PADTHAWAY PWA

GROUNDWATER LEVEL AND SALINITY STATUS REPORT

2011

DEPARTMENT FOR WATER

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Department for Water

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SUMMARY 2011

The Padthaway Prescribed Wells Area (PWA) is located in the Upper South East of South Australia, approximately 250 km south-east of Adelaide. It is a regional-scale prescribed resource for which groundwater is managed under South Australia's *Natural Resources Management Act 2004*. A Water Allocation Plan provides for sustainable management of the water resources.

Metered groundwater extractions for licensed purposes (excluding stock and domestic use) in the Padthaway PWA totalled 22 025 ML in the 2010–11 water-use year. This extraction is sourced entirely from the unconfined aquifer and represents a 31% decrease from the previous water-use year and is the lowest recorded extraction for the PWA.

Irrigation is the dominant use of groundwater, accounting for 99.86% of extraction. Pasture and lucerne accounted for about 32% of the total licensed volume of water extracted for the purpose of irrigation. Vines accounted for about 21% of the volume used for irrigation. Drip irrigation for vines accounted for 47% of the total area irrigated, followed by flood irrigation with 40% and centre pivot irrigation with 11% of the total area.

Groundwater levels in the unconfined aquifer on the Padthaway Flat show a very close correlation with rainfall. Significantly below-average rainfall since 2004 resulted in very little recharge and a decline in groundwater levels of up to 1.5 m. The above-average rainfall during 2009 and 2010 stabilised the declining trend and resulted in a recovery of water levels in some areas. However, slightly below-average rainfall in 2011 has resulted in a slight decline in groundwater water levels since March, despite significantly lower extraction than in previous years.

Although groundwater salinity trends in the shallow unconfined aquifer on the Padthaway Flat are quite variable and are influenced by rainfall patterns and the types of various irrigation practices, there is a general rising salinity trend due to the recycling of irrigation drainage water in the shallow aquifer.

In the Padthaway Ranges, the widespread clearance of native vegetation has resulted in increased recharge rates and hence rising groundwater levels in the unconfined aquifer (average 0.05 m/y). Most observation wells now show stable or declining trends in a delayed response to the below-average rainfall experienced since 1996. The increased recharge following clearing is also flushing salt, which was previously stored in the root zone of the native vegetation, down to the unconfined aquifer. This has caused salinity increases of up to 18 mg/L/y. In areas of permeable soils, the salt has almost been completely flushed and lower-salinity water is now recharging the aquifer resulting in falling salinity levels.

ASSESSMENT OF STATUS

The Padthaway PWA has been assigned a yellow status of "Adverse trends indicating low risk to the resource in the medium term" based on current trends. This status for 2011 is supported by:

- reasonably stable groundwater levels in response to decreasing extractions and near-average rainfall
- long-term gradual rise in groundwater salinity levels due to irrigation recycling on the Padthaway Flat and vegetation clearance in the Padthaway Ranges. This rise could become critical in areas where groundwater salinities are close to the tolerance level for grape vines, which is approximately 1500 mg/L.

Monitoring and groundwater modelling has shown that salinity rises due to vegetation clearance may dissipate in the medium term with recharge of fresh water following the initial flushing of saline soil water.

STATUS 2011

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 Padthaway Prescribed Wells Area (PWA) is located in the Upper South East of South Australia, approximately 250 km south-east of Adelaide (Fig. 1). It is a regional-scale prescribed resource for which groundwater is managed under South Australia's *Natural Resources Management Act 2004*. A Water Allocation Plan provides for sustainable management of the water resources.

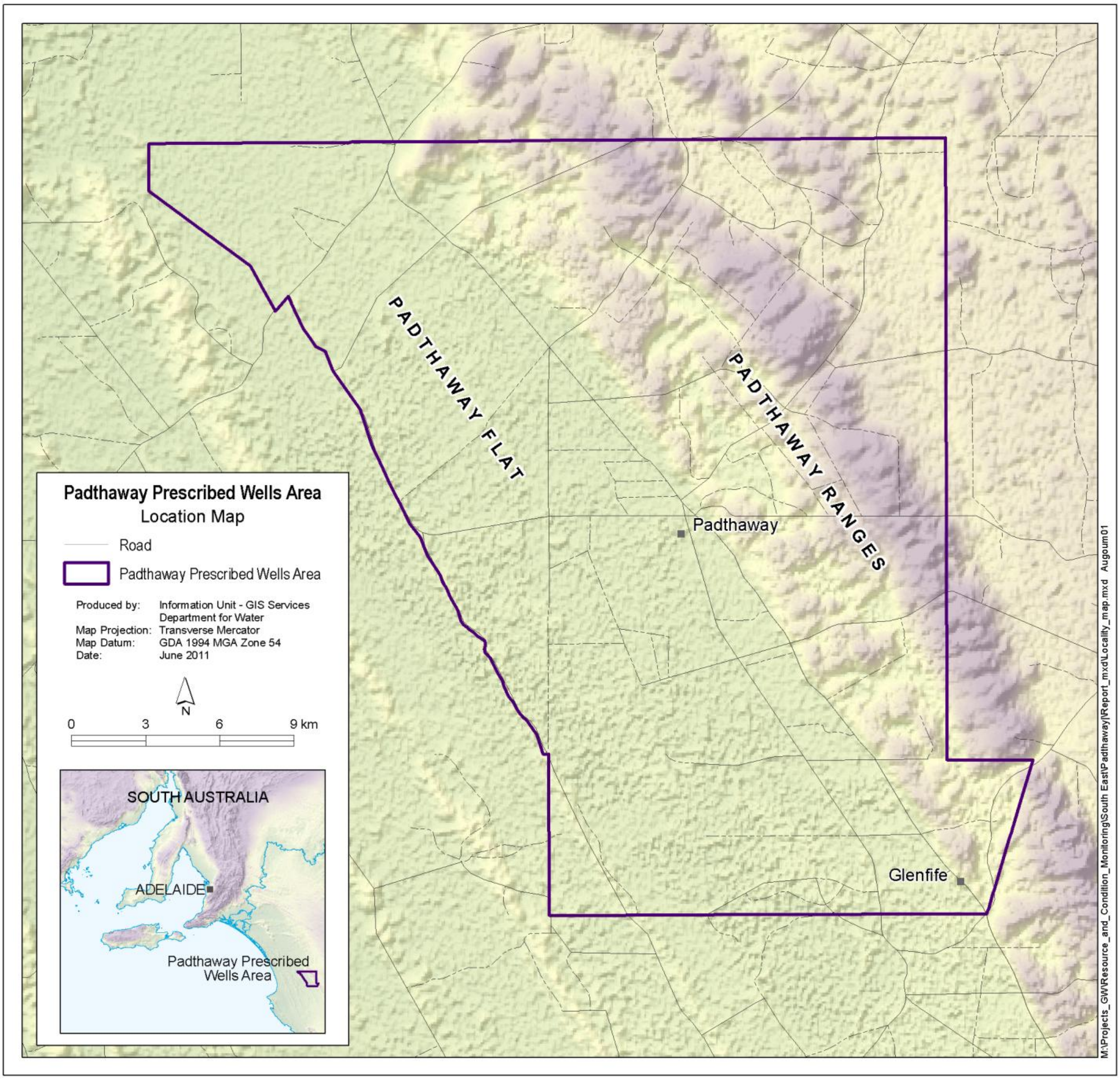

Figure 1. Location of the Padthaway PWA

HYDROGEOLOGY

The Padthaway PWA is underlain by sediments of the Murray Basin and can be divided topographically into two discrete landforms, each with different hydrogeological characteristics and groundwater management issues. The low-lying Padthaway Flat lies to the west, with the Padthaway Ranges to the east (Fig. 1). Both regions are underlain by two aquifer systems—an unconfined limestone aquifer comprising various Quaternary limestone units and a deeper confined sand aquifer. Even though the Padthaway PWA is underlain by the sediments of the Murray Basin, its geographical location within the South East Natural Resources Management region generally results in the hydrogeological units being labelled with the Gambier Basin equivalents. For consistency with other literature on the area this report will also reference the Gambier Basin nomenclature where applicable.

UNCONFINED AQUIFER

Padthaway Flat

A marine transgression about one million years ago eroded away the Tertiary sediments and deposited a range of Quaternary sediments that form the low-lying Flat where the depth to the watertable is generally less than 5 m.

