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# ANGAS BREMER

## PWA

### GROUNDWATER LEVEL AND SALINITY STATUS REPORT

2011

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Water and Natural Resources

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## 2011 SUMMARY

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The Angas Bremer Prescribed Wells Area (PWA) is located on the western side of Lake Alexandrina approximately 60 km south-east of Adelaide. It is a local-scale resource for which groundwater is prescribed under South Australia's *Natural Resources Management Act 2004*. A Water Allocation Plan provides for sustainable management of the PWA's groundwater resources.

Groundwater extractions occur from the confined Murray Group Limestone aquifer, which can be up to 100 m thick. Metered groundwater extractions for licensed purposes in the Angas Bremer PWA totalled 2488 ML in the 2010–11 water-use year, which represents a 53% decrease from the previous water-use year.

The construction of two pipelines from the River Murray during the recent drought has increased the reliability and the volumes of watercourse water available for managed aquifer recharge. Managed aquifer recharge during 2010–11 was 4158 ML, which again represents a significant increase (i.e. greater than 100%) when compared to the previous years, excluding 2009–10.

The recovery of Lake Alexandrina and the construction of two new pipelines from the River Murray have reduced demand on groundwater (from the high extraction levels experienced since the 2006 drought) and facilitated an increase in managed aquifer recharge. This has led to a rise in groundwater levels in the confined limestone aquifer during 2010–11. Groundwater levels have also risen in the overlying Quaternary aquifer in response to increased recharge from rainfall and streamflow.

Widespread decreases in groundwater salinity in the confined limestone aquifer were observed during last few years, in contrast to the significant rises that were observed to occur due to increased extractions between 2006 and 2009. These decreases are due to managed aquifer recharge using lower-salinity water and reduced downward leakage from the overlying saline Quaternary aquifer in response to reduced drawdown in the confined limestone aquifer brought about by lower extractions.

## ASSESSMENT OF STATUS

The Angas Bremer PWA has been assigned a green status of “No adverse trends, indicating a stable or improving situation” for the 2010–11 water-use year. This status is supported by:

- a recovery in groundwater levels over most of the PWA
- decreases in salinity levels in the confined limestone aquifer.

The positive trends, whilst occurring after a period of previously adverse trends resulting from high extraction during the recent (2006) drought period, are expected to continue if the volumes of managed aquifer recharge are maintained or increased and if extraction levels fall to pre-drought levels (below 2000 ML/y).

Continual extractions at levels during the drought (approximately 6500 ML/y) have been demonstrated to be unsustainable in the medium term.

## 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 Angas Bremer Prescribed Wells Area (PWA) is located on the western side of Lake Alexandrina, approximately 60 km south-east of Adelaide (Fig. 1). It is a local-scale resource for which groundwater is prescribed under South Australia's *Natural Resources Management Act 2004*. A Water Allocation Plan provides for sustainable management of the PWA's groundwater resource.

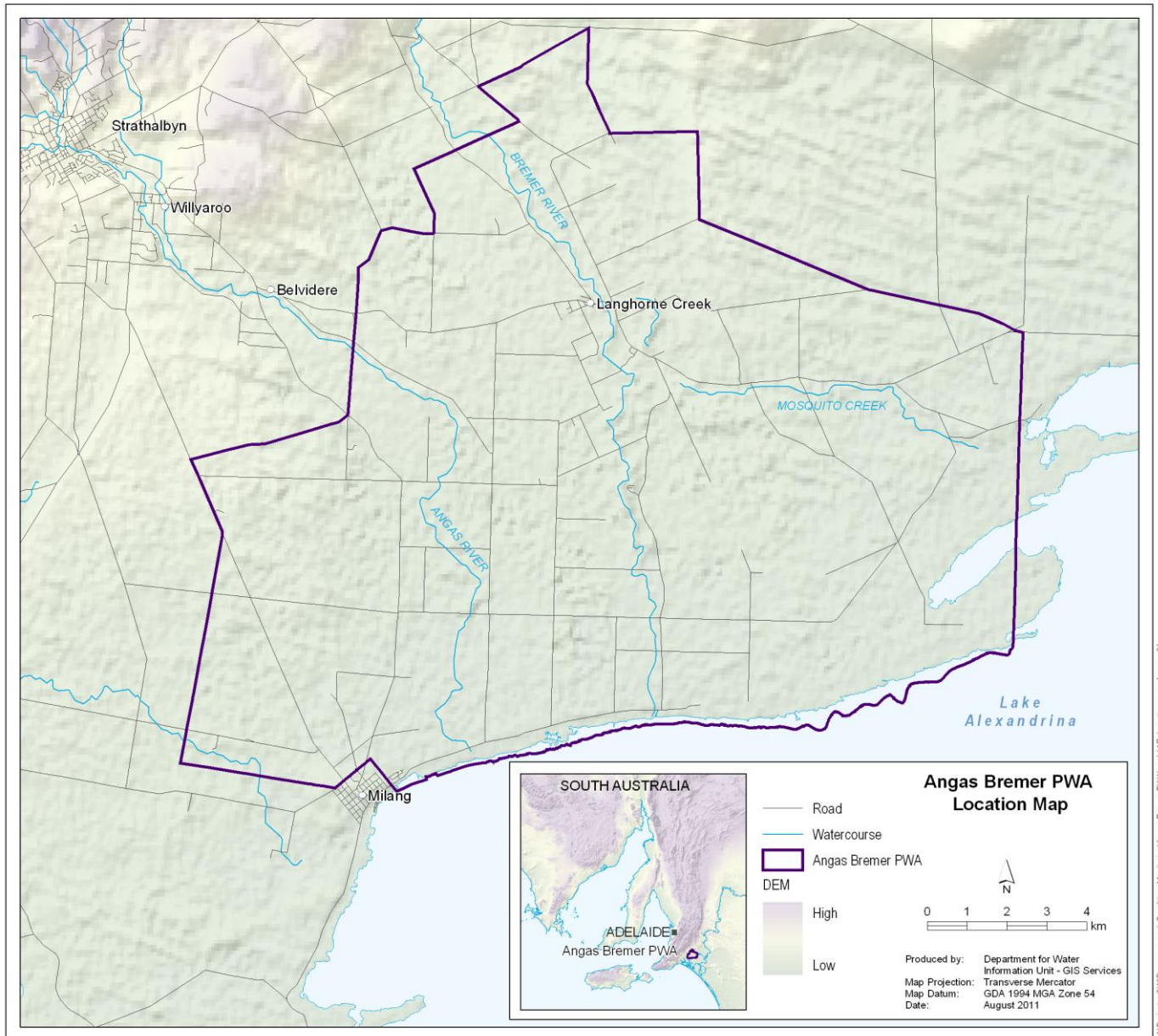


Figure 1. Location of Angas Bremer PWA

## HYDROGEOLOGY

The Angas Bremer PWA is underlain by sediments of the western margin of the Murray Basin where Quaternary and Tertiary sediments are deposited over the Cambrian basement rocks. The hydrogeology of the main aquifers is discussed below.

### QUATERNARY AQUIFER

This aquifer system has developed within a 10–20 m thick sequence of Quaternary sediments that consist mainly of clays, silt, sands and occasional gravels. The Quaternary aquifer is generally highly saline with low yields and has limited use. Good-quality groundwater is only found within narrow zones of rapid recharge, which occur along the Angas and Bremer Rivers during flooding events. This aquifer is mostly unconfined.

### CONFINED LIMESTONE AQUIFER

The confined Murray Group Limestone aquifer is up to 100 m thick and varies in composition from soft clayey limestone, hard sandy limestone to soft bryozoal layers. Irrigation supplies are generally obtained from the fossiliferous limestone member, which can be cavernous in some areas. Well yields vary from about 5 L/s in the north to over 15 L/s to the south, with occasional yields of up to 40 L/s.

The low-permeability aquitard comprising the Ettrick Formation (grey-green glauconitic marl) separates the overlying limestone aquifer from the underlying Renmark Group confined aquifer.

### REMARK GROUP AQUIFER

The Renmark Group aquifer consists of interbedded sands, silt and carbonaceous clay. It is generally thin and discontinuous over the Angas Bremer PWA and is not widely used due to the availability of much larger supplies in the overlying Murray Group Limestone aquifer.

A schematic cross section of the Angas Bremer PWA is displayed in Figure 2.

