MUSGRAVE PWA

GROUNDWATER LEVEL AND SALINITY STATUS REPORT

2009–10

Government of South Australia
Department for Water

SUMMARY 2009–10

The Musgrave Prescribed Wells Area (PWA) is situated in central Eyre Peninsula, approximately 120 km north-west of Port Lincoln and 825 km west of Adelaide. It is prescribed under South Australia's *Natural Resources Management Act 2004* and a Water Allocation Plan provides for sustainable use of the groundwater resources.

Groundwater extractions in the Musgrave PWA occur primarily from areas of low salinity groundwater below 1000 mg/L within the Quaternary Limestone Aquifer (Bridgewater Formation). The vast majority of the extractions have been for public water supply, although a Notice of Restriction placed on the Polda Basin has prevented pumping from this source by SA Water since November 2008 and limited extractions by other licence holders. Extractions from the Bramfield Basin for the Elliston town water supply totalled 70.3 ML during 2009–10. Only 11.4 ML was extracted in 2009–10 for irrigation purposes throughout the Musgrave PWA.

After a long period of declining groundwater levels and below-average rainfall, good winter and spring rainfall in both 2009 and 2010 has increased recharge and led to watertable rises of up to 0.4 m. In some areas the water levels are the highest recorded for the past ten years. Groundwater salinities are stable or decreasing as a result of the recent increased recharge.

While the status assigned below reflects the positive trends observed during 2009–10, it must be remembered that in the past there was a prolonged period of below-average rainfall that resulted in declining water levels in all basins and a gradual rise in groundwater salinities in the Polda Basin. The possibility that such periods of low rainfall will occur again in the future must be considered in long-term planning.

ASSESSMENT OF STATUS

Based on current trends, the Bramfield, Kappawanta, Sheringa and Talia Basins have been assigned a status of green “No adverse trends, indicating a stable or improving situation” for the 2009-10 water use year. This status is supported by:

- a significant recovery in groundwater levels due to higher rainfall during 2009 and 2010; and
- stable salinity levels over most of the PWA.

The Polda Basin has been assigned a status of yellow “Adverse trends indicating low risk to the resource in the medium term” for the 2009-10 water use year because salinity levels have increased due to the previous lack of recharge and although some freshening occurred during 2009 and 2010, values are still high in some areas.

While the status assigned reflects the positive trends observed during 2009–10, it must be remembered that in the past, there was a prolonged period of below-average rainfall that resulted in declining water levels in most basins. The Quaternary Limestone Aquifer has a rapid response to changes in rainfall patterns and consequently, the status of the resource may change readily from year to year.

STATUS (09–10)

🟢 **Bramfield, Kappawanta, Sheringa and Talia Basins**

🟡 **Polda Basin**

🟢 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 five 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 Musgrave Prescribed Wells Area (PWA) is situated in central Eyre Peninsula approximately 120 km north-west of Port Lincoln and 825 km west of Adelaide (Fig. 1). It is prescribed under South Australia's *Natural Resources Management Act 2004* and a Water Allocation Plan provides for sustainable use of the groundwater resources.

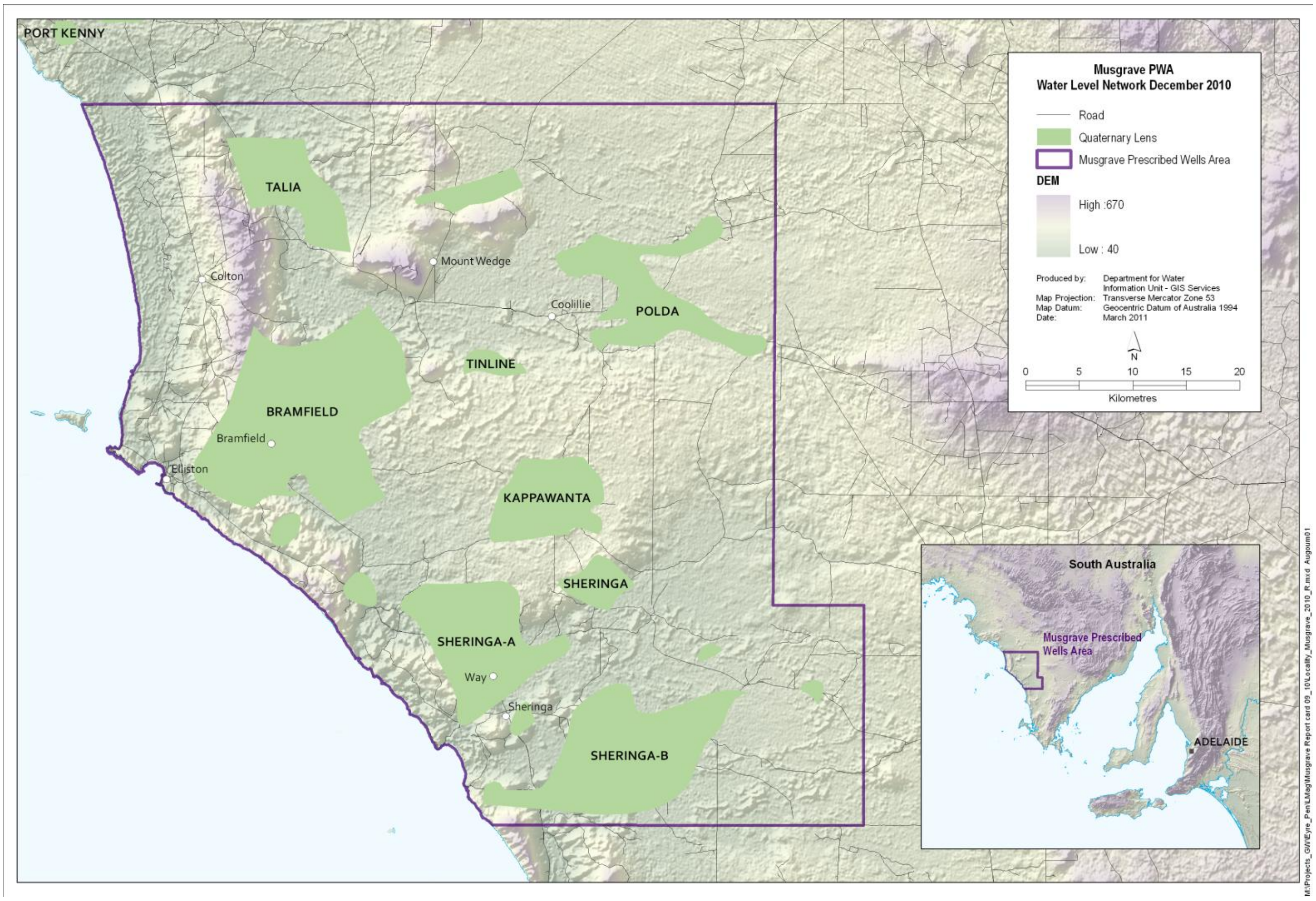

Figure 1. Location of the Musgrave PWA

HYDROGEOLOGY

Groundwater in the Musgrave PWA mainly occurs within two formations, an upper Quaternary Limestone Aquifer and the underlying Tertiary Sand Aquifer (Fig. 2). Underlying these aquifers are Jurassic sediments and fractured basement rocks which based on current knowledge, are considered to be poor aquifers.

Quaternary Limestone Aquifer

All significant extractions in the Musgrave PWA are from the Quaternary Limestone Aquifer which has widely varying aquifer characteristics, ranging from very hard cemented calcrete layers to unconsolidated granular layers of the Bridgewater Formation. Solution features are also common. Significant volumes of low-salinity groundwater are stored in discrete basins within the Quaternary Limestone Aquifer. Within these basins, lenses containing groundwater below 1000 mg/L may occur. Recharge occurs directly from rainfall, with the timing and intensity of the rainfall a major influence on the magnitude of recharge. A close relationship has been observed between rainfall and groundwater levels.

Groundwater generally flows from east to west. Groundwater levels and salinity vary widely across the Musgrave PWA. Evaporative discharge from the shallow watertable in the Quaternary Limestone Aquifer around Poelpena Swamp appears to have resulted in elevated groundwater salinities.

Tertiary Sand Aquifer

A thin mottled red brown clay layer immediately underlies the Quaternary Limestone Aquifer. Below this confining layer, fine grained quartz sand forms the Tertiary Sand Aquifer. The Tertiary Sand Aquifer extends over most of the Musgrave PWA, but has not been developed due to high salinities and low yields. Aquifer salinities range from 500 to 5500 mg/L, but yields are generally poor. The Tertiary Sand Aquifer is recharged by downward leakage from the Quaternary Limestone Aquifer and lateral flow. Groundwater flow direction is predominantly south-westerly towards the Southern Ocean.

Jurassic Sand Aquifer

The Jurassic Sands Aquifer occurs predominantly in the east of the Musgrave PWA and consists of fine grained sands. The aquifer has low yields and high salinity (30 000–50 000 mg/L).

Basement Aquifer

There is limited information on the fractured rock basement aquifer within the Musgrave PWA. There is likely to be large variations in salinity and yield depending on the degree of fracture development and recharge characteristics.