Padthaway Formation is the uppermost geological unit in the Quaternary sequence which occurs largely in the inter-dunal flats and reaches a maximum known thickness of 20 m. It mainly consists of an off-white, well-cemented, non-fossiliferous, fine-grained limestone with a well-developed secondary porosity.

Coomandook Formation consists of interbedded sandy limestones and shelly sandstones up to 15 m thick with moderate permeability.

Bridgewater Formation has been deposited in a series of topographic ridges that run sub-parallel to the coast with thicknesses up to 90 m. Its lithology varies over the region but generally consists of a shelly and sandy aeolianite. In the inter-dunal flats, it underlies the Padthaway Formation.

The Padthaway and Bridgewater Formations are highly transmissive and the resultant high well yields of up to 300 L/s have enabled irrigators to adopt flood irrigation practices.

Padthaway Ranges

Beneath the Ranges, the main unconfined aquifer is the Bridgewater Formation which forms topographic ridges and attains thicknesses of up to 90 m. The depth to water is up to 30 m and average well yields are about 30 L/s. The Tertiary Gambier Limestone (Murray Group Limestone in Murray Basin) aquifer underlies the Bridgewater Formation and comprises a consolidated bryozoal limestone which averages 100 m in thickness. This unit is not generally used as an aquifer in the Padthaway PWA.

CONFINED AQUIFER

The unconfined and confined aquifers are separated by a low-permeability aquitard comprising the Narrawaturk Marl (Ettrick Formation in Murray Basin), a grey-green glauconitic marl which attains a thickness of about 20 m. The Dilwyn Formation (Renmark Group in Murray Basin) confined aquifer, which normally consists of interbedded carbonaceous sands and clays, is generally thin or absent in the Padthaway PWA.

A schematic cross-section of the Padthaway PWA is displayed in Figure 2.

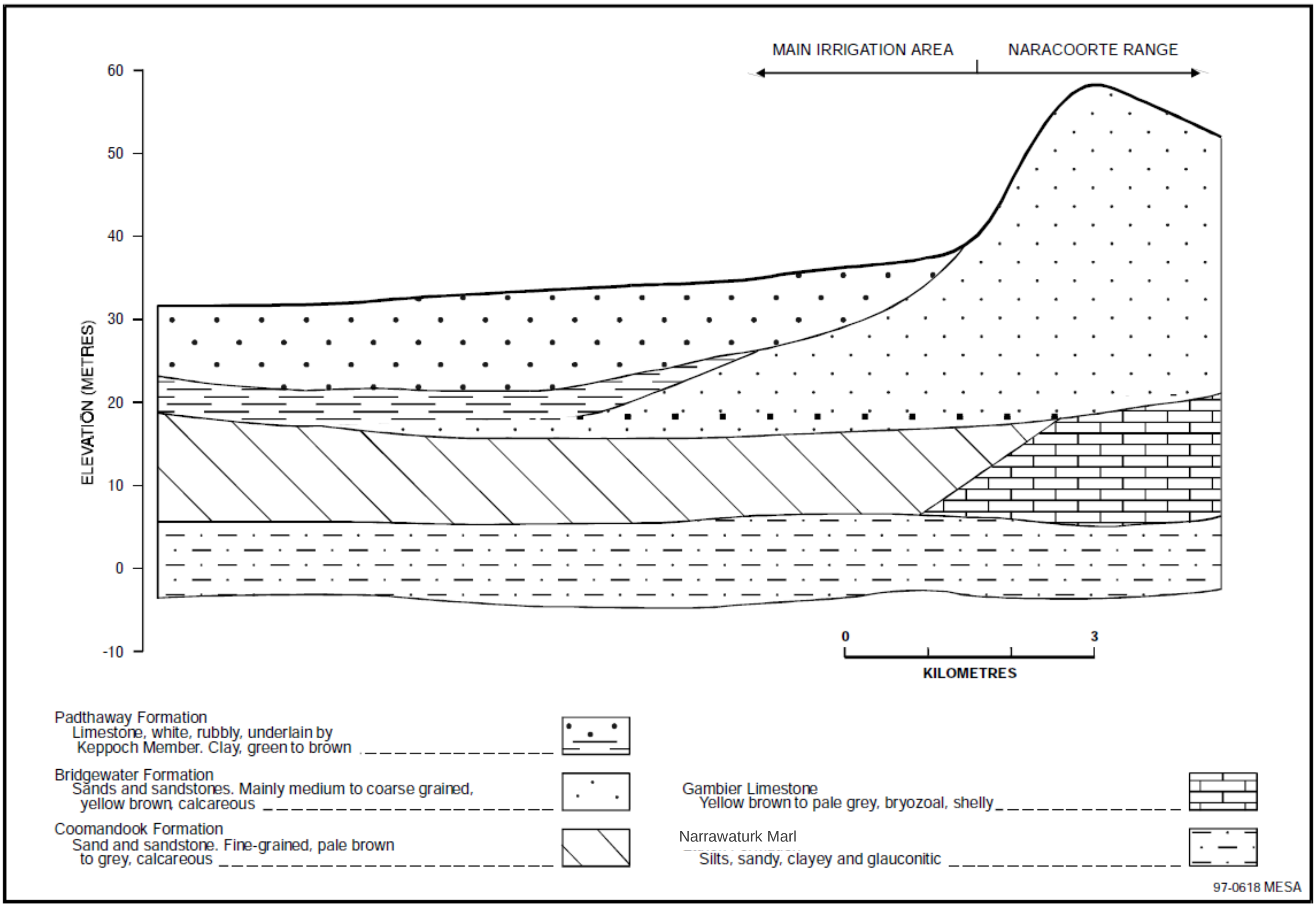

Figure 2. Geological cross-section of the Padthaway PWA

For a more detailed description of the hydrogeology of the Padthaway PWA, see:
http://e-nrims.dwlbc.sa.gov.au/libero/RPT/GW/Sth_East_Rb2000_031.PDF

A summary of the hydrogeology is presented in Table 1.

Table 1. Hydrogeology of the Padthaway PWA

AGE	STRATIGRAPHY		HYDROGEOLOGY	
	Unit	**Lithology**	**Unit**	**Description**
PADTHAWAY FLAT				
Quaternary	Padthaway Formation	Off-white, well-cemented, fine-grained limestone deposited in inter-dunal flats	**Unconfined aquifer**	Mainly used for irrigation and stock supplies. High yields of up to 300 L/s enable flood irrigation. Depth to watertable about 5 m.
	Bridgewater Formation	Shelly and sandy aeolianite deposited in inter-dunal flats and a series of topographic ridges		
	Coomandook Formation	Interbedded sandy limestones and shelly sandstones		
Tertiary	Narrawaturk Marl	Grey-green glauconitic marl	**Aquitard**	Confining layer, Ettrick Formation in the Murray Basin
	Dilwyn Formation	Carbonaceous sands and clays	**Confined aquifer**	Generally thin or absent in the Padthaway PWA, Renmark Group in the Murray Basin
PADTHAWAY RANGES				
Tertiary	Bridgewater Formation	Shelly and sandy aeolianite deposited in inter-dunal flats and a series of topographic ridges	**Unconfined aquifer**	Mainly used for irrigation and stock supplies. Yields of up to 30 L/s.
	Gambier Limestone	White bryozoal limestone		Not generally utilised as an aquifer, Murray Group Limestone in the Murray Basin
	Narrawaturk Marl	Grey-green glauconitic marl	**Aquitard**	Confining layer
	Dilwyn Formation	Carbonaceous sands and clays	**Confined aquifer**	Generally thin or absent in the Padthaway PWA, Renmark Group in the Murray Basin

GROUNDWATER FLOW AND SALINITY

UNCONFINED AQUIFER

The watertable elevation contours for the unconfined aquifer in the Padthaway PWA, shown in Figure 3, illustrate groundwater movement from the east to the west and south-west. The changes in the watertable gradient reflect changes in the permeability of the aquifer. The gradient becomes steeper near the boundary between the Ranges and the Flat, where the transition occurs from the Bridgewater Formation to the Padthaway Formation. The gradient flattens to the west beneath the Plain and reflects the higher permeability in the Padthaway Formation. Groundwater flow also changes to a north-westerly direction beneath the Flat.

The salinity distribution for the unconfined aquifer in the Padthaway PWA is also shown in Figure 3. Generally, the salinity ranges from approximately 1000 mg/L in the east to more than 3000 mg/L in the north-west.

