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# TATIARA

# PWA

## GROUNDWATER LEVEL AND SALINITY STATUS REPORT

2011

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DEPARTMENT FOR  
WATER



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## SUMMARY 2011

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The Tatiara Prescribed Wells Area (PWA) is located in the Upper South East of South Australia, approximately 200 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 (WAP) provides for sustainable management of the water resources.

Metered groundwater extractions for licensed purposes (excluding stock and domestic use) in the Tatiara PWA totalled 59 303 ML in the 2010–11 water-use year which represents a 34% decrease from the previous water-use year. The majority of this extraction was sourced from the unconfined aquifer, with extraction from the confined aquifer accounting for 109 ML.

Previous studies indicate that lucerne (hay and seed) is the dominant irrigated crop type in the Tatiara PWA, accounting for 76% of the total licensed volume of water extracted for the purpose of irrigation. Flood irrigation accounts for 70% of the total area irrigated (mainly on the Coastal Plain where groundwater salinities are higher), followed by centre pivot irrigation at 26% of the total area.

On the low-lying Coastal Plain, groundwater levels in the unconfined aquifer show a steady and consistent declining trend of 0.2 m/y, which corresponds with the prolonged period of below-average rainfall since 1996 that is exacerbated by groundwater extraction. The above-average rainfall during 2009 to 2011 does not appear to have had any impact on the declining trend. Numerous irrigation wells are showing a persistent rising salinity trend, ranging between 60 and 170 mg/L/y, due to the recycling of irrigation drainage water in the shallow aquifer. Some wells on the eastern margin of the irrigated areas on the Coastal Plain are now showing stable or decreasing trends due to the inflow of lower-salinity groundwater from the Highlands to the east.

Beneath the Highland area, the widespread clearance of native vegetation has resulted in increased recharge rates and hence rising groundwater levels in the unconfined aquifer. 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 58 mg/L/y. In areas of low elevation and permeable soils near the Coastal Plain, the salt has almost been completely flushed and lower-salinity water is now recharging the aquifer, resulting in falling salinity levels. However, in the eastern part of the PWA, where the depth to the watertable is over 30 m, the impacts of clearing have yet to reach the watertable and no salinity rises have been observed.

The groundwater level trends of the confined aquifer are very similar to those observed in the overlying unconfined aquifer in both the Coastal Plain and Highland zones. There is little extraction from the confined aquifer on the Coastal Plain and no direct recharge from rainfall and as a result, the identical trends are thought to be caused by the process of hydrostatic loading. It should be noted that investigations are underway elsewhere in the South East to examine leakage between the aquifers. Salinity trends in the confined aquifer throughout the Tatiara PWA are stable.

## ASSESSMENT OF STATUS

The Tatiara 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:

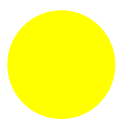
- long-term decline in groundwater levels in the unconfined aquifer on the Coastal Plain in response to below-average rainfall and more intense extraction
- long-term rise in groundwater salinity levels in the unconfined aquifer caused by the recycling of irrigation drainage water (Coastal Plain) and clearance of vegetation (Highlands).





Although the watertable decline in the Coastal Plain unconfined aquifer represents less than a 10% reduction of groundwater volumes stored in the aquifer over the last 10 years and will not compromise access to the resource by users in the short term, the lower groundwater level may result in the development of a cone of depression in areas of heavy extraction. This could result in flow reversal, bringing more saline groundwater into the area from the west and a cessation of throughflow that would normally transport salt from beneath irrigated areas.

The rise in salinity levels in the Coastal Plain unconfined aquifer is a cause for concern, however, as the dominant crop type (lucerne) is quite salt tolerant, the observed salinity rises are not expected to significantly affect production in the medium term.

The rise in salinity levels beneath the Highlands due to vegetation clearance may be showing signs of reaching its peak in some areas where a decline is being observed. In other areas where the watertable is deep (>30 m), the salinity rise has not yet commenced.

## STATUS 2011



<p> <u>No adverse trends, indicating a stable or improving situation</u> Trends are either stable (no significant change), or improving (i.e. decreasing salinity or rising water levels).</p> <p> <u>Adverse trends indicating low risk to the resource in the medium term</u> 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.</p> <p> <u>Adverse trends indicating high risk to the resource eventuating in the short to medium term</u> 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.</p> <p> <u>Degradation of the resource compromising present use within the short term</u> 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.</p>
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# BACKGROUND

The Tatiara Prescribed Wells Area (PWA) is located in the Upper South East of South Australia, approximately 200 km south-east of Adelaide (Fig. 1). It is a regional-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 water resources.

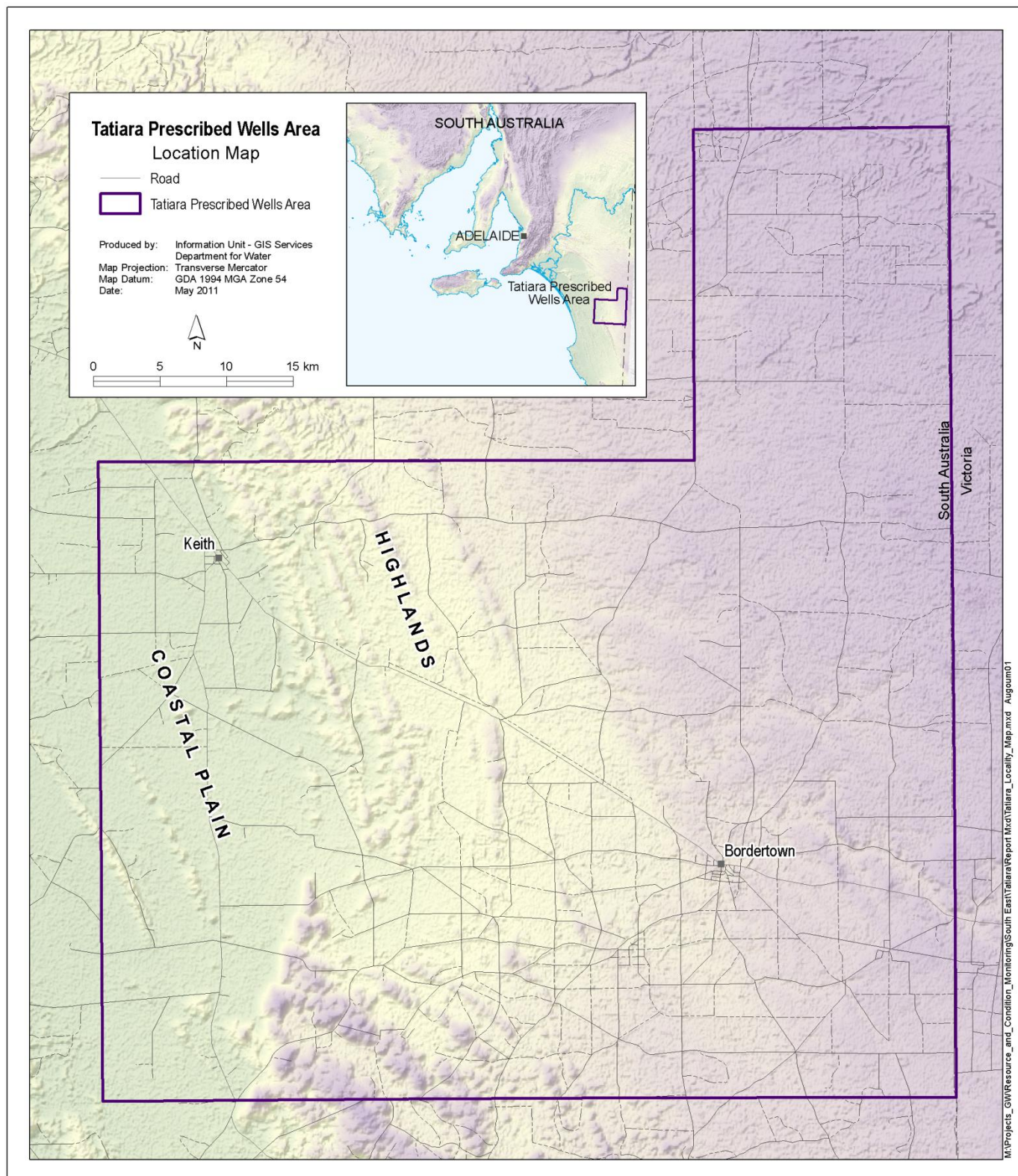


Figure 1. Location of the Tatiara PWA

## HYDROGEOLOGY

The Tatiara PWA is underlain by sediments of the Murray Basin and can be divided topographically into two discrete landforms, each with different hydrogeological characteristics and different groundwater management issues. A low-lying Coastal Plain lies to the west, with Highlands located to the east. Both regions are underlain by two aquifer systems—an unconfined limestone aquifer comprising various Quaternary limestone units and a deeper confined sand aquifer.

### UNCONFINED AQUIFER

#### *Coastal Plain*

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 plain where the depth to the watertable is generally less than 5 m.

