TATIARA PWA

GROUNDWATER LEVEL AND SALINITY STATUS REPORT

2009–10

DEPARTMENT FOR WATER

Government of South Australia
Department for Water

SUMMARY 2009–10

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 94 230 ML in 2009–10 which represents a 13% decrease from the previous year. The majority of this extraction is from the unconfined aquifer, with only 382 ML of the total coming from the confined aquifer.

Lucerne (hay and seed) was 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 accounted for 70% of the total area irrigated (mainly on the Coastal Plain where groundwater salinities are higher), followed by centre pivot irrigation with 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/yr which corresponds with the prolonged period of below average rainfall since 1996 and is exacerbated by groundwater extraction. The above average rainfall during 2009 and 2010 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/yr 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 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 43 mg/L/yr. 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 confined aquifer groundwater level trends are very similar to those observed in the overlying unconfined aquifer in both the Coastal Plain and Highland zones. 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 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 aquifers. Salinity trends in the confined aquifer throughout the Tatiara PWA are stable.

ASSESSMENT OF STATUS

The Tatiara PWA has been assigned a status of yellow "Adverse trends indicating low risk to the resource in the medium term" based on current trends. This status for 2009–10 is supported by:

- long term decline in groundwater levels in the unconfined aquifer on the Coastal Plain in response to below average rainfall and extraction; and
- long term rise in groundwater salinity levels in the unconfined aquifer caused by recycling of irrigation drainage water (Coastal Plain) and vegetation clearance (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 is possibly showing some 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 (2009–10)

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 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.

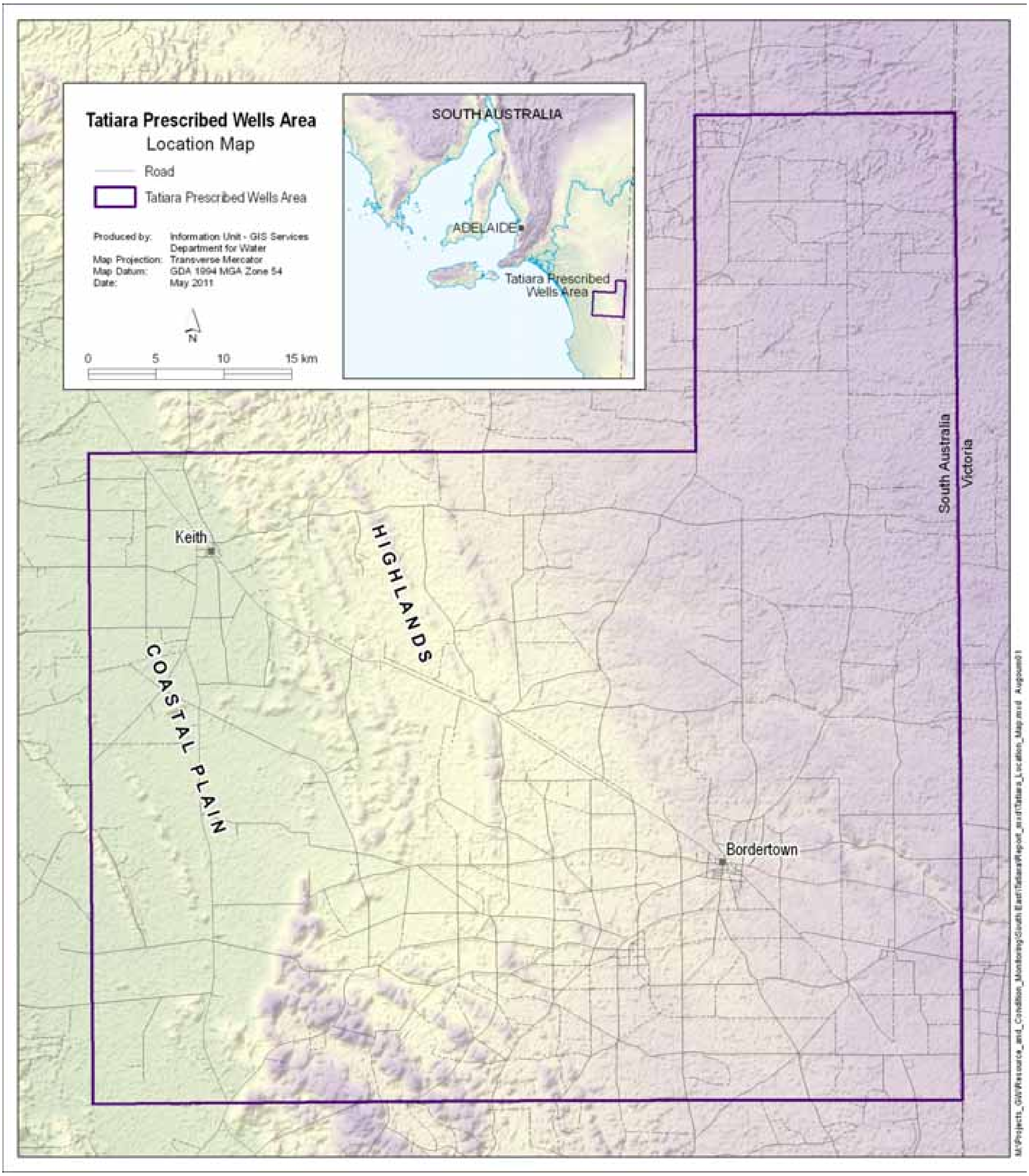

Figure 1. Location of the Tatiara PWA

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 which 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 which 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 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/sec 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 which 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/sec. Overlying the limestone aquifer is a considerable thickness of Pliocene Sands (Parilla Sands) which 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.