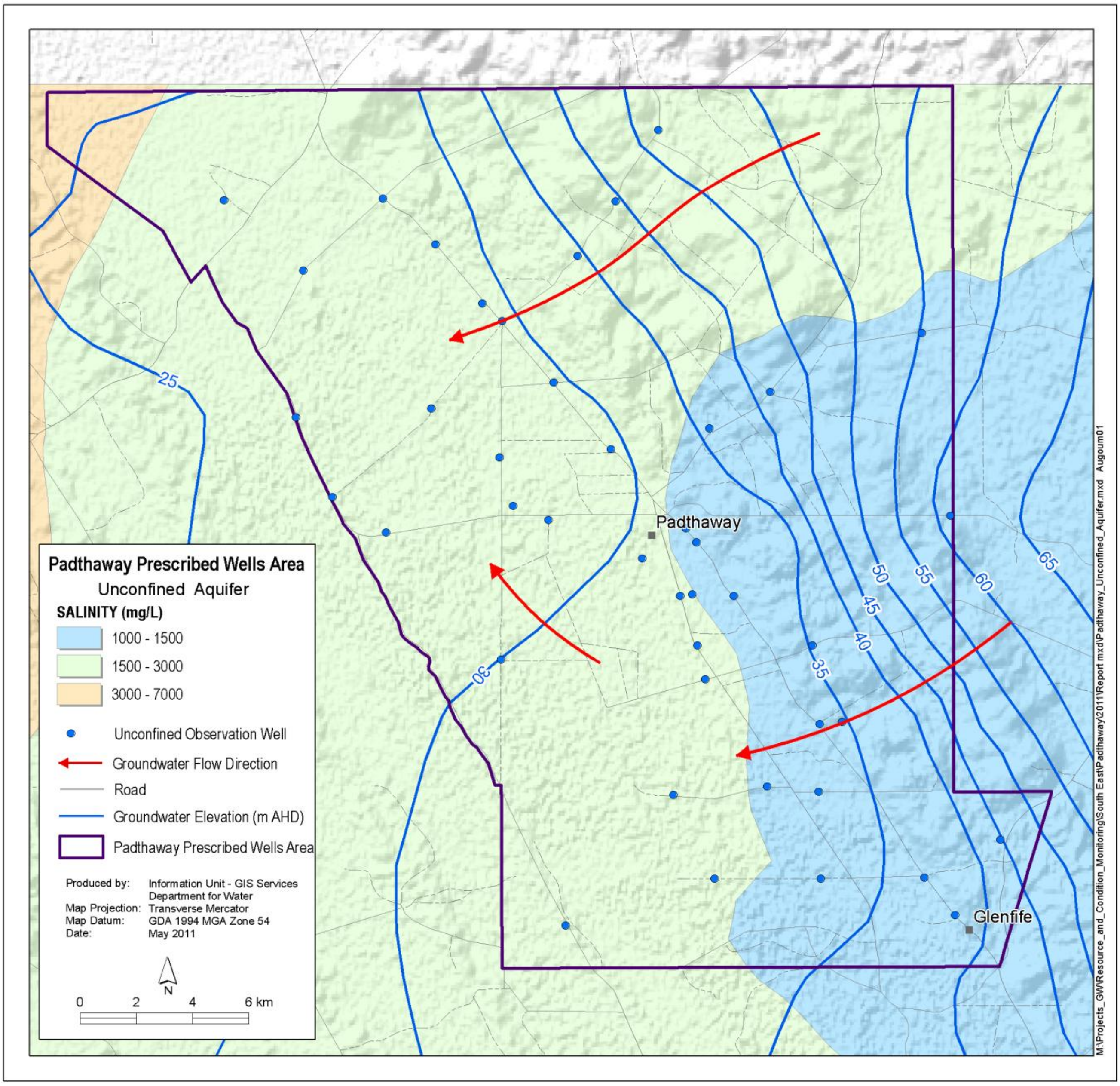

Figure 3. **Groundwater flow direction and salinity distribution (winter 2010) for the unconfined aquifer in the Padthaway PWA***

* As there were no discernible changes in water levels or salinity, the potentiometric surface and salinity ranges from the previous year have been used

CONFINED AQUIFER

Although there are limited data within the Padthaway PWA, the regional contours of groundwater flow and salinity in the confined aquifer are presented in Figure 4 and show broadly similar east to west flow directions to those in the overlying unconfined aquifer. The salinities are also similar to the unconfined aquifer.

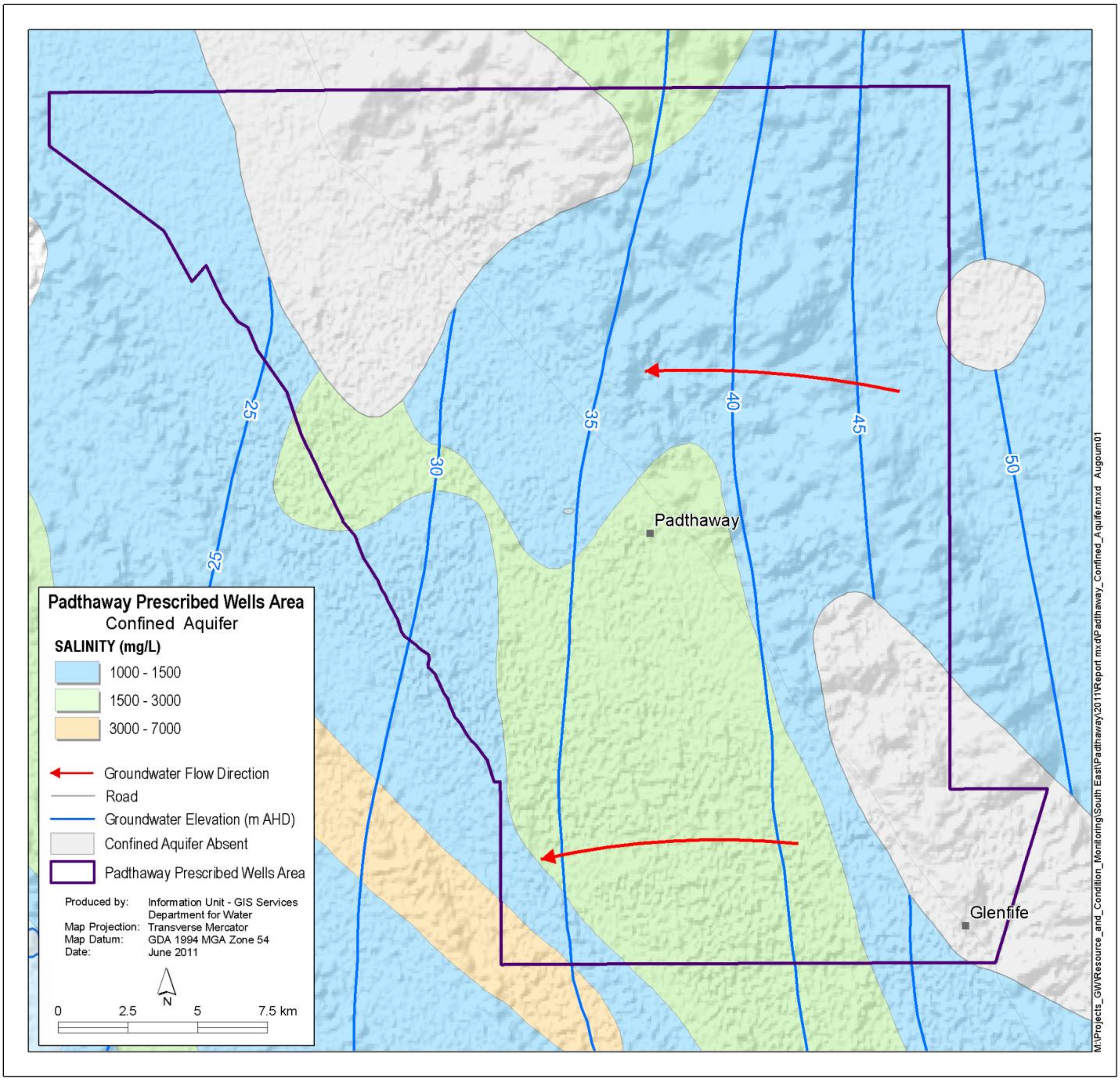

Figure 4. Groundwater flow direction and salinity distribution (winter 2010) for the confined aquifer in the Padthaway PWA*

* As there were no discernible changes in water levels or salinity, the potentiometric surface and salinity ranges from the previous year have been used

GROUNDWATER DEPENDENT ECOSYSTEMS

Whilst groundwater dependent ecosystems (GDEs) have not been considered in the assessment of the annual trend status of the groundwater resource, it is important to note the presence and ecological characteristics of the GDEs found in the Padthaway PWA. 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. Shallow watertables are more susceptible to changes in groundwater levels that affect connectivity to GDEs and the ecological value of sites. The exception to this is stygofauna (animals that inhabit water-filled cracks and pools below the ground), which can be found at greater depths.