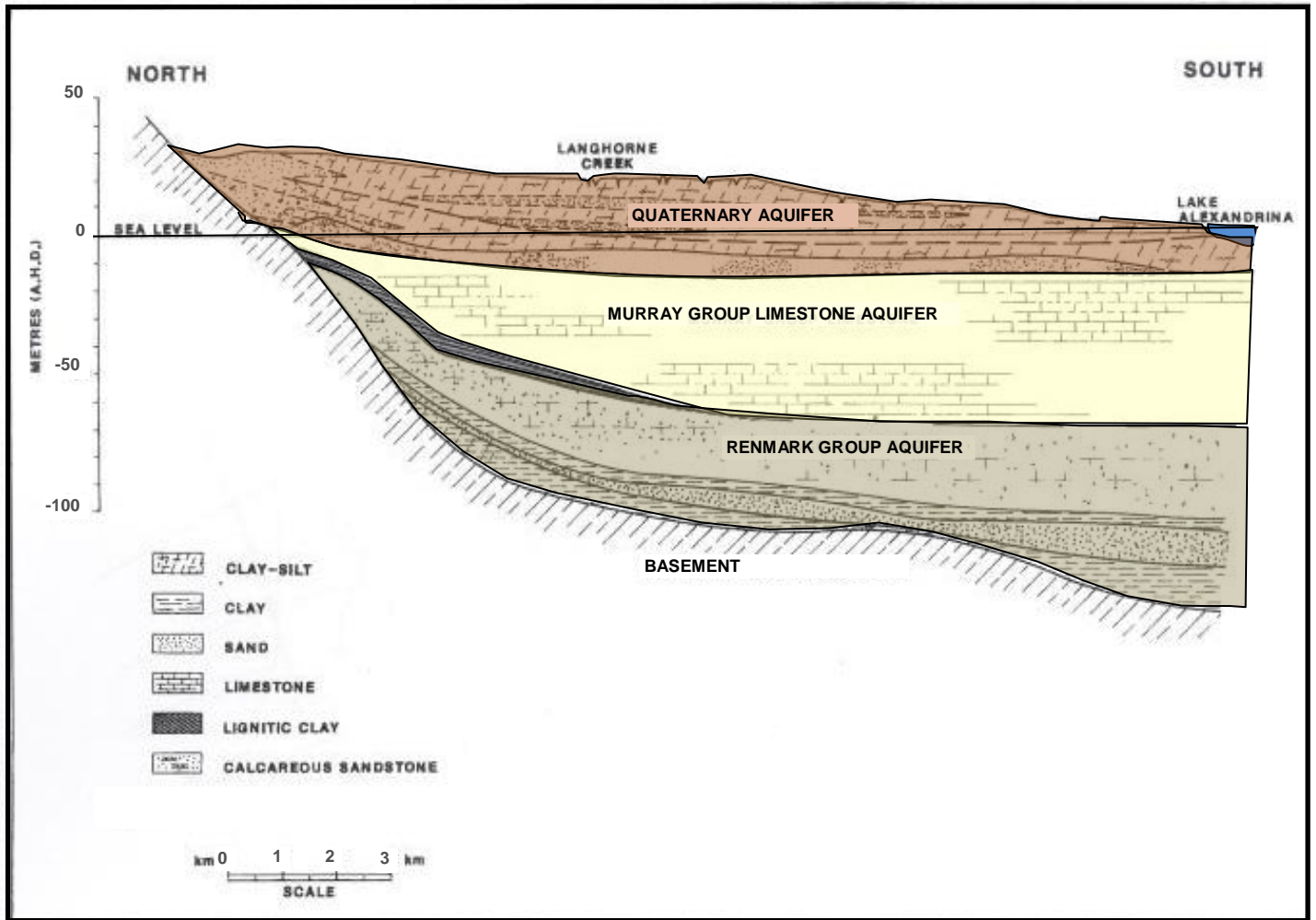


Figure 2. Geological cross section of the Angas Bremer PWA

For further information regarding the hydrogeology and previous status of the PWA, see: [http://www.waterconnect.sa.gov.au/BusinessUnits/InformationUnit/Technical%20Publications/ki\\_dwlbc\\_report\\_2007\\_27.pdf](http://www.waterconnect.sa.gov.au/BusinessUnits/InformationUnit/Technical%20Publications/ki_dwlbc_report_2007_27.pdf)

A summary of the hydrogeology is presented in Table 1

**Table 1. Hydrogeology of the Angas Bremer PWA**

AGE	STRATIGRAPHY		HYDROGEOLOGY	
	Unit	Lithology	Unit	Description
Quaternary	Various Quaternary sediments	Alluvial and lacustrine clays, sands, silts with occasional gravels	<b>Unconfined/confined aquifer</b>	Salinities range up to 20 000 mg/L. Low yields (< 5 L/sec) for stock water supply only.
		Clay, sands and silts	<b>Confining layer</b>	
Tertiary	Murray Group	Fossiliferous limestone with sandy and marly interbeds	<b>Confined aquifer</b>	Salinities range from ~1000 to 10 000 mg/L, yields 5 - 40 L/sec. Main source of groundwater irrigation supplies
	Ettrick Formation	Glauconitic, fossiliferous marl and calcareous clay	<b>Confining layer</b>	
	Renmark Group	Carbonaceous sands and clays	<b>Confined aquifer</b>	Confined aquifer, not used extensively for irrigation due to low yields and discontinuous nature.
Cambrain	Kanmantoo Group	Metamorphosed sandstone, siltstone, greywacke	<b>Fractured rock aquifer</b>	Poor aquifer, generally with high salinities and low yields.

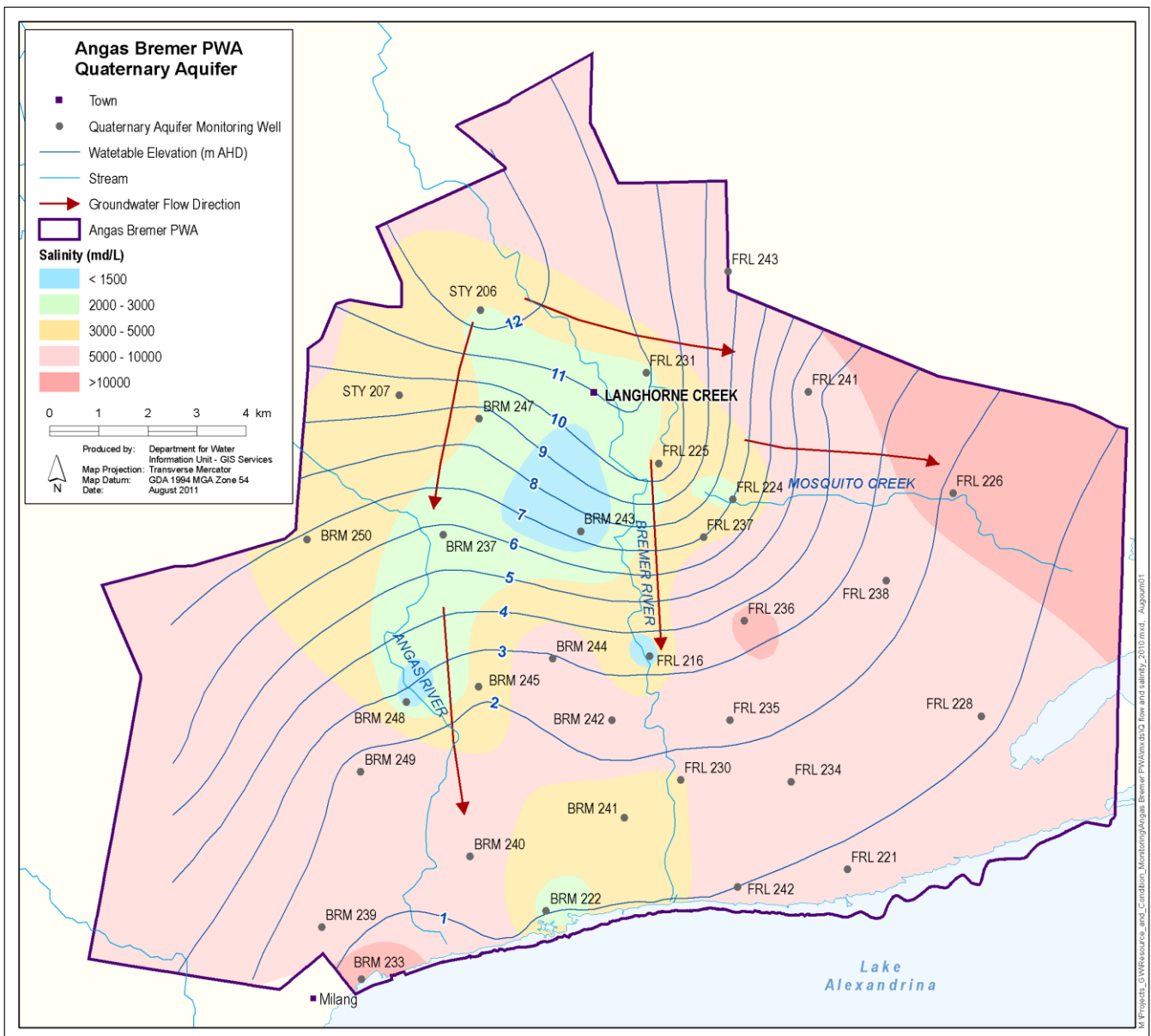


# GROUNDWATER FLOW AND SALINITY

## Quaternary Aquifer

The water level elevation contours for the Quaternary aquifer in the Angas Bremer PWA are presented in Figure 3 and show groundwater flows generally towards Lake Alexandrina, in a north to south and north-west to south-east direction. In the vicinity of Langhorne Creek, a watertable mound has formed in the Quaternary aquifer in response to infiltration of river and floodwater from the Bremer River, causing groundwater to flow radially away from it to the east and south.

Groundwater salinities are generally lowest near streams where river recharge and occasional flooding occurs.



