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Department of Water, Land and Biodiversity Conservation

GROUNDWATER RESOURCE ASSESSMENT OF THE BAROOTA PRESCRIBED WATER RESOURCES AREA

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INTRODUCTION

A Notice of Prohibition was first introduced over the groundwater resources in the Baroota area on 30 June 2000 in response to concerns about the impacts of increased extractions in the area. As part of this process in 2001, groundwater users in the area were assessed and issued with authorisations that would allow them to continue to operate as they had in the past, while meters were installed and the resource assessment was completed. The watercourse water, surface water and wells were subsequently prescribed as the Baroota Prescribed Water Resources Area (BPWRA) under the *Natural Resources Management Act 2004* (the Act) on 19 June 2008.

This report provides an assessment of the capacity of the groundwater resources to help determine the amount of groundwater that can be allocated (as required by Sec 155 of the Act). The social and economic impacts from such extractions (as required by Sec 76 of the Act) are outside the scope of this report, and will be considered during the formulation of the Water Allocation Plan.

The BPWRA is located about 25 km north of Port Pirie and encompasses an area of 132 km^2 on the coastal plains between the Flinders Ranges and Spencer Gulf (Fig. 1).

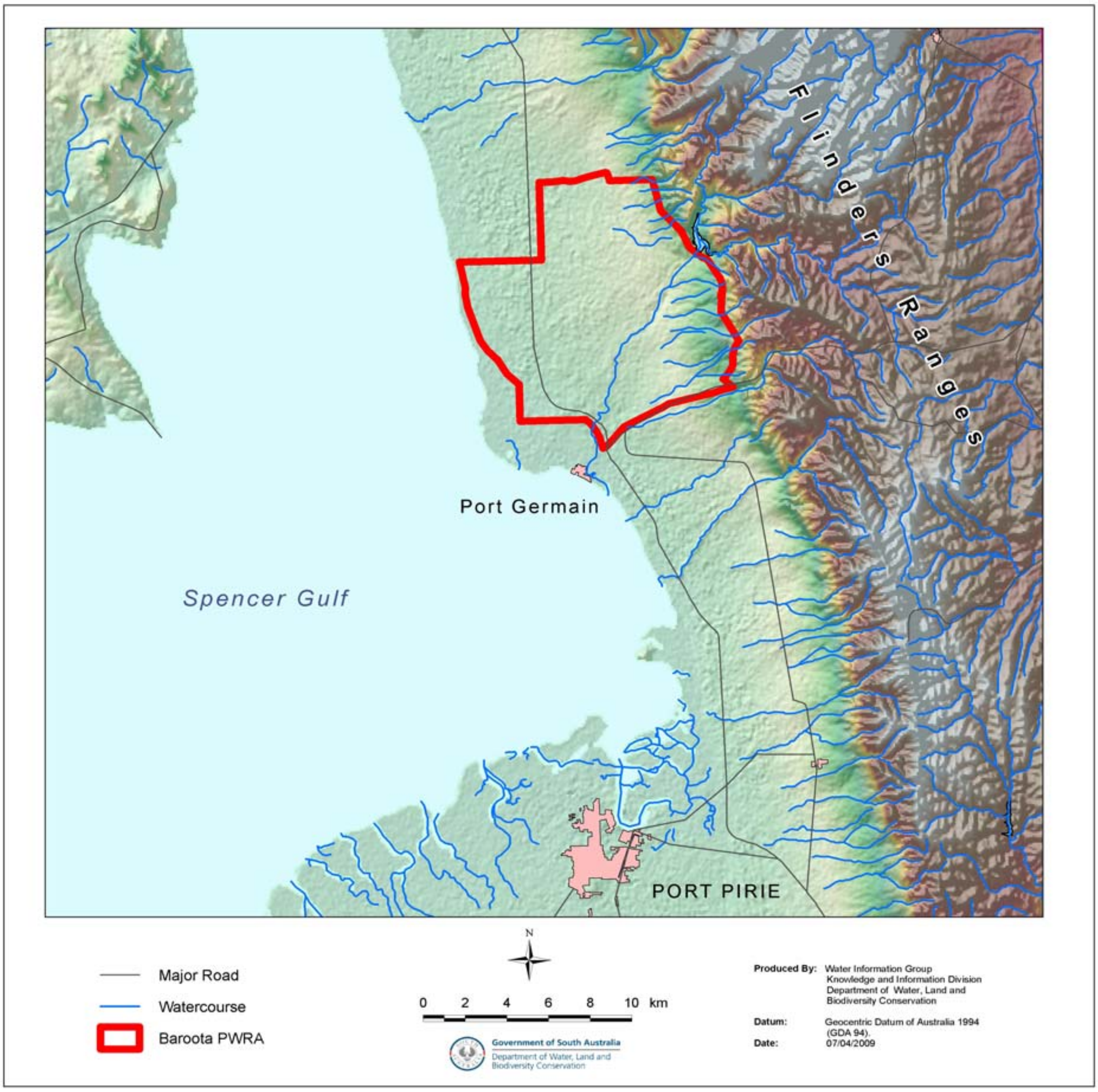

Figure 1. Location of Baroota PWRA

HYDROGEOLOGY

Because of the strong interaction between surface water and groundwater in the BPWRA, a discussion of the surface hydrology is important to gain an understanding of how the groundwater system operates.

SURFACE HYDROLOGY

The catchment area of the Baroota Creek (approximately 136 km^2) is the largest for any creek in the Flinders Ranges that flows to the west across the sediments of the Pirie Basin, between Port Pirie and Port Augusta. The Baroota Dam was completed in 1921 with a capacity of 6100 ML, on Baroota Creek just upstream of the point where it flows out onto the plains (Fig. 2).

Soon after completion it was noted the dam was leaking, with the amount of seepage in Baroota Creek below the dam proportional to the reservoir water level (Clarke, 1990). In 1942, collection of the seepage began by pumping from a system of ditches in the streambed. A more recent investigation (Warneke, 1979), found that although the amount recovered varied between 0.5 and 6 ML/day (depending on the reservoir level), an average of 2 ML/day was not recovered and would have contributed to groundwater recharge. Later in 1986, the seepage recovery program was terminated in response to concerns about falling groundwater levels in the area (Clarke, 1990), thus facilitating even more groundwater recharge.

In addition to the underflow recharge provided by leakage, the dam occasionally overflows, providing short periods (several days in length) of intensive recharge via the gravelly and highly permeable bed of Baroota Creek (Evans, 2004). During the 1989 overflow event, an estimated flow of 100 L/sec was observed in Baroota Creek 500 m downstream of the dam. At observation well BTA 9 located a further 3.5 km downstream, the flow had diminished to only 20 L/sec (Clarke, 1990).