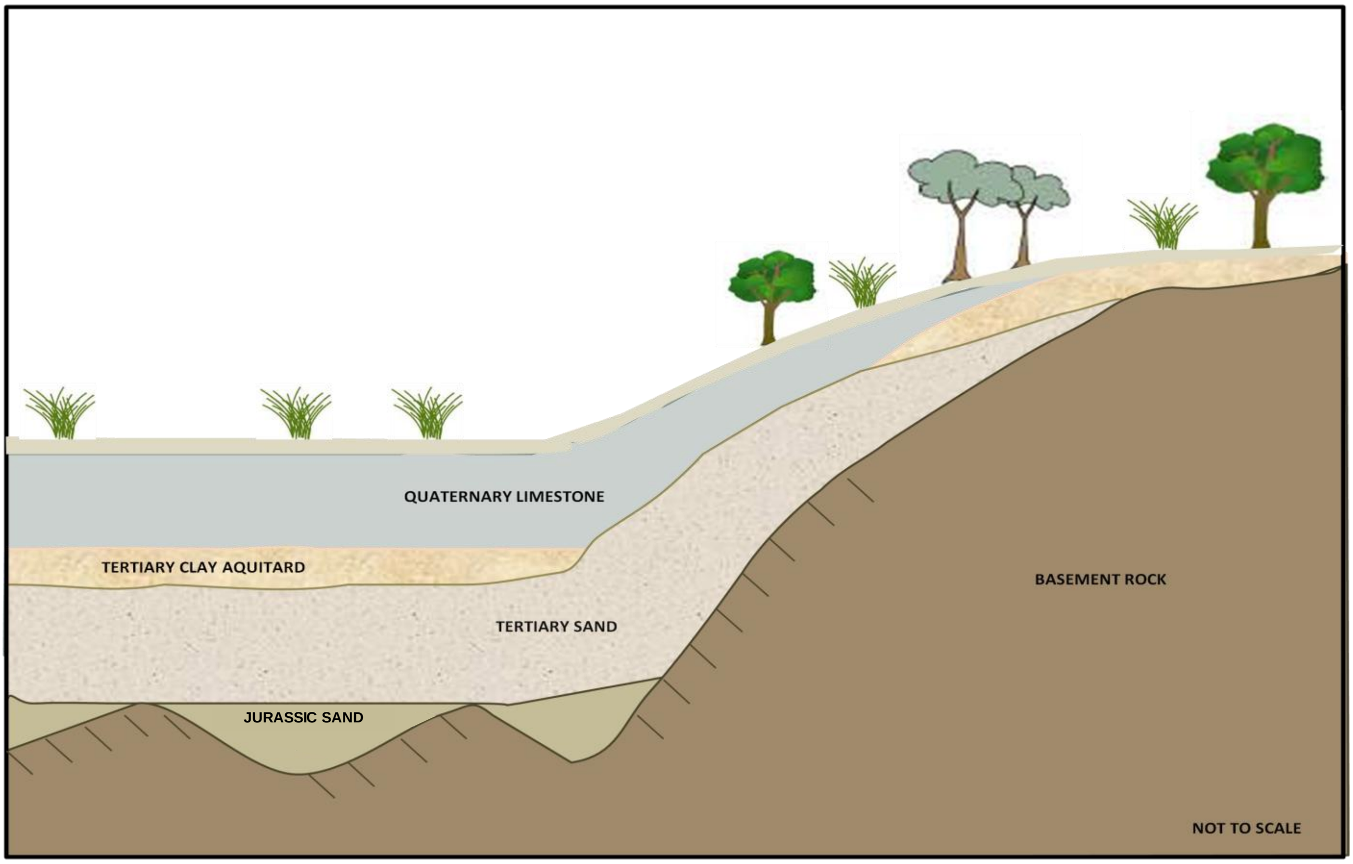

Figure 2. Schematic cross-section of the Musgrave PWA aquifers

GROUNDWATER DEPENDENT ECOSYSTEMS

Whilst groundwater dependent ecosystems (GDEs) have not been considered in this assessment of the status of the groundwater resource, it is important to note the presence and ecological characteristics of the GDEs found in the Musgrave 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.

Water dependent ecosystems that potentially have a dependence on groundwater have been mapped throughout the Musgrave PWA and comprise wetlands, terrestrial plants and subsurface biota inhabiting water filled voids (stygofauna).

Groundwater dependent wetlands are mostly located close to the coastal edge of the Musgrave PWA. Most of these wetlands are intermittent or seasonal and support bird populations and a wide suite of groundwater dependent terrestrial vegetation species. Lake Newland is the only mapped permanent groundwater dependent wetland within the PWA and supports a diversity of aquatic and terrestrial vegetation, fish and bird species of national conservation significance which are subject to international treaties.

There is little information on the condition the GDEs in the Musgrave PWA; however, the regional decline in groundwater levels over the last 10–15 years has possibly resulted in increased risks to these GDEs. A decline in red gum health has been observed in some areas; however, the exact cause of the decline is yet to be determined.

Direct groundwater discharge to the marine environment which may also support marine animals and plants occurs from the Quaternary Limestone Aquifer along the coastal margin of the Musgrave PWA.

RAINFALL

The Musgrave region is characterised by a Mediterranean climate with warm to hot, dry summers and mild, wet winters. Rainfall is winter dominant. Data from the Elliston rainfall station (18069) and a combination of Terre Station (18081) and Terrah Winds (18165) were chosen for analysis of rainfall trends (locations are shown in Fig. 6). Terre Station was closed in 2002, but Terrah Winds (located 13 km away) has been operational since 1969. Examination of data from both stations over a common period indicates a 93% statistical correlation, which indicates the trends are virtually identical. Interpolation of rainfall data to areas between measured sites is common practice and is carried out by the Bureau of Meteorology.

The cumulative deviation from mean monthly rainfall is graphed in blue in Figures 3 and 4 to identify periods where rainfall trends are above or below average. An upward slope indicates a period where the rainfall is greater than the average, while a downward slope indicates a period where the rainfall is below the average.

Both stations show a prolonged period of below-average rainfall since 1981, with the exception of very wet years in 1994 and 2007. Above-average rainfall was recorded during 2009–10.

Groundwater levels in the Musgrave PWA are highly dependent on recharge from rainfall and the historic data has indicated that above or below-average trends can last for up to 25 years. More effective recharge is observed when rainfall occurs in high intensity events between the months of May and October.

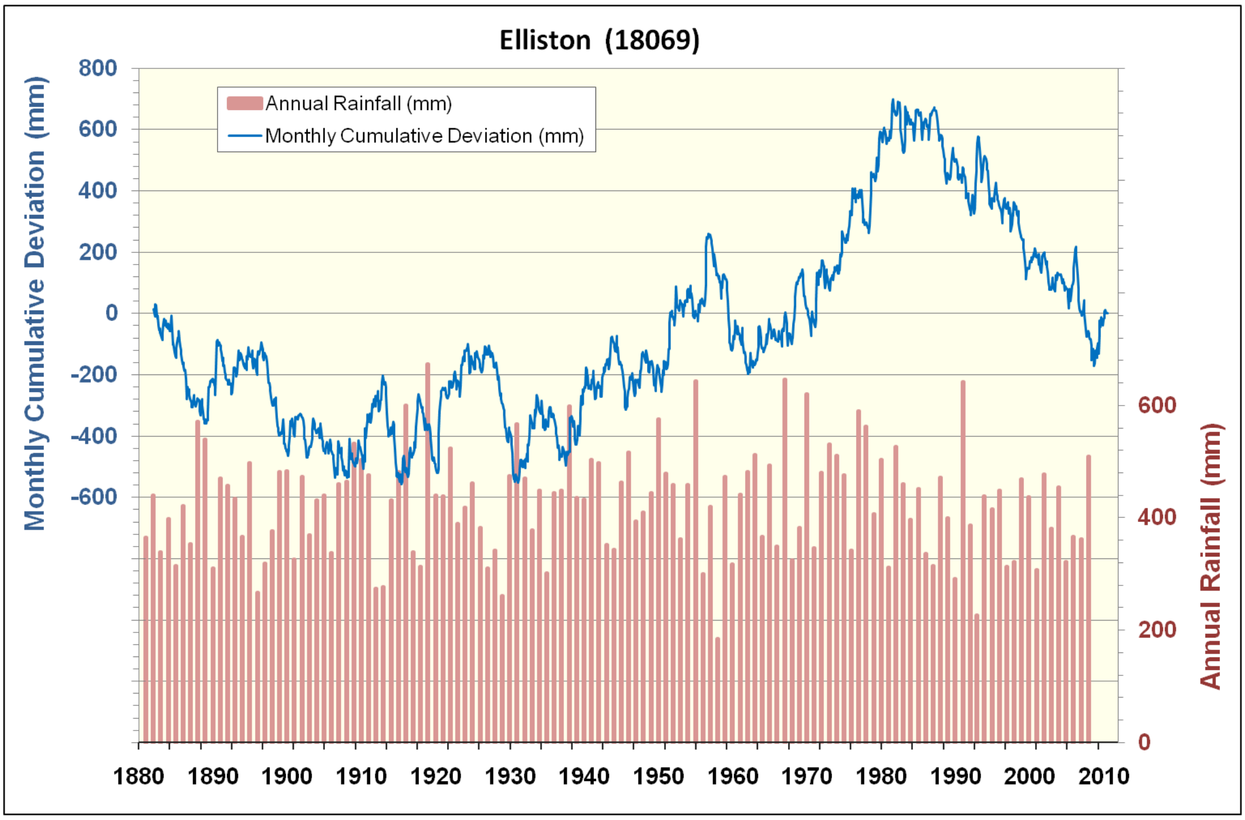

Figure 3. Annual rainfall and cumulative deviation for mean monthly rainfall for the Elliston station in the Musgrave PWA