Padthaway Formation is the uppermost geological unit in the Quaternary sequence that occurs largely in the inter-dunal flats and reaches a maximum known thickness of 20 m. It consists mainly 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 of 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.

#### *Highlands*

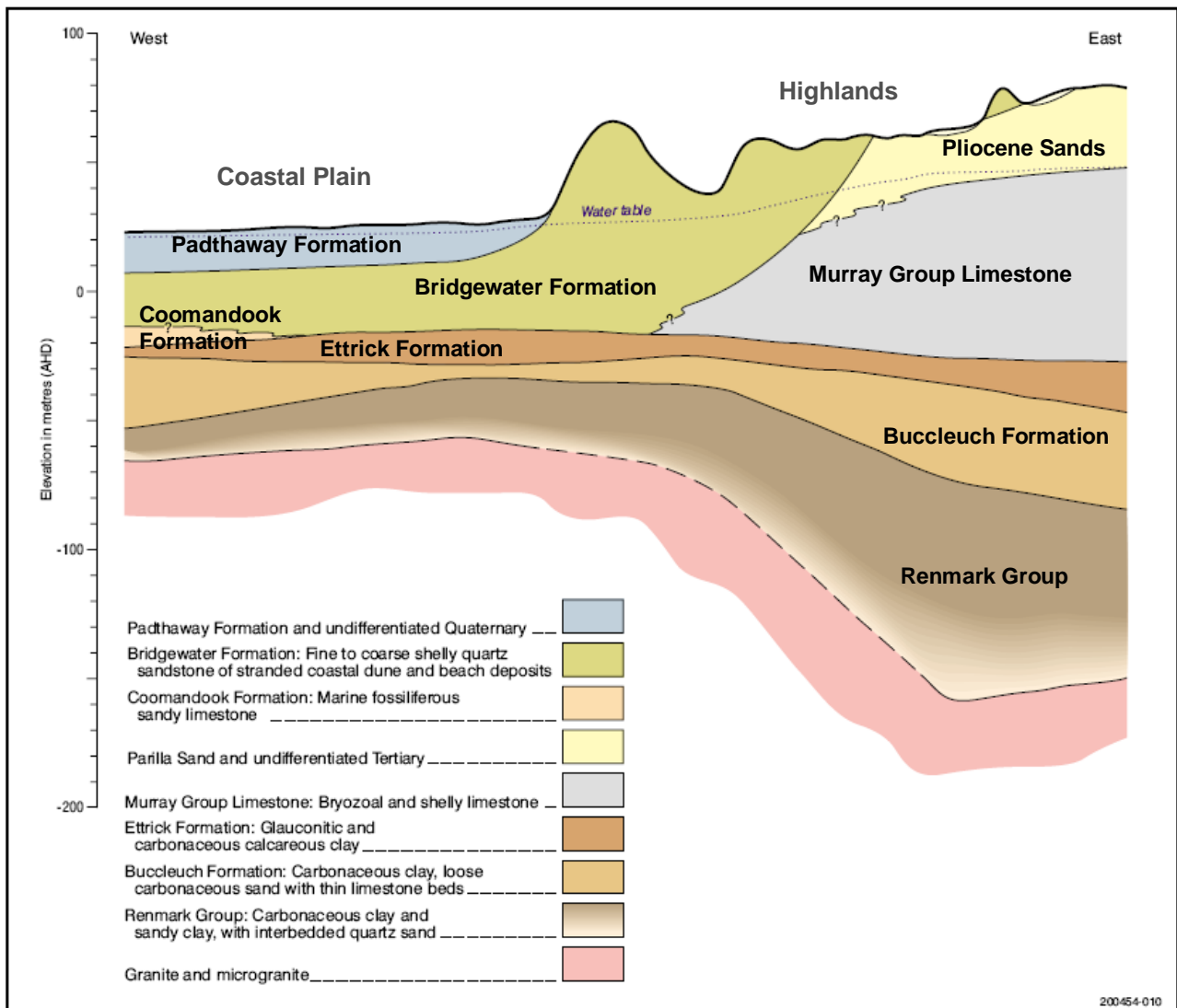
Beneath the Highlands, the unconfined aquifer is contained within the Tertiary Murray Group Limestone aquifer which comprises a bryozoal limestone that averages 100 m in thickness. Due to the elevated topography, the depth to the watertable in the Murray Group Limestone can exceed 40 m and typical well yields range between 50 and 200 L/s. Overlying the limestone aquifer is a considerable thickness of Pliocene Sands (Parilla Sands) that are dry.

### CONFINED AQUIFER

The unconfined and confined aquifers are separated by a low-permeability aquitard comprising the Ettrick Formation (grey-green glauconitic marl) and the black lignitic clays at the top of the confined aquifer. The combined thickness of the aquitard is generally about 20 m.

The main confined aquifer in this area is referred to as the Renmark Group, which consists of interbedded sands, silt and carbonaceous clay. It extends over the whole PWA and underlies the relatively thin Buccleuch Formation, which comprises brown carbonaceous clays and quartz sand with interbeds of limestone. The confined aquifer is not widely used due to the availability of much larger supplies in the overlying unconfined aquifer.

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



**Figure 2. Geological cross-section of the Tatiara PWA**

For a more detailed description of the hydrogeology of the Tatiara PWA, see: [http://www.waterconnect.sa.gov.au/BusinessUnits/InformationUnit/Technical%20Publications/sth\\_east\\_rb2000\\_036.pdf](http://www.waterconnect.sa.gov.au/BusinessUnits/InformationUnit/Technical%20Publications/sth_east_rb2000_036.pdf)

A summary of the hydrogeology is presented in Table 1.

**Table 1. Hydrogeology of the Tatiara PWA**

AGE	STRATIGRAPHY		HYDROGEOLOGY	
	Unit	Lithology	Unit	Description
<b>COASTAL PLAIN</b>				
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/sec enable flood irrigation. Depth to the watertable about 5 m. Salinity increases westward from 3000 mg/L to over 7000 mg/L.
	Bridgewater Formation	Shelly and sandy aeolianite deposited in a series of topographic ridges		
	Coomandook Formation	Interbedded sandy limestones and shelly sandstones		
Tertiary	Ettrick Formation	Grey-green glauconitic marl	Aquitard	Confining layer
	Buccleuch Formation	Interbedded sand and carbonaceous clay units with minor bryozoal limestone layer	Confined aquifer	Not widely used due to low yields
	Renmark Group	Carbonaceous sands and clays		
<b>HIGHLANDS</b>				
Tertiary	Pliocene Sands	Unfossiliferous, non marine, fine to medium-grained clayey quartz sand with thin beds of sandy clay		Unsaturated
	Murray Group Limestone	White bryozoal limestone	Unconfined aquifer	Mainly used for irrigation and stock supplies. Well yields range from 50 to 200 L/sec, with salinities generally less than 2000 mg/L. Depth to the watertable can exceed 40 m. Has lower permeability than Quaternary limestone on Coastal Plain.
	Ettrick Formation	Grey-green glauconitic marl	Aquitard	Confining layer
	Renmark Group	Carbonaceous sands and clays	Confined aquifer	Not widely used due to low yields



# GROUNDWATER FLOW AND SALINITY

## UNCONFINED AQUIFER

The watertable elevation contours for the unconfined aquifer in the Tatiara PWA, shown in Figure 3, indicate that groundwater movement is from east to west. The changes in the watertable gradient reflect changes in the permeability of the aquifer. The gradient becomes steeper near the boundary between the Highlands and the Coastal Plain, where the transition occurs from the Murray Group Limestone to the Quaternary sediments. The gradient flattens to the west of the PWA and reflects the higher permeability in the Padthaway and Bridgewater Formations beneath the Coastal Plain.

The salinity distribution for the unconfined aquifer in the Tatiara PWA in Figure 3 shows a significant variation from approximately 1000 mg/L in the east to more than 7000 mg/L in the west where the watertable is close to the ground surface.