Phreatophytic vegetation (deep rooted plants that access groundwater) can be found within the Naracoorte Range, with stands of River Red Gum (*Eucalyptus camaldulensis*) associated with Morambro Creek and the inter-dunal flats where the underlying watertable is found within 5 m of the surface, indicating a likely dependence on groundwater. These trees may be susceptible to increasing groundwater salinity and a rising watertable, resulting in waterlogging of roots, salt stress and die back.

Wetlands can be supported by the discharge of groundwater or the presence of shallow watertables. Monitoring has not detected any increase in salinity in any freshwater wetlands, suggesting that there is minimal groundwater discharge to them. Semi-permanent saline lakes have little remnant vegetation with the exception of *Melaleuca halmaturorum*. The saline conditions most likely reflect groundwater discharge and evaporative concentration.

Karst features (also known as solution features) are known to occur in the Padthaway PWA, but their ecology or dependence on groundwater is currently unknown.

RAINFALL

The climate in the Padthaway PWA is dominated by hot, dry summers and cool, wet winters. The Marcollat rainfall station (26017) was chosen as it has the longest record within the Padthaway PWA (Fig. 5). It is located 15 km north-west of the Padthaway township and has an average annual rainfall of 519 mm. Figure 6 shows the actual annual rainfall recorded 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 annual rainfall. An upward trend in this line indicates above-average rainfall and conversely, a downward trend indicates below-average rainfall.

There are two very broad trends indicated in Figure 6. A long period of above-average rainfall was experienced from 1940 to 1976, with generally below-average rainfall from 1993 until 2009. This below-average trend is pronounced after 1996. Above-average rainfall was recorded during 2009–10 with slightly below-average rainfall recorded in 2011.

Shallow watertables on the low-lying plains in the west show strong correlation with the timing and magnitude of rainfall events.

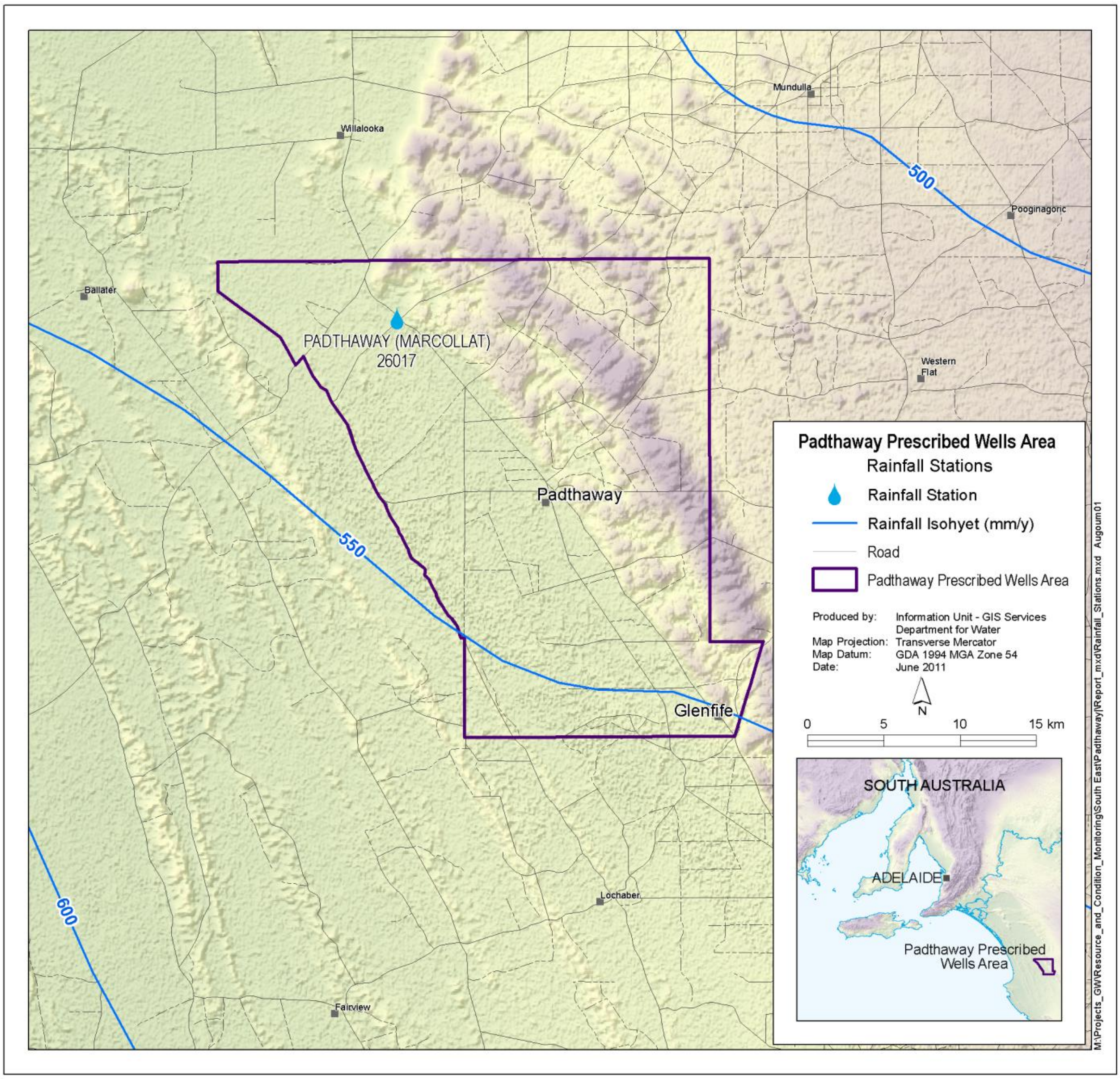

Figure 5. Location of rainfall stations and rainfall isohyets in the Padthaway PWA

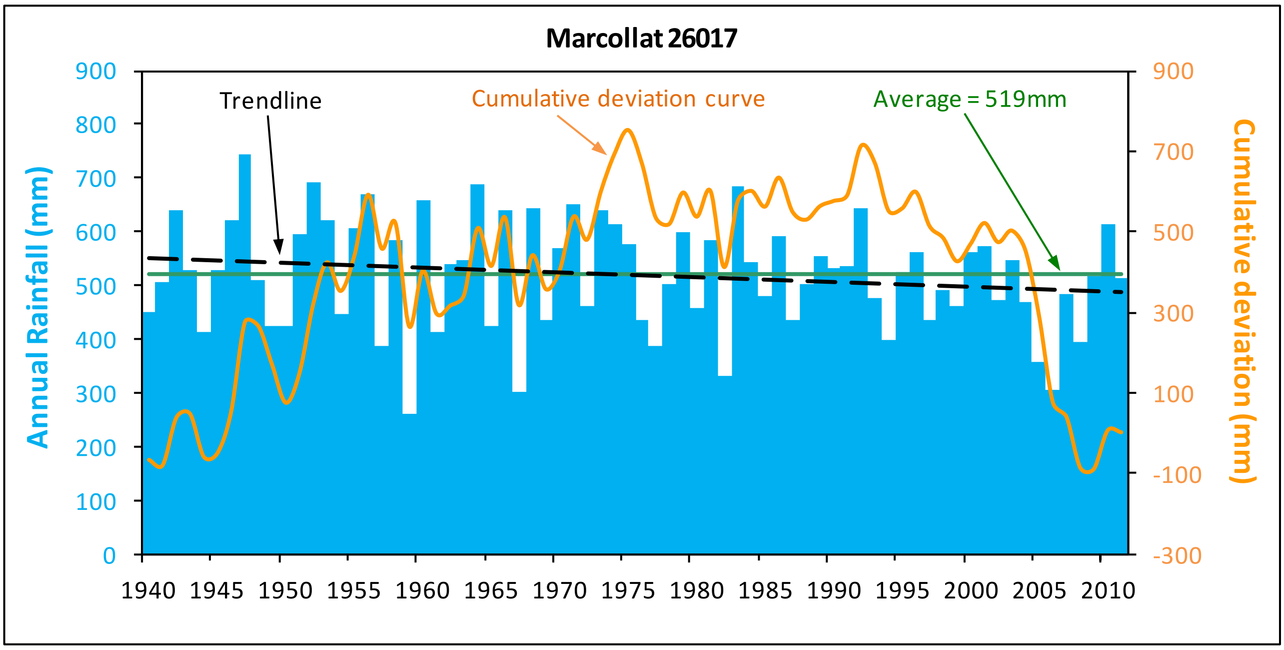

Figure 6. Annual rainfall and cumulative deviation from average annual rainfall for Marcollat