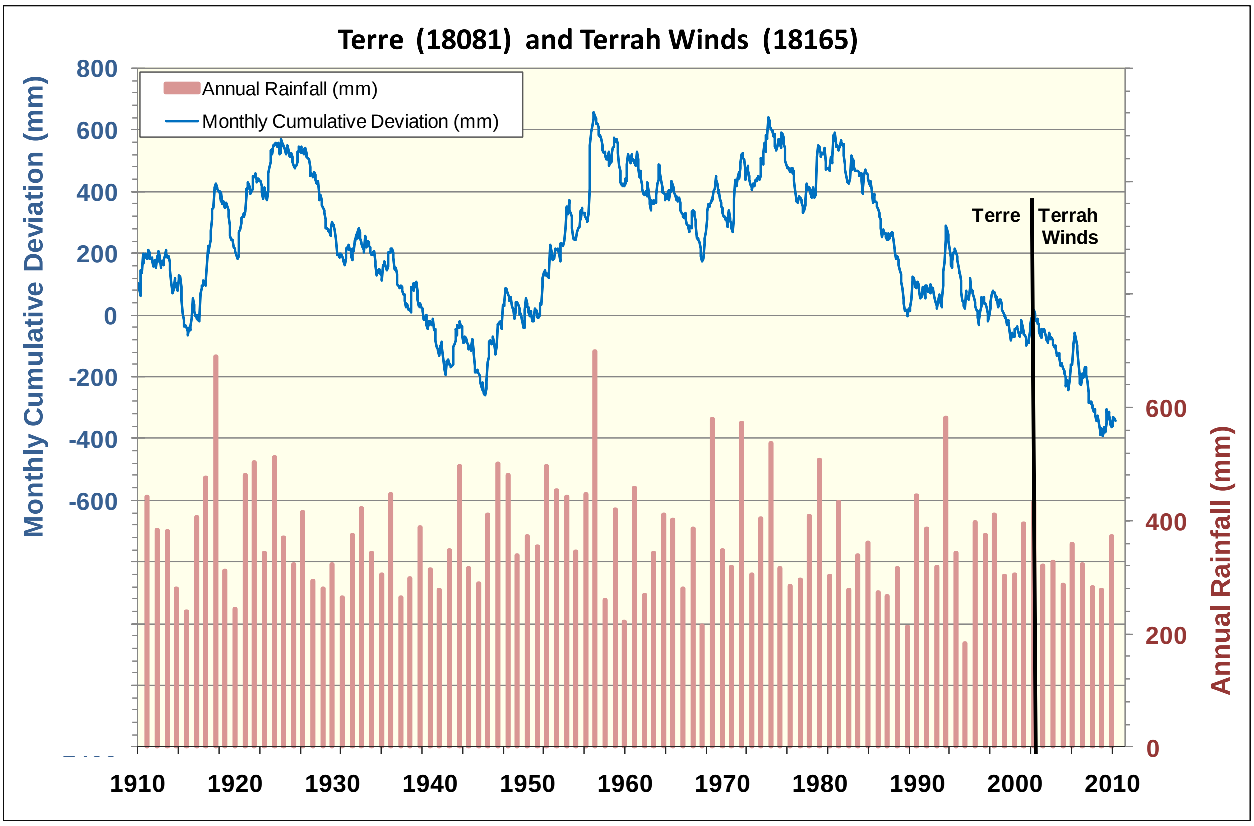

Figure 4. Annual rainfall and cumulative deviation for mean monthly rainfall for the Terre and Terrah Winds station in the Musgrave PWA

GROUNDWATER USE

Licensed groundwater extractions in the Musgrave PWA for 2009–10 totalled 81.7 ML (Fig. 5). This figure is derived from metered data and is virtually identical to extractions during the previous year. The vast majority of the extractions in the Musgrave PWA are for public water supply, with only 11.4 ML extracted in 2009–10 for other licensed purposes such as irrigation (Table 1). These volumes represent only 5–10% of the licensed extraction limit which is displayed in blue in Figure 5 (the scale is shown on the right hand axis). The licensed extraction limit is defined as 40% of the calculated recharge to the Quaternary Limestone Aquifer and is determined in accordance with the current Water Allocation Plan.

The sharp fall in extractions since 2003–04 has been the result of falling groundwater levels in the Polda Basin caused by an extended period of below-average rainfall. Water restrictions imposed on the public water supply since 2008 also reduced demand.

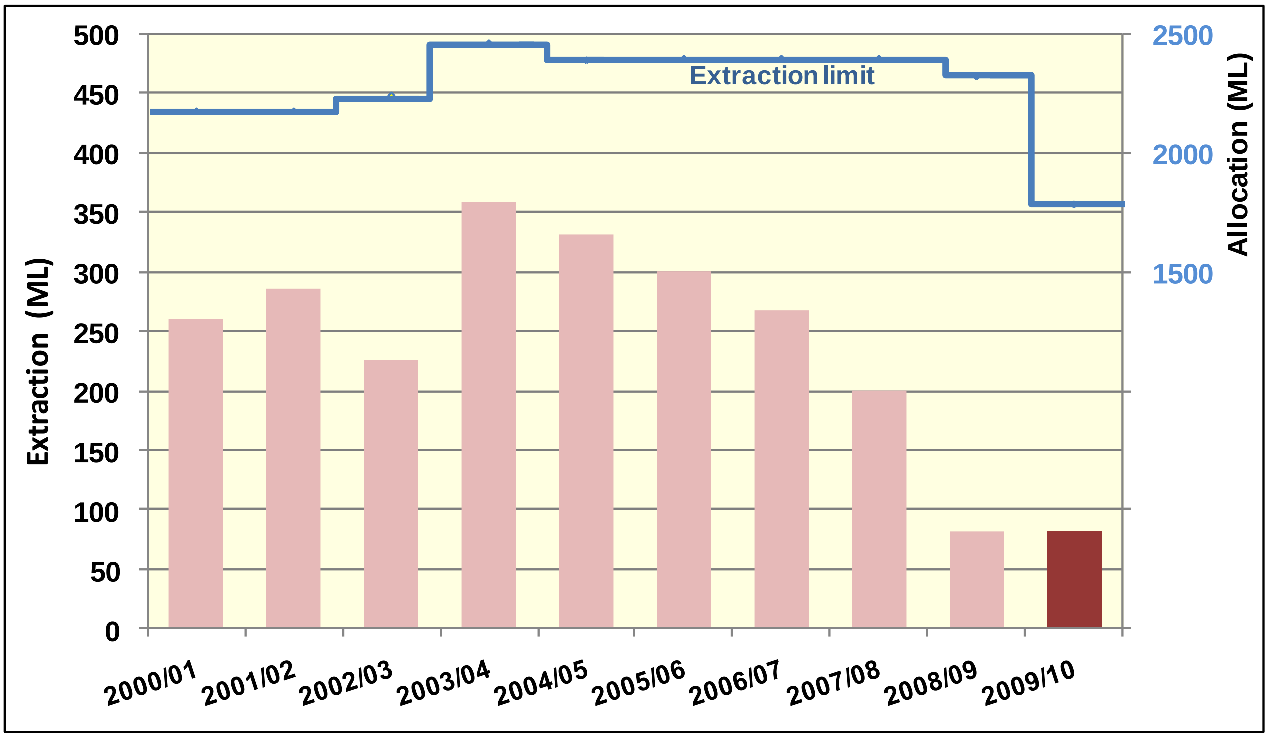

Figure 5. Historic licensed groundwater use and extraction limit in the Musgrave PWA

Table 1. Licensed groundwater use per basin in the Musgrave PWA for 2009-10

Basin	Extraction (ML)
Polda	
Public supply	0
Irrigation	0.6
Bramfield	
Public supply	70.3
Irrigation	10.8
Total	**81.7 ML**

GROUNDWATER OBSERVATION NETWORKS

WATER LEVEL NETWORK

The groundwater level observation network for the Musgrave PWA can be seen in Figure 6. Groundwater level monitoring of the various Musgrave Basins began in 1962. There are currently 127 wells monitoring water levels, with 64 known to monitor the Quaternary Limestone Formation (Table 2). Most of these wells are monitored on a monthly basis to enable the assessment of both the long and short-term trends.

Table 2. Groundwater level observation wells per aquifer/lens in the Musgrave PWA

Aquifer	Lens	Number of wells
Quaternary (Bridgewater Formation)	Polda	34
	Bramfield	7
	Kappawanta	10
	Sheringa	12
	Talia	1
Tertiary (Poelpena Formation)		61
Pre-Tertiary Basement		2
Total		**127**

SALINITY NETWORK

The salinity observation network consists of 78 wells (Fig. 7), the majority of which are monitored annually. Of this total, 46 monitor the Quaternary Bridgewater Formation and 32 monitor the Tertiary Poelpena Formation (Table 3).

Table 3. Groundwater salinity observation wells per aquifer/lens in the Musgrave PWA

Aquifer	Lens	Number of wells
Quaternary (Bridgewater Formation)	Polda	24
	Bramfield	6
	Kappawanta	6
	Sheringa	9
	Talia	1
Tertiary (Poelpena Formation)		32
Total		**78**