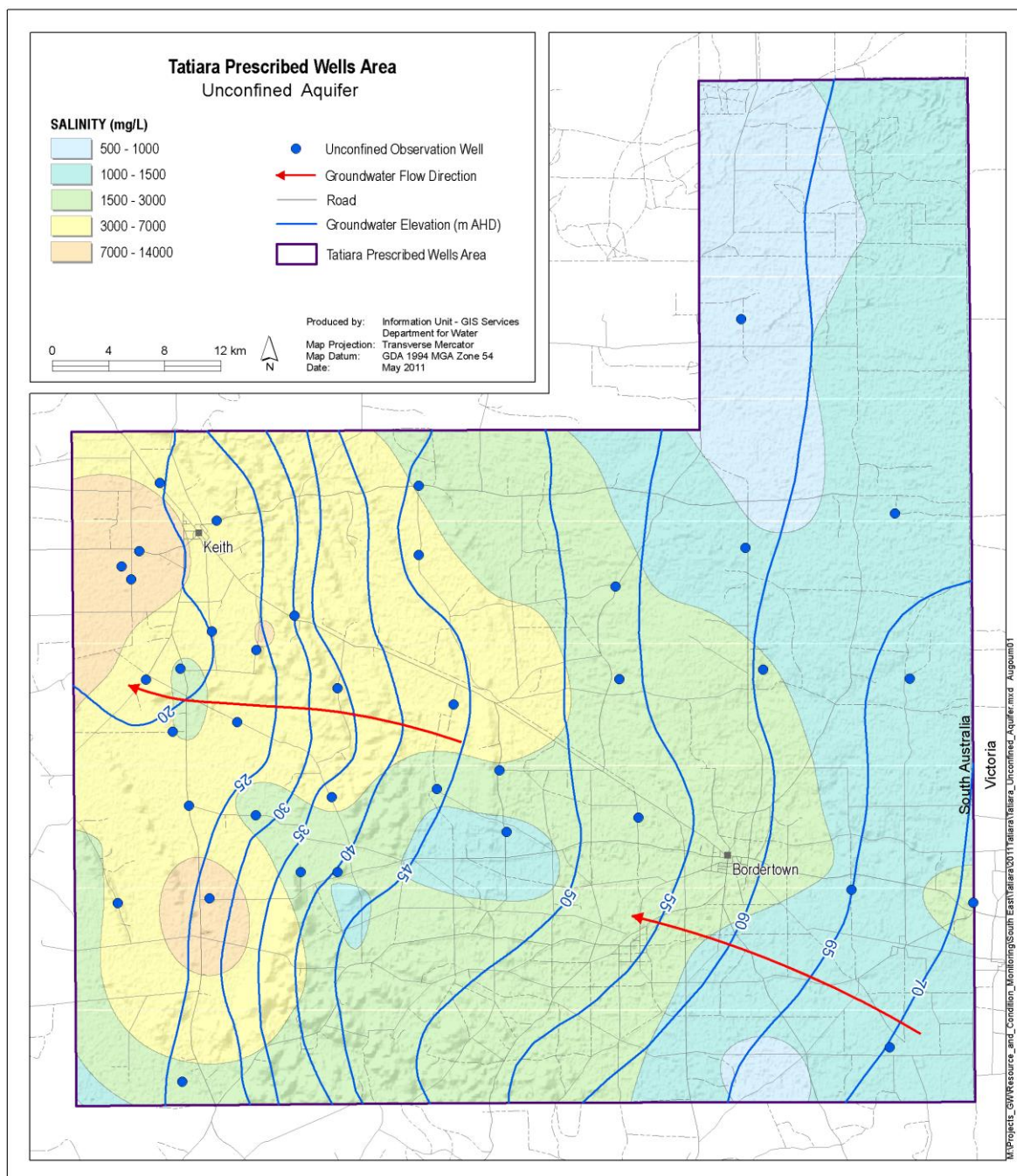


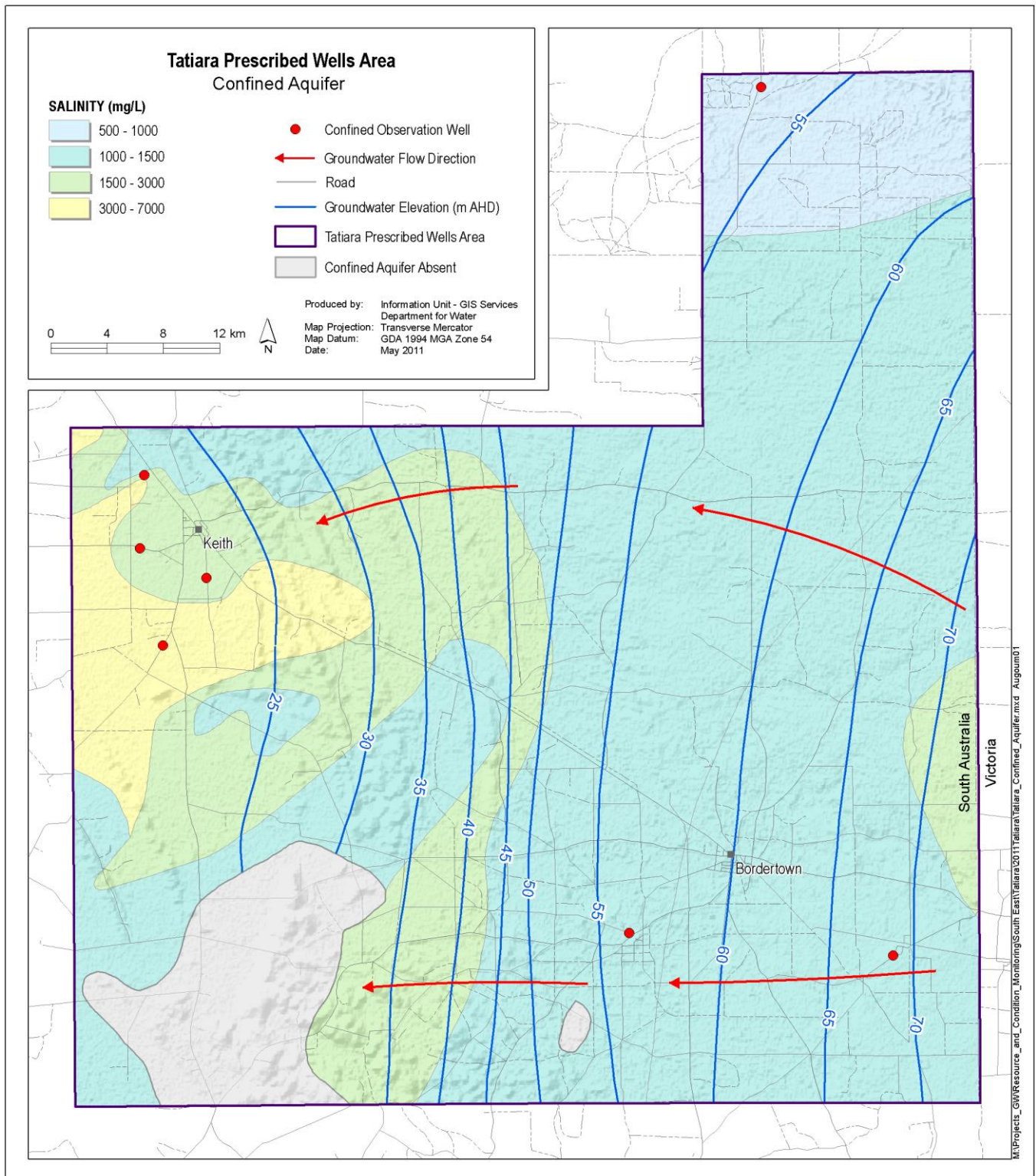
Figure 3. Groundwater flow and salinity distribution (winter 2010) for the unconfined aquifer in the Tatiara PWA\*

\*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

The water level elevation contours for the confined aquifer are shown on Figure 4 which show groundwater movement is from east to west, similar to the overlying unconfined aquifer.

The salinity distribution in the confined aquifer is similar to the overlying unconfined aquifer (Fig. 3). It increases from approximately 600 mg/L in the north-east to more than 3000 mg/L in the west.



**Figure 4. Groundwater flow and salinity distribution (winter 2010) for the confined aquifer in the Tatiara 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 status of the groundwater resource, it is important to note the presence and ecological characteristics of the GDEs found in the Tatiara 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, either permanently, seasonally or intermittently. It is generally considered that shallow watertables less than 5 m below the surface are more likely to support GDEs than deeper watertables. Shallow watertables are more susceptible to changes in groundwater levels which 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.

The main groundwater dependent ecosystem in the Tatiara PWA is phreatophytic vegetation. Throughout the PWA there are remnants of native vegetation usually associated with shallow groundwater, which can be dependent on the unconfined aquifer and episodic flooding. These associations are River Red Gum (*Eucalyptus camaldulensis*) and Swamp Gum (*Eucalyptus ovata*) woodland.

A recent survey found stygofauna present in the unconfined aquifer within the Tatiara PWA. The stygofauna is rather diverse with at least 6 new species identified. Considering the potential habitat created by a high number of karst features (runaway holes) in the aquifer, there is a high likelihood that numerous stygofauna species may be present.

# RAINFALL

The climate in the Tatiara PWA is dominated by hot, dry summers and cool, wet winters with the annual average rainfall for Keith rainfall station (25507) being 463 mm (Fig. 5). The annual rainfall recorded at Keith can be seen on Figure 6 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 three very broad trends indicated in Figure 6. A long period of below-average rainfall was experienced from 1910 to 1945 that was followed by generally above-average rainfall until 1993. A significant below-average trend was experienced after 1993 and particularly after the 2006 drought until 2008. Most recently, the rainfall trend has been above average.