GROUNDWATER USE

Metered groundwater extractions for licensed purposes (excluding stock and domestic use) in the Padthaway PWA totalled 22 025 ML in the 2010–11 water-use year (Fig. 7). This extraction is sourced entirely from the unconfined aquifer and represents a 31% decrease from the previous water-use year and is the lowest recorded extraction for the PWA in recent time.

Prior to the adoption of the latest Water Allocation Plan (April 2009), total allocations were estimated at 86 709 ML/y based on the conversion from the area-based Irrigation Equivalent licensing system to a volumetric basis of allocation. Using the output from a numerical underground water flow and salt transport model, developed specifically for the Padthaway PWA for the Department for Water, it was determined that 48 000 ML/y should be the Acceptable Level of Extraction. In response to the model findings, the current Water Allocation Plan sets out principles to ensure that volumetric allocations are reduced to the Acceptable Level of Extraction (Extraction Limit) during the life of the plan by issuing allocations to a total of 55 096 ML/y at the date of adoption, followed by a further reduction to the Acceptable Level of Extraction in the fifth operational year of the plan.

The 2007–08 water-use year was the first that used meters to determine extraction volumes. Prior to this, estimates were made based on the area irrigated and the theoretical crop irrigation requirement. Consequently, the observed significant increase in use in 2007–08 may not only be due to below-average rainfall, but could also be due to a more accurate measurement of the extraction.

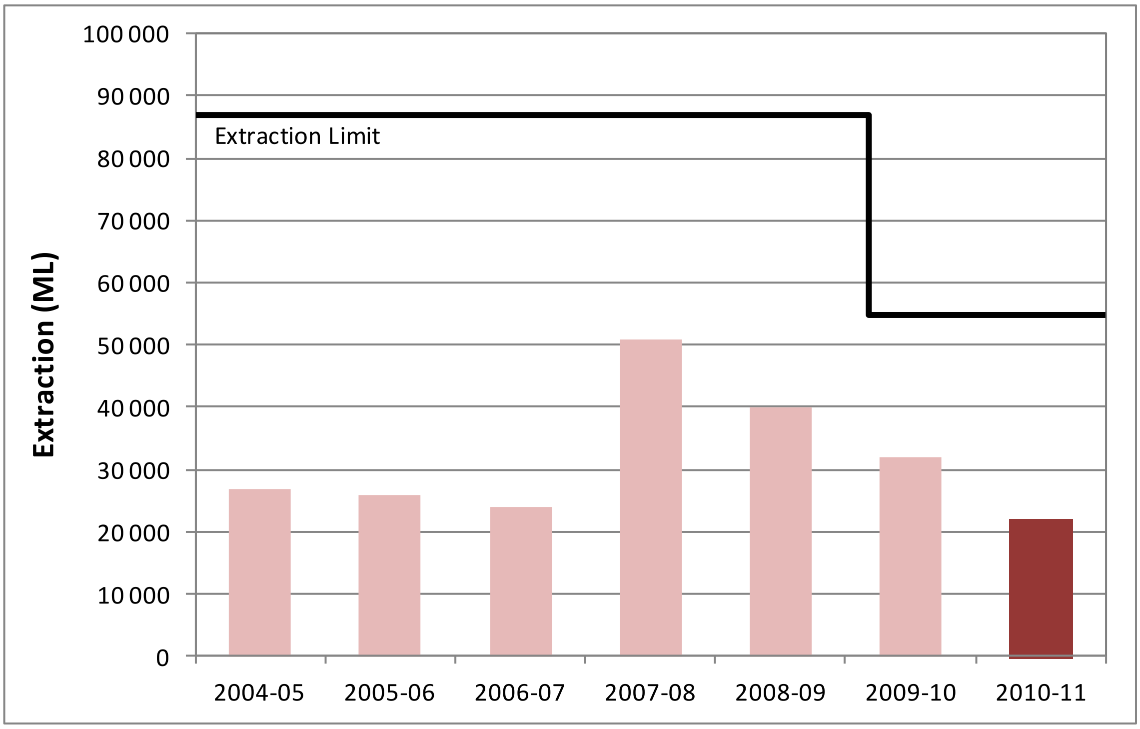

Figure 7. Historical licensed groundwater use for the Padthaway PWA

Table 2 below shows the various categories of licensed groundwater use in the Padthaway PWA for 2010–11 shaded in yellow, which can be compared to previous years. Irrigation is dominant with 99.86% of groundwater use.

Table 2. Description of licensed groundwater use for the Padthaway PWA

WATER USE	2010–11 (ML)	% of use	2009–10 (ML)	% of use	2008–09 (ML)	% of use	2007–08 (ML)	% of use
Irrigation	21 988	99.83	31 750	99.65	39 923	99.78	50 918	99.81
Industrial	21	0.09	83	0.26	57	0.14	68	0.13
Recreation	9	0.04	15	0.05	20	0.05	16	0.03
Aquaculture	0	0	0	0	0	0	0	0
Town Water Supply	7	0.04	11	0.04	10	0.02	11	0.02
Total use (ML)	**22 025**	**100**	**31 859**	**100**	**40 010**	**100**	**51 013**	**100**

Figure 8 shows the proportion of water applied to the various irrigated crops in 2008–09, expressed as a percentage of the total volume extracted. This data set was used because the information is not available for 2010–11. Pasture was the dominant irrigated crop type in the Padthaway PWA in 2008–09 accounting for 32% of the total licensed volume of water extracted and applied for the purpose of irrigation. Lucerne used 31%, with vines using 21%. Drip irrigation accounted for 47% of the total area irrigated, followed by flood irrigation with 40% and centre pivot irrigation with 11% of the total area. It should be noted that not all crop types irrigated by licensees are recorded; consequently these figures should be used as a guide only.

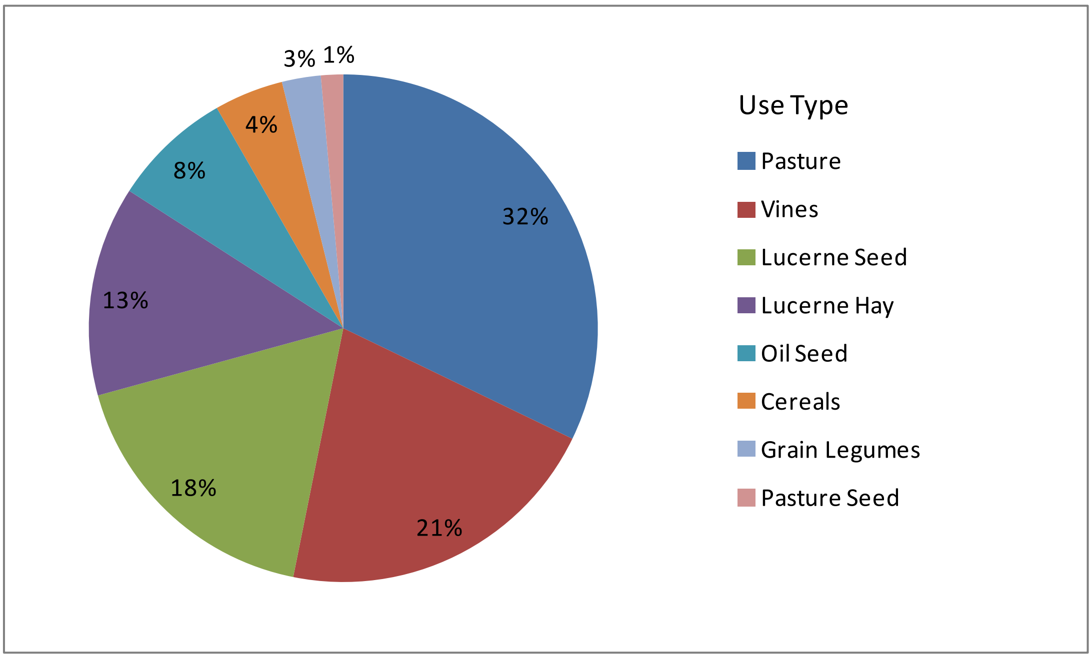

Figure 8. Groundwater proportions used per type of crop for the Padthaway PWA in 2008–09

WATER LEVEL NETWORK

The water level observation network for the unconfined aquifer in the Padthaway PWA is shown in Figure 9. Groundwater level monitoring began in 1970 when concerns were first expressed about falling watertables in the area. There are currently 48 wells monitoring water levels in the unconfined aquifer.