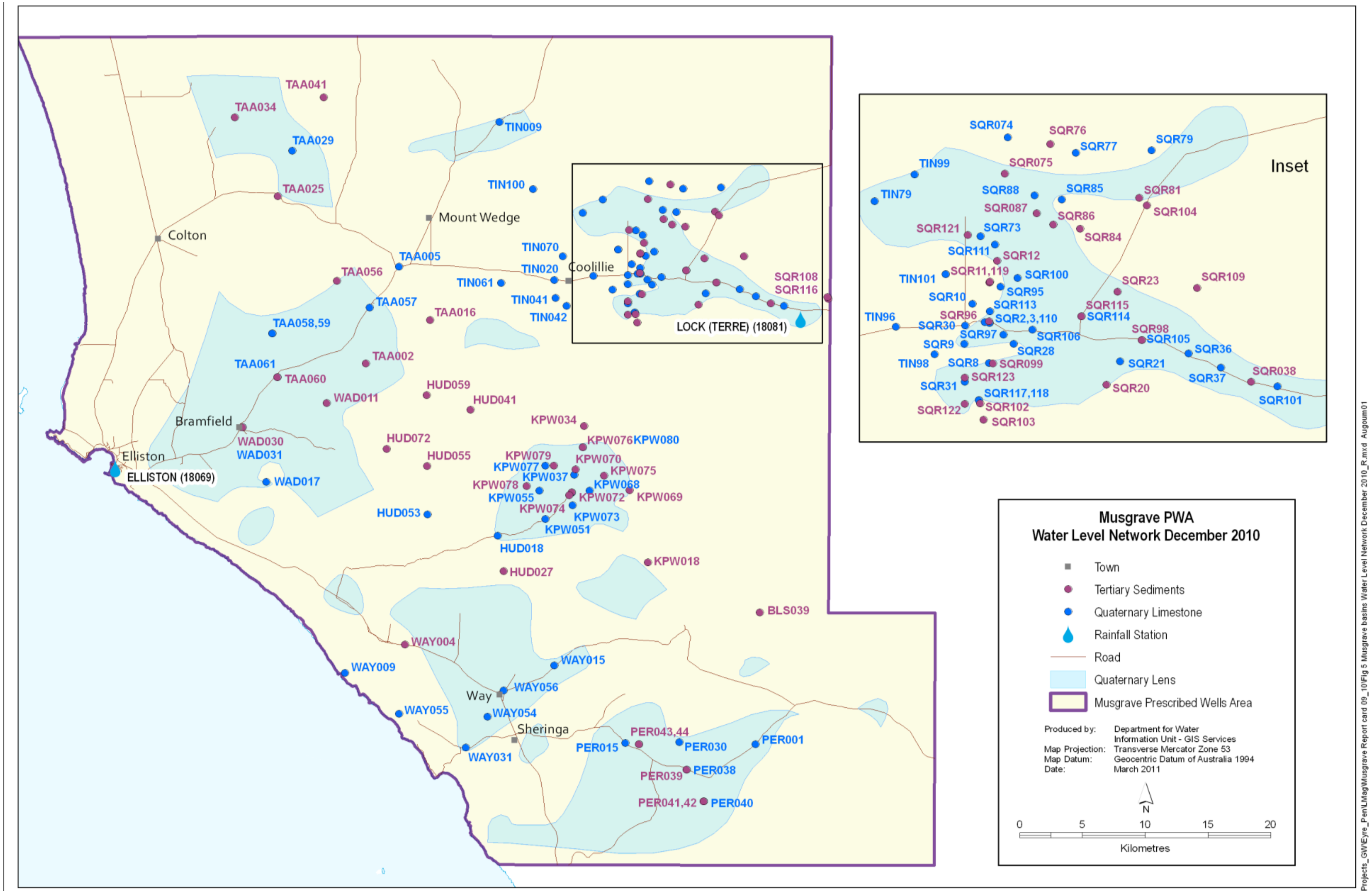

Figure 6. Location of groundwater level observation wells in Musgrave PWA

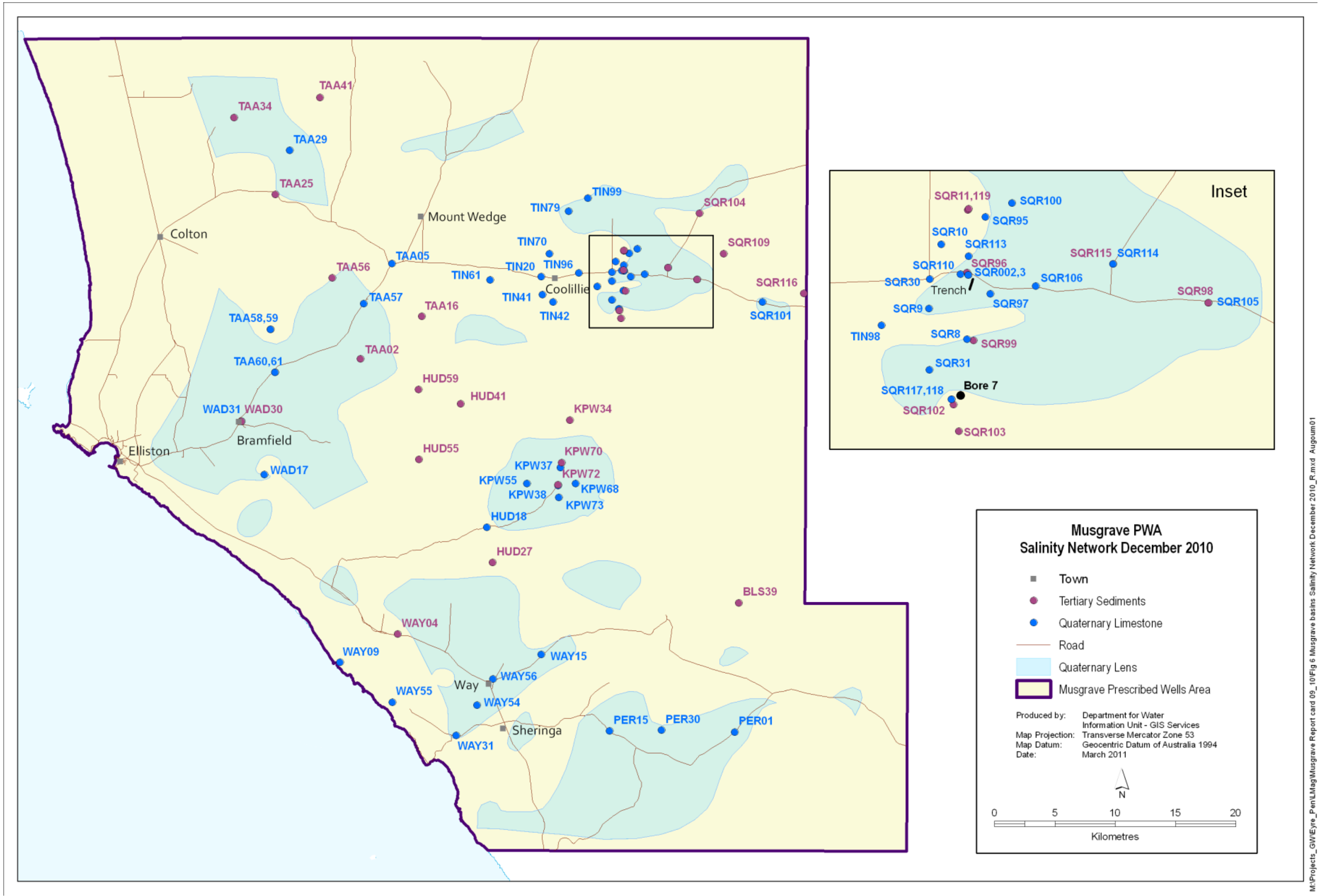

Figure 7. Location of groundwater salinity observation wells in Musgrave PWA

BASIN TRENDS

Within the Musgrave PWA there are several basins that contain groundwater in the Quaternary Limestone Aquifer. Within these basins there are lenses with salinities of less than 1000 mg/L which are defined in Figure 8. The extent of these lenses may cover most of the recognised basin areas or, in some cases, only part of a basin which may contain generally higher salinity groundwater. The extent of the lenses may also change over time depending on long term trends in rainfall (and hence recharge). The basins have been used for extraction to varying degrees and trends from groundwater monitoring data for each basin are discussed in turn.

Figure 8. Location of freshwater lenses within the Musgrave PWA

POLDA BASIN

The Polda Basin has provided groundwater for the Eyre Peninsula reticulated water supply system since 1963. Before 2000, this contribution has averaged about 15% of the total supply. SA Water extracts groundwater from the Trench and Bore 7 which are located in the inset in Figure 7. Due to the continued low effective recharge, increasing groundwater salinity and the characteristics of the extraction infrastructure, groundwater extraction by SA Water (the main user of groundwater in the Basin) ceased from Polda Lens in June 2008 and is currently restricted by a Notice of Prohibition. This notice also significantly restricts extractions by other licence holders.

The Polda Basin has been divided into three lenses based on hydrogeology and groundwater flow direction as shown by the blue dashed lines in Figure 11.

GROUNDWATER USE

Figure 9 shows the extraction history since 2000–01, which has shown a decreasing trend in use since 2003–04. Extractions for this period have always been well below the licensed extraction limit shown in blue in Figure 9. This extraction limit is determined by a process outlined in the Water Allocation Plan.

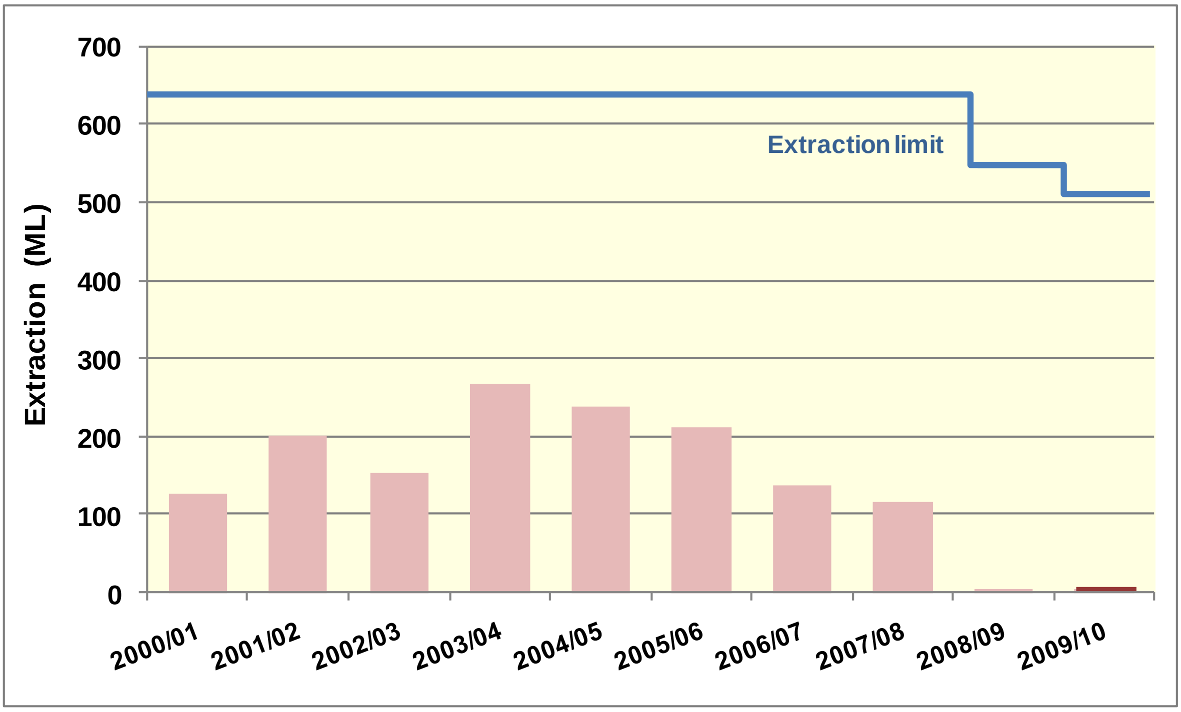

Figure 9. Historic licensed groundwater use and extraction limit in the Polda Basin

WATER LEVEL TRENDS

Long-term groundwater level trends can be observed using wells which have long monitoring records and have a representative distribution throughout the basin. Figure 10 displays trends from the Quaternary Limestone Aquifer in each of the three lenses within the Polda Basin (the extent of each lens is shown in Fig. 11). A consistent gradual long-term decline in groundwater levels of up to 3 m is apparent since 1980. This decline shows a very close correlation with below-average rainfall as can be seen by the graph of cumulative deviation from mean monthly rainfall for Terre/Terrah Winds plotted in light blue in Figure 10.