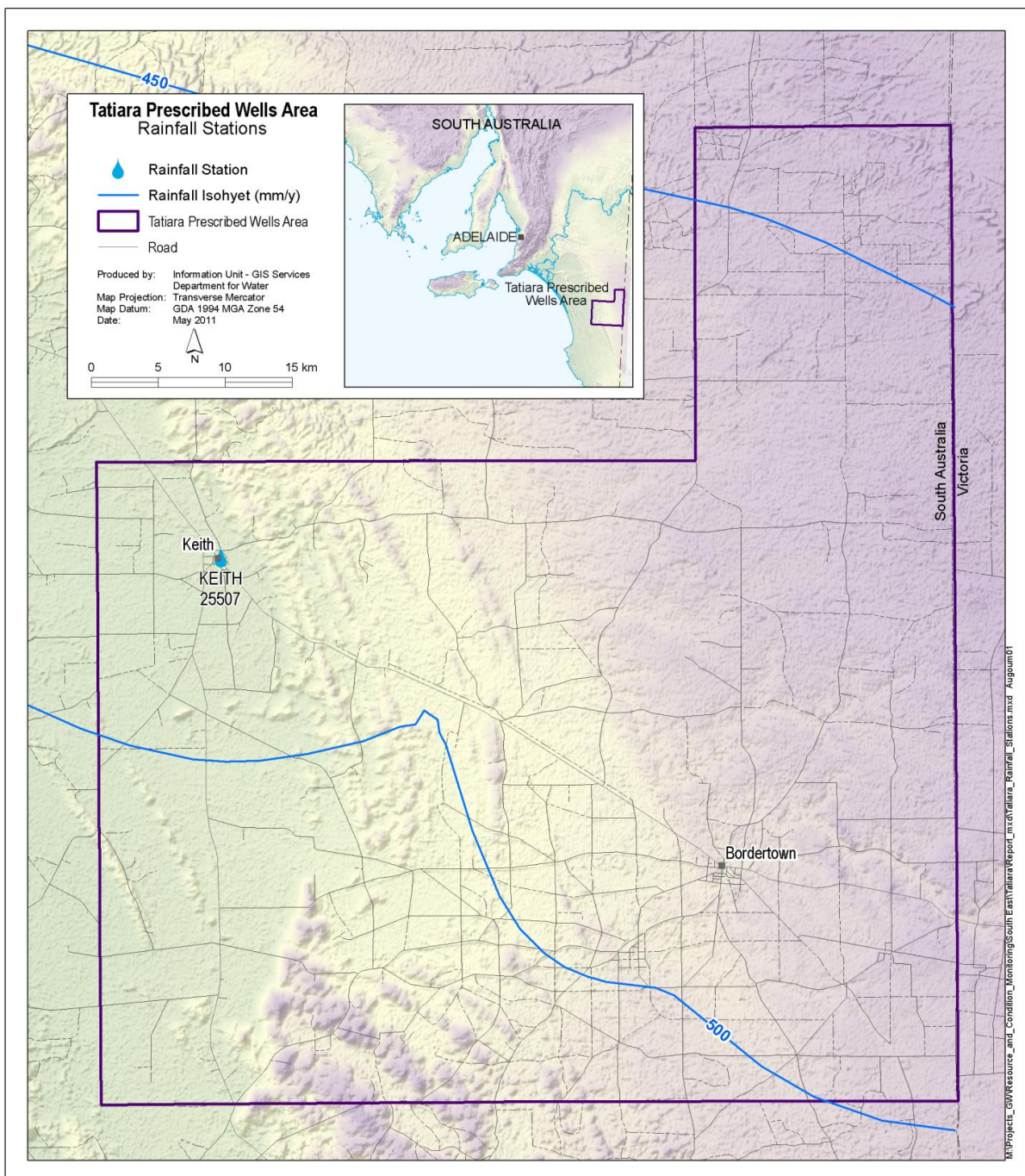


Figure 5. Location of rainfall station and rainfall isohyets in the Tatiara PWA

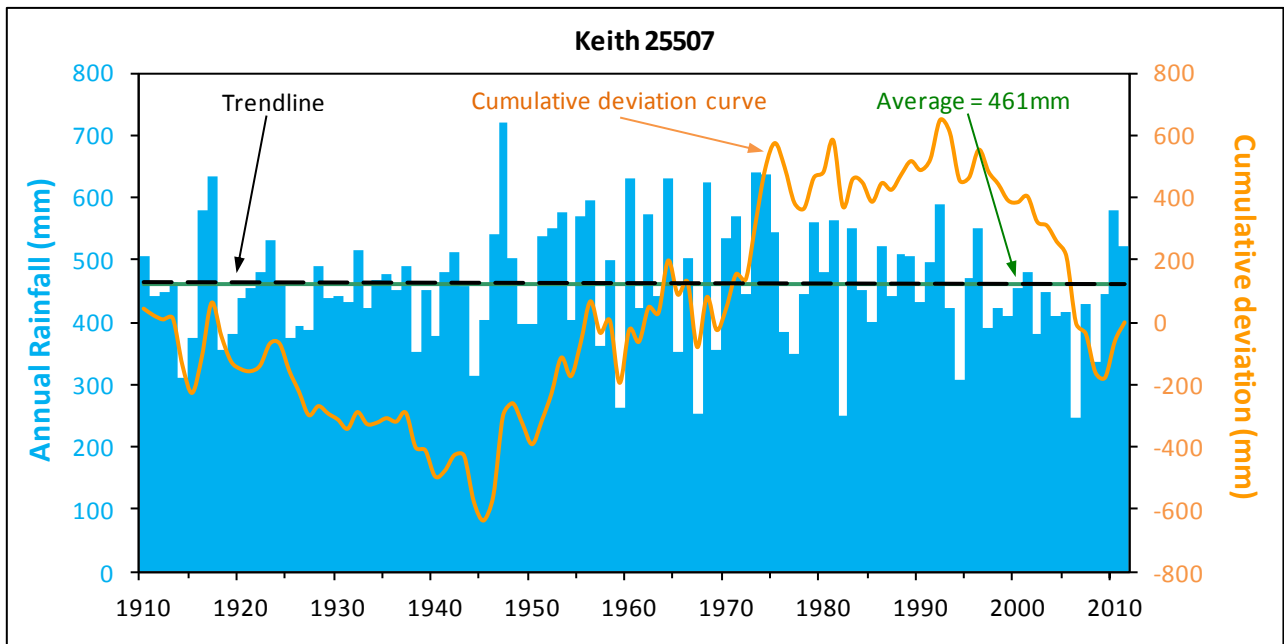


Figure 6. Annual rainfall and cumulative deviation for annual average rainfall for Keith

Shallow watertables on the low lying Coastal Plain in the west show a strong correlation with the timing and magnitude of rainfall events (Fig. 11).

## GROUNDWATER USE

Metered groundwater extractions for licensed purposes (excluding stock and domestic use) in the Tatiara PWA totalled 59 303 ML for the 2010–11 water-use year (Fig. 7), with the majority of extraction sourced from the unconfined aquifer, with only 109 ML extracted from the confined aquifer. This represents an approximately 34% decrease from the previous water-use year. The 2007–08 water-use year was the first to use meters to determine extraction volumes. Prior to this, estimates were based on the area irrigated and the theoretical crop irrigation water-use requirement. Consequently, the observed significant increase 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. The 2010 Tatiara Water Allocation Plan provides for a series of reductions to groundwater allocations to occur over the life of the plan. The first stages of the reductions commenced in July 2010. Licensed allocations for the 2010–11 water-use year for the unconfined and confined aquifers were 152 298 and 365 ML, respectively.