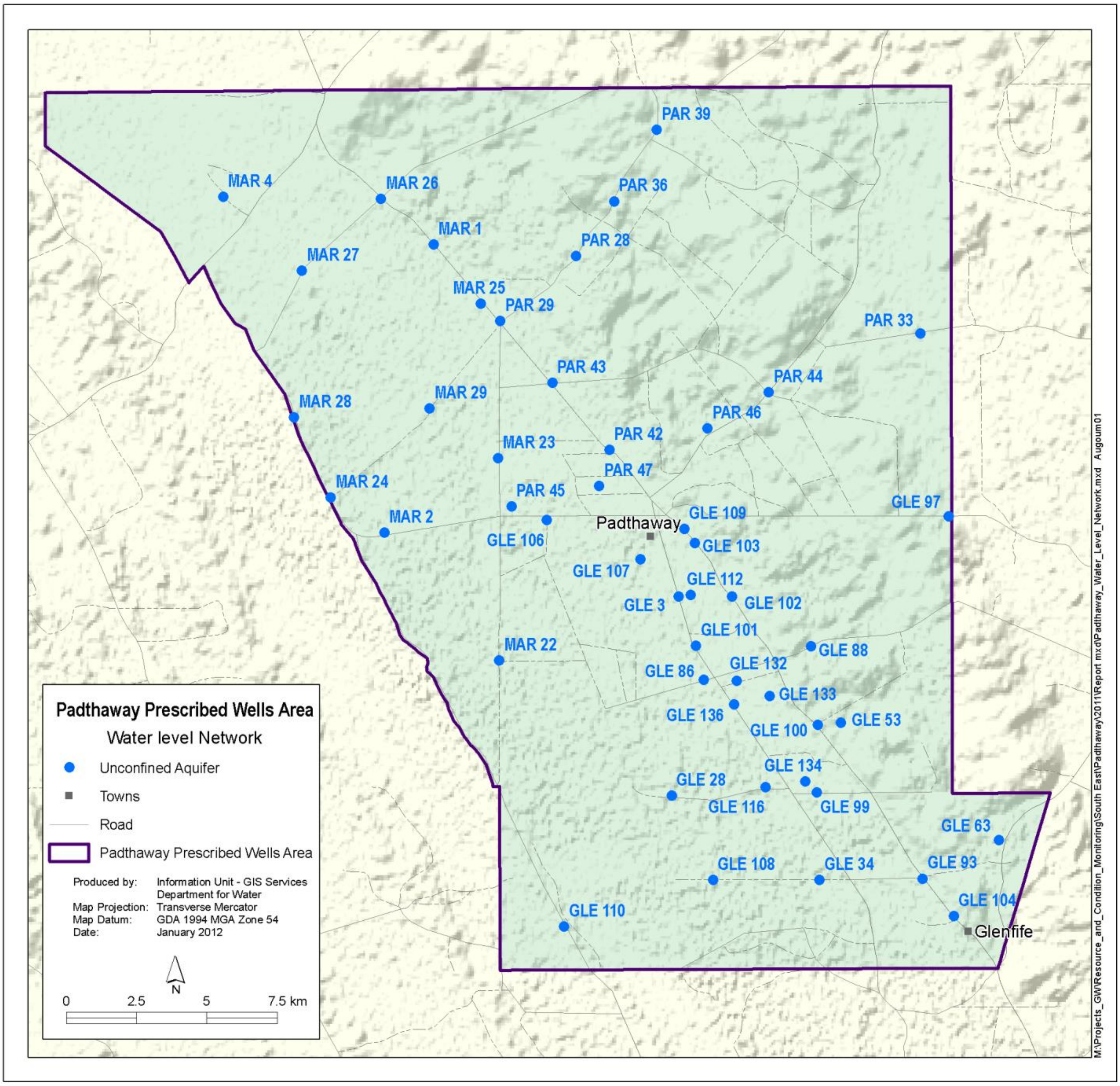

Figure 9. Location of water level observation wells for the Padthaway PWA

SALINITY NETWORK

The groundwater salinity observation network for the unconfined aquifer in the Padthaway PWA is shown in Figure 10. Regular salinity monitoring commenced in 1978 and there are currently 32 salinity observation wells for the unconfined aquifer and none for the confined aquifer. Salinity is also monitored on an as needs basis in 61 irrigation wells, 30 of which have been monitored at least once since January 2010 (not pictured).