Up until 1997, the reservoir was being used as a balancing storage for the reticulation of River Murray pipeline water, resulting in water levels being higher than those produced from the contributions from local catchment runoff. However since then, SA Water has removed the Baroota Reservoir from the major water distribution network due to water quality issues, and water levels have been consistently lower than before 1997, apart from the wet winters of 2000 and 2001.

HYDROGEOLOGY

The Pirie Basin contains a considerable thickness of alluvial and fluvial Quaternary clays and gravels deposited as outwash from the Flinders Ranges. These units are underlain by Tertiary sediments which directly overlie the Neo-Proterozoic basement (Evans, 2004). In the Baroota area, groundwater extractions for irrigation are obtained solely from permeable gravel beds within the Quaternary sediments whose thickness extends to about 100 m.

These gravel beds are frequently discontinuous and are not laterally extensive. Consequently, mapping discrete aquifers is virtually impossible, as is the determination of the connection between the various gravel layers. In addition, some wells extract from more than one aquifer through multiple screened intervals.

This heterogeneity of the aquifer system can only allow broad interpretations of groundwater level and salinity trends, and prevents a detailed assessment of the resource capacity.

Regionally within the Pirie Basin, groundwater would flow from the fractured rock aquifers of the Flinders Ranges in the east, through the Quaternary and Tertiary sediments, to discharge at the coast in the west. Recent drilling in the Ranges about 7 km southeast of Baroota Reservoir found groundwater salinities of below 1500 mg/L in several wells, suggesting that the groundwater contribution from the fractured rock aquifer to the Pirie Basin sediments can be of reasonable quality. However because of the generally low permeability of the basin sediments and very slow groundwater movement, salinities quickly rise downgradient to the west to levels over 5000 mg/L.

Only at locations where surface water discharge from the Ranges is concentrated in streams flowing out onto the plains (such as Baroota Creek), does local recharge occur, with the impacts superimposed on the regional flow system. The permeable sand and gravel beds deposited by streams over geological time enhance the recharge process, which has formed significant areas of low salinity useable groundwater.

Figure 2 presents the groundwater salinity distribution in the Baroota PWRA which shows the reasonably large area of low salinity groundwater developed for irrigation. Also shown are the location of irrigation wells (in red), and the area where the chloride:calcium ratio is below 7, indicating probable recharge by surface water from the Baroota Reservoir (Clarke, 1990).