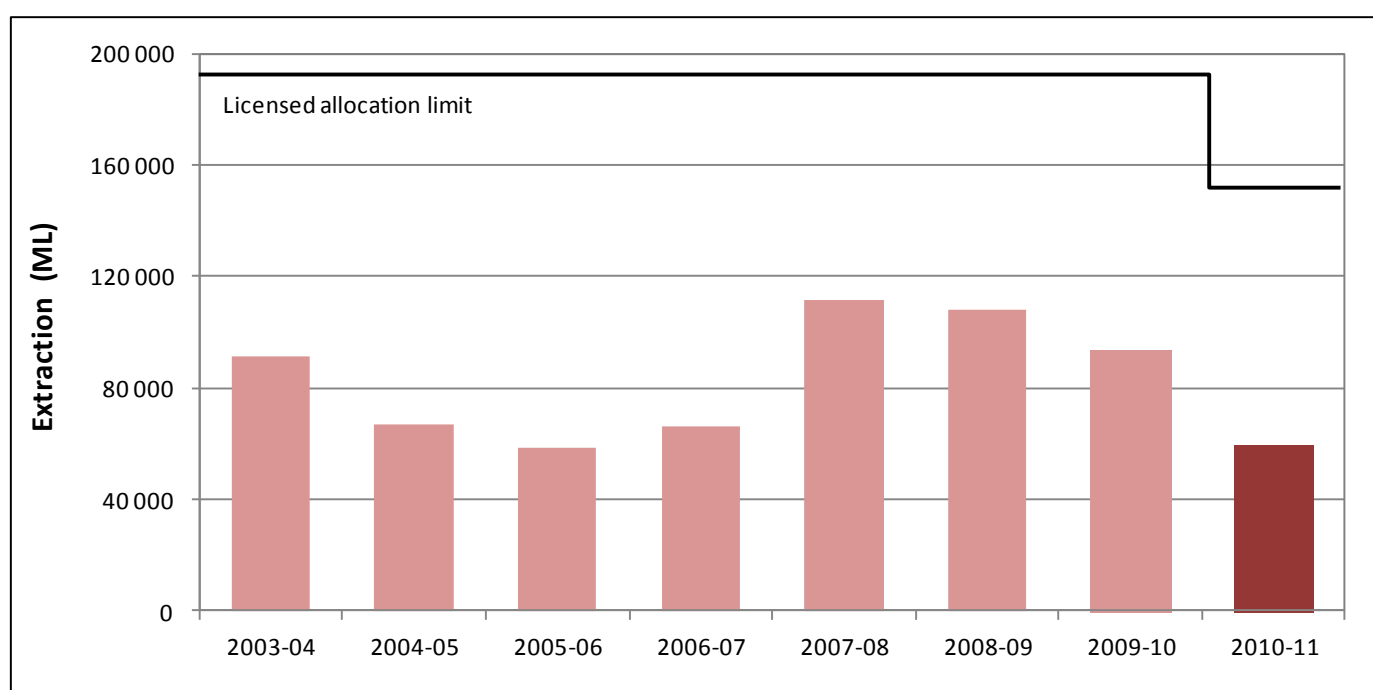


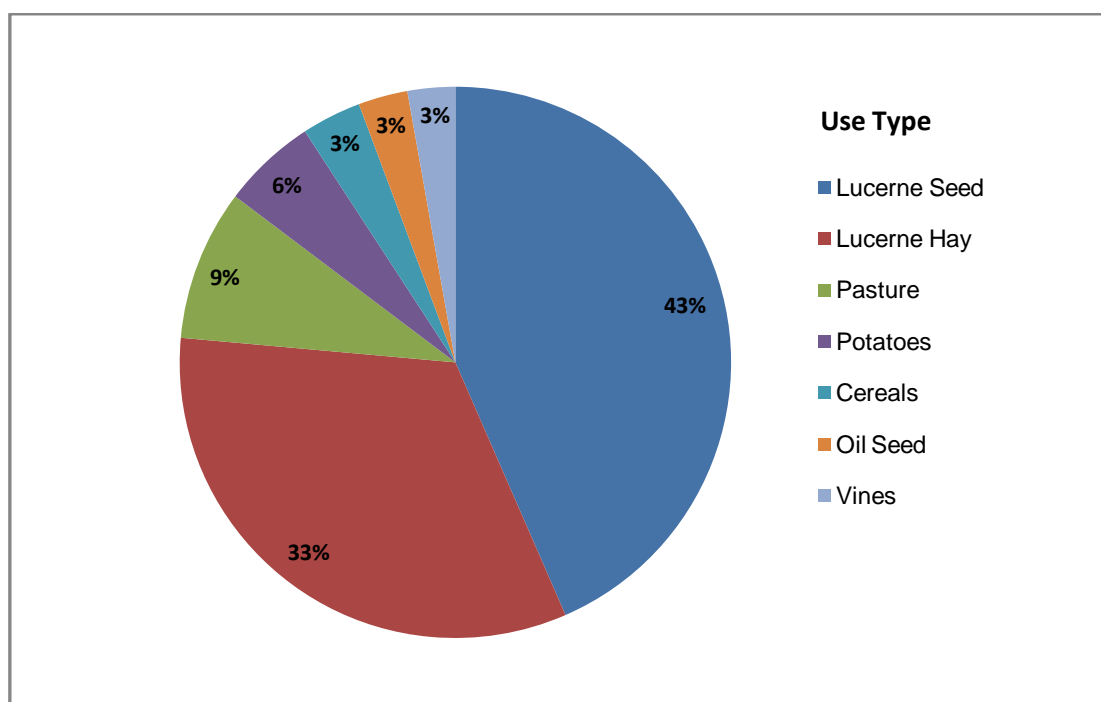
Figure 7. Historical licensed groundwater use for the Tatiara PWA

Table 2 below shows the various categories of licensed groundwater use in the Tatiara PWA for 2010–11 shaded in yellow, which can be compared to the previous years.

**Table 2. Description of licensed groundwater use for the Tatiara PWA**

WATER USE	2010–11 (ML)	% of use	2009–10 (ML)	% of use	2008–09 (ML)	% of use	2007–08 (ML)	% of use
Irrigation	58 286	98.3	92 915	98.6	106 187	98.5	108 514	97.1
Industrial	387	0.65	615	0.65	685	0.64	486	0.44
Recreation	338	0.57	318	0.3	478	0.44	463	0.41
Aquaculture	3	0.005	5	0.01	7	0.01	1829	1.64
Town Water Supply	290	0.5	377	0.4	420	0.39	417	0.37
<b>Total use (ML)</b>	<b>59 303</b>	<b>100</b>	<b>94 230</b>	<b>100</b>	<b>107 777</b>	<b>100</b>	<b>111 709</b>	<b>100</b>

Figure 8 shows the proportion of water applied to the various irrigated crops in 2008–09, expressed as a percentage of the total licensed volume. This data set was used because the information is not available for 2010–11. Lucerne (hay and seed) was the dominant irrigated crop type in the Tatiara PWA in 2008–09, accounting for over 76% of the total licensed volume of water extracted for the purpose of irrigation. Flood irrigation accounted for 70% of the total area irrigated (mainly on the Coastal Plain where groundwater salinities are higher), followed by centre pivot irrigation at 26% of the total area.



**Figure 8. Groundwater proportions use per type of crop for the Tatiara PWA in 2008–09**

# GROUNDWATER OBSERVATION NETWORKS

## WATER LEVEL NETWORK

The groundwater level observation network for both the unconfined and confined aquifers in the Tatiara PWA is shown in Figure 9. Monitoring of groundwater levels began in 1975 and there are currently 89 wells monitored in the unconfined aquifer and seven wells monitored in the confined aquifer. The main concentration of observation wells is located in areas of intensive irrigation in the western part of the PWA to monitor the potential impacts of extraction.