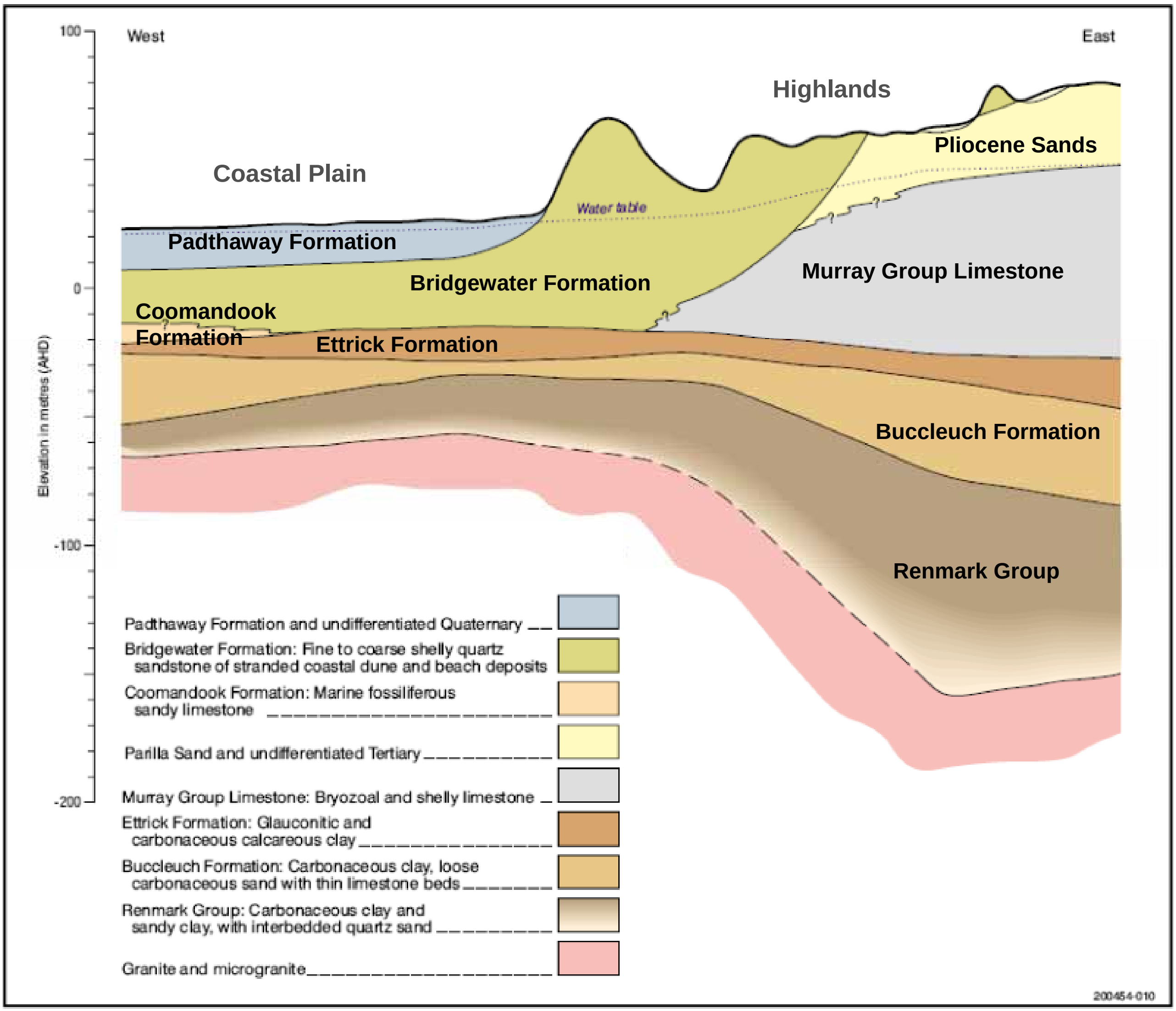

Figure 2. Geological cross-section of the Tatiara PWA

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

A summary of the hydrogeology is presented in Table 1.

Table 1. Hydrogeology of the Tatiara PWA

<table>
<tr><th>AGE</th><th colspan="2">STRATIGRAPHY</th><th colspan="2">HYDROGEOLOGY</th></tr>
<tr><th></th><th>Unit</th><th>Lithology</th><th>Unit</th><th>Description</th></tr>
<tr><td colspan="5">COASTAL PLAIN</td></tr>
<tr><td rowspan="3">Quaternary</td><td>Padthaway Formation</td><td>Off-white, well-cemented, fine-grained limestone deposited in inter-dunal flats</td><td rowspan="3">Unconfined aquifer</td><td rowspan="3">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.</td></tr>
<tr><td>Bridgewater Formation</td><td>Shelly and sandy aeolianite deposited in a series of topographic ridges</td></tr>
<tr><td>Coomandook Formation</td><td>Interbedded sandy limestones and shelly sandstones</td></tr>
<tr><td rowspan="3">Tertiary</td><td>Ettrick Formation</td><td>Grey-green glauconitic marl</td><td>Aquitard</td><td>Confining layer</td></tr>
<tr><td>Buccleuch Formation</td><td>Interbedded sand and carbonaceous clay units with minor bryozoal limestone layer</td><td rowspan="2">Confined aquifer</td><td rowspan="2">Not widely used due to low yields.</td></tr>
<tr><td>Renmark Group</td><td>Carbonaceous sands and clays</td></tr>
<tr><td colspan="5">HIGHLANDS</td></tr>
<tr><td rowspan="4">Tertiary</td><td>Pliocene Sands</td><td>Unfossiliferous, non marine, fine to medium-grained clayey quartz sand with thin beds of sandy clay</td><td></td><td>Unsaturated</td></tr>
<tr><td>Murray Group Limestone</td><td>White bryozoal limestone</td><td>Unconfined aquifer</td><td>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.</td></tr>
<tr><td>Ettrick Formation</td><td>Grey-green glauconitic marl</td><td>Aquitard</td><td>Confining layer</td></tr>
<tr><td>Renmark Group</td><td>Carbonaceous sands and clays</td><td>Confined aquifer</td><td>Not widely used due to low yields.</td></tr>
</table>

GROUNDWATER FLOW AND SALINITY

UNCONFINED AQUIFER

The watertable elevation contours for the unconfined aquifer in the Tatiara PWA, shown on 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 rise 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.

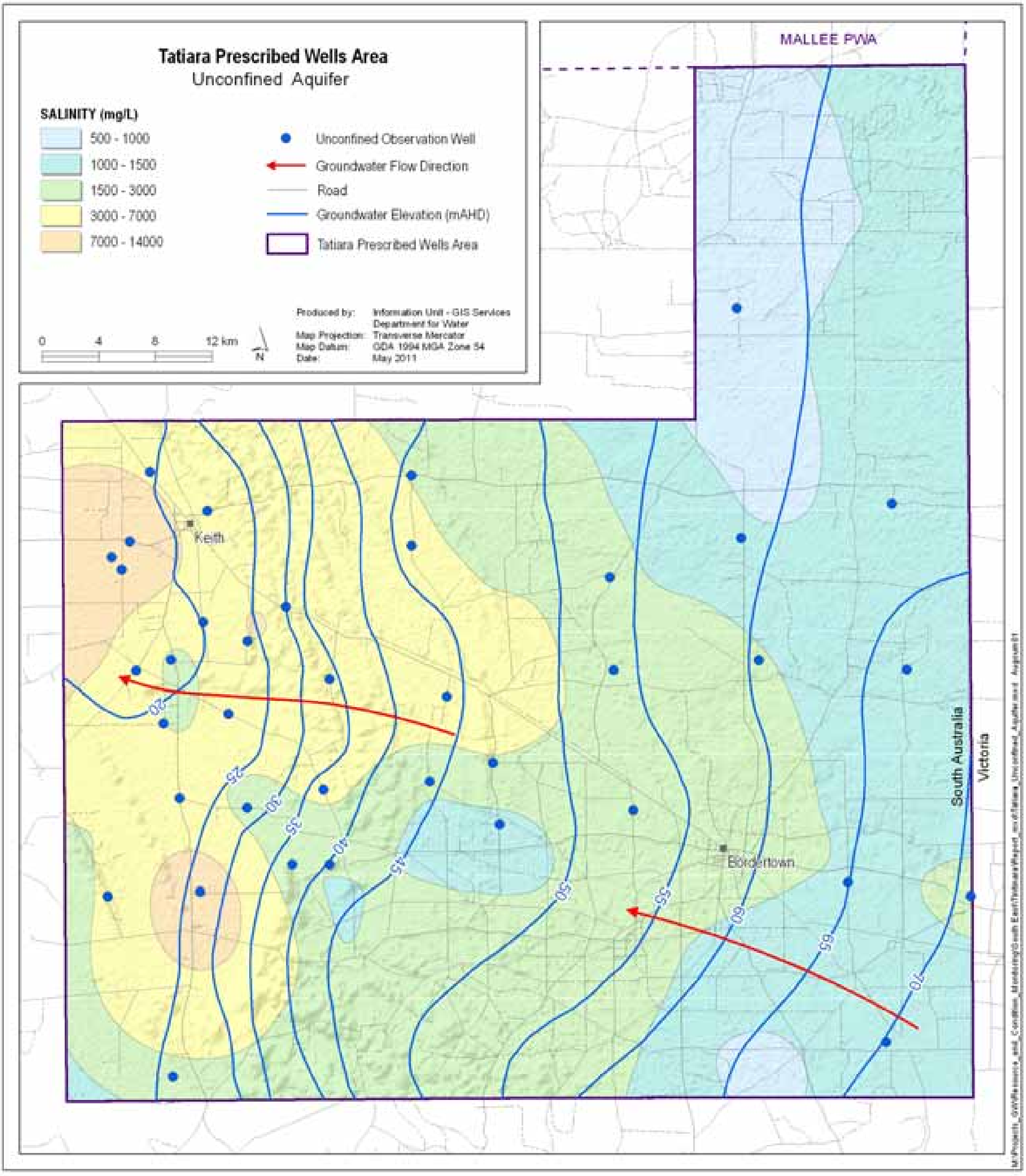

Figure 3. Groundwater flow and salinity distribution (Winter 2010) for the unconfined aquifer in the Tatiara PWA

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.