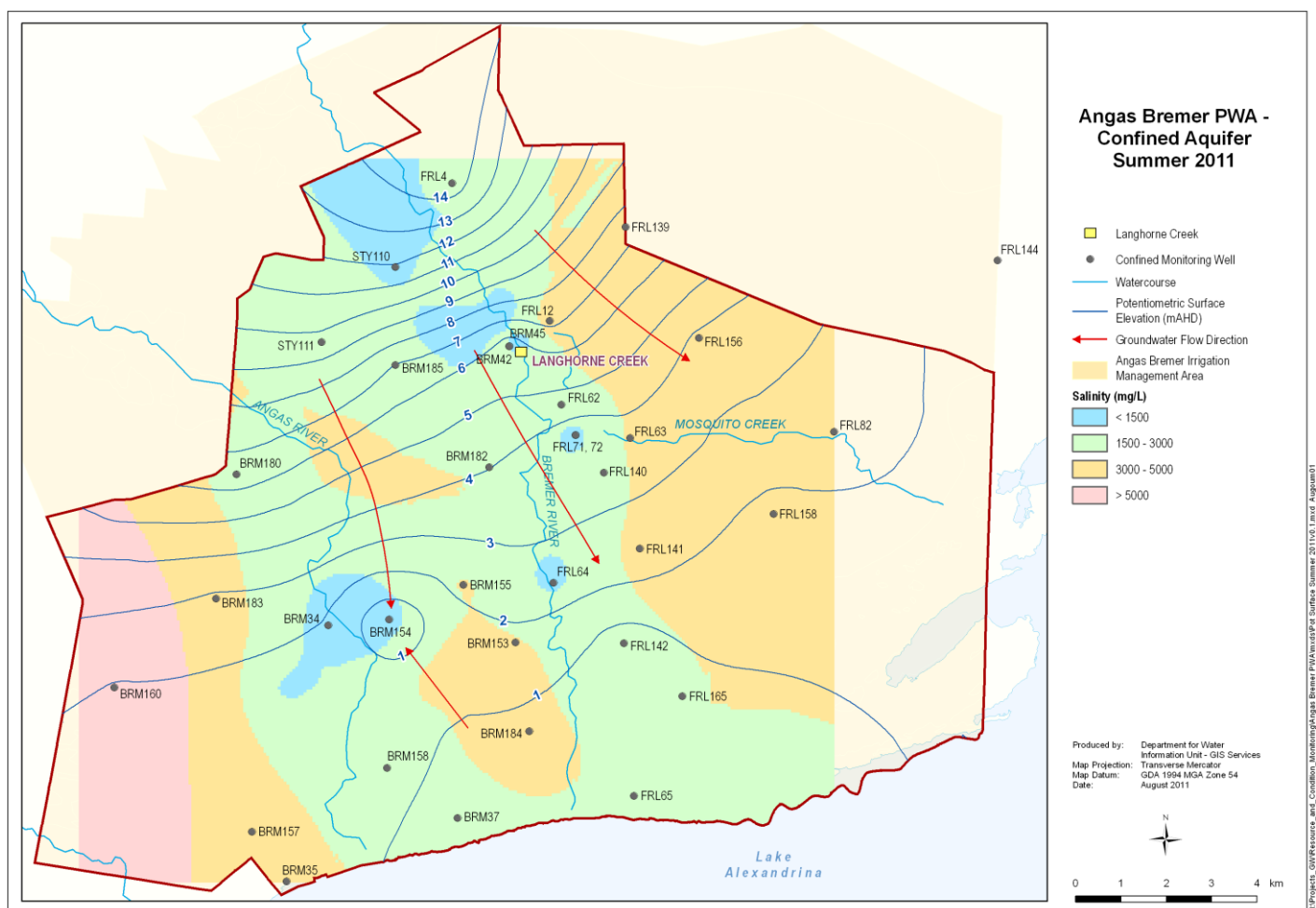
**Figure 3. Groundwater flow and salinity distribution (2010) for the Quaternary aquifer in the Angas Bremer PWA\***

\* Upon review of 2011 data, there was very little discernable difference in water level or salinity, hence the potentiometric surface and salinity ranges from the previous year are shown in Figure 3.

## Confined Aquifer

The water level elevation contours for the confined limestone aquifer measured in March 2010 (at the end of the irrigation season) are presented in Figure 4 and show the general groundwater flow direction towards Lake Alexandrina in a south-easterly direction.

The salinity distribution in the confined limestone aquifer shows low-salinity groundwater limited to relatively narrow zones parallel to the Angas and Bremer Rivers, where salinity ranges from less than 1500 mg/L to 3000 mg/L. Towards the margins of the basin to the east and west, salinities can be as high as 10 000 mg/L. The revised water level elevation contours displayed below (Fig. 4) show strong recovery in water levels south of the 3 m AHD contour toward Lake Alexandrina when compared to the same time in the previous year. This recovery in water levels is due to decreased extraction and managed aquifer recharge. Salinity in the aquifer appears to have also improved marginally<sup>1</sup>.



**Figure 4. Groundwater flow and salinity distribution (2011) for the confined limestone aquifer in the Angas Bremer PWA**

<sup>1</sup> As the salinity data is interpolated it should be considered as indicative only and used as a guide.

## GROUNDWATER DEPENDENT ECOSYSTEMS

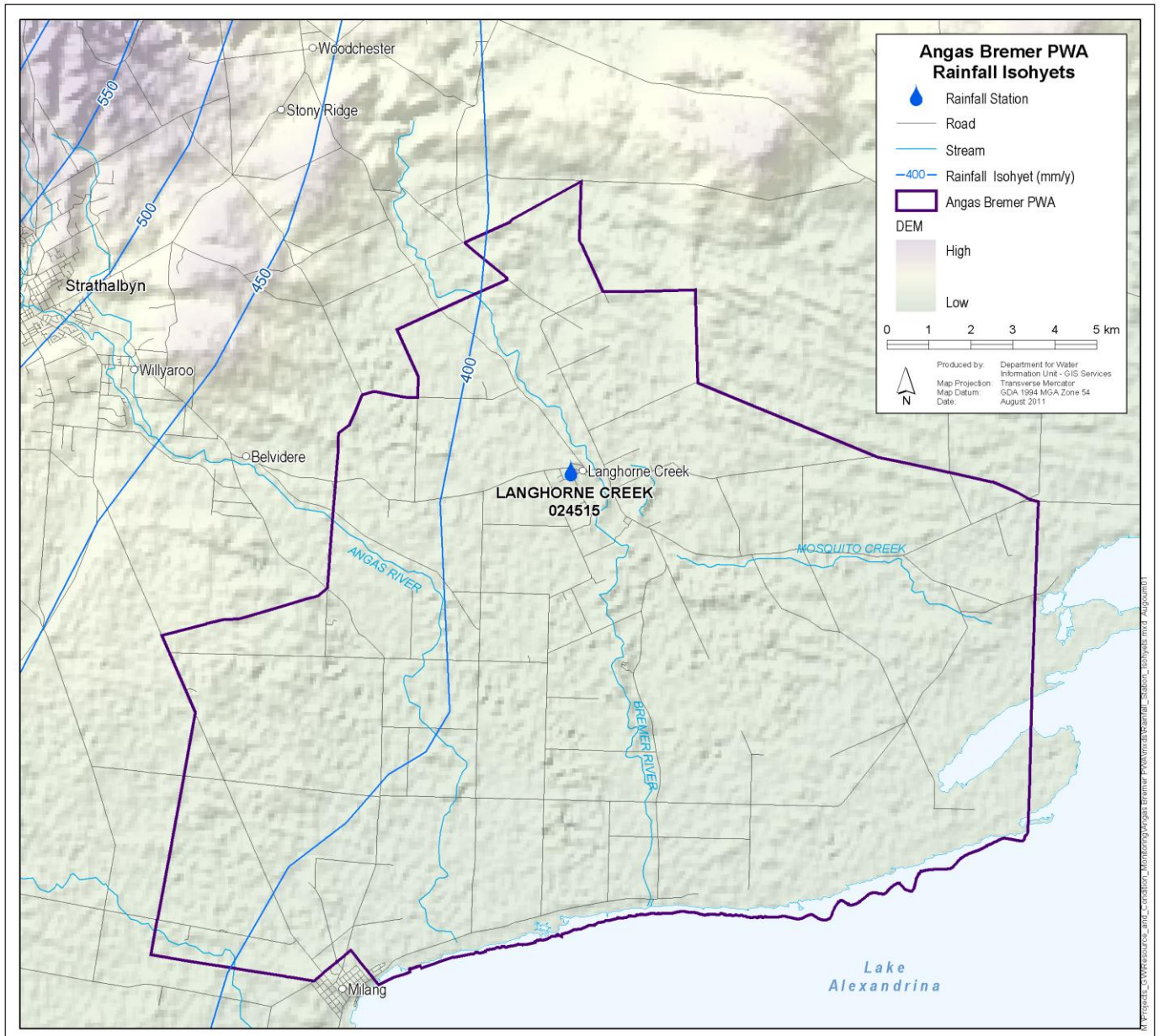
Whilst groundwater dependent ecosystems (GDEs) have not been considered in the assessment of the status of this groundwater resource, it is important to note the presence and ecological characteristics of the GDEs in the Angas Bremer PWA. Water Allocation Plans must include an assessment of the water required by ecosystems; this includes water from both surface water and groundwater resources. Groundwater dependent ecosystems can be defined as ecosystems where groundwater provides all or part of the water quantity, chemistry or temperature requirements. It is generally considered that shallow watertables less than ten metres 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.

Plants with a dependence on groundwater exist along the watercourses within the PWA and largely consist of River Red Gum (*Eucalyptus camaldulensis*). These trees may use groundwater from the shallow unconfined Quaternary aquifer, which is not widely used by licensees or stock and domestic users because of low yields and high salinities.

The Murray Group Limestone, which is developed for irrigation, is considered too deep below the surface to support any terrestrial vegetation or wetlands.

# RAINFALL

The climate in the Angas Bremer PWA is dominated by hot, dry summers and cool, wet winters. The location of the Langhorne Creek rainfall station (24515) and rainfall isohyets are displayed in Figure 5.



**Figure 5. Location of Langhorne Creek rainfall station (24515) and rainfall isohyets**

The average annual rainfall for Langhorne Creek is 389 mm for the period 1889 to 2011. Figure 6 shows the annual rainfall recorded at Langhorne Creek (station 24515) in blue columns. The cumulative deviation is also plotted in orange and measures the difference between the actual measured rainfall and the long-term average rainfall on an annual basis. An upward trend in this line indicates above-average rainfall and conversely, a downward trend indicates below-average rainfall.

The Langhorne Creek rainfall station shows generally above-average rainfall from 1930 until 1956, which was followed by a period of mostly average rainfall until the extremely wet period in 1992. Since then, there has been below-average rainfall, particularly since 2006. Above-average rainfall was recorded in both 2010 and 2011.