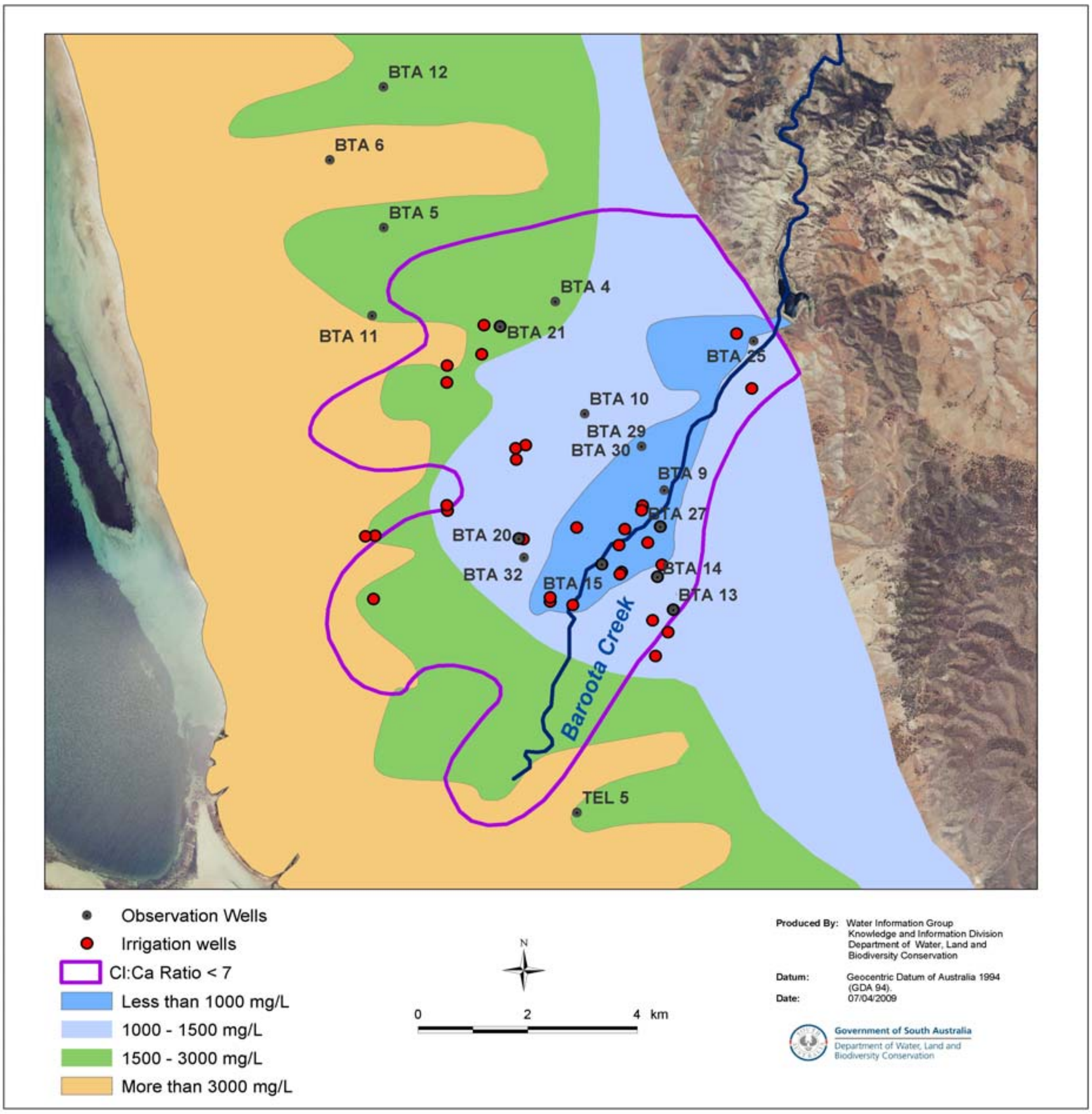

Figure 2. Groundwater salinity in Baroota PWRA

GROUNDWATER EXTRACTIONS

Prior to 2002, estimates of changes in extraction volumes could be made by examining colour aerial photography to determine the area irrigated. Figure 3 presents the estimated areas using data from Evans (2004). Even though there is ambiguity in some cases, there appears to be a large increase in irrigated area in late 1998 to about 140 ha as a result of increased viticultural development.

