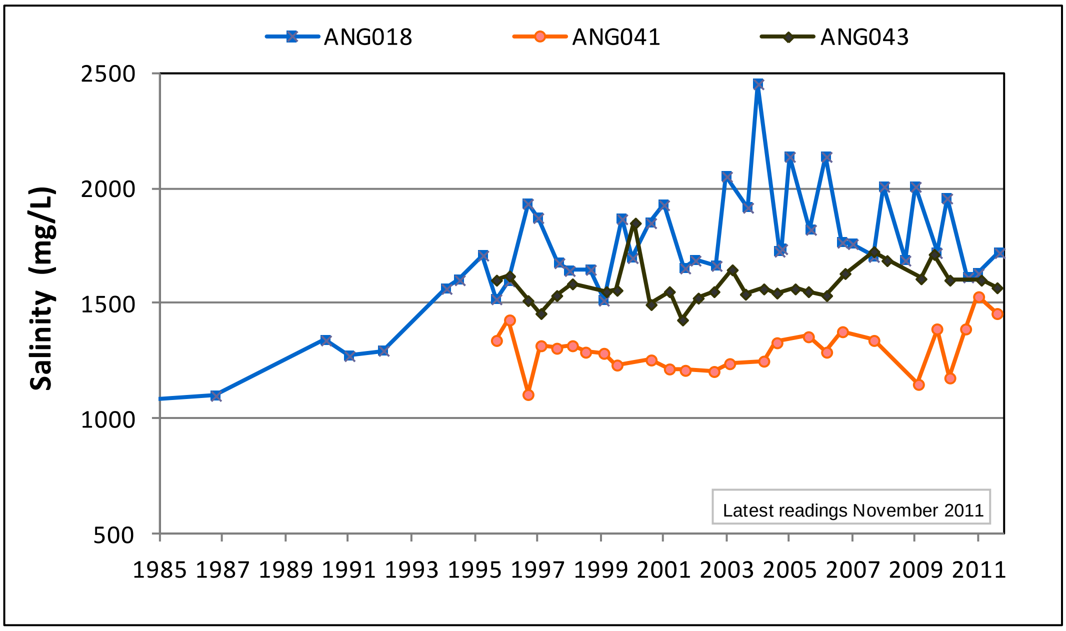

Figure 18. Groundwater salinity trends of the unconfined limestone aquifer in the Marne Saunders PWRA

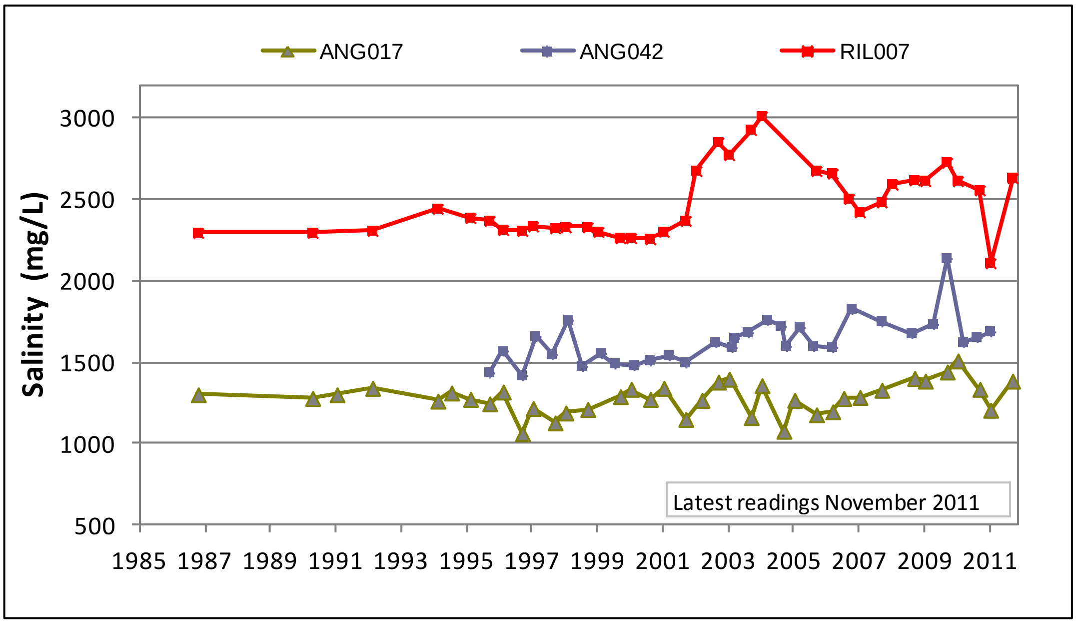

Figure 19. Groundwater salinity trends of the unconfined limestone aquifer in the Marne Saunders PWRA

Within the confined portion of the limestone aquifer, groundwater flows from west to east. The groundwater salinity also increases from west to east. One of the risks of pumping from the confined aquifer is that excessive drawdowns may cause a reversal in groundwater flow which would result in an influx of more saline groundwater from the east. A line of observation wells is being monitored to detect if there is sustained flattening of the pressure gradient between pumping seasons or reversal of the pressure gradient, as this is a 'trigger for action' in the Water Allocation Plan.