Higher rainfall in 2009 and 2010 has led to a rise in groundwater levels throughout most of the basin. These levels however, are still lower than those recorded prior to the early 1990s.

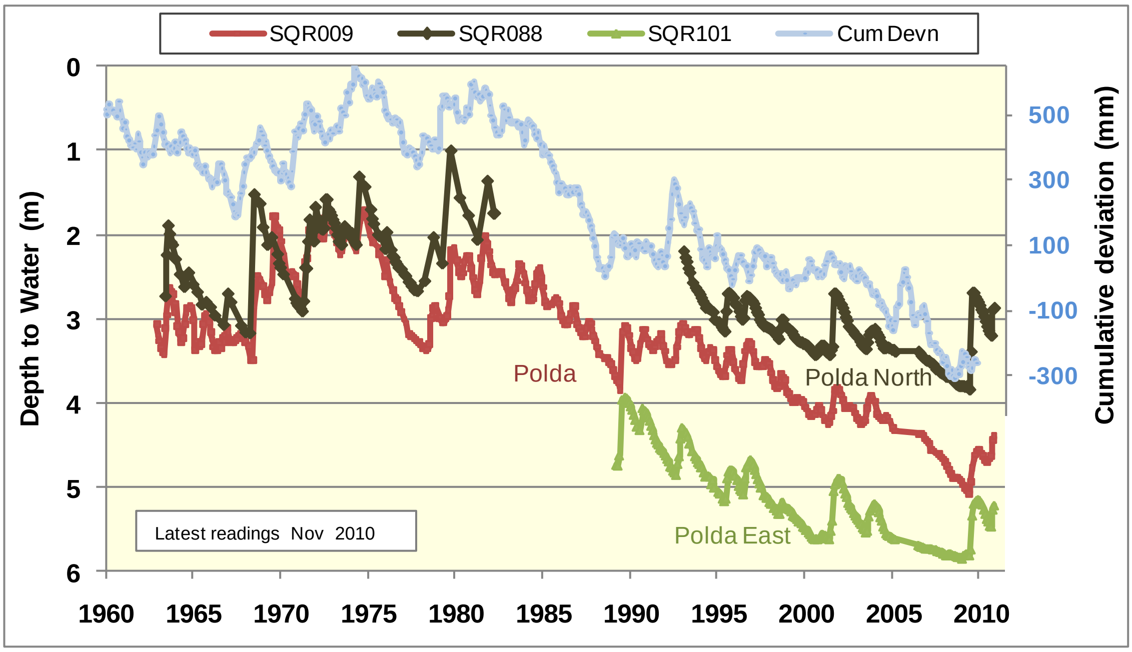

Figure 10. Groundwater level trends for the Polda Basin

Figure 11 shows the observed groundwater level rise (in metres) for each observation well completed in the Quaternary Limestone Aquifer within the Polda Basin from July 2009 to December 2010. Virtually all of the wells throughout the basin show rises of over 0.5 m, ranging from 0.53 m at observation well TIN098, to 1.7 m at observation well SQR111.

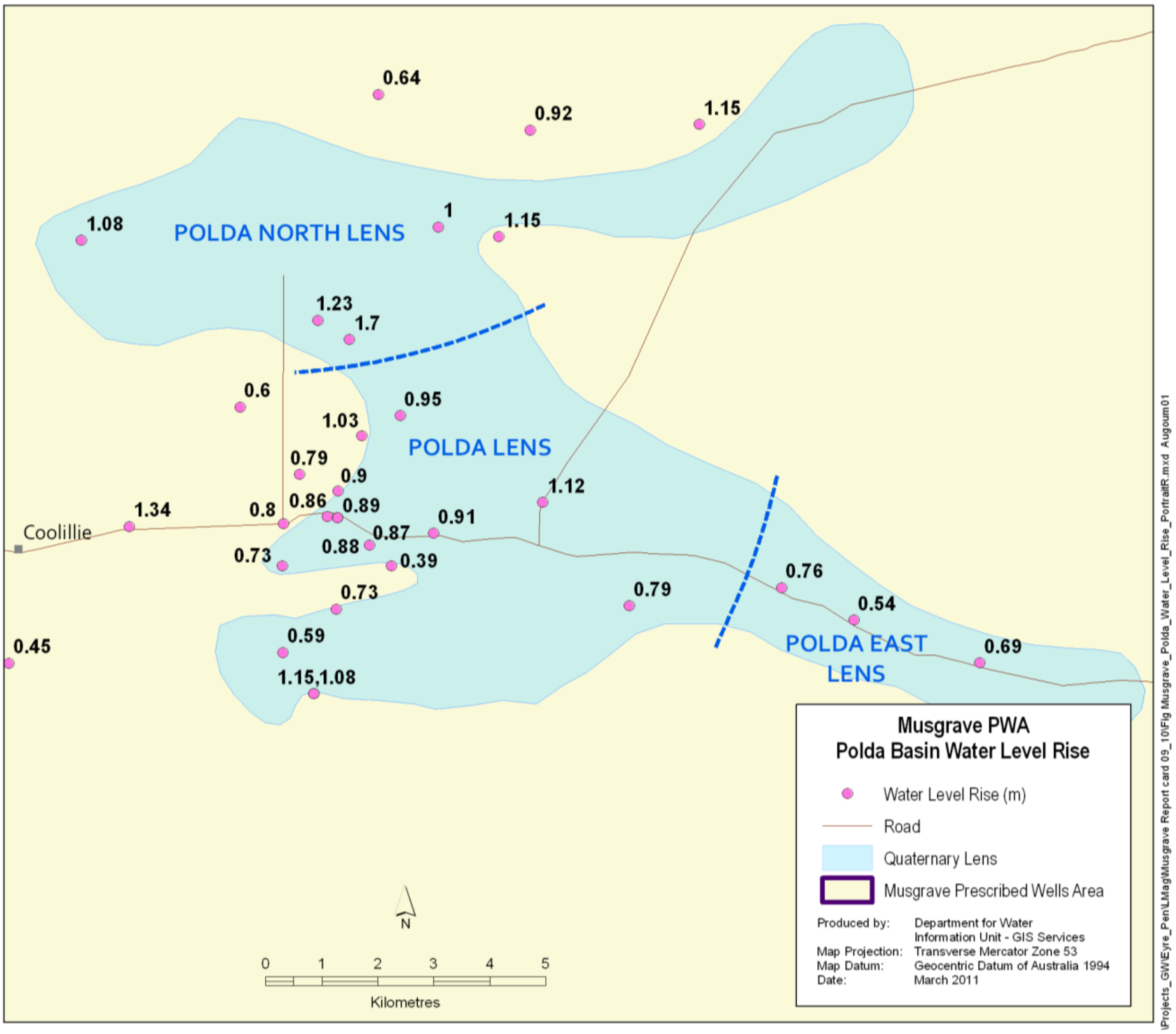

Figure 11. Water level rise for the Polda Basin (July 2009 to December 2010)

SALINITY TRENDS

Figure 12 shows the observed groundwater salinity trends from representative Quaternary Limestone Aquifer observation wells located in the three lenses of the Polda Basin. Observation well SQR101 (black) is in the Polda East lens, observation wells SQR031 (in orange) and SQR106 (in red) in the Polda lens, while observation wells SQR111 and TIN079 (in green) are located in the Polda North lens. All show a rise in salinity after 2005, compared to the previous measurements taken in the early 1990s. The widespread increase in groundwater salinity measured in most observation wells coincided with a prolonged period of below-average rainfall, much reduced recharge and declining groundwater levels. The increases from all the monitored wells ranged up to 350 mg/L which represents a 70% increase in salinity. No monitoring was carried out between 1996 and 2006.

The cause of this salinity increase is being investigated, but the evidence so far suggests concentration of salt by evapotranspiration (whereby water is discharged from the aquifer but the salt remains behind) as a possible mechanism.

Most of the monitored wells show a freshening trend after November 2009 in response to the increased recharge caused by above-average rainfall experienced in 2009 and 2010. Wells SQR101 and SQR111 do not have a complete sampling record in recent years due to the falling groundwater level in the wells making sampling impractical.

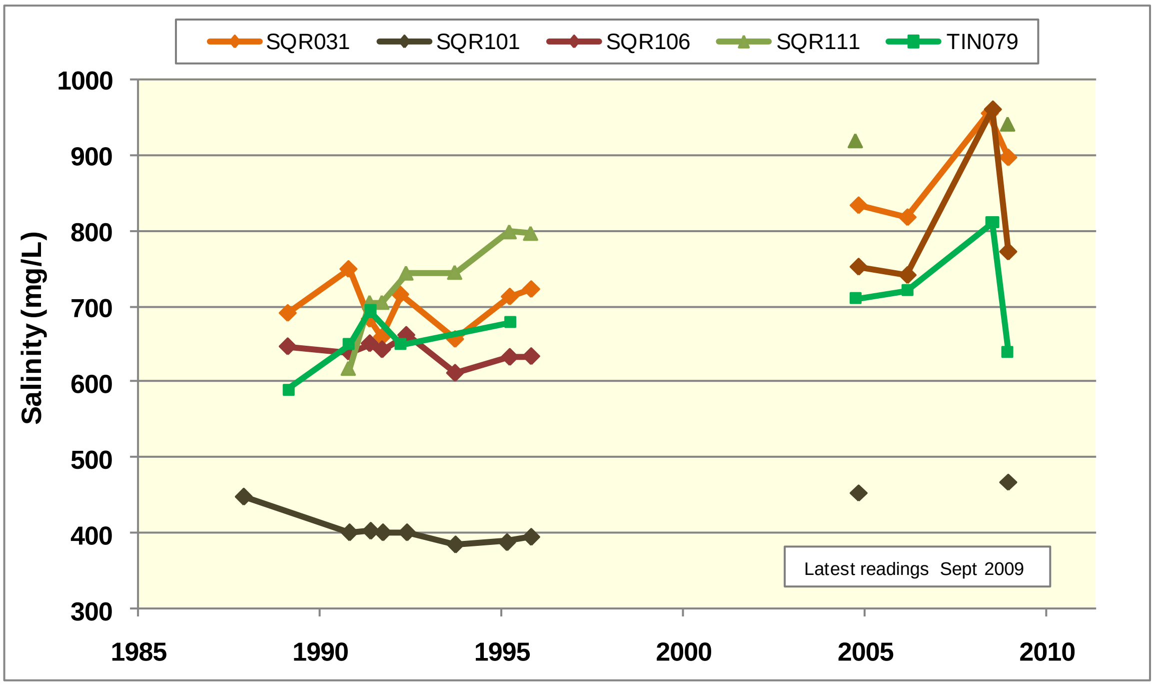

Figure 12. Groundwater salinity trends for the Polda Basin

BRAMFIELD BASIN

Major extractions from the Bramfield Basin, which lies just to the east of Elliston, commenced in 1974 with the commissioning of the Elliston town water supply. Volumes of licensed extraction from the basin since 2000–01 are presented in Figure 13. In 2009–10, SA Water extracted 70 ML for the Elliston town water supply, with an additional 11 ML extracted by other licence holders for irrigation purposes. There has been little change in extractions over recent years, which are well below the licensed extraction limit displayed in blue in Figure 13 (the scale is shown on the right hand axis). The licensed extraction limit is defined as 40% of the calculated recharge to the Quaternary Limestone Aquifer and is determined in accordance with the current Water Allocation Plan.