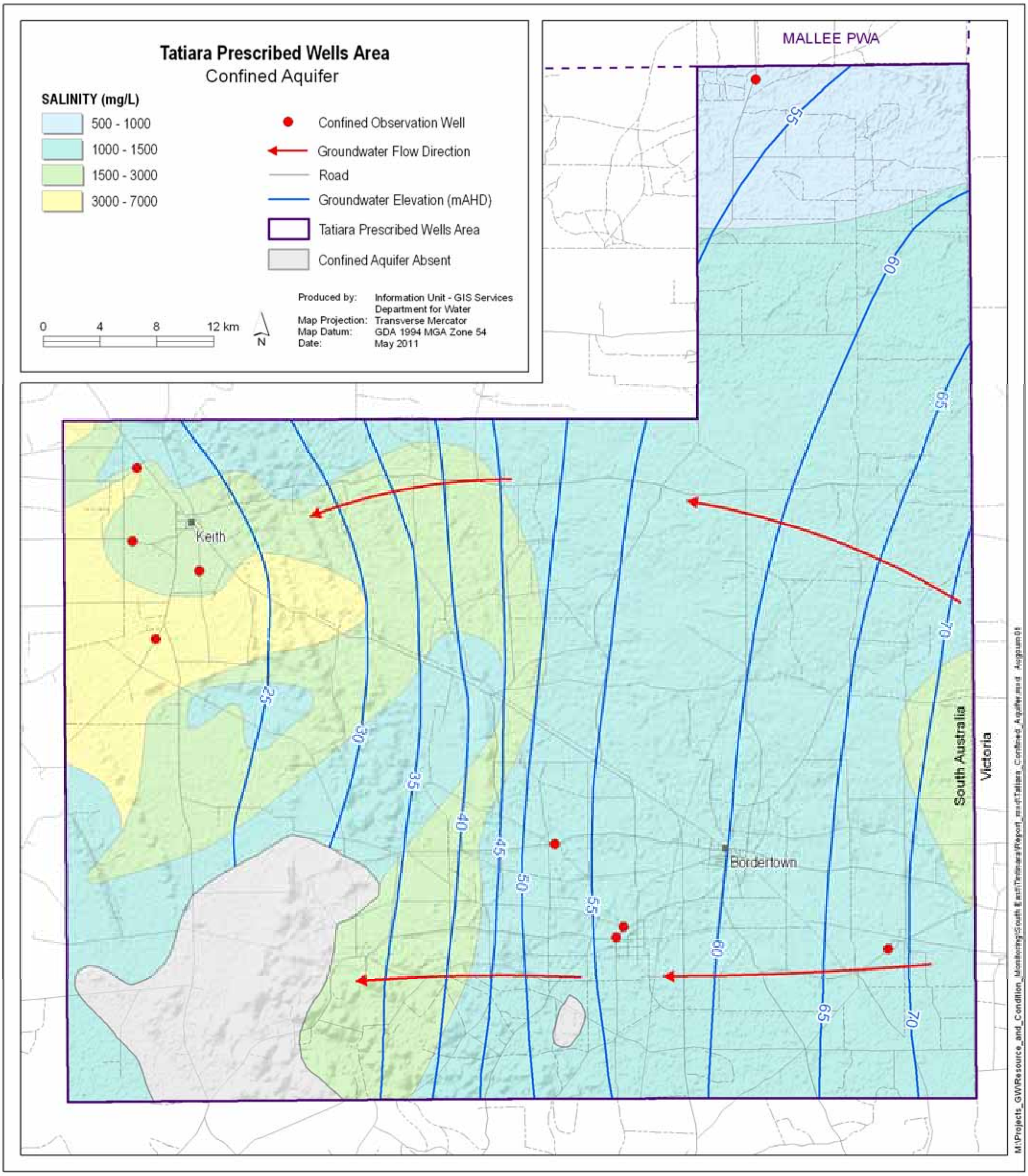

Figure 4. Groundwater flow and salinity distribution (Winter 2010) for the confined aquifer in the Tatiara PWA

GROUNDWATER DEPENDENT ECOSYSTEMS

Whilst groundwater dependent ecosystems (GDEs) have not been used 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 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, i.e. those 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 470 mm (Fig. 5). The annual rainfall recorded at Keith can be seen on Figure 6 in red columns. The cumulative deviation is also plotted in blue and measures the difference between the actual measured rainfall and the long term average rainfall on a monthly basis. 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, which was followed by generally above average rainfall until 1993. A significant below average trend has been experienced since 1993 and particularly after the 2006 drought.