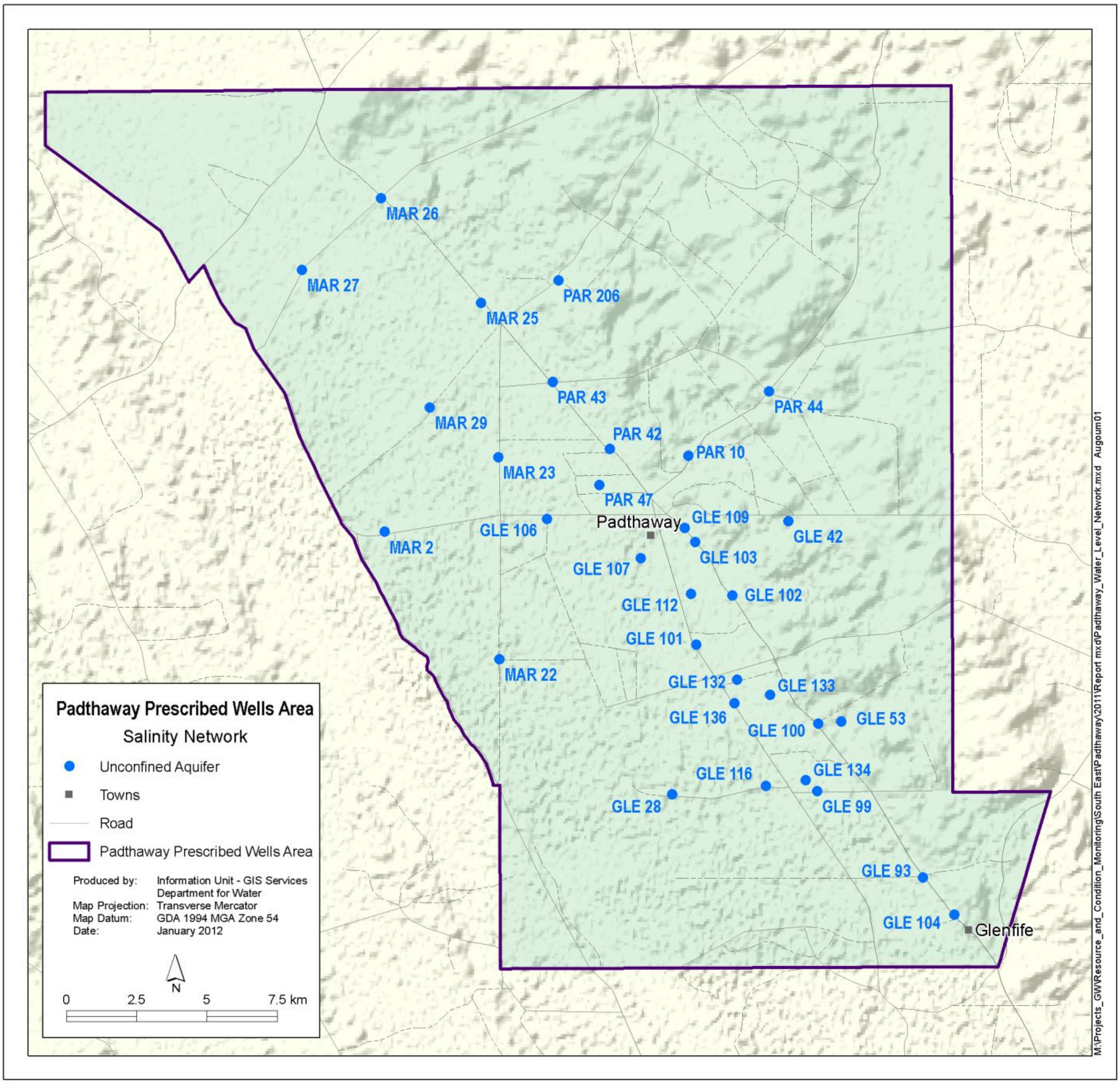

Figure 10. Location of salinity observation wells for the Padthaway PWA

PADTHAWAY FLAT

The shallow depth to the watertable of up to 5 m in the unconfined aquifer on the low-lying Padthaway Flat results in the groundwater level trends being very responsive to rainfall. Figure 11 depicts the long-term trends from representative observation wells which show a very close correlation with the cumulative deviation from average annual rainfall graphed in orange. Significantly below-average rainfall since 2004 resulted in very little recharge and a decline in groundwater levels of up to 1.5 m. The above-average rainfall during 2009 and 2010 has stabilised the declining trend and resulted in a recovery of water levels in some areas. The reported decline in water use for the 2009–10 water-use year may also have contributed to recent recovery to some degree. However, recent slightly below-average rainfall has correlated with in a slight decline in groundwater water levels since March 2011 despite significantly lower extraction volumes than in previous years.

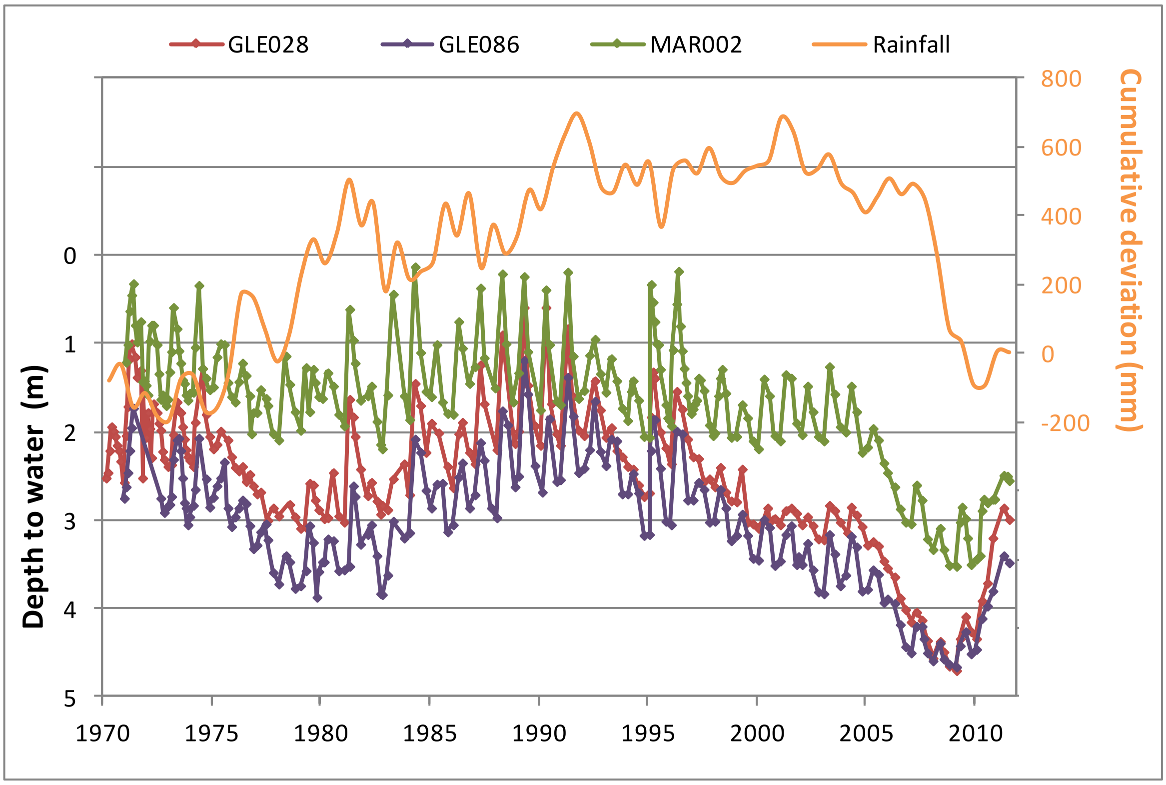

Figure 11. Groundwater level trends for the Padthaway Flat in the Padthaway PWA

PADTHAWAY RANGES

In the unconfined aquifer beneath the Ranges, where the depth to the watertable is more than 10 m, groundwater level trends are responding to very different processes to those found on the Flat. The widespread clearance of native vegetation has resulted in increased recharge rates and hence rising groundwater levels across the Highlands zone. Figure 12 presents the gradual rising trend averaging 0.05 m/y for several representative observation wells. This rising trend persisted for several years after the prolonged period of average to below-average rainfall commenced in the mid 1990s, as shown by the cumulative deviation from mean monthly rainfall graphed in orange.

Most observation wells now show stable or slightly declining trends in a delayed response to the below average rainfall, with the lag time varying depending on the depth to the watertable and the permeability of the sediments.

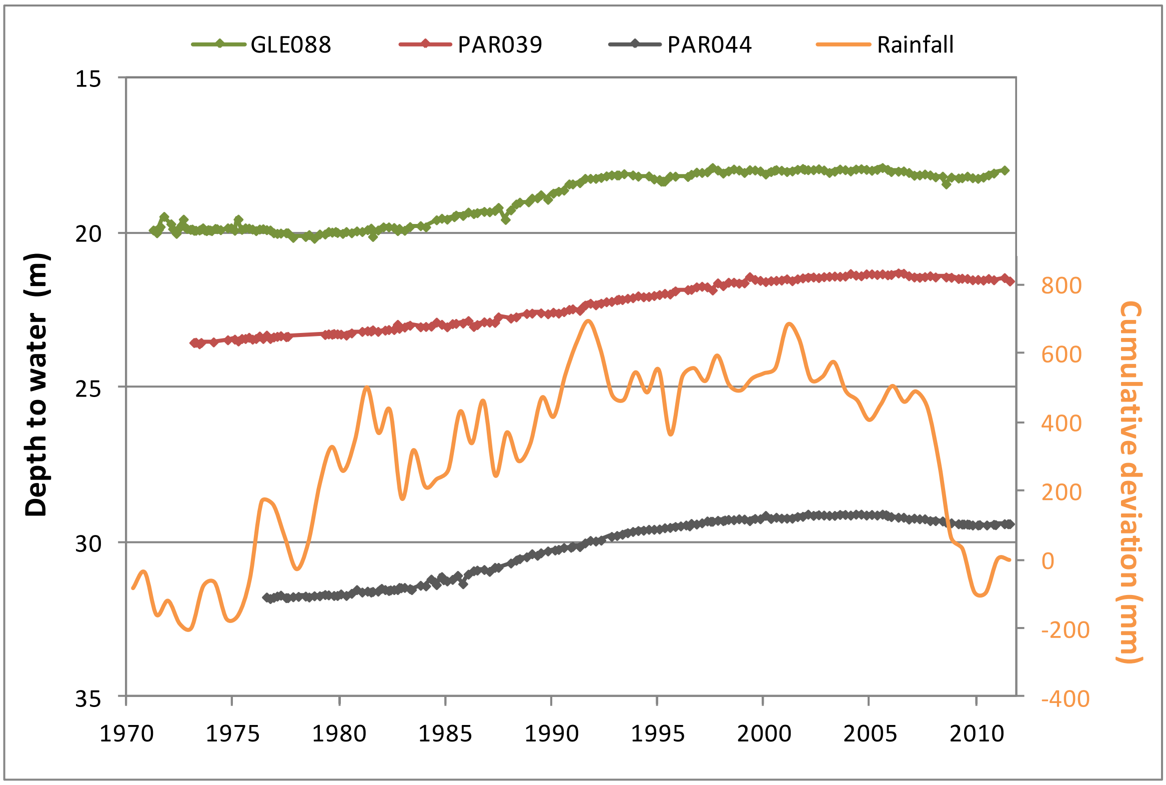

Figure 12. Groundwater level trends for the Padthaway Ranges in the Padthaway PWA