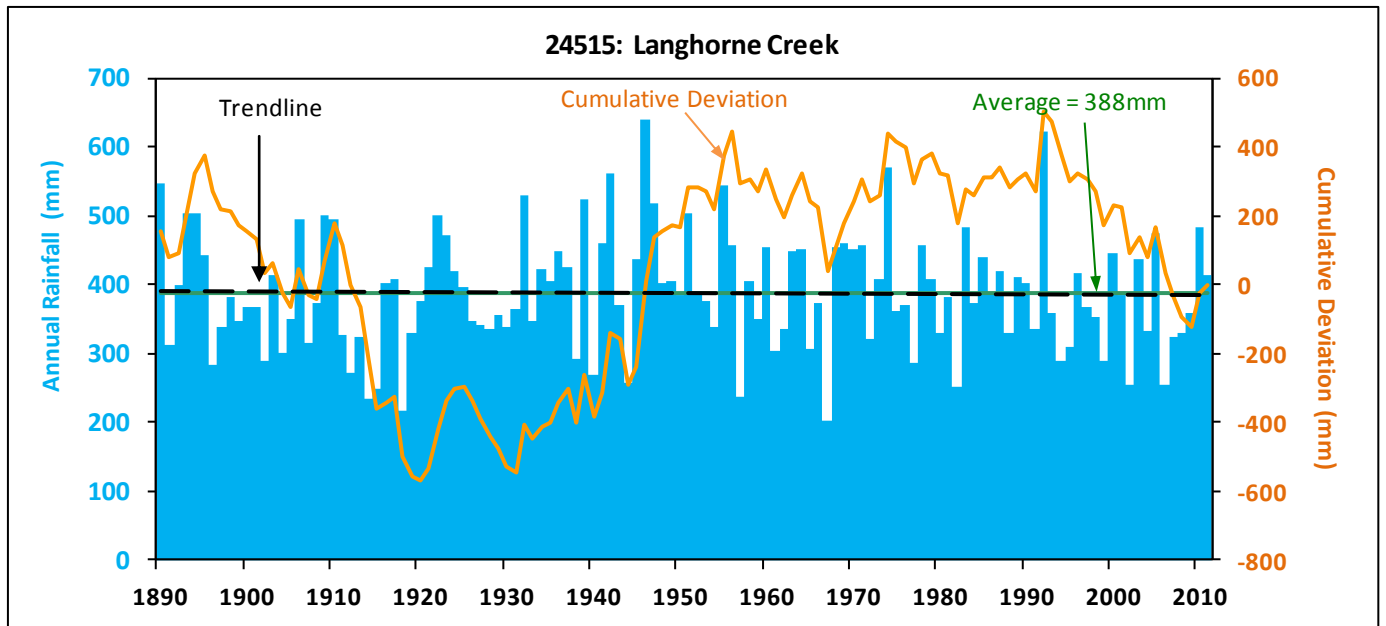


Figure 6. Annual rainfall and cumulative deviation for mean monthly rainfall for Langhorne Creek

## GROUNDWATER USE

Metered groundwater extractions for licensed purposes (excluding stock and domestic use) in the Angas Bremer PWA totalled 2488 ML<sup>2</sup> in the 2010–11 water-use year (Fig. 7), which represents a 53% decrease from the previous water-use year. The increase in extraction after 2005–06 was due to River Murray Prescribed Watercourse allocations sourced from Lake Alexandrina being unsuitable because of high salinity and access difficulties due to the receding shoreline. As a consequence, demand for groundwater increased significantly. The recent decrease in groundwater extractions reflects the recovery in the condition of the lake and increased access to River Murray water allocations via two new pipelines.

Groundwater use during the 2010–11 water-use year has returned to the volume extracted at commencement of the 2006 drought period.

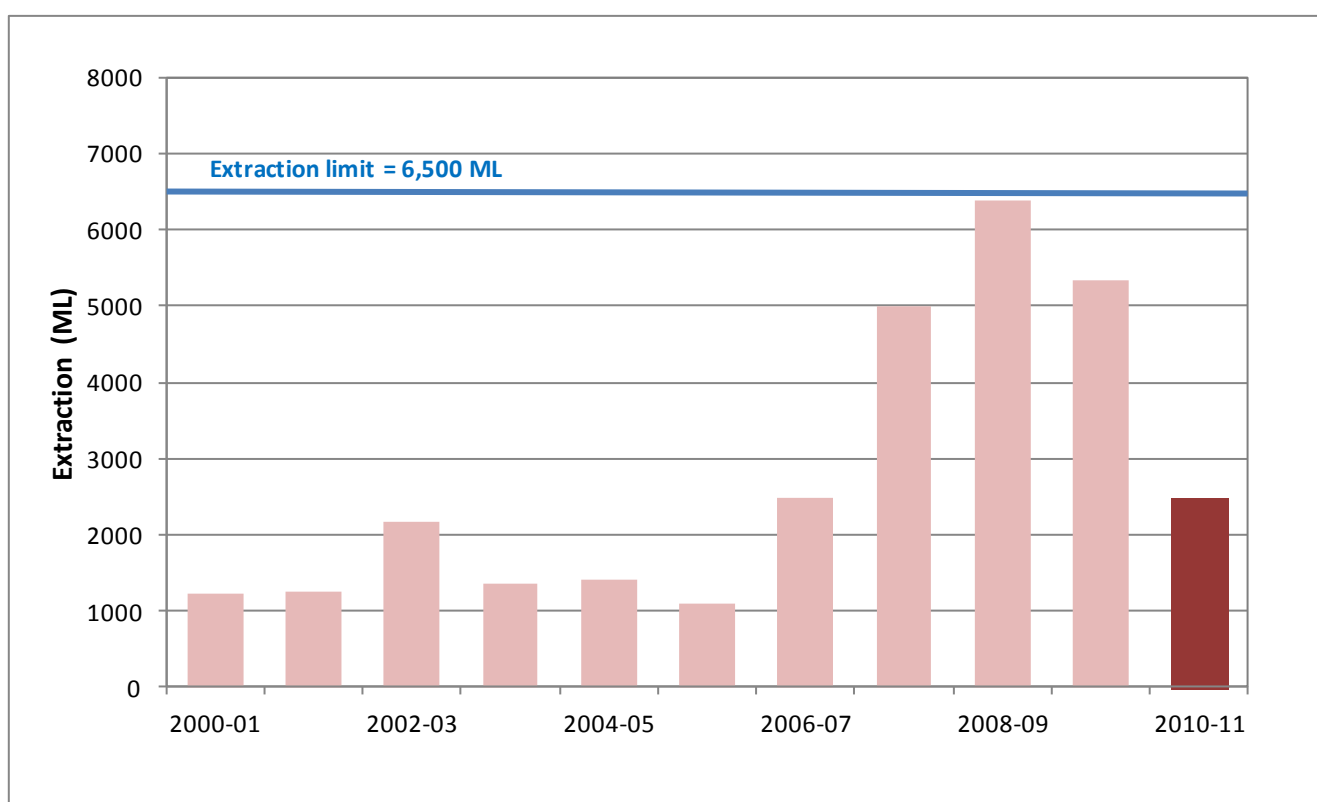


Figure 7. Historical licensed groundwater use for the Angas Bremer PWA

<sup>2</sup> This figure may include use of groundwater allocations, managed aquifer recharge allocations and rollover allocations.

## MANAGED AQUIFER RECHARGE

Managed aquifer recharge commenced in the Angas Bremer PWA in the early 1980s. Until recently, most managed aquifer recharge occurred along the Bremer River, with fewer sites located adjacent to the Angas River and Mosquito Creek. The amount of surface water injected into the confined limestone aquifer from these sources varies significantly, depending on the availability of stream flow with salinities less than 1500 mg/L. The construction of two pipelines from the River Murray during the recent drought has increased the reliability and the volumes of water available for managed aquifer recharge.

Figure 8 shows that the volume of managed aquifer recharge water (displayed in blue) injected into the confined limestone aquifer during 2010–11 was 4158 ML, which again represents a significant increase (i.e. greater than 100%) compared to years prior to 2009–10.

Figure 8 also presents extraction volumes. During 2010–11, the volume of water injected into the confined limestone aquifer (4158 ML) exceeded the volume of water extracted (2488 ML, refer to Fig. 7) from the groundwater resource resulting in a net gain to the aquifer of 1670 ML. The volumes of water injected to the aquifer are likely to offset the adverse impacts caused by high extraction in the previous three water-use years.

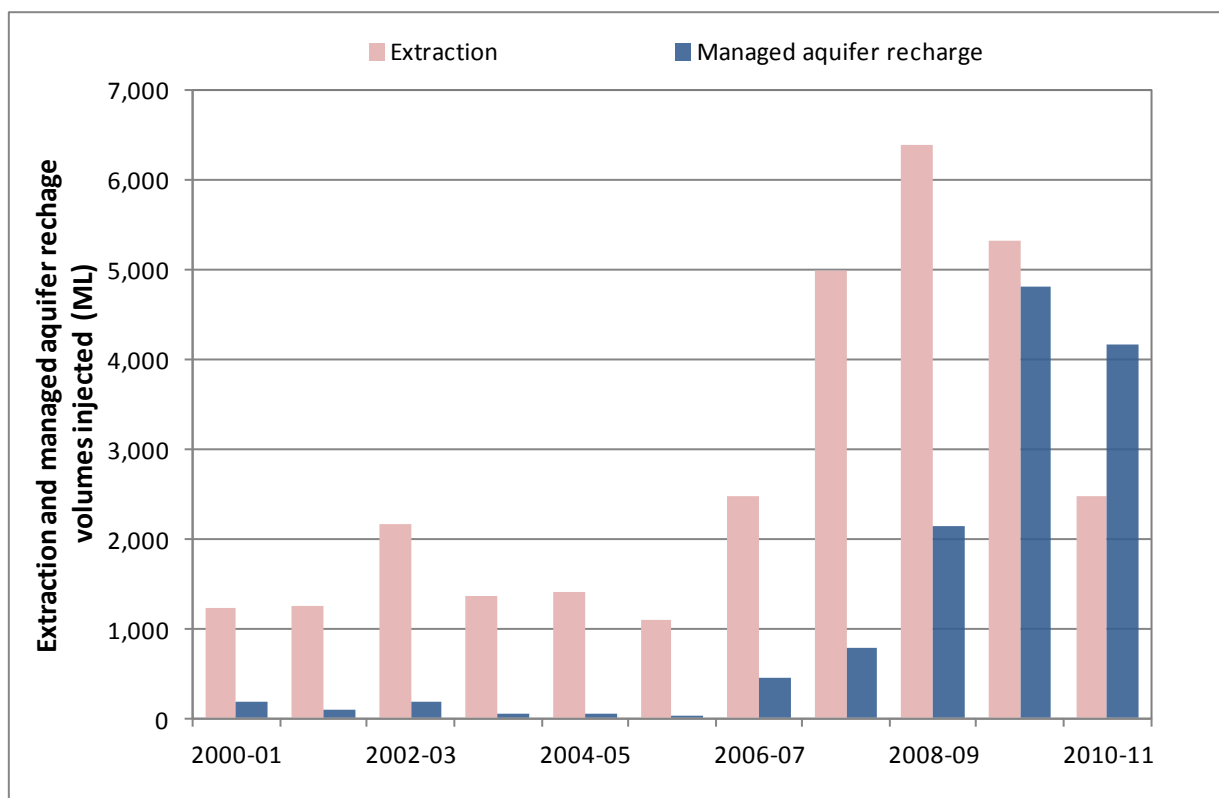


Figure 8. Historical licensed extraction and managed aquifer recharge<sup>3</sup> injection in the Angas Bremer PWA.