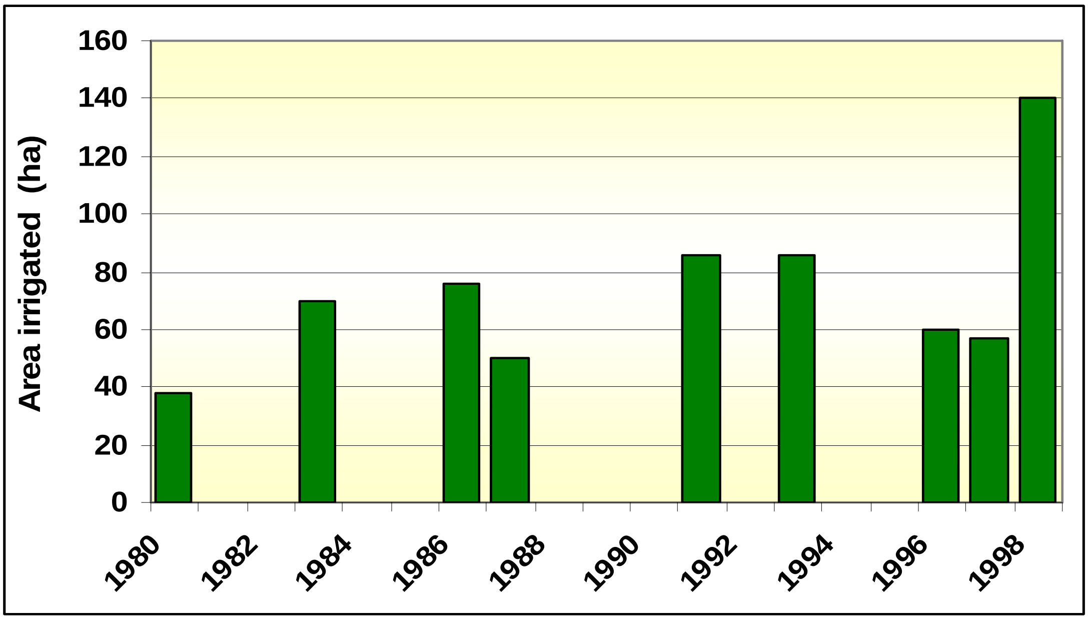

Figure 3. Estimates of irrigated area

A Land and Water Use Survey carried out in 2001 recorded an area of 692 ha, either under irrigation, or having a financial commitment to irrigate, as shown in Figure 4.

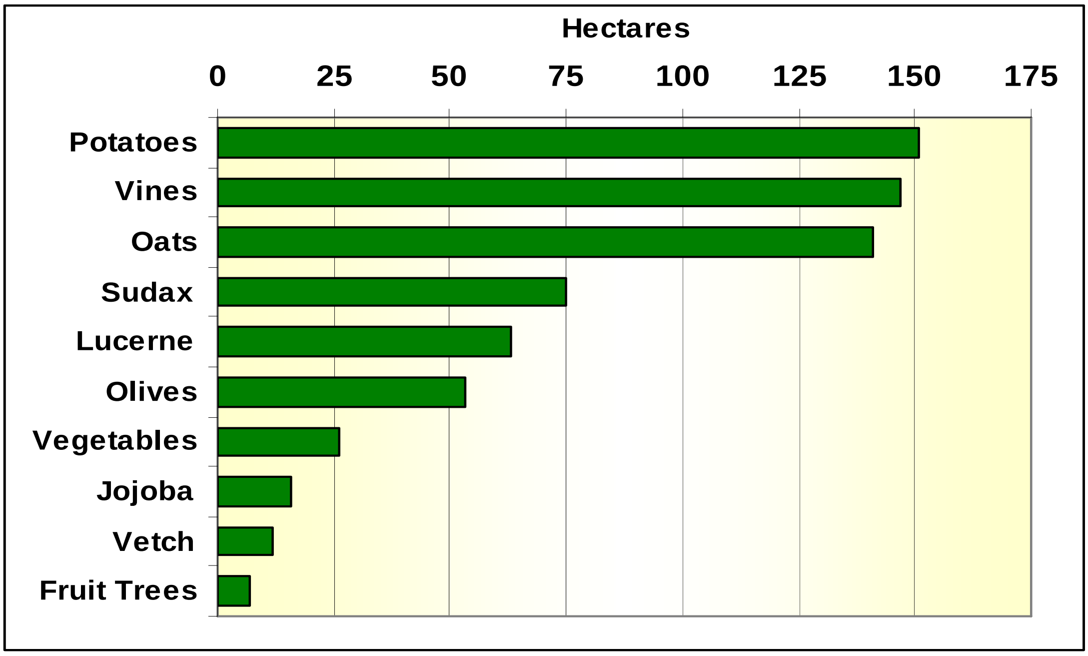

Figure 4. Surveyed areas of irrigated crops

Meters have been installed on all irrigation wells in the Baroota PWRA since 2002 in response to the Local Area Catchment Plan which was formulated by the District Council of Mount Remarkable in consultation with local irrigators. Figure 5 displays the total metered extraction for the Baroota PWRA since then, which averages about 1500 ML/y despite the authorised volumes totalling a much higher 3800 ML/y.