GROUNDWATER SALINITY TRENDS

PADTHAWAY FLAT

Groundwater salinity trends in the shallow unconfined aquifer are quite variable (Fig. 13) and are influenced by rainfall patterns and the efficiency of various irrigation practices. Although there is a general rising salinity trend due to the recycling of irrigation drainage water in the shallow aquifer, there are some variations in the trend:

- Rising trend since 1993 – Wells GLE086, MAR023 and PAR043 all show a consistent rising trend of 14–32 mg/L/y which corresponds to an extended period of below-average rainfall. The dry period may have resulted in increased extraction and more irrigation drainage which has flushed salt into the aquifer. These wells are located close to areas of flood irrigation.
- Well GLE101 displays a salinity trend which mirrors the rainfall cumulative deviation trends plotted in orange. This response suggests that rainfall recharge is the main process that flushes salt into the aquifer rather than irrigation drainage. This trend would be expected in areas of efficient drip irrigation where high salt accumulations have been found in the unsaturated zone.
- Well PAR042 recorded a rising trend of 16 mg/L/y until 1996 when the trend stabilised. It appears to be correlated to the rainfall trend from 2009.

Some wells on the eastern margin of the irrigated areas on the Flat may show stable or decreasing trends in the future, due to the inflow of groundwater from beneath the Ranges to the east. As mentioned previously, groundwater salinities in some areas of the Ranges are reducing as low salinity recharge enters the aquifer following flushing of the unsaturated zone salt.

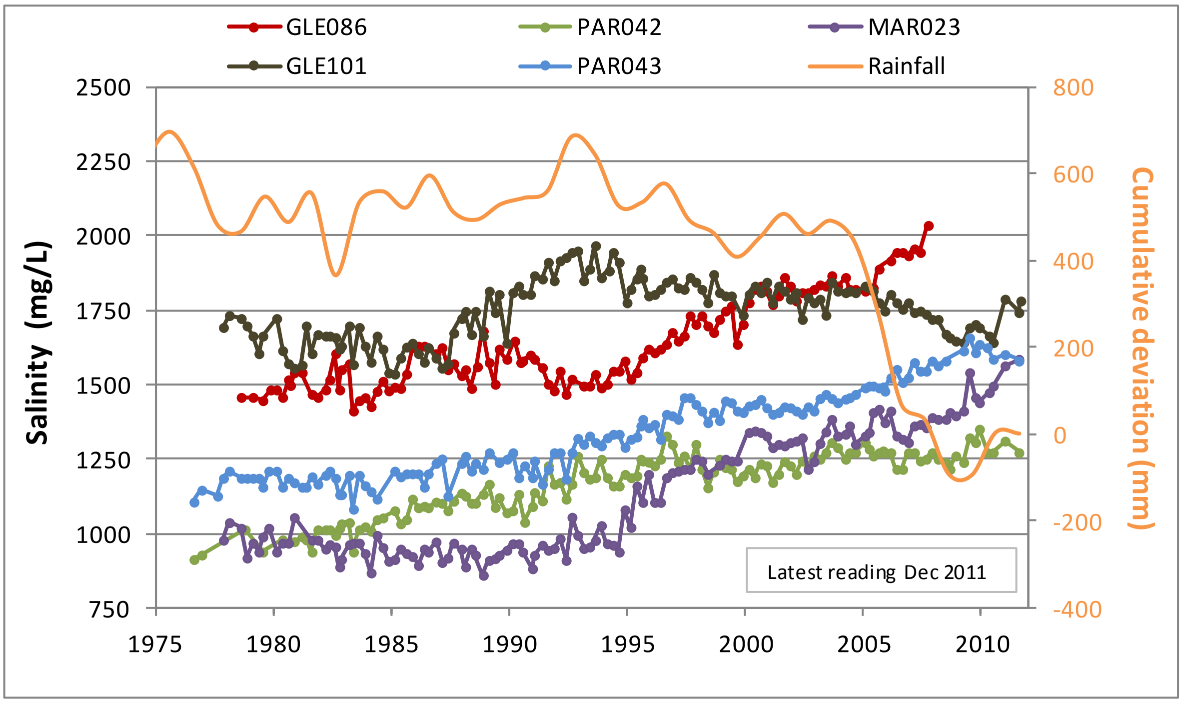

Figure 13. Groundwater salinity trends for the Padthaway Flats in the Padthaway PWA

PADTHAWAY RANGES

In the Padthaway Ranges, the widespread clearance of native vegetation has resulted in increased recharge rates and the flushing of salt, which was previously stored in the root zone of the native vegetation, down to the watertable. This process is occurring independent of any irrigation activity, although drainage from irrigated areas will accelerate the process locally.

Figure 14 shows the rising salinity trend in a number of observation wells that varies between 5 and 18 mg/L/y. Several wells are displaying a continuing rising trend, however wells PAR036 and PAR206 have both recorded a decreasing trend over the last 10 years, which indicates that in areas of permeable soils, the unsaturated-zone salt has almost been completely flushed and lower-salinity water is now recharging the aquifer. This freshening of the groundwater following a salinity increase is also recorded in the Tatiara PWA to the north and the Naracoorte Ranges to the south-east.

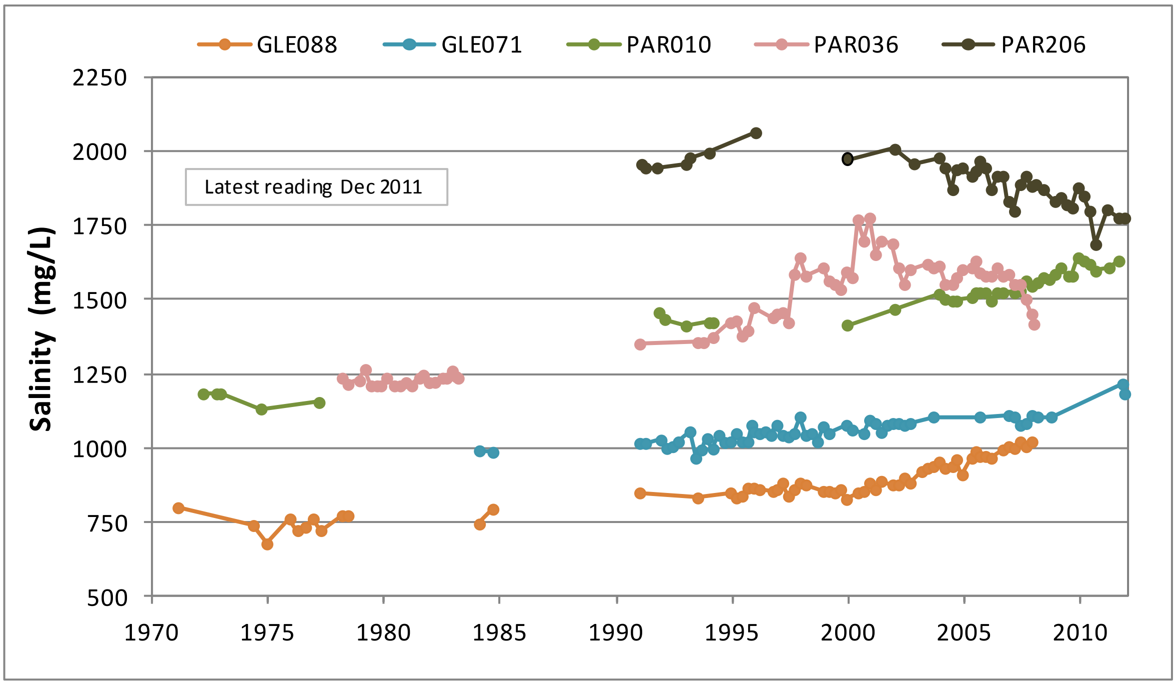

Figure 14. Groundwater salinity trends for the Padthaway Ranges in the Padthaway PWA

The salinity processes in both the Padthaway Flat and Padthaway Ranges have been the subject of intensive investigation in recent years. For further information, please see:

http://www.waterconnect.sa.gov.au/BusinessUnits/InformationUnit/Technical%20Publications/ki_report_2005_35.pdf