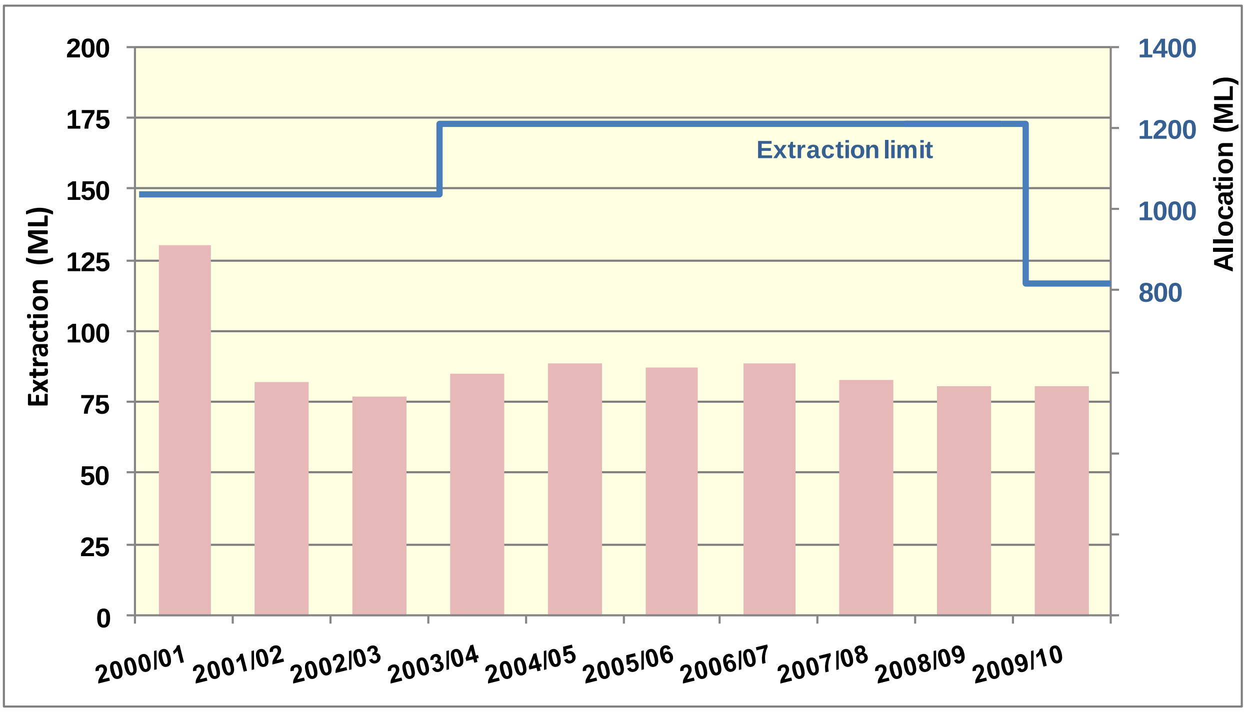

Figure 13. Historic licensed groundwater use and extraction limit from the Bramfield Basin

WATER LEVEL TRENDS

Long term groundwater level trends are presented as hydrographs (Fig. 14) of representative Quaternary Limestone Aquifer observation wells from various locations within the Bramfield Basin. They show a steady decline in groundwater levels of 2 to 3 m over the past 20 years, until the wetter period of 2009 and 2010 resulted in a significant rise in water levels. As in other areas, there is a close relationship between water level trends and rainfall patterns with recharge (and water level rises) occurring only in wet years. The graph of cumulative deviation from mean monthly rainfall for Elliston is plotted in light blue in Figure 14.

The recent above-average rainfall has resulted in significant groundwater level rises in the Bramfield Basin. Figure 15 presents the rises in water level from July 2009 to December 2010, which range from 0.67 m at observation well TAA058, to 2.77 m at observation well WAD017, with an average rise of 1.3 m.

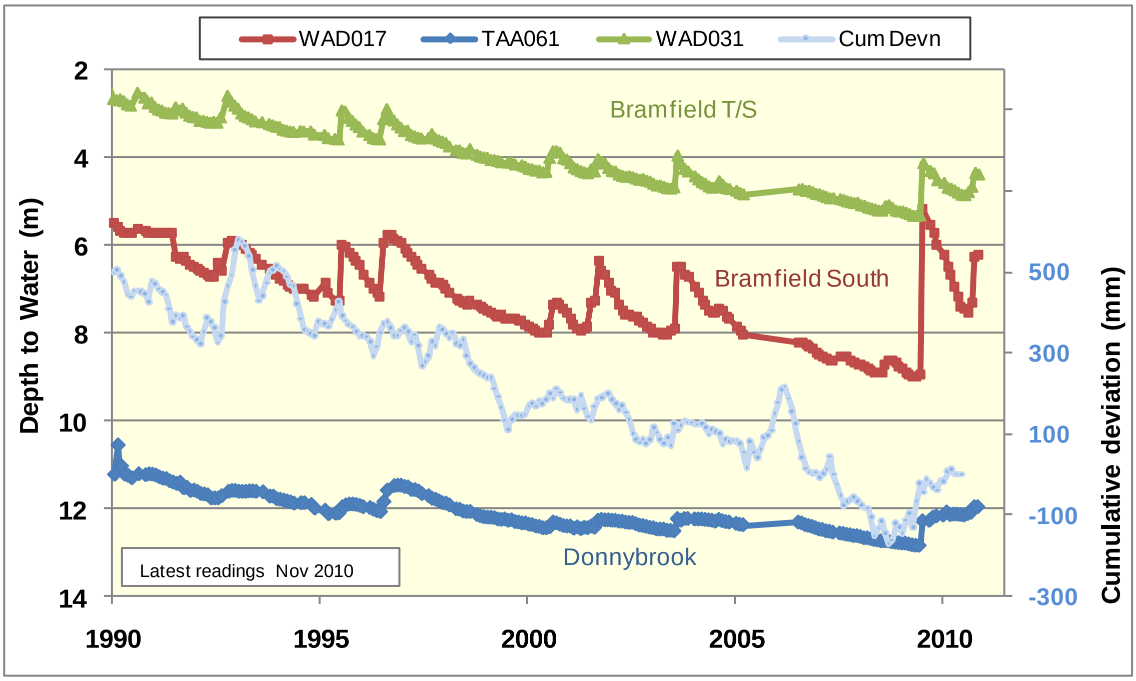

Figure 14. Groundwater level trends for the Bramfield Basin

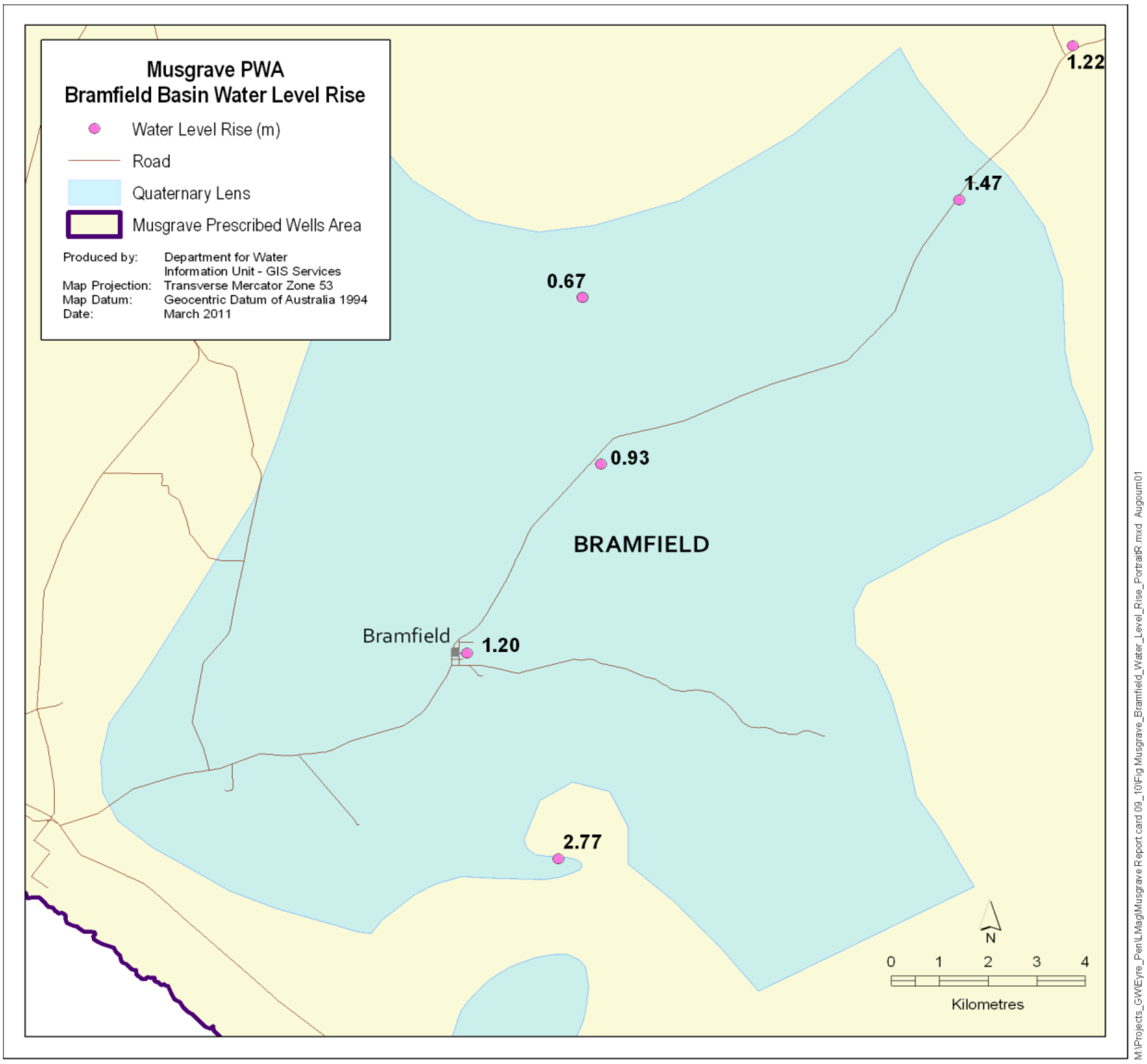

Figure 15. Water level rise for the Bramfield Basin (July 2009 to December 2010)