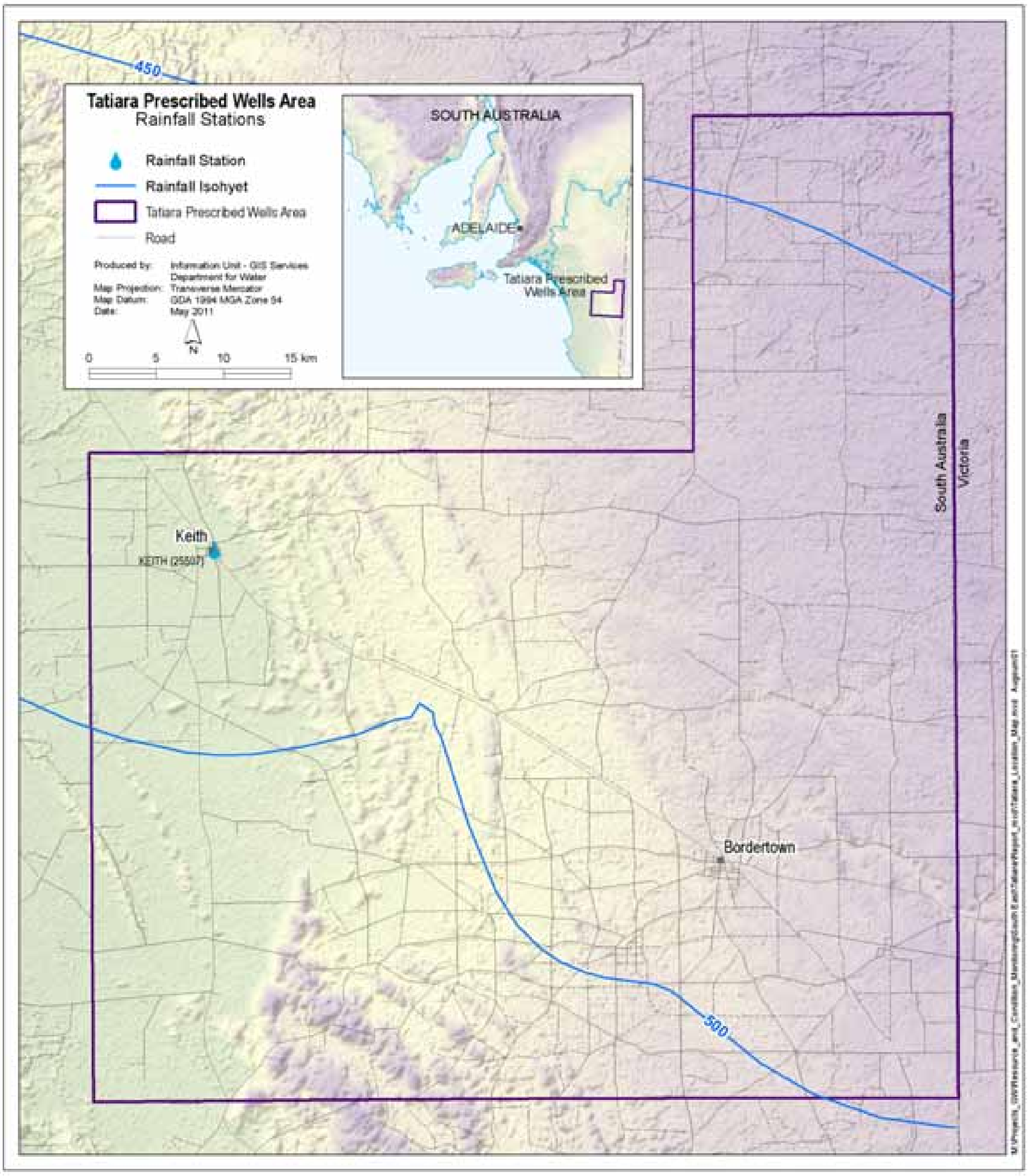

Figure 5. **Location of rainfall station and rainfall isohyets in the Tatiara PWA**

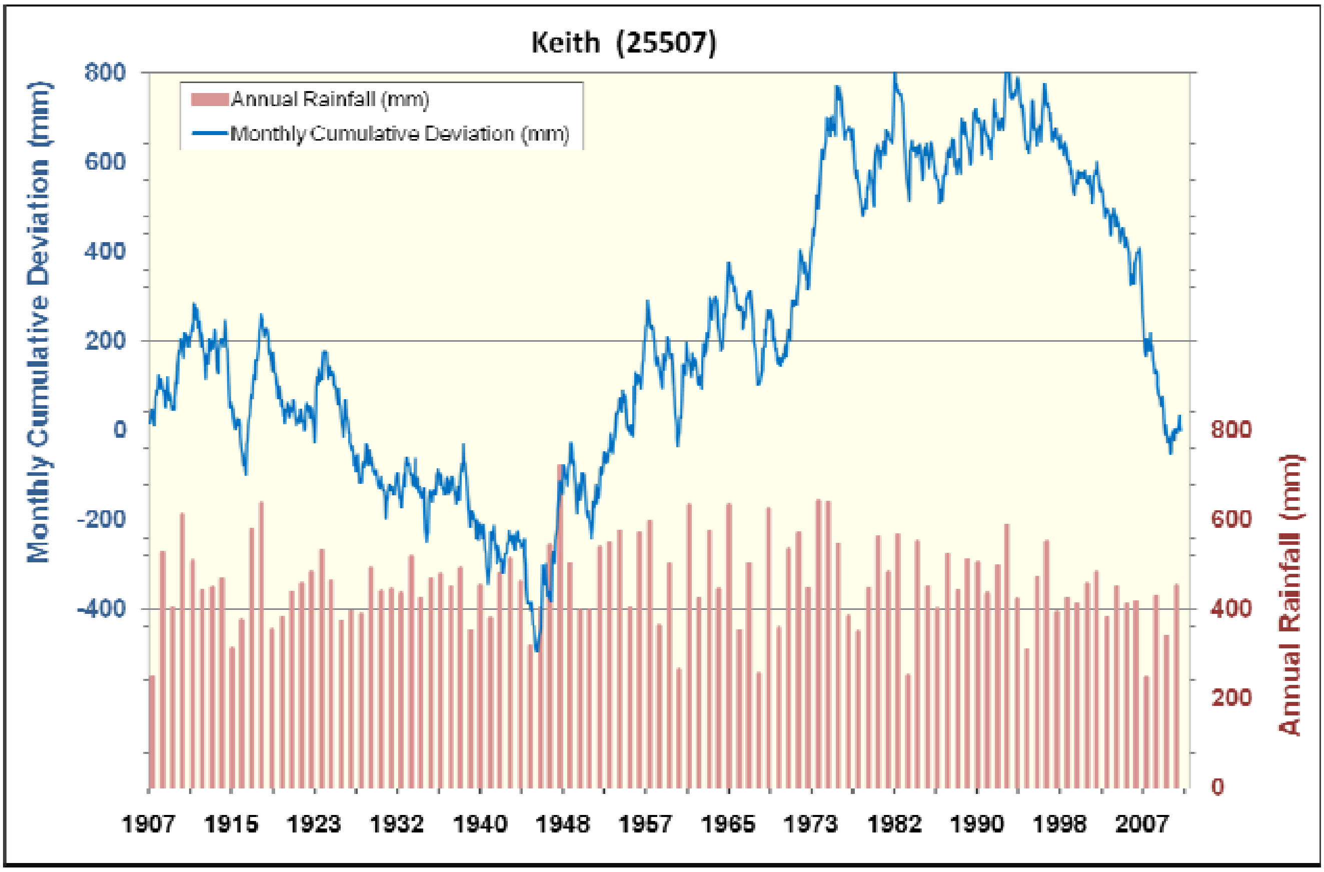

Figure 6. Annual rainfall and cumulative deviation for mean monthly rainfall for Keith

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

GROUNDWATER USE

Metered groundwater extractions for licensed purposes (excluding stock and domestic use) in the Tatiara PWA totalled 94 230 ML in 2009–10 (Fig. 7), which represents a 13% decrease from the previous year. 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 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 vast majority of this extraction is from the unconfined aquifer, with only 382 ML of the total coming from the confined aquifer.