<sup>3</sup> Source of data for managed aquifer recharge volumes from 2000–01 to 2002–03 is the Angas Bremer Water Management Committee. Data from 2003–04 onwards is sourced from DFW WILMA Database.

# GROUNDWATER OBSERVATION NETWORKS

## WATER LEVEL NETWORK

A groundwater monitoring network in the Angas Bremer PWA was established in the late 1960s in response to falling groundwater levels and rising groundwater salinity. There are currently 92 wells monitoring water levels in the Angas Bremer water level network, with 75 of these wells falling within the Angas Bremer PWA. Water levels were monitored monthly until 2005, but since then have been monitored on a three monthly basis. The wells used to monitor water levels for all the aquifers in the Angas Bremer PWA are shown in Figure 9.

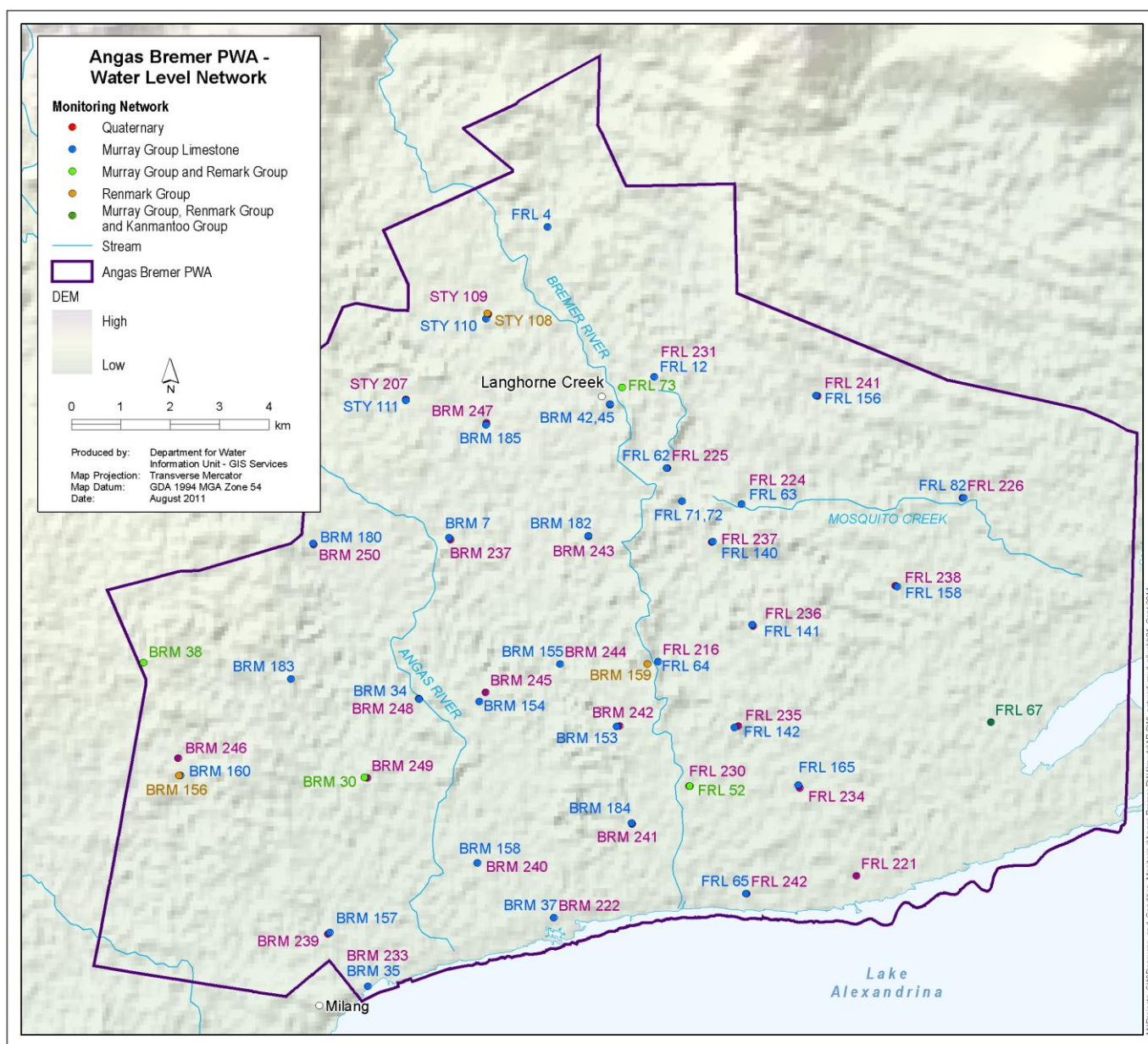


Figure 9. Location of water level observation wells in the Angas Bremer PWA



**Table 2. Groundwater level observation wells per aquifer in the Angas Bremer PWA**

Aquifer	Number of wells
Quaternary	33
Murray Group Limestone	34
Murray Group Limestone and Renmark Group	4
Renmark Group	3
Murray Group Limestone, Renmark Group and Kanmantoo Group <sup>4</sup>	1
<b>Total</b>	<b>75</b>

A shallow (6 m deep) observation well network of 172 wells was established in 1997 by the Angas Bremer Water Management Committee to monitor shallow watertables beneath irrigated areas at risk of waterlogging. Of these, only 57 are currently recording water levels with the remainder now dry.

## SALINITY NETWORK

There are currently 81 wells monitoring salinity in the Angas Bremer network, with 73 of these wells falling within the Angas Bremer PWA, as displayed in Figure 10. The frequency of salinity monitoring has varied over the years, however it typically occurs twice a year; once during autumn (i.e. following irrigation season) and once during spring (i.e. prior to irrigation season). Salinity observation wells are completed into all aquifers within the PWA, as detailed in Table 3.

**Table 3. Groundwater salinity observation wells per aquifer in the Angas Bremer PWA**

Aquifer	Number of wells
Quaternary	32
Murray Group Limestone	33
Murray Group Limestone and Renmark Group	4
Renmark Group	3
Murray Group Limestone, Renmark Group and Kanmantoo Group	1
<b>Total</b>	<b>73</b>

<sup>4</sup> Kanmantoo Group is also referred to as the Basement and is displayed in Figure 2 and Table 1.