SALINITY TRENDS

Figure 16 shows the observed long-term salinity trends in the Bramfield Basin since 1990. Observation wells TAA061 and WAD031 are characterised by a gradual increasing salinity trend of 4 mg/L/y since 1990. Only observation well TAA058 showed a freshening due to increased recharge in 2009–10.

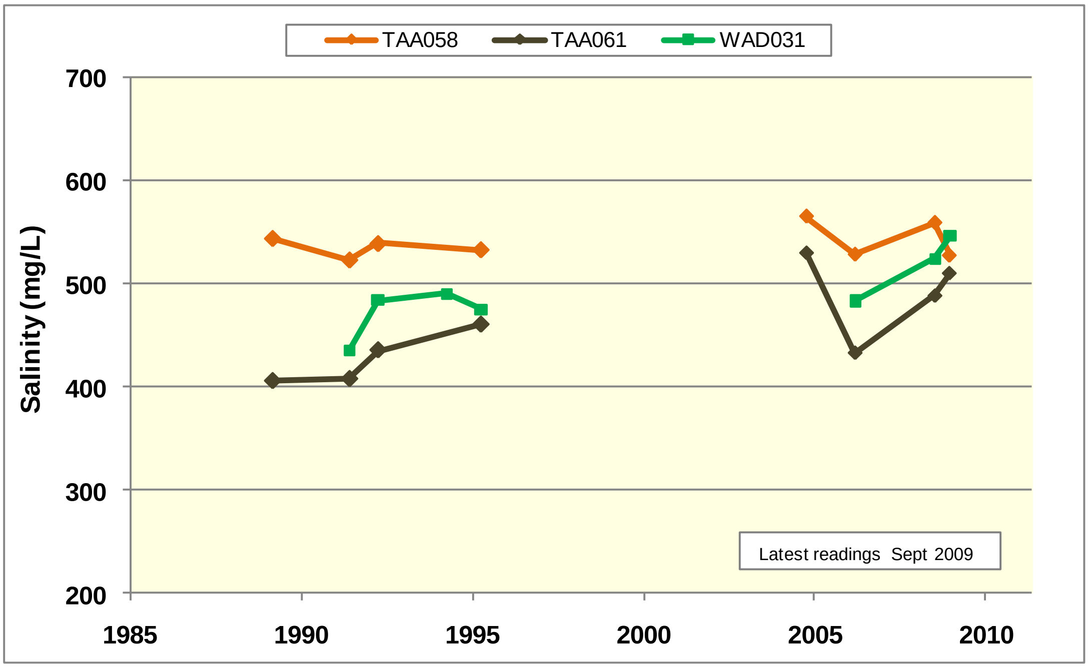

Figure 16. Groundwater salinity trends for Bramfield Basin in the Musgrave PWA

MINOR BASINS

Monitoring data for the Kappawanta, Sheringa and Talia Basins is analysed as a whole, rather than individually, as there are no significant extractions except for stock and domestic purposes.

WATER LEVEL TRENDS

Long-term groundwater level trends from representative observation wells within the minor basins of the Musgrave PWA are presented in Figure 17. The observed trends are fairly consistent and show significant declines in groundwater levels over the past 20 years due to below-average rainfall. Water levels in all minor basins indicate a response to the wetter period of 2009 and 2010.

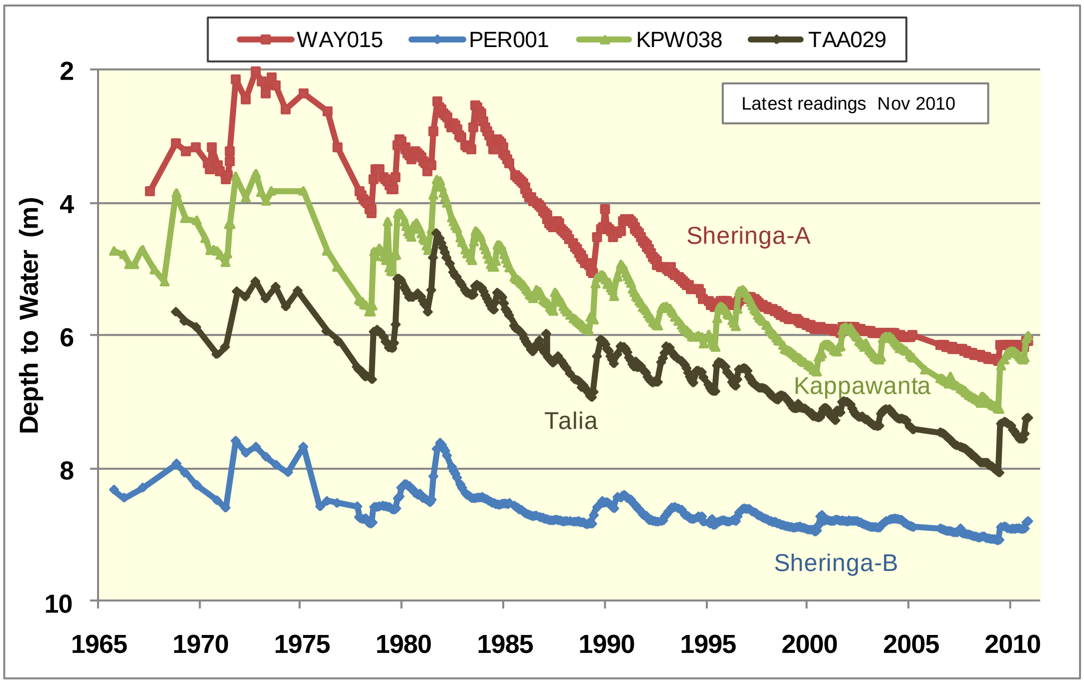

Figure 17. Groundwater level trends for minor basins in the Musgrave PWA

Figure 18 shows the observed water level rises in the Quaternary Limestone Aquifer for the minor lenses due to the high rainfall during 2009–10. The rises varied from 0.17 m in observation well PER030 to 2.1 m in observation wells KPW038 and TAA009.

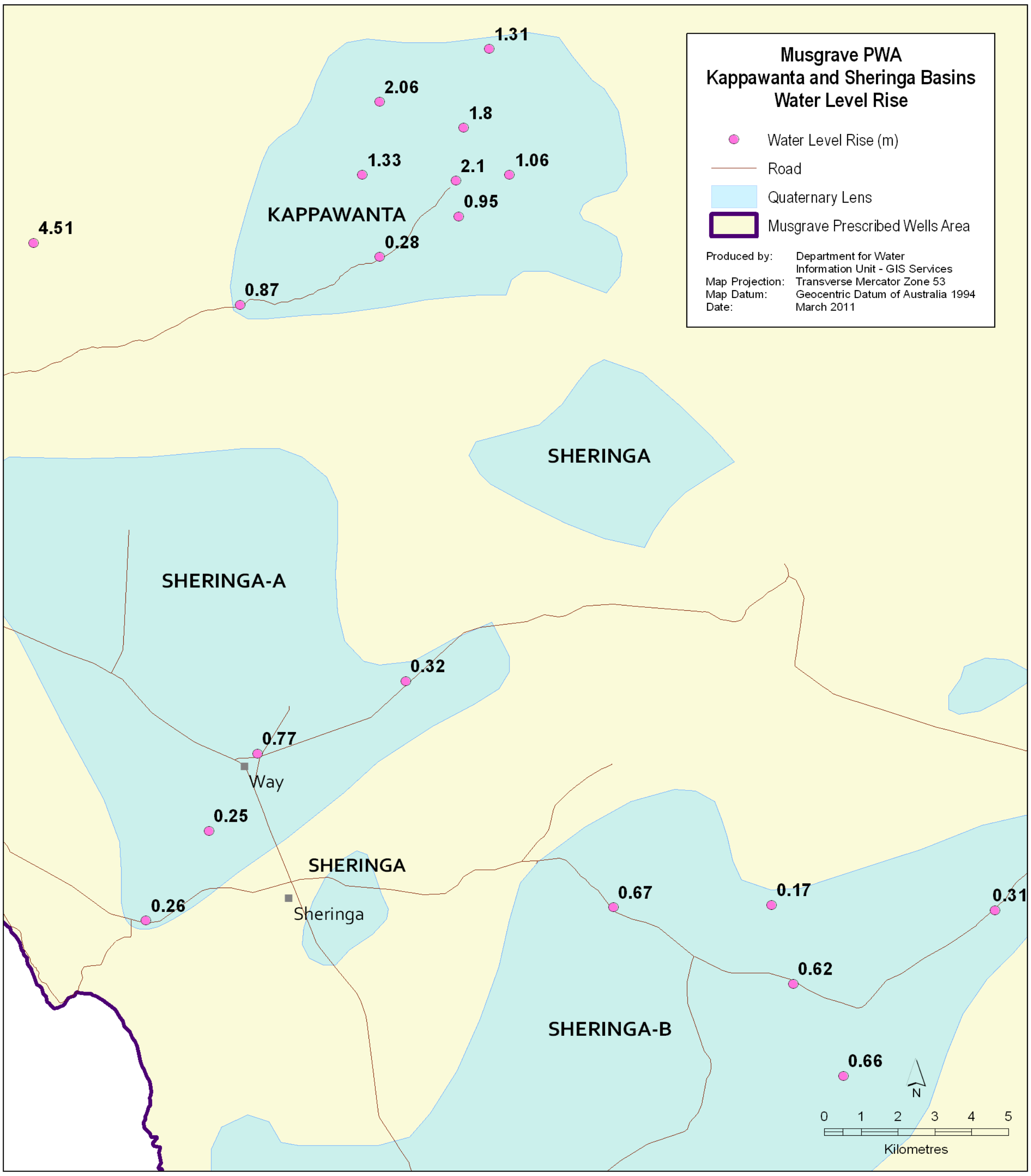

Figure 18. Water level rise for the minor basins (July 2009 to December 2010)

SALINITY TRENDS

Figure 19 shows groundwater salinity trends from wells located in the various minor lenses. The graph shows that salinity levels are relatively stable, despite the lack of monitoring between 1996 and 2006.