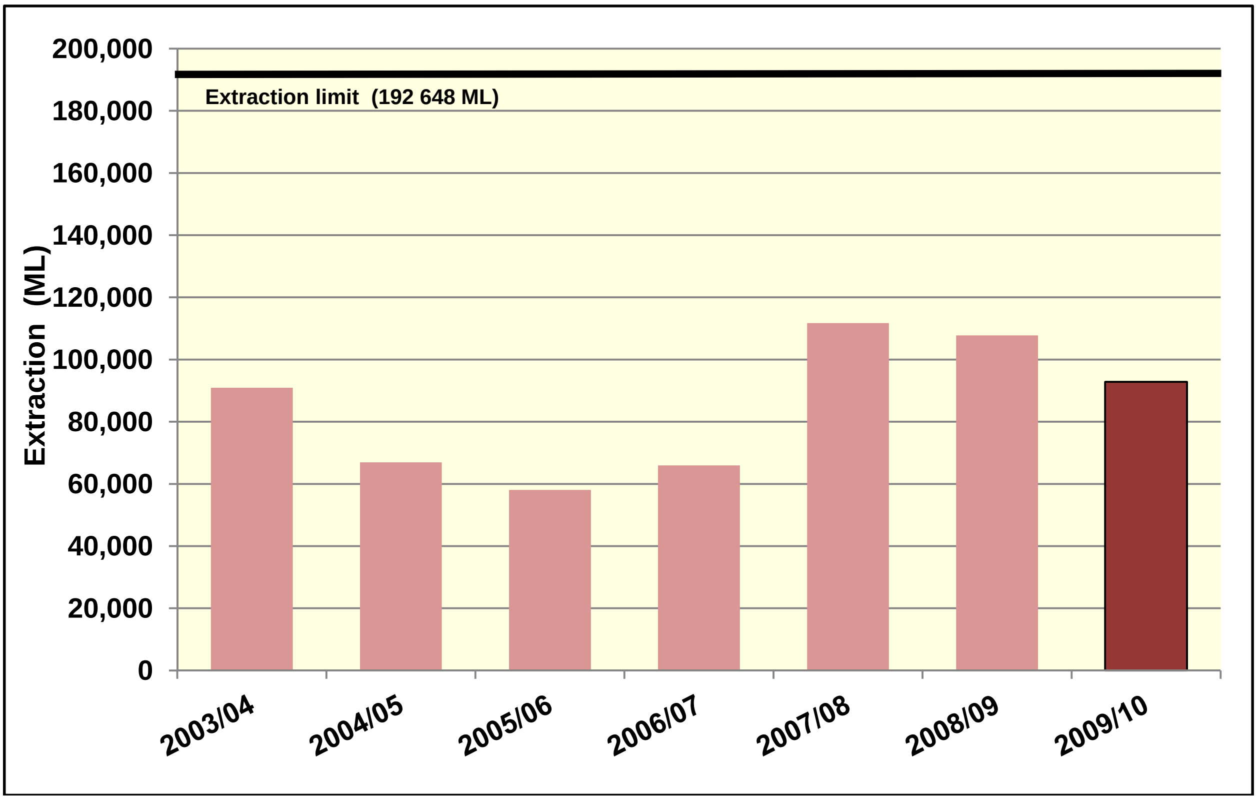

Figure 7. Historical licensed groundwater use for the Tatiara PWA

Table 2 below shows the various categories of licensed groundwater use in the Tatiara PWA for 2009–10 shaded in yellow, which can be compared to the previous years.

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

WATER USE	2009–10 (ML)	% of use	2008–09 (ML)	% of use	2007–08 (ML)	% of use
Irrigation	92 915	98.6	106 187	98.5	108 514	97.1
Industrial	615	0.65	685	0.64	486	0.44
Recreation	318	0.3	478	0.44	463	0.41
Aquaculture	5	0.01	7	0.01	1829	1.64
Town Water Supply	377	0.4	420	0.39	417	0.37
Total use (ML)	94 230	100	107 777	100	111 709	100

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 currently available for 2009–10. 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 with 26% of the total area.

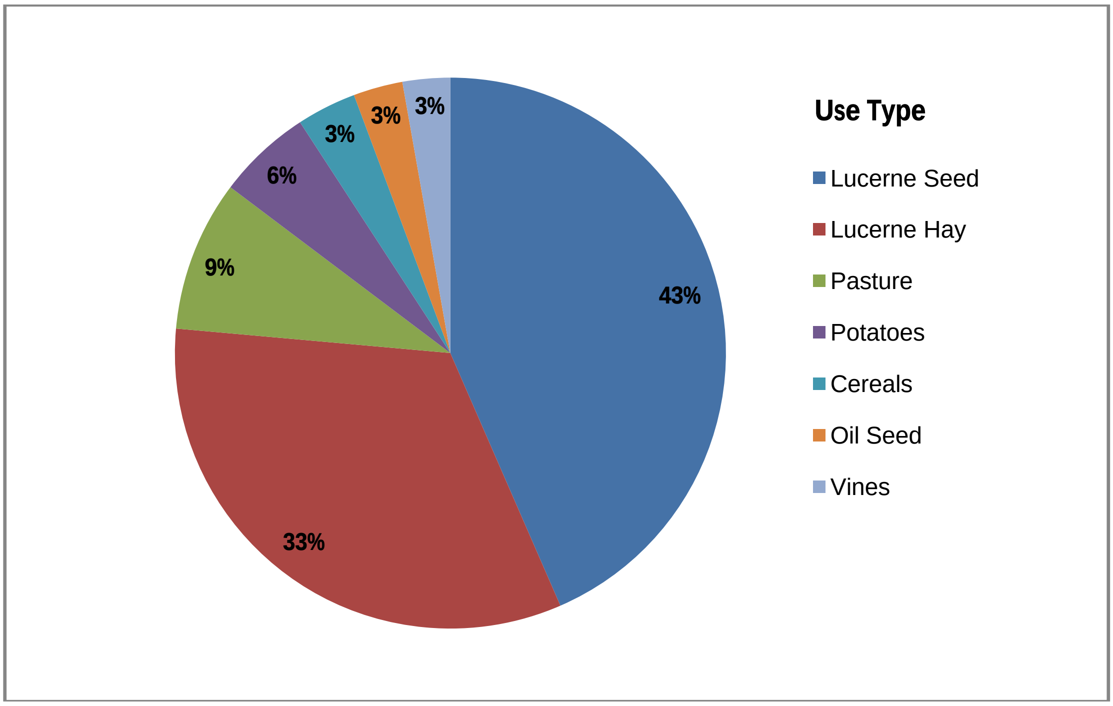

Figure 8. Groundwater proportions use per type of crop for the Tatiara PWA in 2008–09

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 92 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.

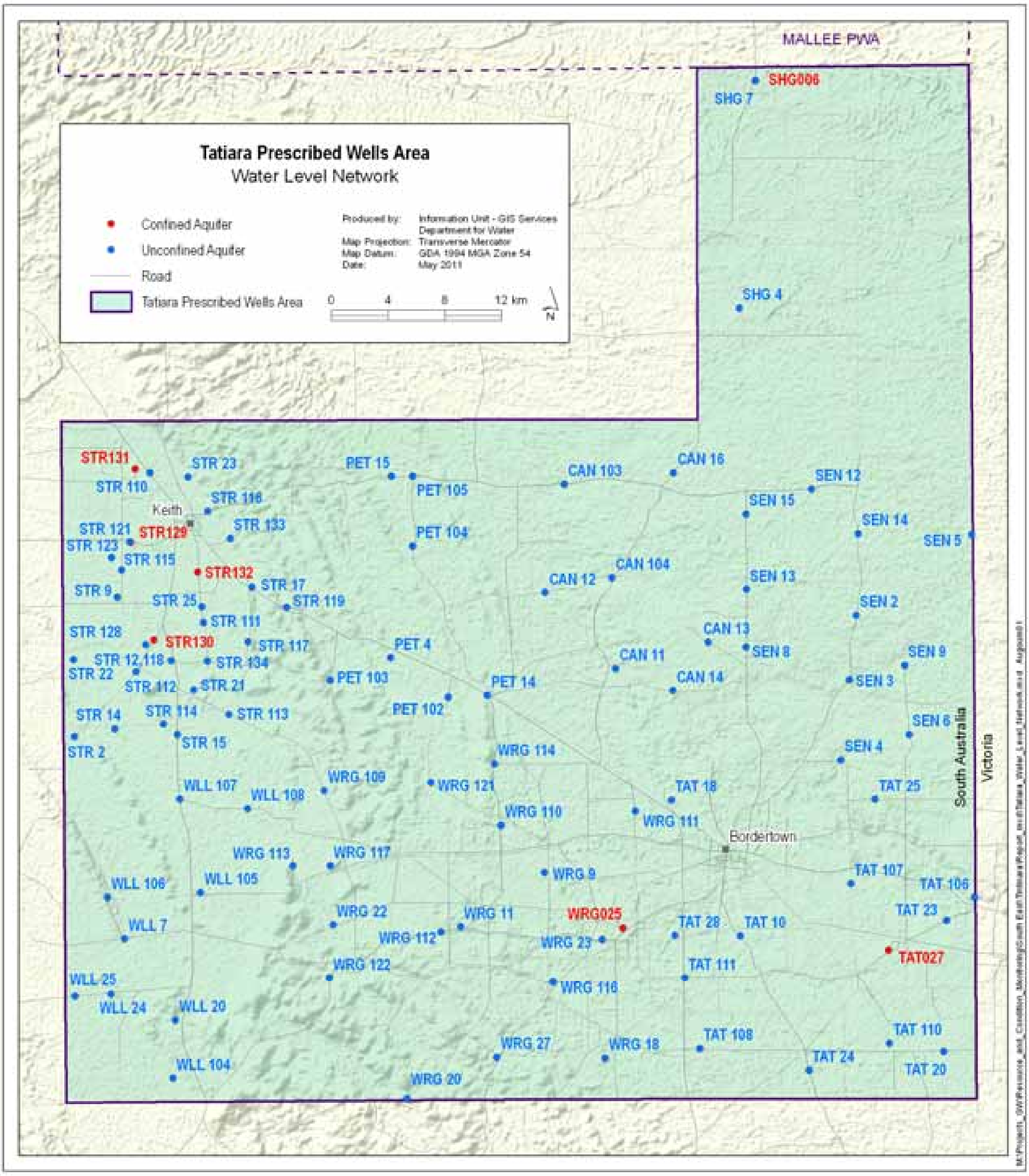

Figure 9. Location of water level observation wells in the Tatiara PWA

SALINITY NETWORK

The groundwater salinity observation network in the Tatiara PWA is shown in Figure 10. There are 45 wells currently monitoring the unconfined aquifer and three monitoring the confined aquifer.