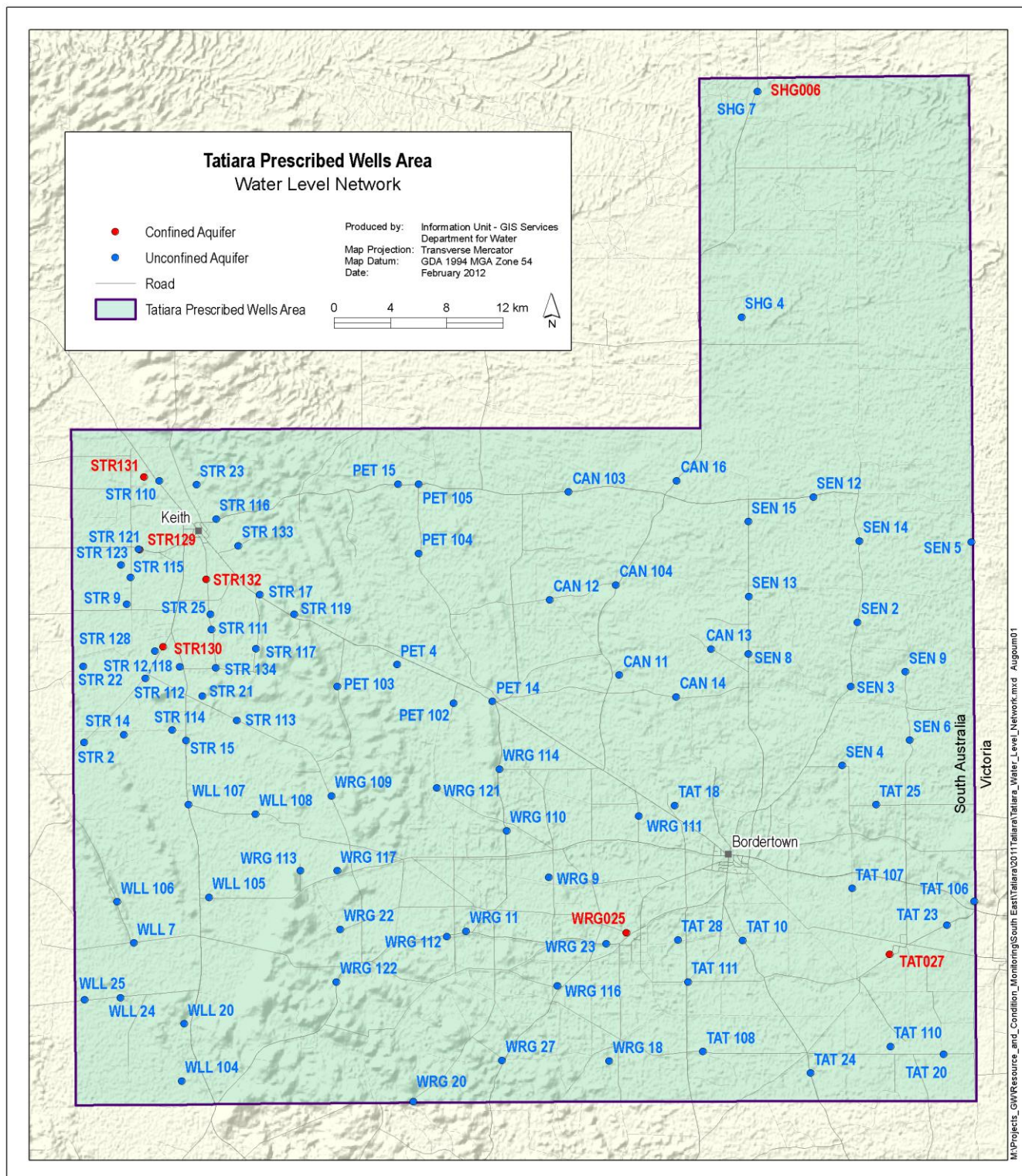


Figure 9. Location of water level observation wells in the Tatiara PWA



# SALINITY NETWORK

The groundwater salinity observation network in the Tatiara PWA is shown in Figure 10. There are 46 wells currently monitoring the unconfined aquifer and three monitoring the confined aquifer.

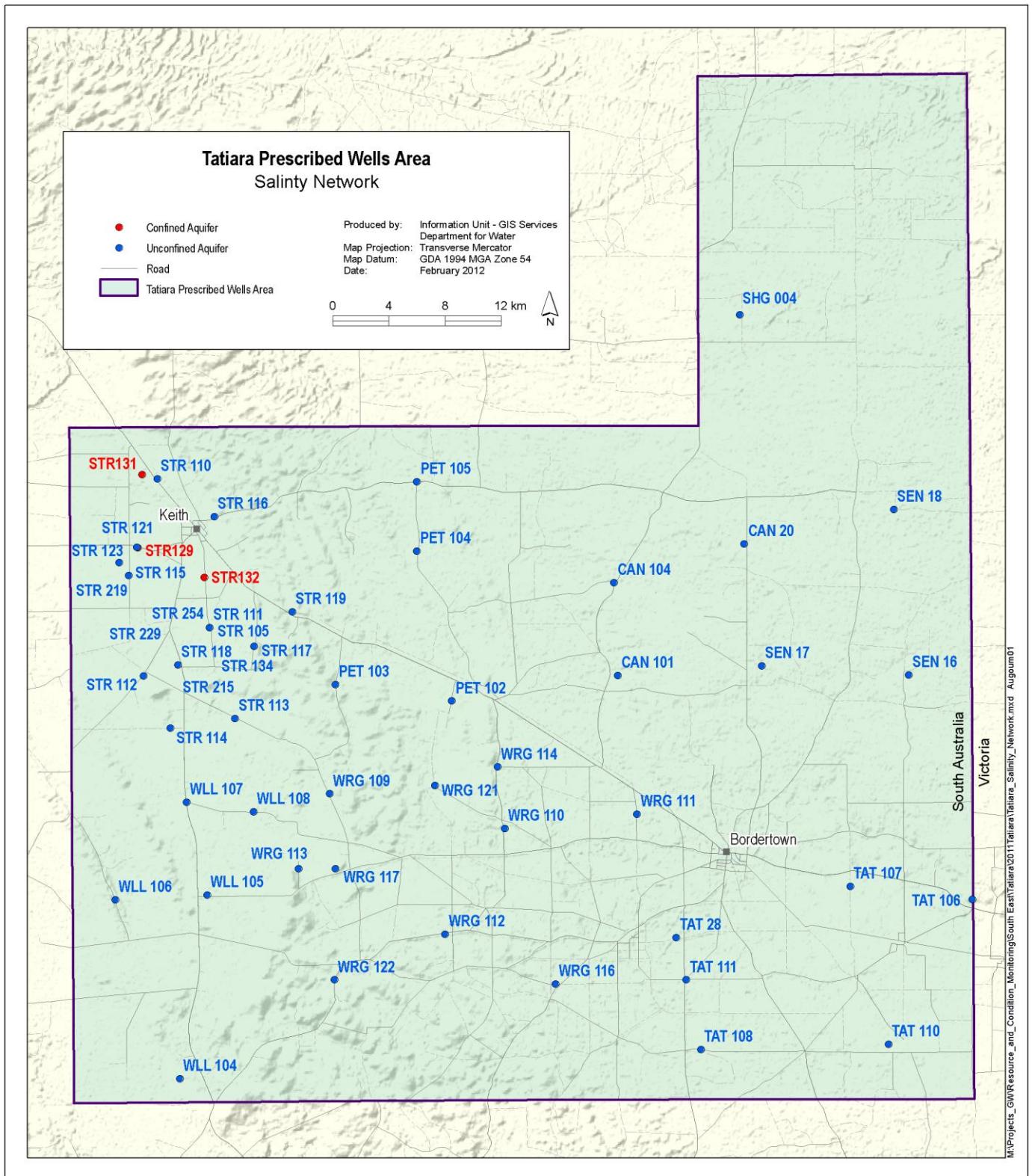


Figure 10. Location of salinity observation wells in the Tatiara PWA

# GROUNDWATER LEVEL TRENDS

## UNCONFINED AQUIFER

### COASTAL PLAIN

The shallow depth to the watertable of 5 to 10 m in the unconfined aquifer on the low-lying Coastal Plain results in the groundwater level trends being responsive to rainfall. Figure 11 depicts representative long-term trends from an area of intensive irrigation to the south of Keith. There is a steady and consistent declining trend in water levels of 0.2 m/y that corresponds with the prolonged period of below-average rainfall since 1996 (shown by the cumulative deviation from average annual rainfall graphed in orange). Observation well STR119 is located upgradient of irrigation activities and hence shows no direct abstraction impacts. However, wells STR017 and STR021 are affected by extraction, displaying seasonal drawdowns and a stabilisation in water levels during a period of above-average rainfall between 1985 and 1993 (which caused a rise in STR119).

The above-average rainfall during 2009 to 2011 appears to have resulted in a stabilisation of groundwater levels.

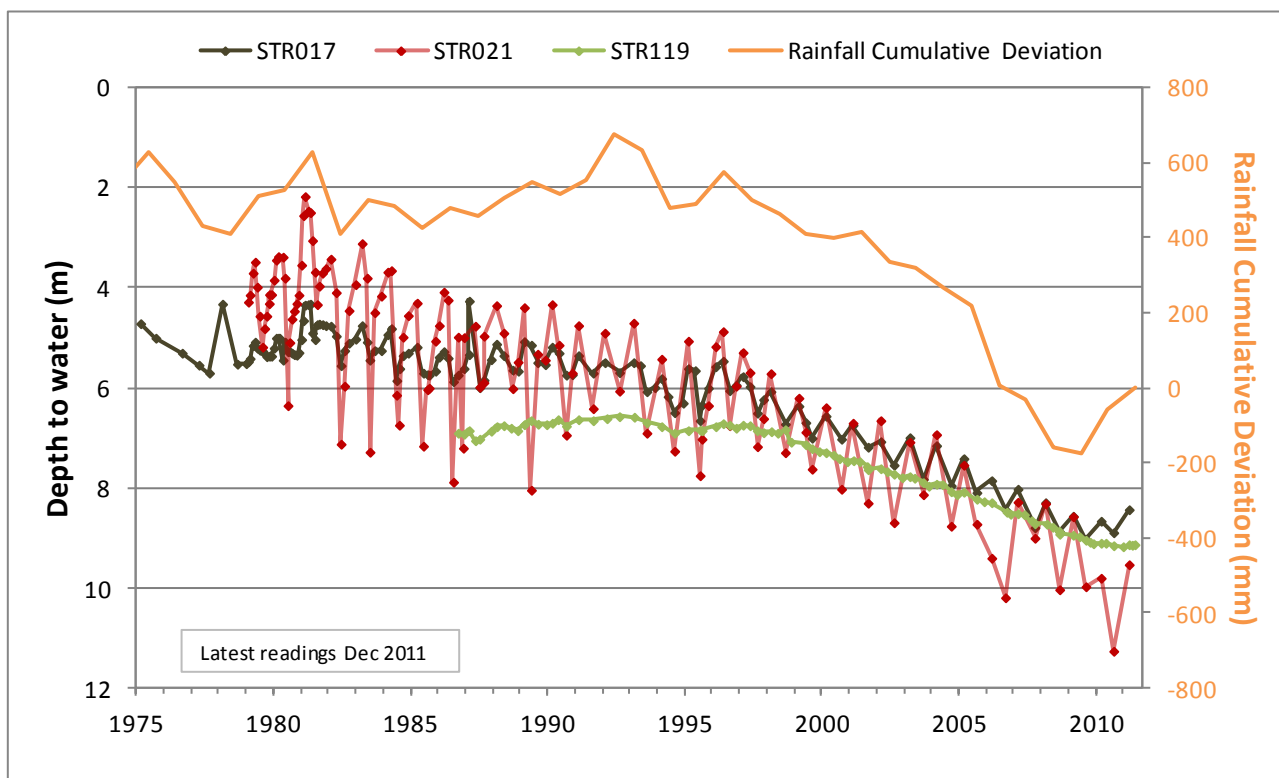


Figure 11. Groundwater level trends for the Coastal Plain unconfined aquifer in the Tatiara PWA

## HIGHLANDS

In the unconfined aquifer beneath the Highlands 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 Coastal Plain. 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 below-average rainfall commenced in the mid 1990s, as shown by the cumulative deviation from average annual 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.