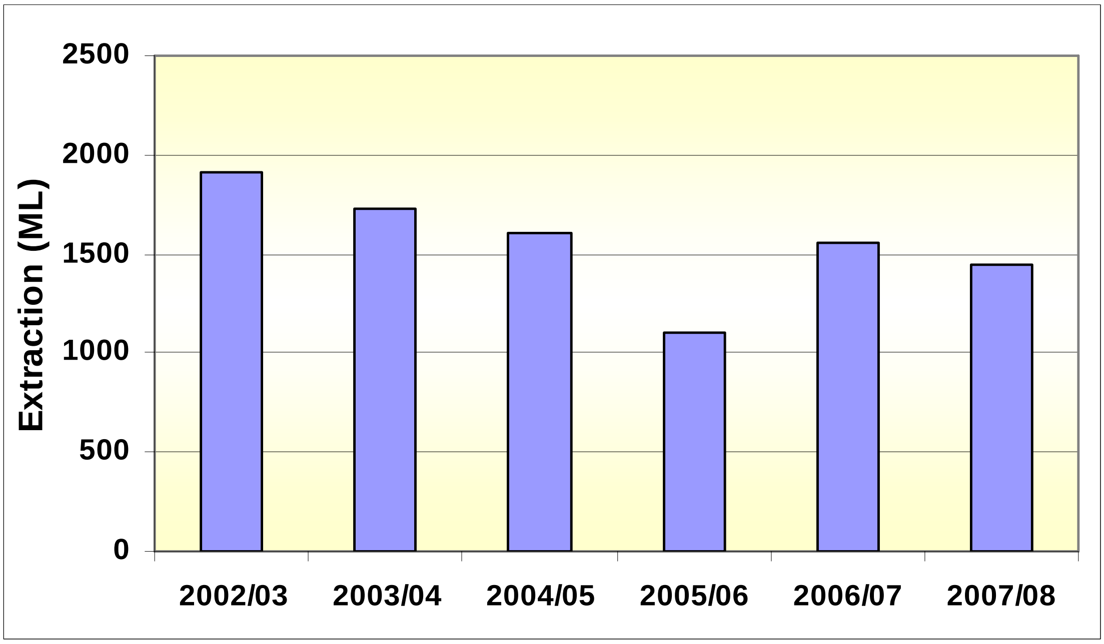

Figure 5. Metered extraction in the Baroota PWRA since 2001.

Figure 6 shows the percentage of each authorisation developed, using the average annual metered use since 2001/02. There is a considerable variation, ranging from 0 to 104 %.