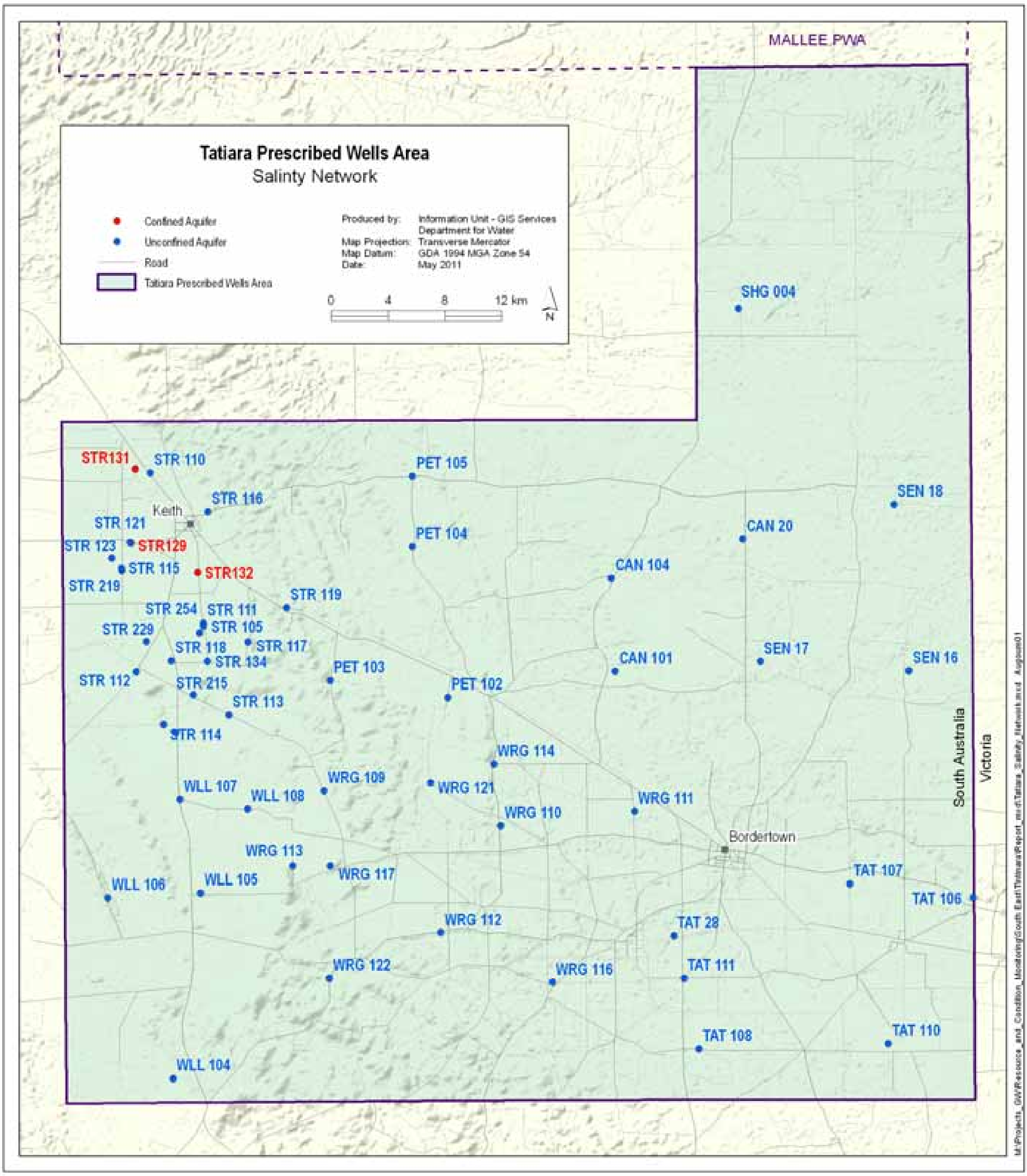

Figure 10. Location of salinity observation wells in the Tatiara PWA

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 which corresponds with the prolonged period of below average rainfall since 1996 (shown by the cumulative deviation from mean monthly rainfall graphed in light blue). 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 also a decline 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 and 2010 does not appear to have had any substantial impact on the declining trend.

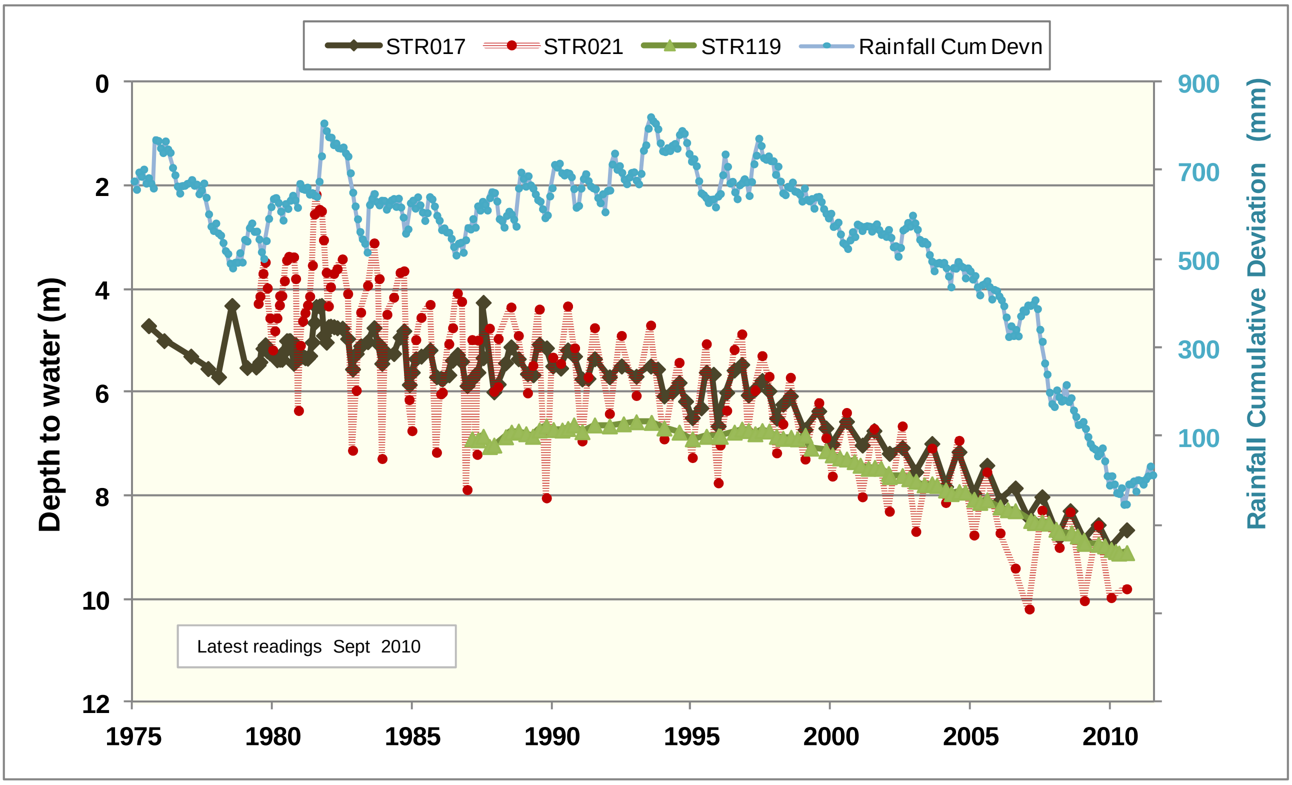

Figure 11. Groundwater level trends for the Coastal Plain unconfined aquifer in the Tatiara PWA

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/yr 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 mean monthly rainfall graphed in light blue.