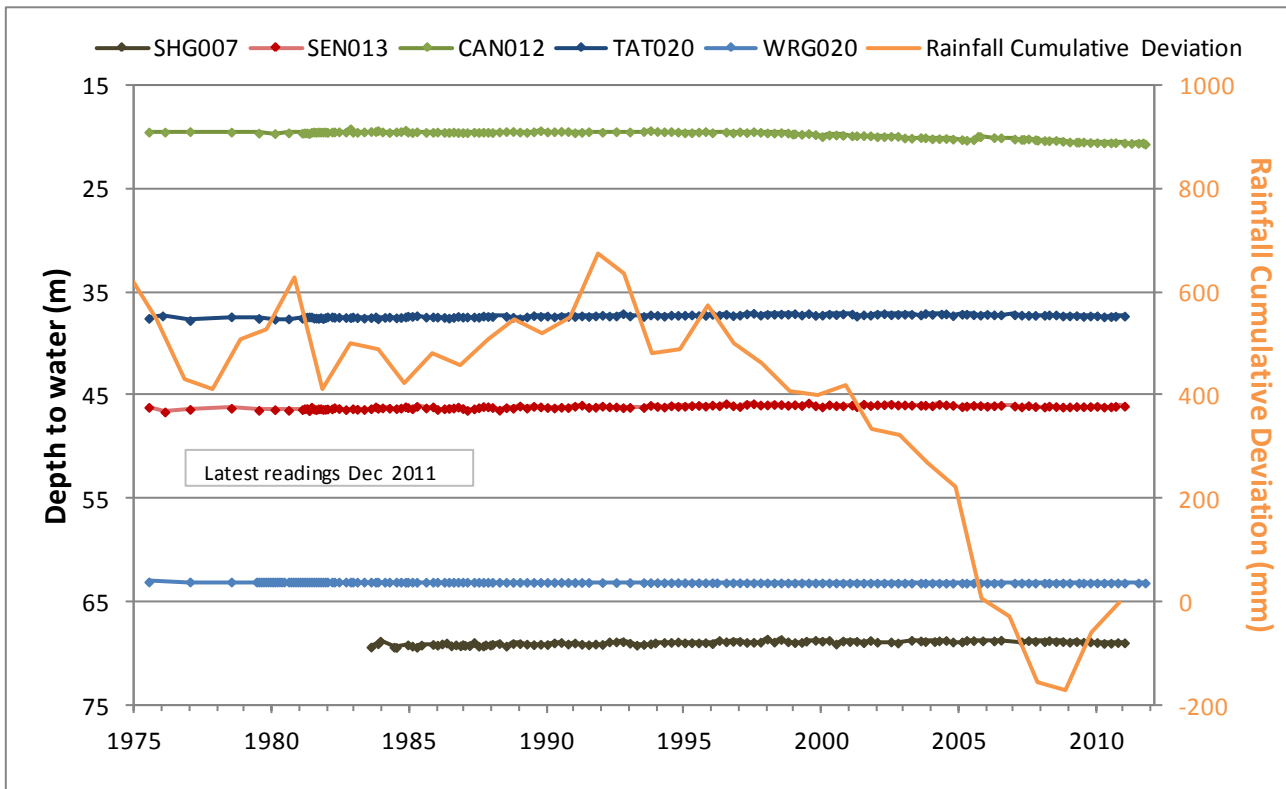


Figure 12. Groundwater level trends for the Highland unconfined aquifer in the Tatiara PWA

## CONFINED AQUIFER

The groundwater level trends observed in the confined aquifer (Fig. 13) are very similar to those observed in the overlying unconfined aquifer in both the Coastal Plain and Highland zones. Observation wells SHG006, TAT027 and WRG025 show the typical highland response to clearing and below-average rainfall, while STR132 (refer to scale on right hand axis in green) displays the declining trend and seasonal drawdowns typical of the Coastal Plain.

There is no extraction from the confined aquifer on the Coastal Plain and no direct recharge from rainfall and as a result, the identical trends to those observed in the overlying unconfined aquifer in the Coastal Plain are thought to be caused by the process of hydrostatic loading. A falling watertable means less water is stored in the unconfined aquifer and consequently, less weight is pressing down on the confining layer. This lower weight reduces the hydrostatic pressure on the underlying confined aquifer and causes confined water levels to fall. It should be noted that investigations are underway elsewhere in the South East to examine the contribution of leakage between the aquifers in causing these falling trends.

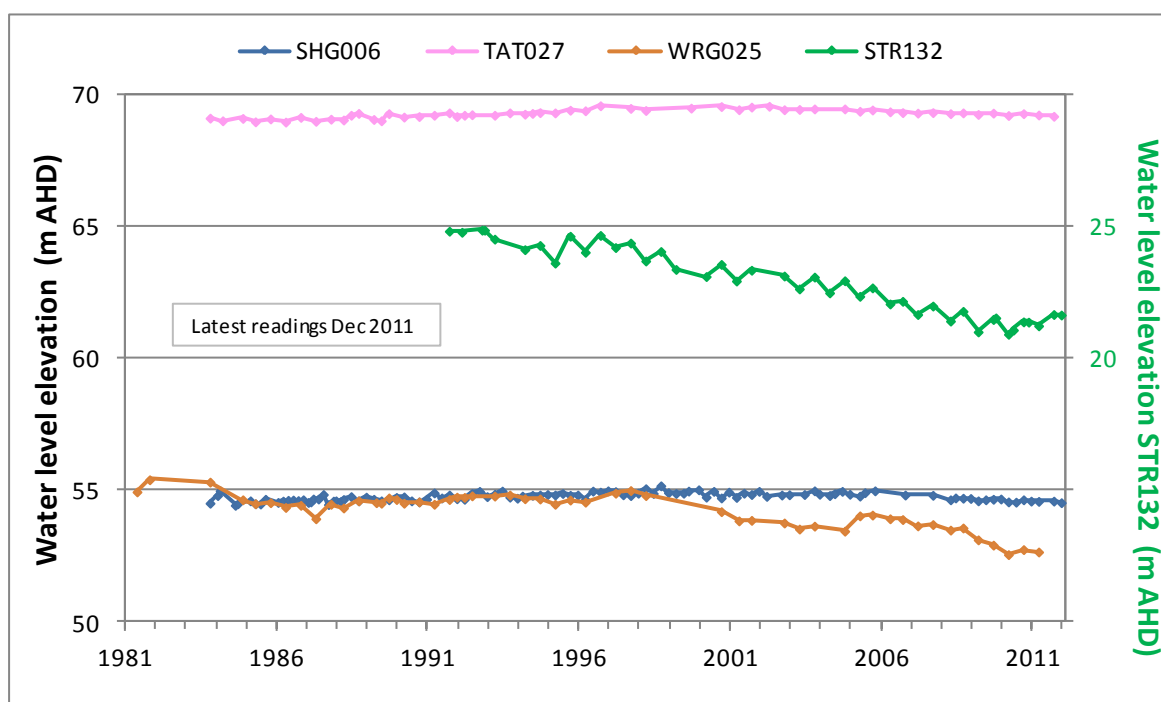


Figure 13. Groundwater level trends for the confined aquifer in the Tatiara PWA

# GROUNDWATER SALINITY TRENDS

## UNCONFINED AQUIFER

### COASTAL PLAIN

Groundwater salinity trends in irrigation wells in the unconfined aquifer are quite variable, as shown in Figure 14. Numerous irrigation wells are showing a rising salinity trend due to the recycling of irrigation drainage water in the shallow aquifer. Persistent salinity rises beneath areas of flood irrigation range between 60 mg/L/y (STR113) and 170 mg/L/y (STR115). Some wells on the eastern margin of the irrigated areas on the Coastal Plain (STR 116 and 117) are now showing stable or decreasing trends. This is likely due to falling groundwater levels, which have increased the inflow of lower-salinity groundwater from the Highlands to the east.