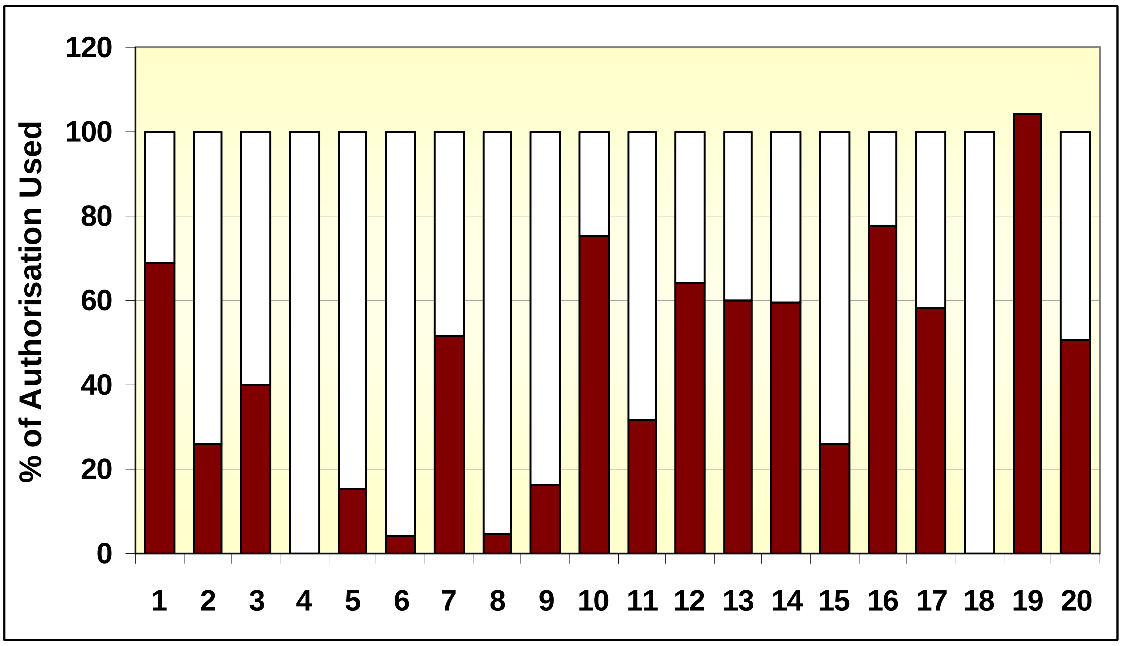

Figure 6. Percentage of authorisations used.

GROUNDWATER MONITORING

The main causes of changes in groundwater level or salinity, are variations of inputs to the groundwater system (recharge), and also changes in outputs (extraction, natural discharge). Successful management of the groundwater resource requires identification of the driver causing the observed changes.

DWLBC have been carrying out groundwater monitoring in the Baroota area since 1977 when concerns were expressed about the increase in irrigation in the area. In 2004 under the National Action Plan for Salinity and Water Quality, a project to augment the monitoring network and drill new observation wells was funded (Evans, 2004).

All observation well data for the Baroota PWRA can be obtained from the OBSWELL database via the web at this address; https://obswell.pir.sa.gov.au/

The network name of PIRIE should be entered to examine or download observation well data (water levels and salinity). The locations of the observation wells are shown in Figure 2.

WATER LEVELS

Although up to 24 wells have been monitored for groundwater levels historically, there are currently 17 wells being monitored on a semi regular six-monthly frequency.

Figure 7 shows water level hydrographs from observation wells located more than three kilometres away from the irrigated areas. It also displays the cumulative deviation from mean rainfall (in blue) 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.

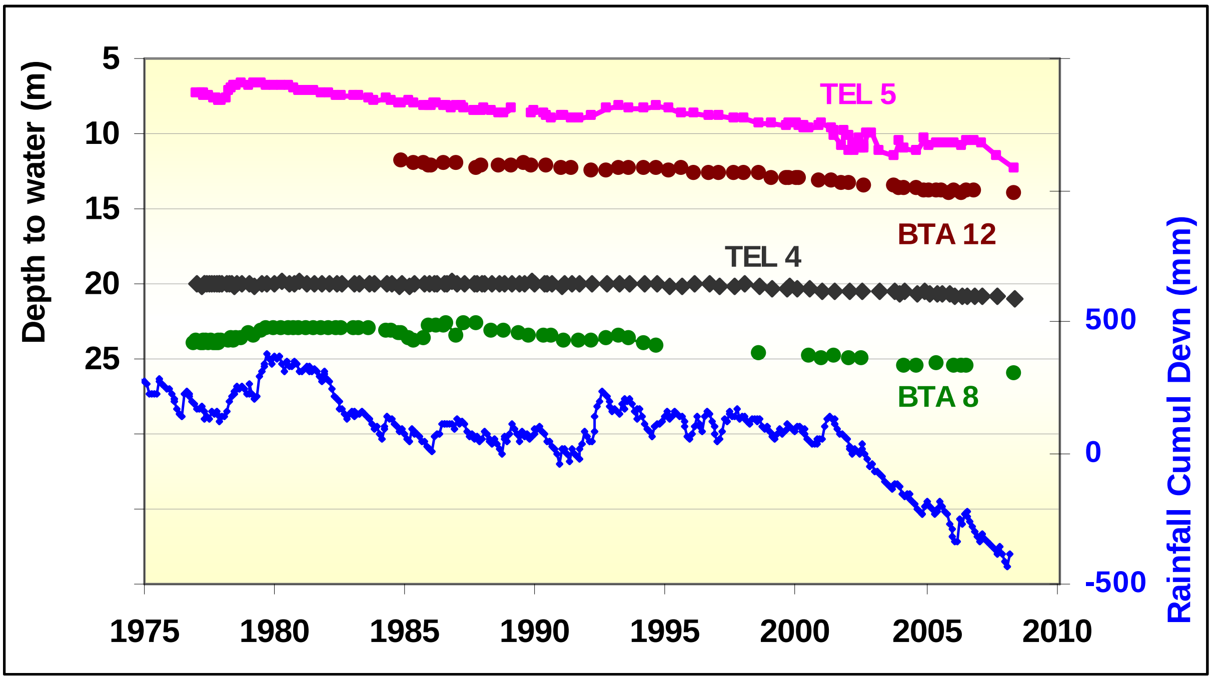

Figure 7. Hydrographs for wells unaffected by irrigation

From Figure 7, the water levels can be seen showing a muted response to episodic wet years (such as 1979-80 and 1992–93). Otherwise, there have been significant periods of below average rainfall since 1993 which has resulted in a slow decline in water levels, especially since 2002. The magnitude of the decline since 1993 varies in the range of 0.9 to 2.5 m.