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.

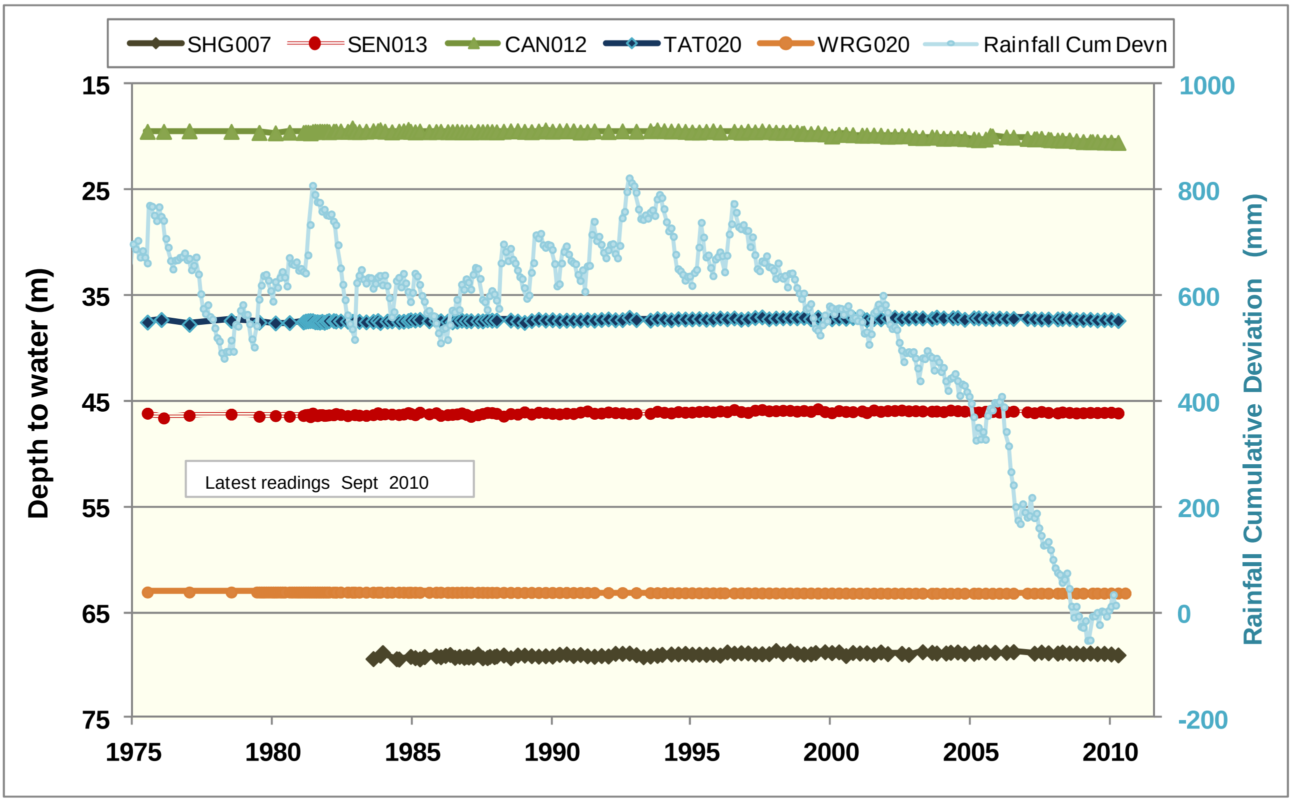

Figure 12. Groundwater level trends for the Highland unconfined aquifer in the Tatiara PWA

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 results in less water being stored in the unconfined aquifer and consequently, less weight 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 aquifers in causing these falling trends.

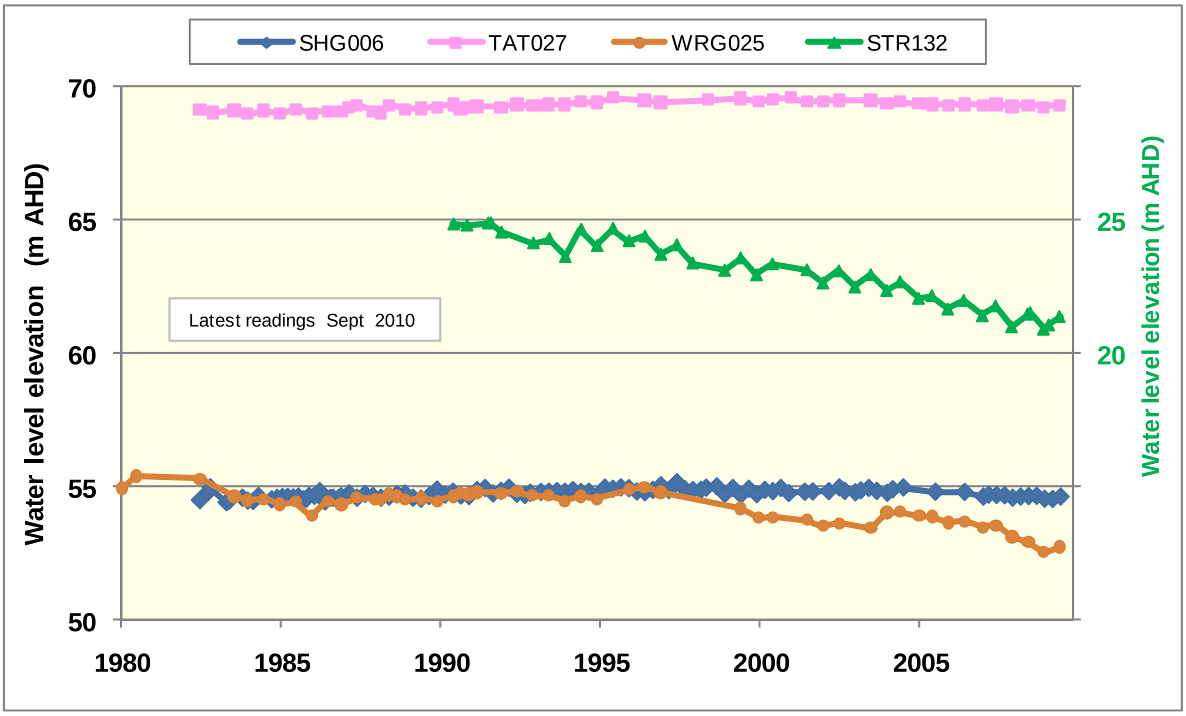

Figure 13. Groundwater level trends for the confined aquifer in the Tatiara PWA

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/yr (STR113) and 170 mg/L/yr (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.