Figure 20 shows the observed gradient during the non-pumping period in July 2011. The flow gradient from west to east was occurring at this point in time.

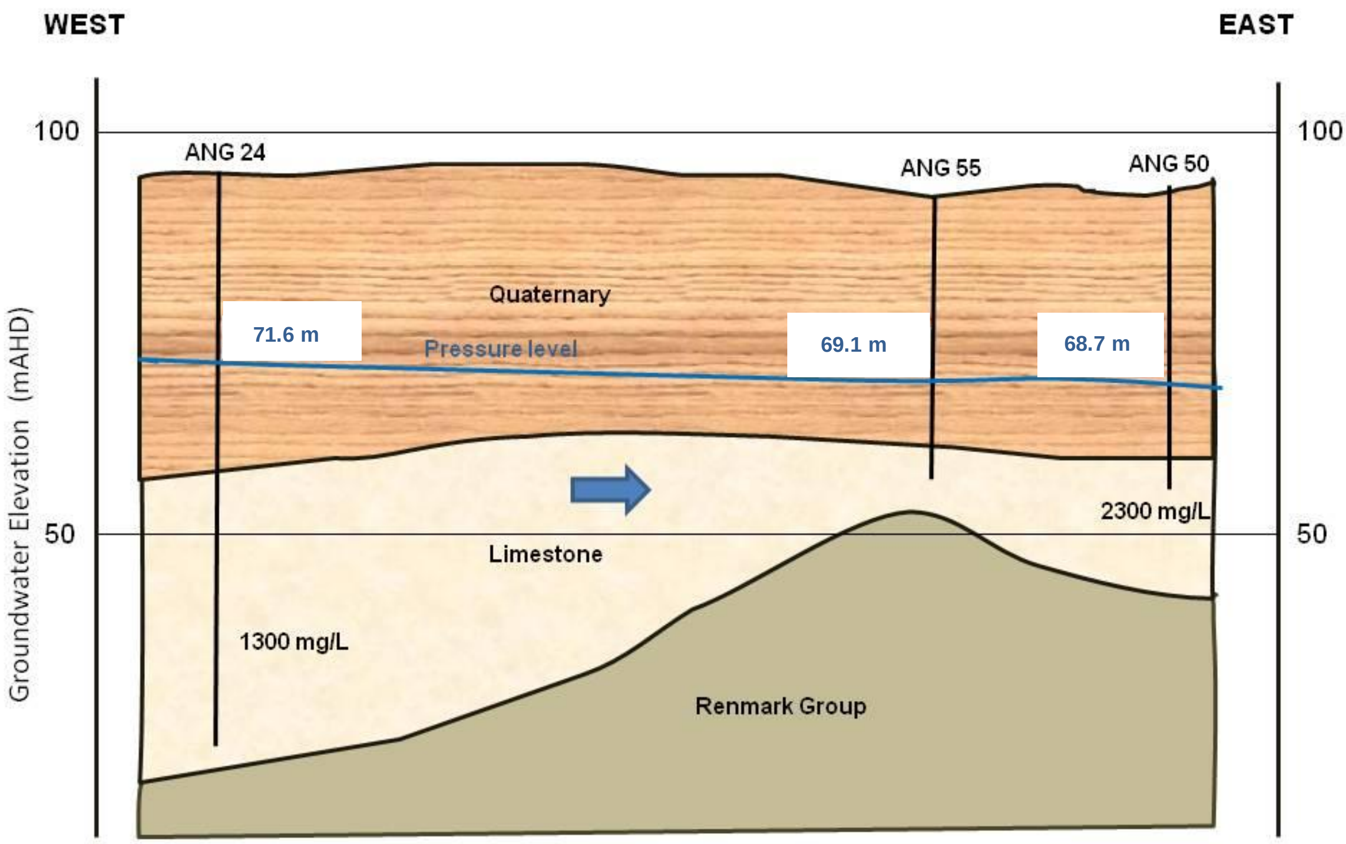

Figure 20. Confined aquifer flow gradient in the Marne Saunders PWRA in July 2011