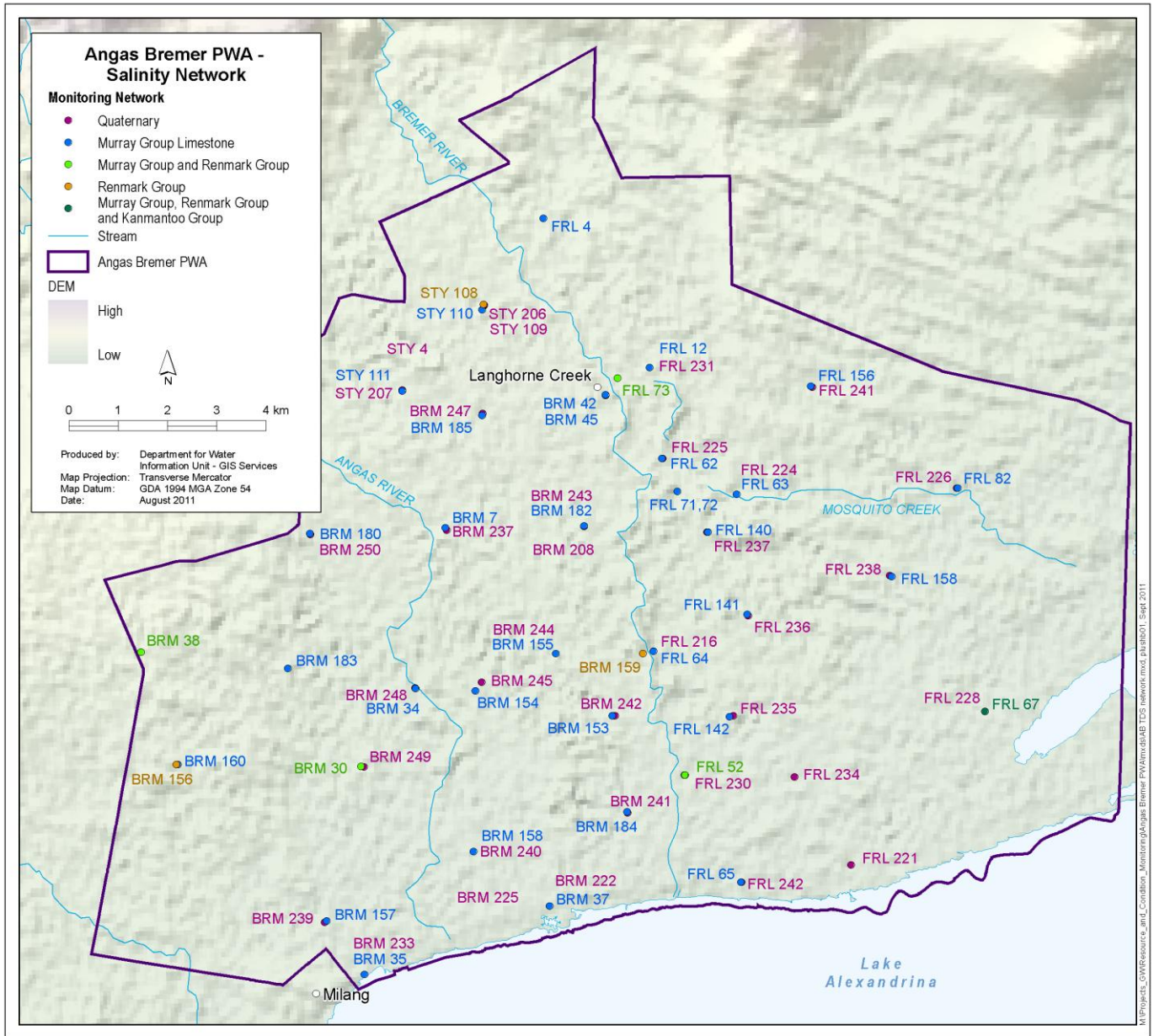


Figure 10. Location of salinity observation wells in the Angas Bremer PWA

# GROUNDWATER LEVEL TRENDS

## CONFINED LIMESTONE AQUIFER (MURRAY GROUP)

The groundwater level trends observed in the confined limestone aquifer are strongly controlled by groundwater extractions from this aquifer. As a result of the high connectivity in some areas, these extractions also influence trends in the overlying and underlying aquifers. Figure 11 depicts trends from throughout the Angas Bremer PWA that all show seasonal fluctuations to varying degrees and a decreasing or stable trend prior to the significant reduction in groundwater extraction in the early 1990s.

The reductions in groundwater extraction were in response to the increased availability of River Murray water allocations sourced from Lake Alexandrina. This reduction in groundwater extractions resulted in a substantial recovery in groundwater levels, which continued until the 2006 drought when extractions increased due to the decreasing availability of River Murray water from Lake Alexandrina (due to access and salinity problems).

Drawdowns in the confined limestone aquifer reached a peak during early 2009 to early 2010<sup>5</sup> after which flood waters flowing into the lake and two new pipelines from the River Murray reduced demand on groundwater. The reduced demand on the groundwater resources coupled with significant volumes of managed aquifer recharge water injected to the aquifer produced a recovery in water levels during 2010 and 2011 which is clearly evident in observation wells FRL064 and BRM007 (Fig. 11).

Locally, managed aquifer recharge activities can enhance the recovery of groundwater levels during winter and spring as shown by the increased amplitude in well FRL064 in the early 1990s.

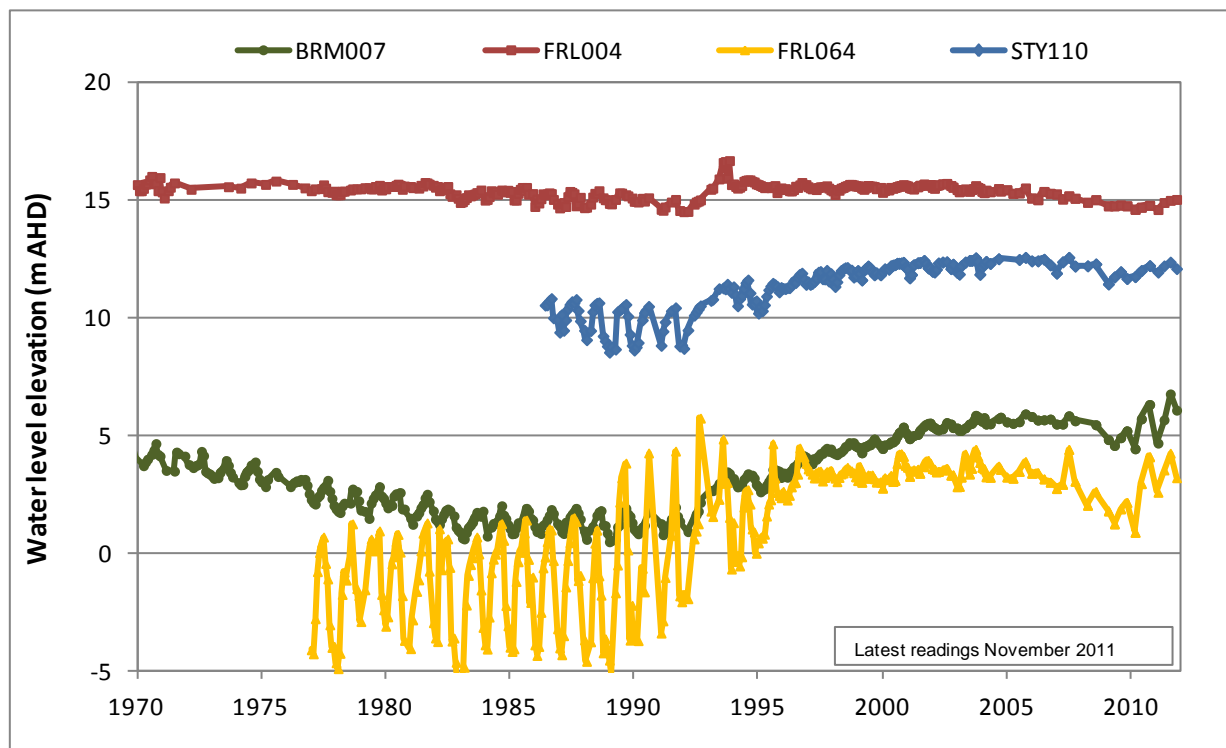


Figure 11. Groundwater level trends for the confined limestone aquifer in the Angas Bremer PWA

<sup>5</sup> February 2009 (STY110), November 2009 (FRL004) and March 2010 (wells BRM007 and FRL064)

## QUATERNARY AQUIFER

A variety of monitoring trends for the unconfined Quaternary aquifer can be seen in Figure 12, with the impact of the very wet 1992–93 season visible in most observation wells. The cumulative deviation from Figure 6 is plotted in orange and shows that below-average rainfall was experienced following the 1992 high rainfall event. Observation well FRL224 displays a reasonably close relationship with rainfall, with BRM222, located close the lakeshore, showing a more subdued response.

Observation well FRL216 is located adjacent to the Bremer River and displays marked seasonal variations which indicate recharge to the shallow unconfined aquifer by infiltration of streamflow. These seasonal variations may also indicate some degree of connection with the underlying limestone aquifer.

Well FRL226 is located on the eastern end of Mosquito Creek (Fig. 9) and shows an almost continuous decline of about 3 m since 1976. The lack of seasonal variation since about 1997 is probably the result of a lack of river water flows that are of sufficient magnitude to reach the end of the Mosquito Creek system and provide recharge to the watertable in that area.

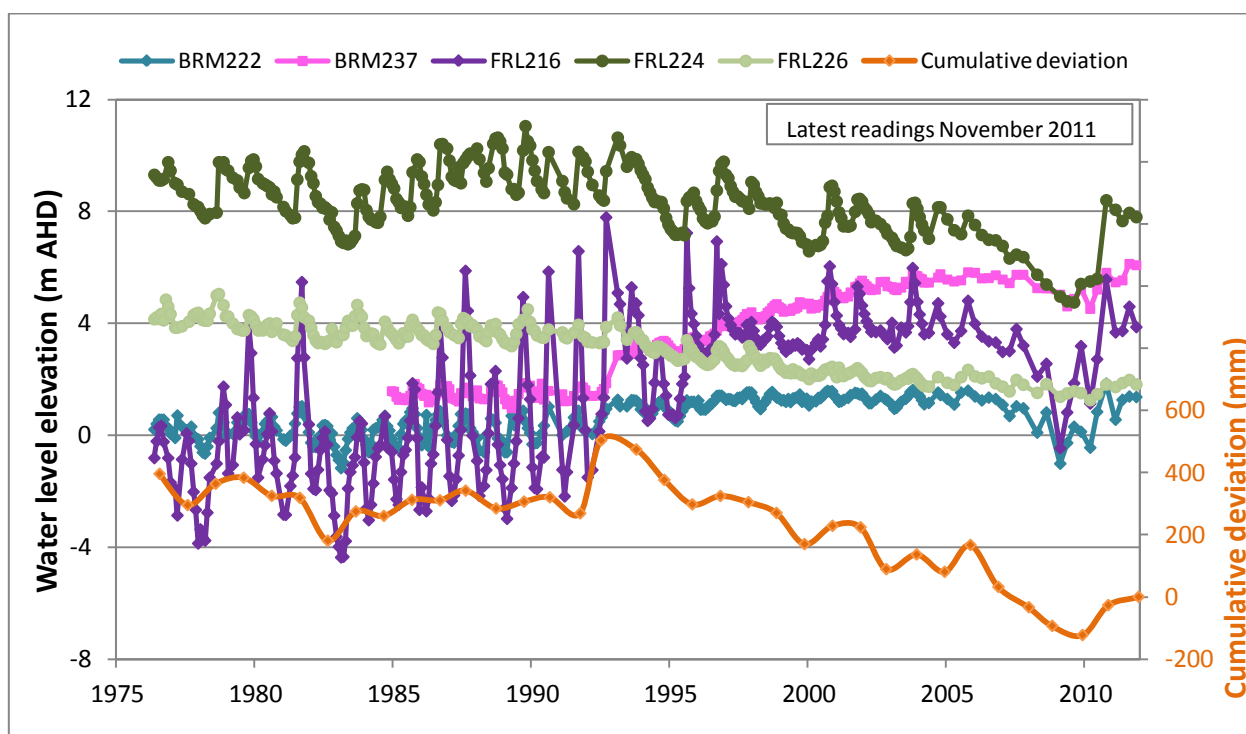


Figure 12. Groundwater level trends for the Quaternary aquifer in the Angas Bremer PWA

## RENMARK GROUP AQUIFER

Groundwater level trends in the Renmark Group confined aquifer (from which no known extractions occur) are almost identical to those in the overlying limestone aquifer (Fig. 13), which suggests good connectivity between the aquifers and a lack of a continuous impermeable confining layer.