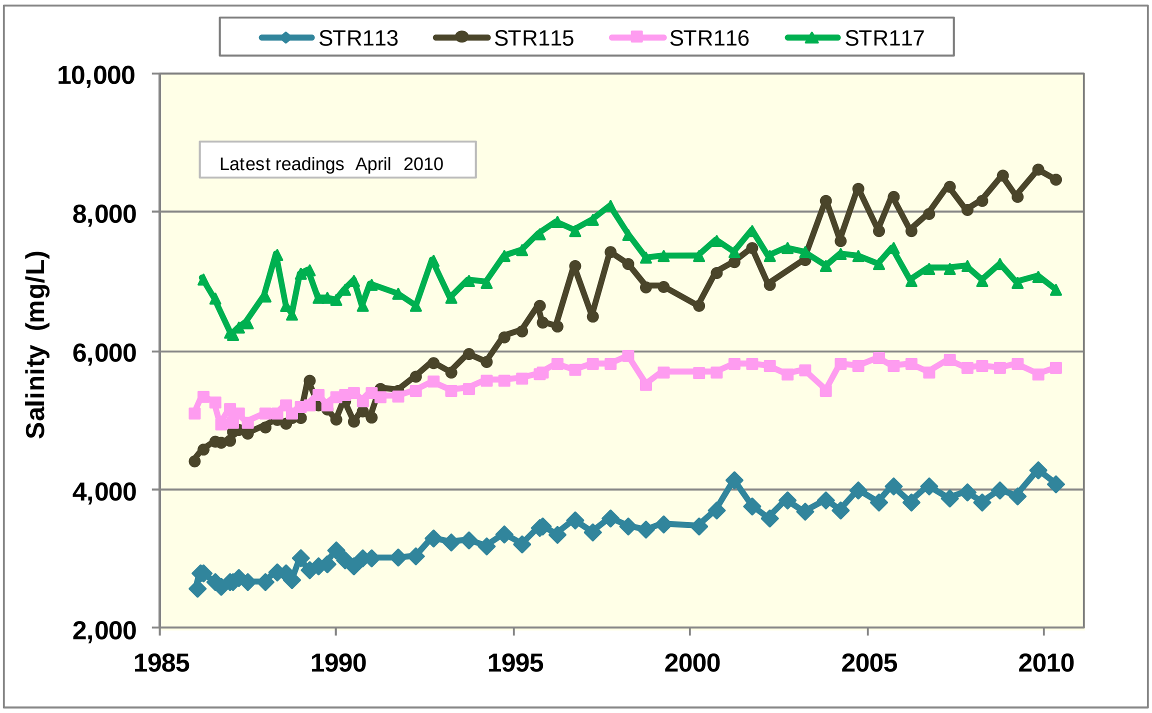

Figure 14. Groundwater salinity trends for the Coastal Plain unconfined aquifer in the Tatiara PWA

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 43 mg/L/yr since 1996, whilst the initial salinity rise in CAN104 of 24 mg/L/yr 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 Padthaway PWA to the south.

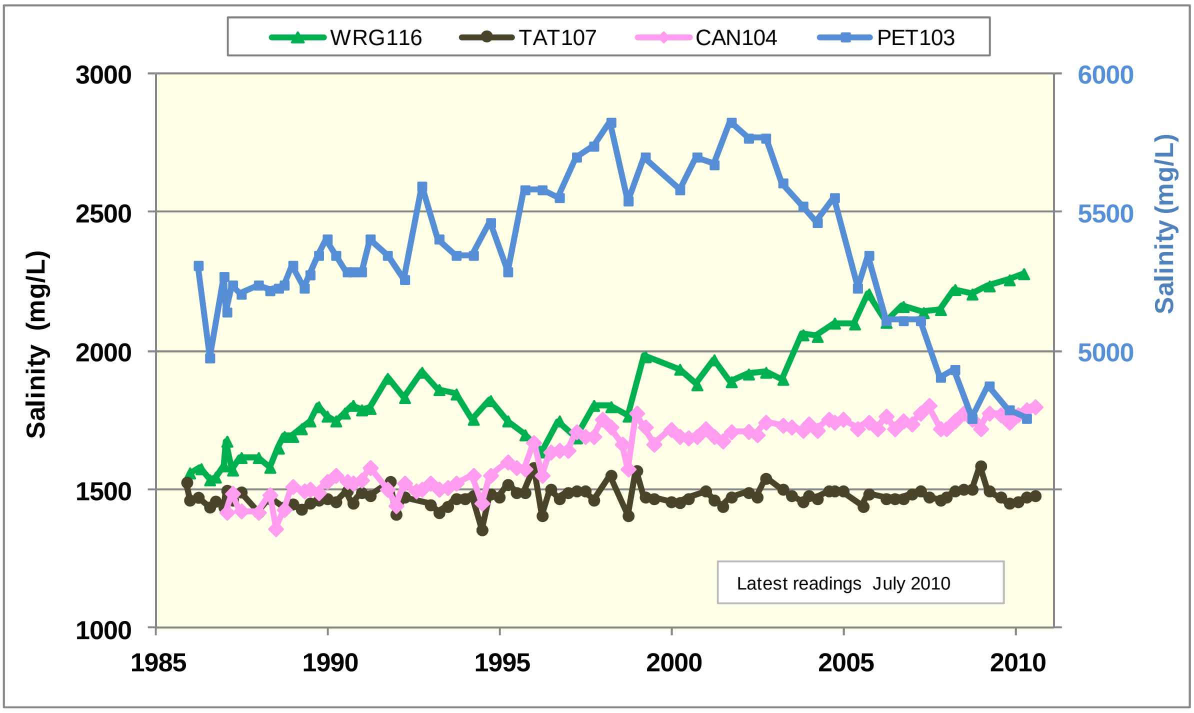

Figure 15. Groundwater salinity trends for the Coastal Plain unconfined aquifer in the Tatiara PWA

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.

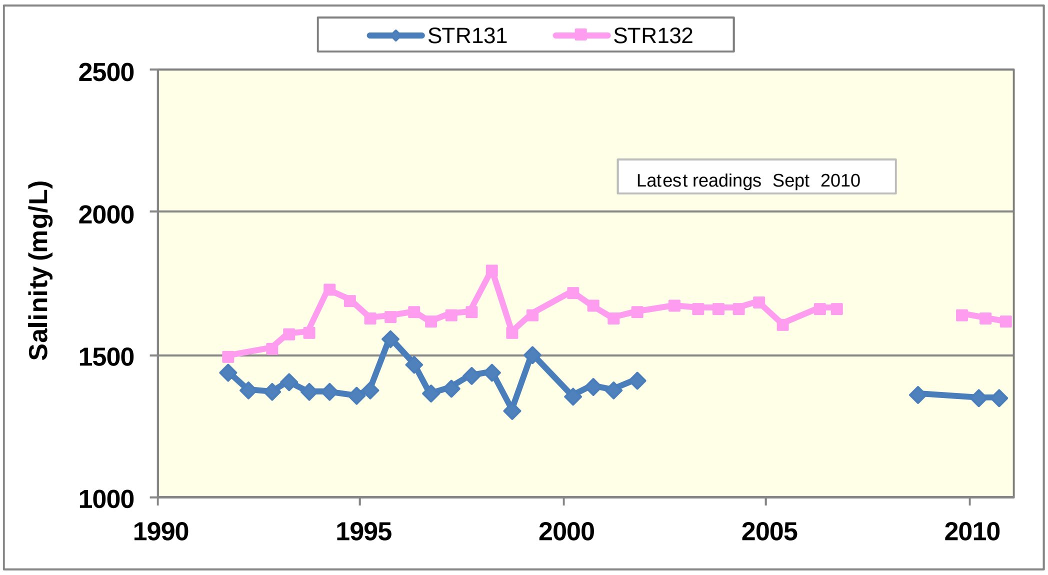

Figure 16. Groundwater salinity trends for the confined aquifer in the Tatiara PWA