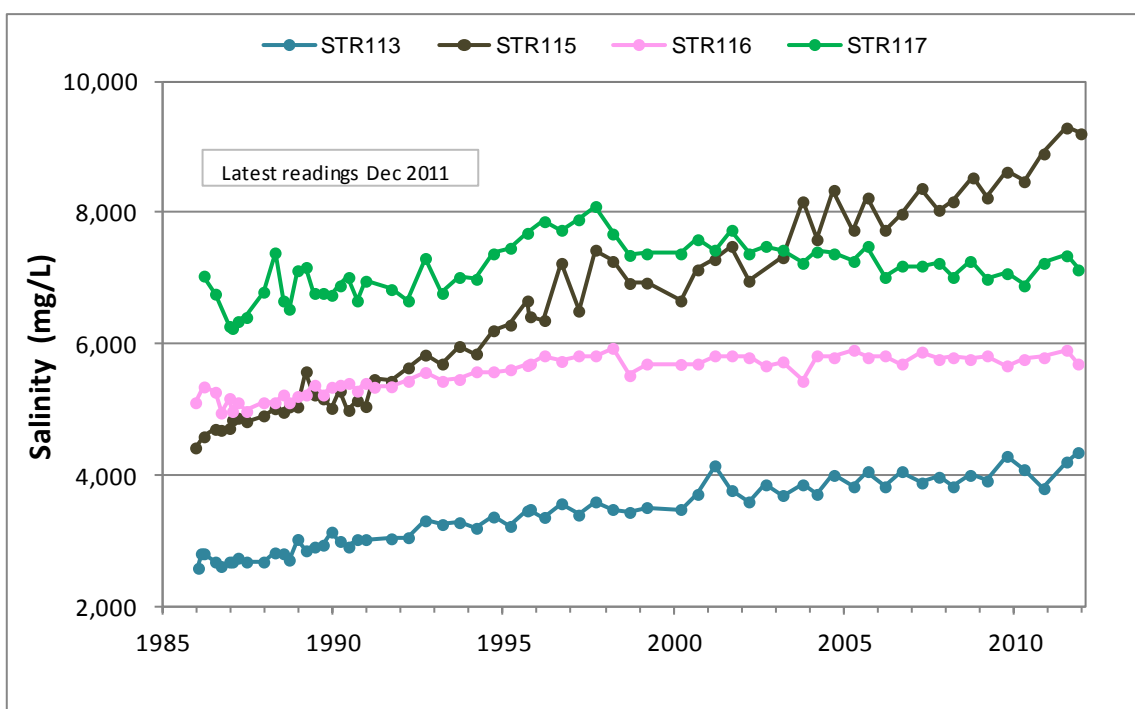


Figure 14. Groundwater salinity trends for the Coastal Plain unconfined aquifer in the Tatiara PWA

### HIGHLANDS

Groundwater salinity trends in the Highlands are responding to a very different process to that found on the Coastal Plain. 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 15 shows a variety of trends. Well TAT107 is located in the eastern part of the PWA where the depth to the watertable is over 30 m. Consequently, the trends in this area are stable with no significant rises in salinity. Well WRG116 is in a dryland setting and is showing a continuing rise of 58 mg/L/y since 1996, whilst the initial salinity rise in CAN104 of 24 mg/L/y has now shown signs of stabilising.

Well PET103 (graphed on the secondary Y axis, in blue) is displaying a decreasing trend over the last 10 years which may indicate that in areas of lower topography near the boundary with the Coastal Plain, 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 well documented in the Pathway PWA to the south.

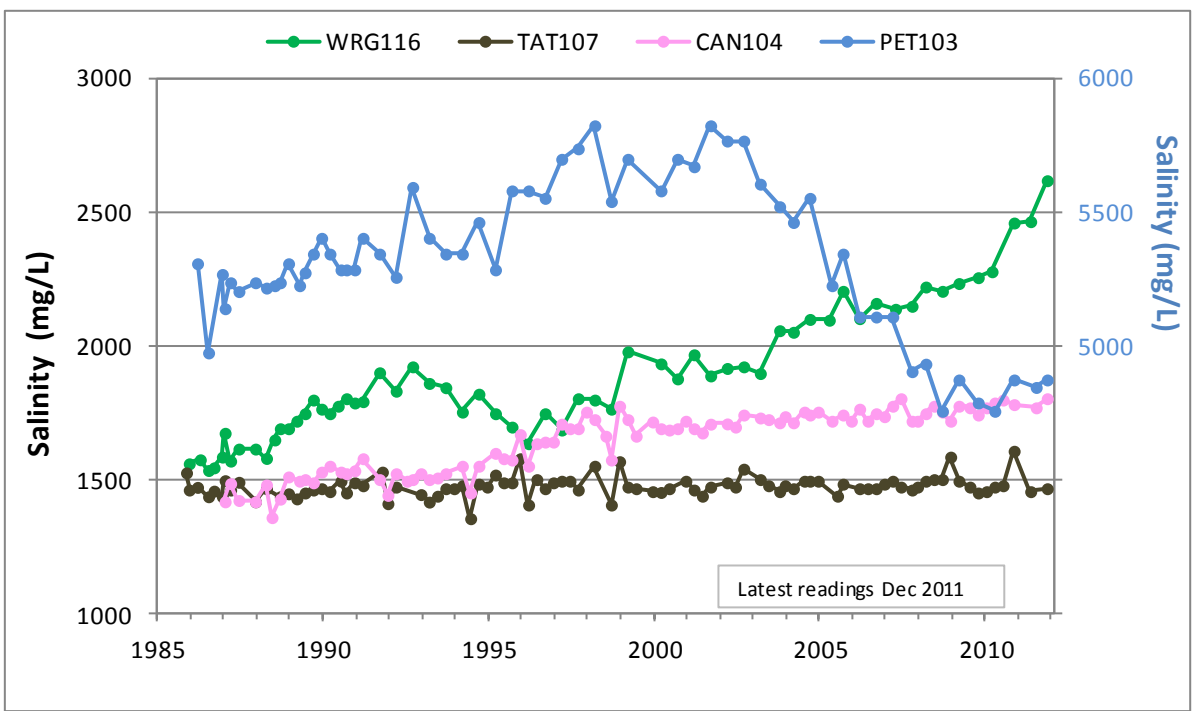


Figure 15. Groundwater salinity trends for the Coastal Plain unconfined aquifer in the Tatiara PWA

## CONFINED AQUIFER

Groundwater salinity trends in the confined aquifer near Keith are stable, as shown in Figure 16. There is no extraction from this aquifer.

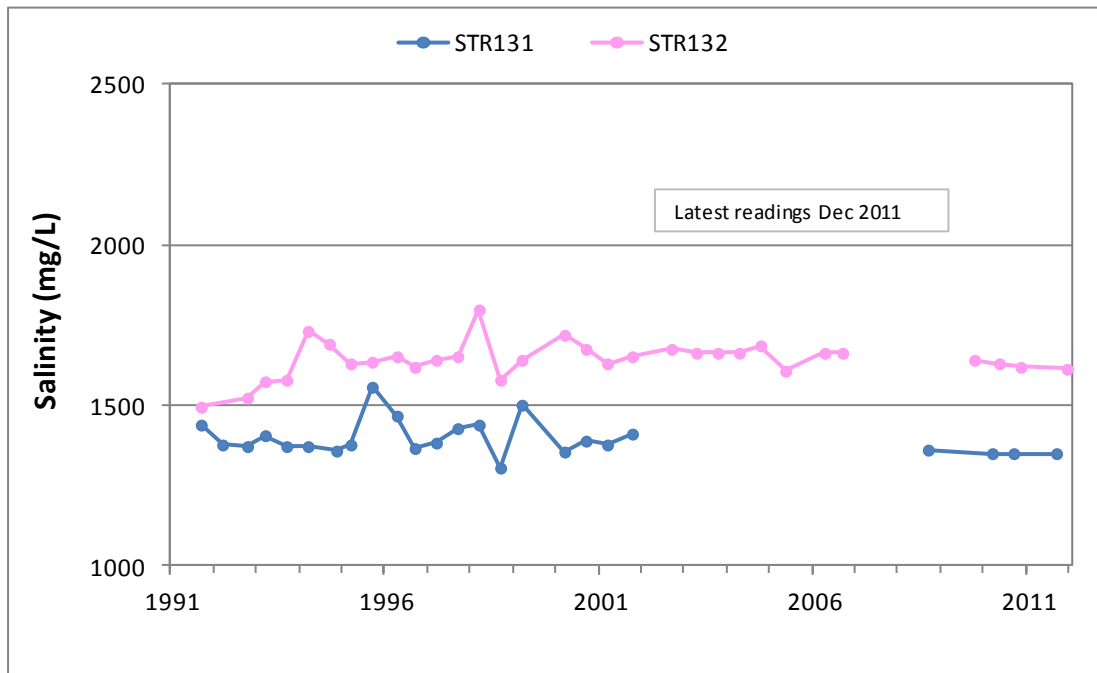


Figure 16. Groundwater salinity trends for the confined aquifer in the Tatiara PWA