Groundwater levels have continued to rise since 2009 up to and including 2011, albeit with some seasonal variation.

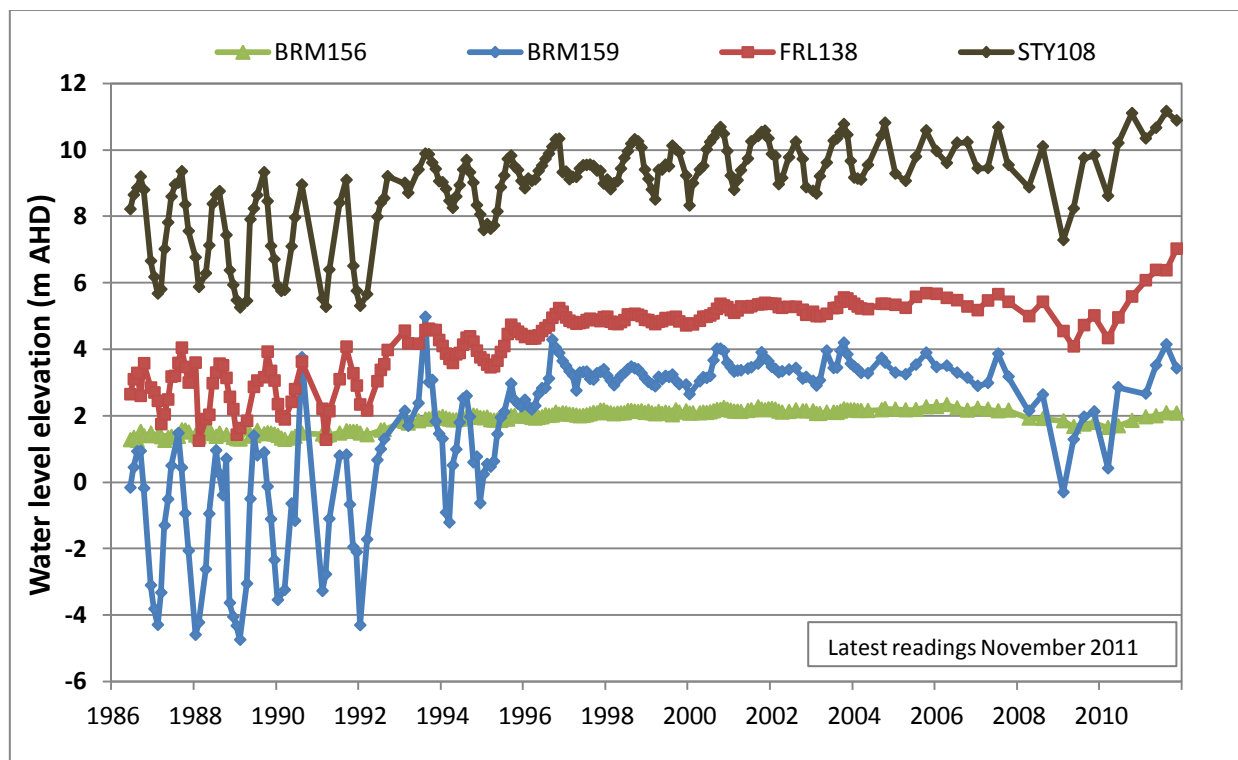


Figure 13. Groundwater level trends for the Renmark Group aquifer in the Angas Bremer PWA

# GROUNDWATER SALINITY TRENDS

## CONFINED LIMESTONE AQUIFER (MURRAY GROUP)

Increases in salinity in the confined limestone aquifer have been identified as the main threat to the long term sustainability of irrigation in the Angas Bremer PWA. Downward leakage from the overlying brackish to saline Quaternary aquifer is the predominant cause of such salinity increases and is driven by the head difference between the two aquifers. The head difference and downward leakage are higher during periods of high extraction both on a regional scale and locally where large drawdowns in an individual irrigation well may induce significant leakage. The relationship between extraction and salinity is well illustrated in Figure 14, which shows the salinity in observation well BRM030 in blue on the right axis and the extraction for the whole of the Angas Bremer PWA in red on the left axis.

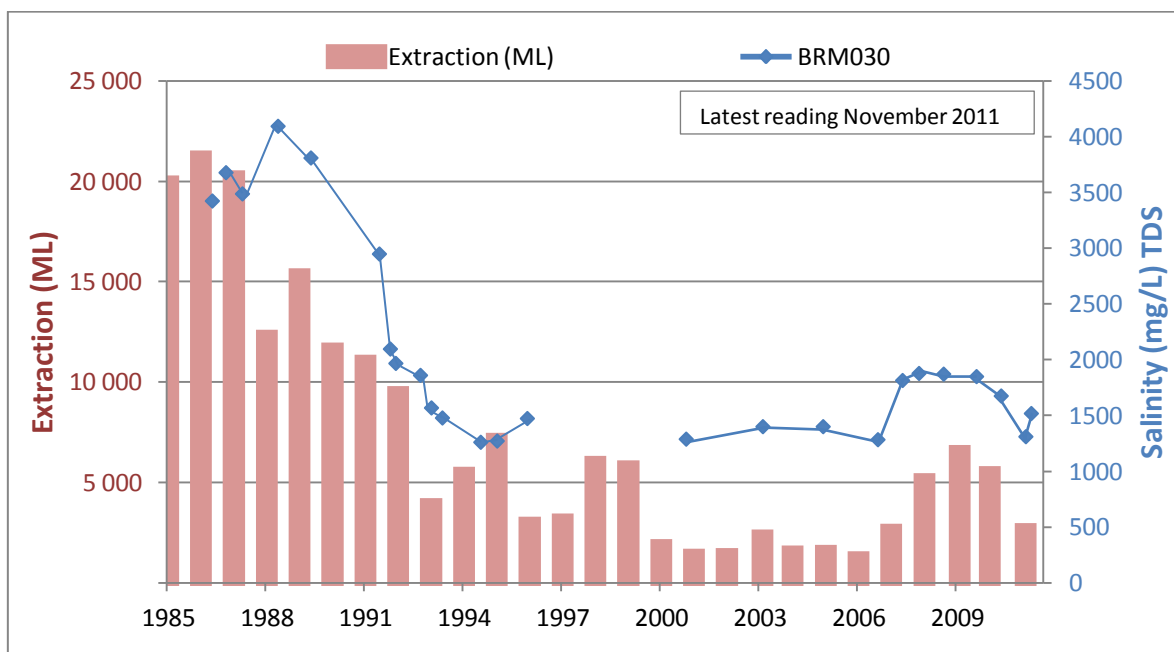


Figure 14. Relationship between extraction and salinity in the Angas Bremer PWA

Figure 15 presents trends from a number of observation wells throughout the Angas Bremer PWA. Whilst the trends may be affected by a number of processes, such as nearby managed aquifer recharge activity in wells, most show a decrease since the period of high extraction before the early 1990s and more significantly, an increase in salinity since the 2006 drought when extractions increased significantly.

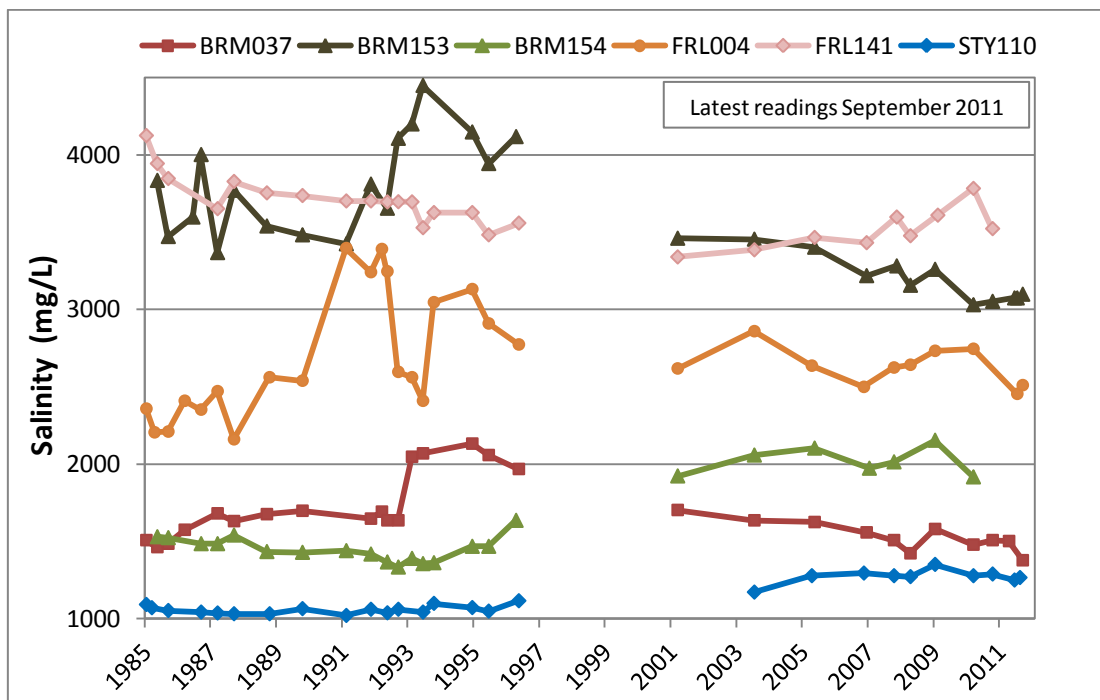


Figure 15. Salinity trends for the confined limestone aquifer in the Angas Bremer PWA

Most observation wells are showing a reduction in salinity during 2009–10 and 2010–11 in response to reduced extractions and the injection of fresh water (salinity less than 1500 mg/L) through managed aquifer recharge.