Observation wells downstream of Baroota Reservoir display a very different response to recharge which is predominantly driven by leakage from the reservoir. Figure 8 shows the pronounced peaks in water levels which occur in response to recharge events corresponding to overflow of the reservoir wall which occurs when water levels (in blue) reach a critical level exceeding 20 m. The high groundwater levels are sustained for longer periods if the overflow persists, as occurred in 1992-93.

Figure 8 also shows the water level response to recharge diminishes laterally with distance from the Baroota Creek (compare BTA 9 adjacent to the creek, with BTA 10 located 2 km northwest of the creek). Similarly, the response also diminishes with distance downstream from the reservoir (compare BTA 3 located 2 km downstream, with BTA 10 at 4 km)

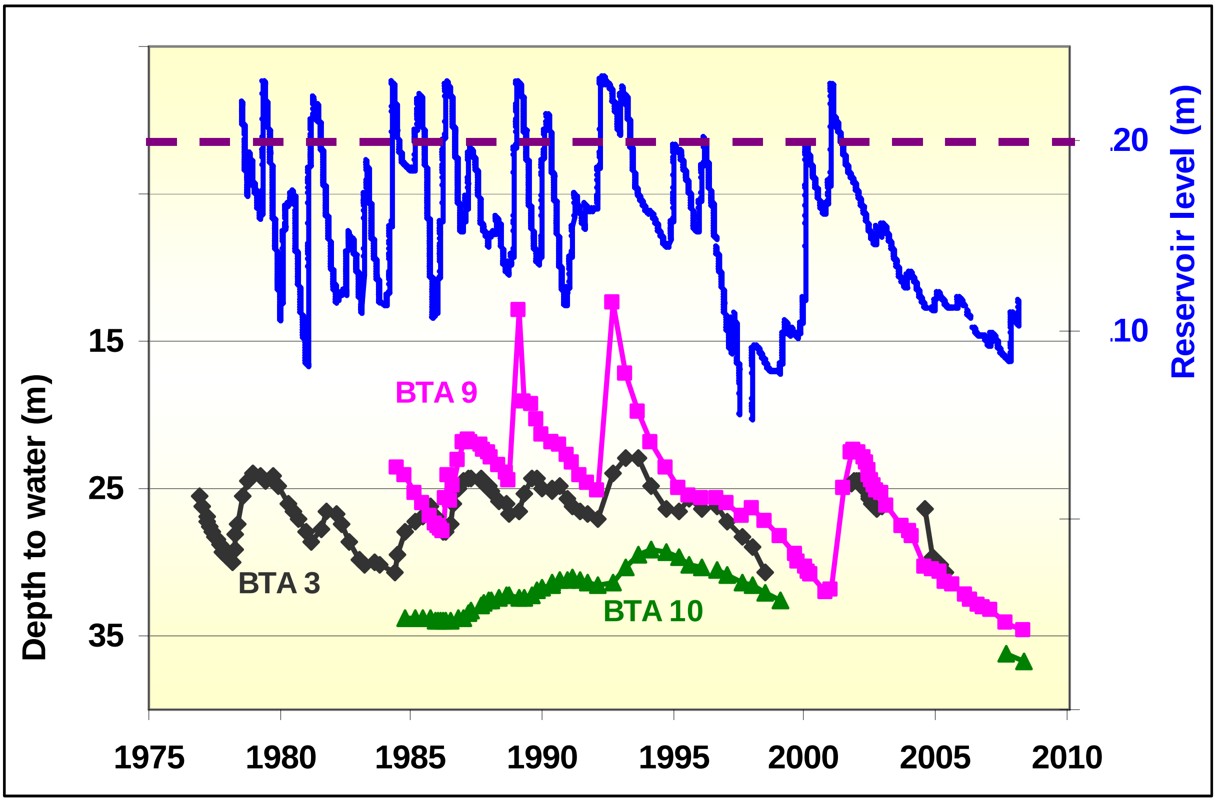

Figure 8. Unconfined aquifer observation network

As a result of the falling water levels, there are currently no operational observation wells within 3.5 km of Baroota Reservoir. In particular BTA 3, BTA 17 and BTA 19 should be deepened if possible.