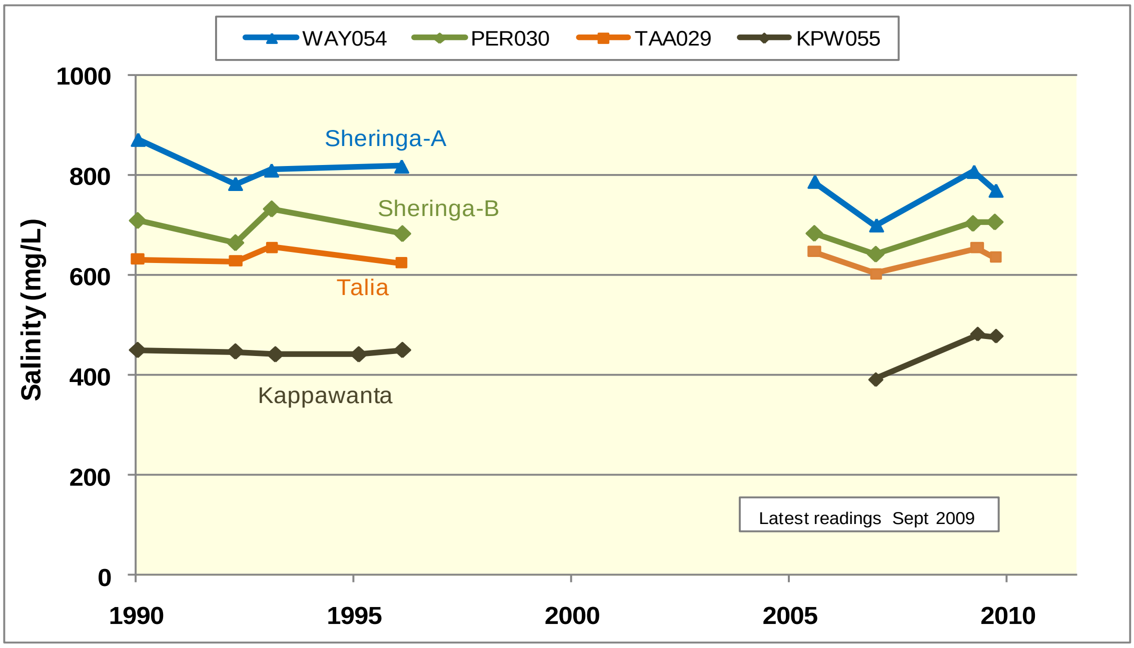

Figure 19. Groundwater salinity trends for minor lenses in the Musgrave PWA

TERTIARY SAND AQUIFER

WATER LEVEL TRENDS

Long-term groundwater level trends in the Tertiary Sand Aquifer, for representative observation wells from various basins within the Musgrave PWA, are presented in Figure 20. There are no extractions from this aquifer in the basins shown. The trends are virtually identical to those observed in the overlying Quaternary Limestone Aquifer in each basin and similarly show long-term declines due to below-average rainfall. For the water levels for observation well KPW079, refer to the right hand axis in blue.

The hydrographs in Figure 20 generally show a water level decline of several metres since the wet year in 1993. All wells show an increase in groundwater level indicating a significant response to the wetter 2009 and 2010 period, with rises ranging from 0.84 to 1.75 m since July 2009.

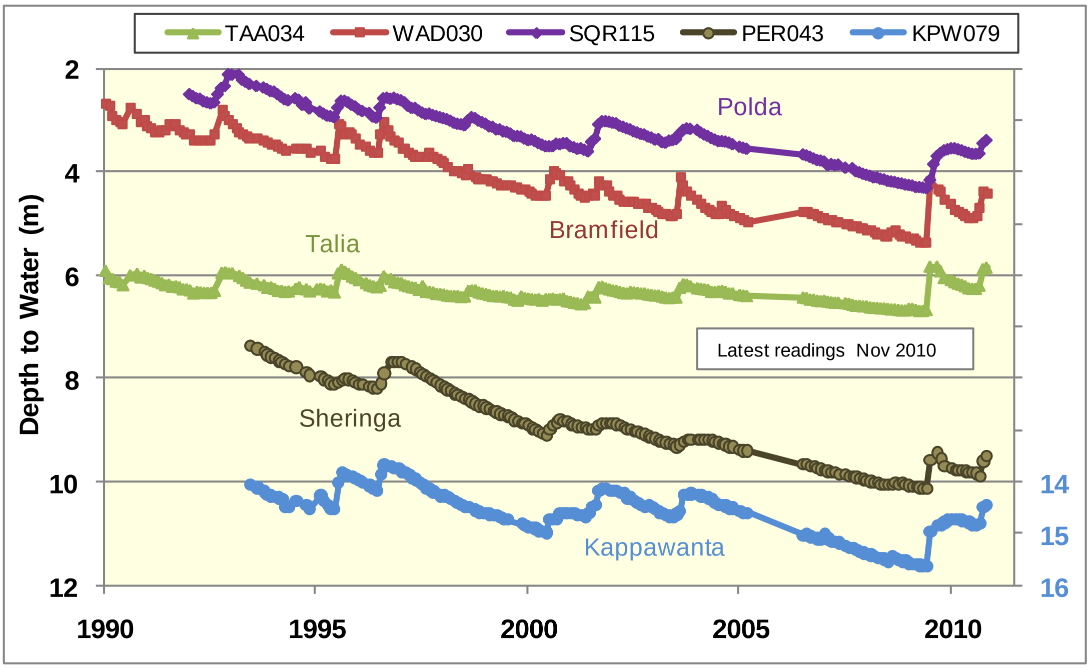

Figure 20. Groundwater level trends for the Tertiary Sand Aquifer in the Musgrave PWA

The near-identical trends indicate a strong hydraulic connection between the limestone and sand aquifers which would be facilitated by a thin or absent clay confining layer. In deeper parts of the basins where the confining layer is extensive, the identical trends may be caused by a hydrostatic loading effect.

SALINITY TRENDS

Long-term groundwater salinity trends in the Tertiary Sand Aquifer are presented in Figure 21. There are a limited number of observation wells with suitable data for salinity analysis. Despite the lack of monitoring between 1996 and 2006, the trends show no significant changes in salinity.

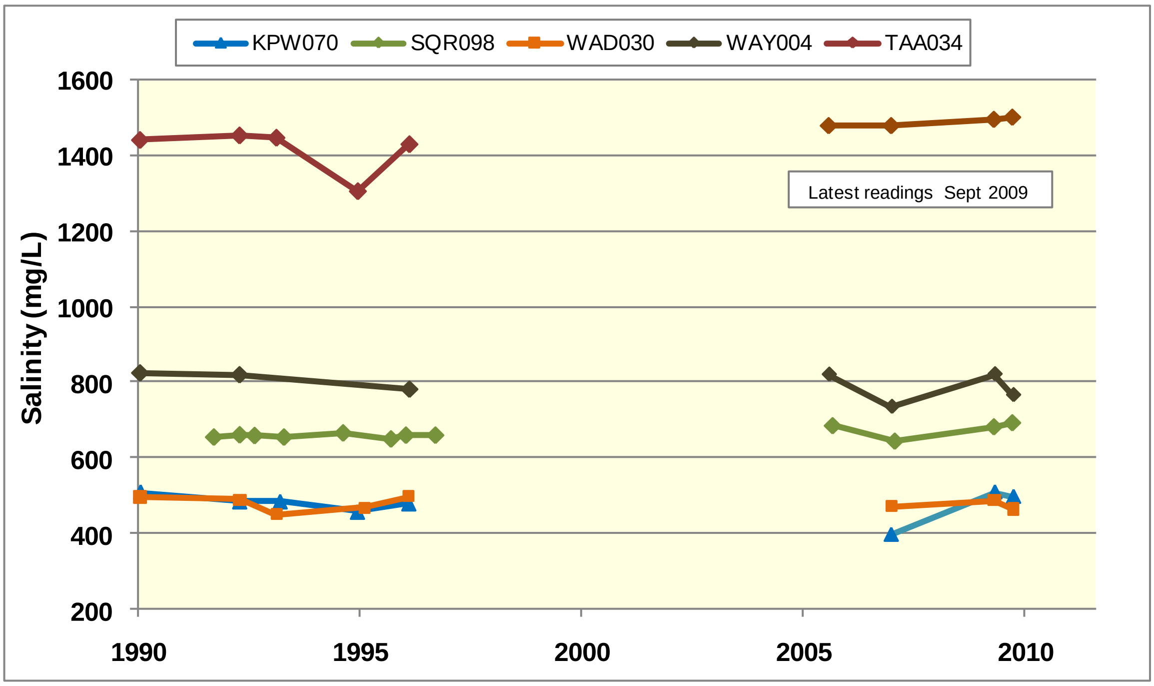

Figure 21. Groundwater salinity trends for the Tertiary Sand Aquifer in the Musgrave PWA