Salinity trends for observation wells along the eastern and western margins of the PWA where salinities are higher are shown in Figure 16. These trends are not influenced by managed aquifer recharge and four of the five wells are displaying a gradual continuous rise in salinity averaging 31.8 mg/L/y since monitoring began in 1985 and up until 2010. This increase is most probably the result of the slow lateral movement of locally more-saline groundwater down-gradient toward the lake. Downward leakage from the Quaternary aquifer is not likely to be the cause, as the head difference indicates upward leakage from the limestone aquifer at some wells and where downward leakage is indicated, the salinities of the two aquifers are very similar. From 2010 to 2011 there has been a slight decrease in salinity in several wells in the marginal areas.

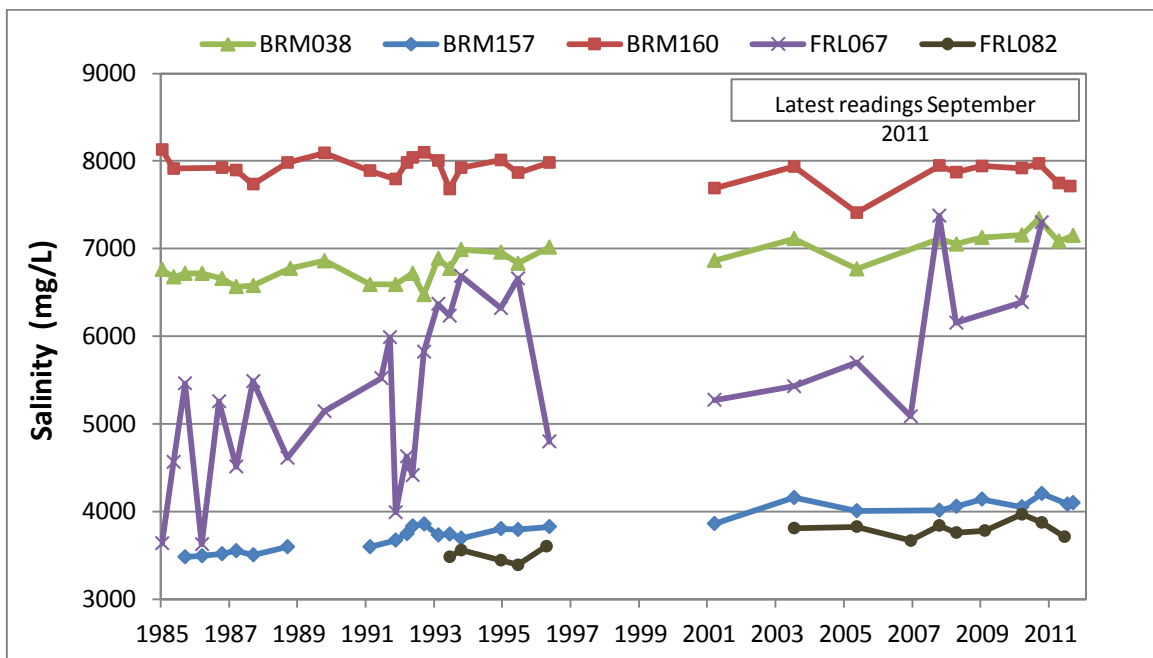


Figure 16. Groundwater salinity trends for the confined limestone aquifer in the margins of the Angas Bremer PWA

## QUATERNARY AQUIFER

Groundwater salinity trends in the Quaternary aquifer are quite variable as shown in Figure 17. Long-term increases from 1975 to 2010 at rates of 26 and 95 mg/L/y have been observed in wells FRL216 and FRL226 respectively, whilst an even higher rate of 144 mg/L/y has been recorded for well BRM247 since 1993. The cause of these increases is most likely the process of evapotranspiration from the relatively shallow watertable, which removes water but leaves salt behind. Salinity observations during 2011 are typically either stable or decreasing.

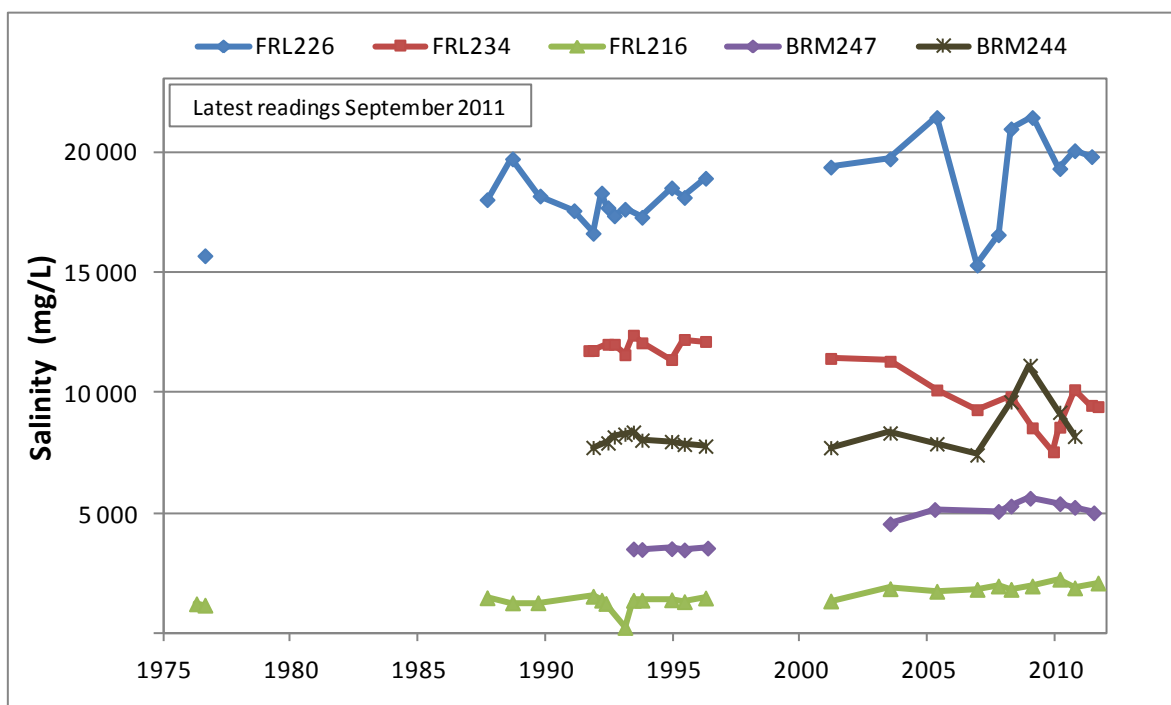


Figure 17. Groundwater salinity trends for the Quaternary aquifer in the Angas Bremer PWA



## RENMARK GROUP AQUIFER

Salinity trends in the Renmark Group aquifer as shown in Figure 18 appear relatively stable since monitoring began. The sudden decline in salinity in 1993 for well BRM159, which is located adjacent to the Bremer River, was possibly caused by the ingress of flood waters into the well, or via managed aquifer recharge. From 2009 to 2011, wells BRM159 and FRL138 displayed a slight decreasing trend, which may be due to the recent increase in managed aquifer recharge and reduced groundwater extraction from the overlying limestone aquifer.

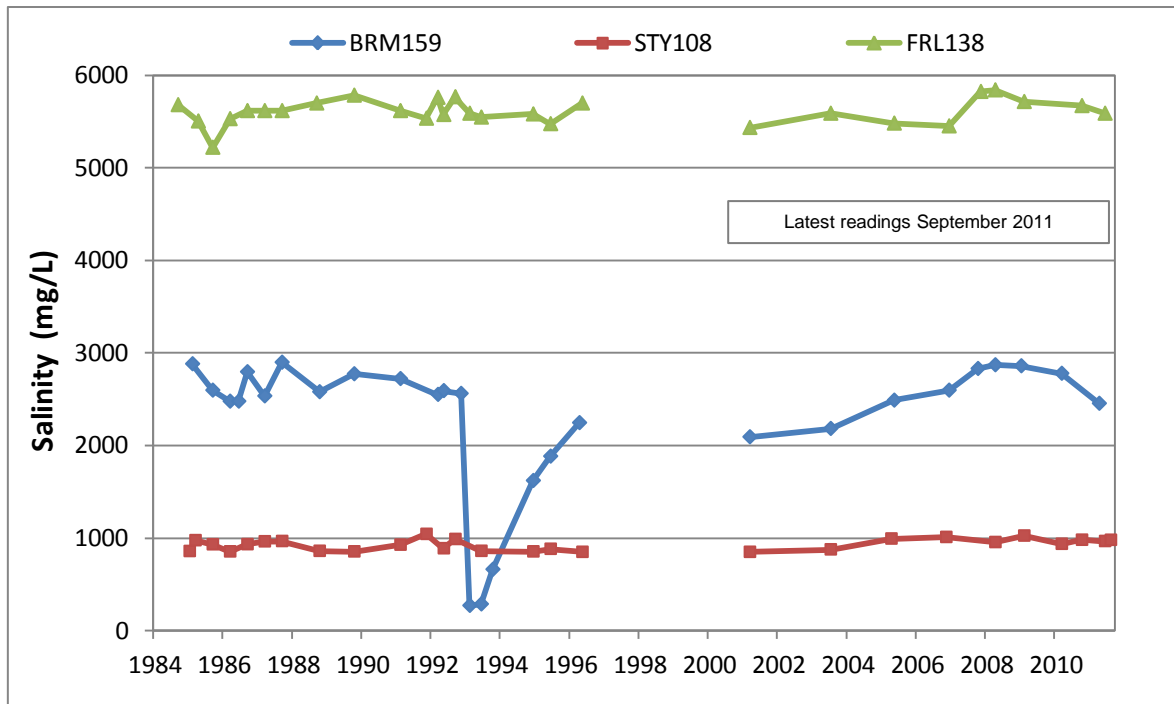


Figure 18. Groundwater salinity trends for the Renmark Group aquifer in the Angas Bremer PWA