SALINITY

There are currently nine wells that have groundwater salinity monitored randomly, although up to 13 wells were monitored in the past.

The sporadic nature of salinity monitoring in the past, and the variation in completion depths of the wells sampled, make interpretation of any salinity trends difficult. Figure 9 shows salinity trends for wells in the irrigation area, together with Baroota Creek.

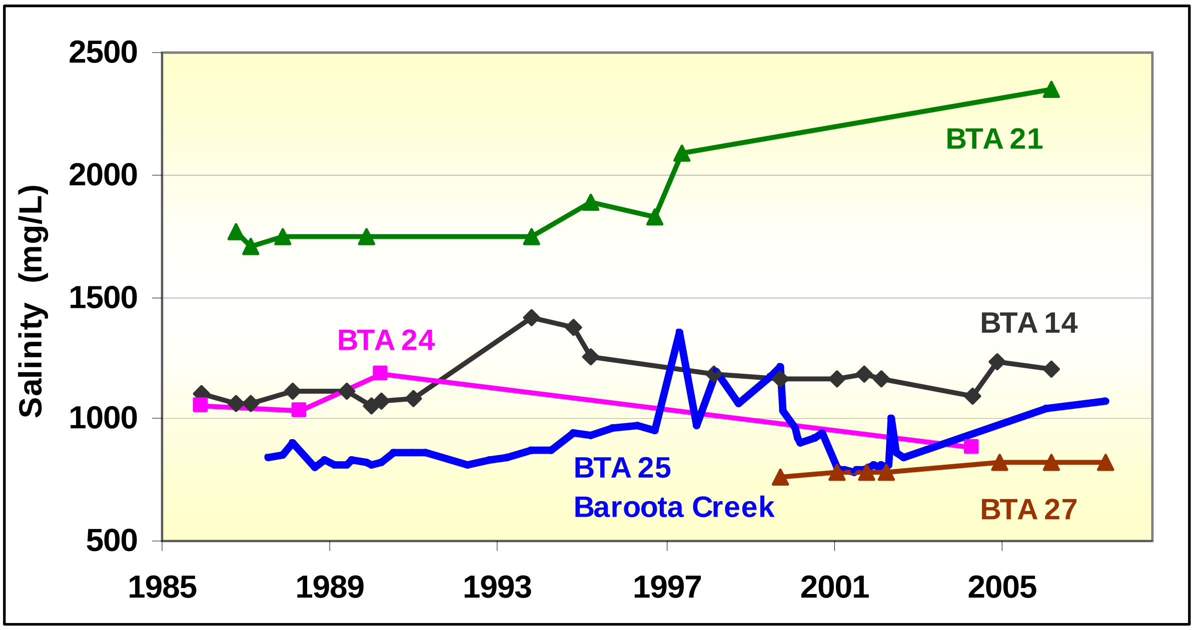

Figure 9. Groundwater salinity trends in the Baroota PWRA

A variety of trends is evident in Figure 9, with all observed increasing trends below a rate of 2 % increase per year. Well BTA 21 is an irrigation well completed in the deep Tertiary sand aquifer. Despite the widespread fall in water levels since 2002, there is no evidence of any corresponding rise in salinities throughout the irrigation area.

More comprehensive sampling will be required in the future. In order to achieve this, a condition should be placed on each licence requiring a water sample be provided from each irrigation well, at least once a year.

SUSTAINABILITY ISSUES

In the Baroota PWRA, the main sustainability issues that should be considered when determining the resource capacity, are whether there are any adverse impacts on the groundwater resource resulting from the observed water level and salinity trends, and any changes in the recharge regime.

GROUNDWATER LEVEL TRENDS

The groundwater levels in Figure 8 show a very close relationship with reservoir water levels, especially after 1992. Since 2002, despite a reasonably constant total extraction averaging 1500 ML/y, the groundwater levels are falling at an average rate of 1.0 m/y to the lowest levels recorded in over 30 years, with no real sign of a new equilibrium being reached. While these trends are alarming in themselves, any adverse impacts arising from these trends should be the main consideration.

The most immediate impact will be on groundwater users who will be required to lower, and possibly upgrade their pumps to cope with the deeper water levels. Some shallow supply wells may also have to be deepened to maintain supply. Although these social and economic impacts may be of concern, they do not necessarily indicate that degradation of the resource is occurring.

Figure 10 displays a schematic cross section of Baroota PWRA showing the salinity distribution and the significant decrease in water levels measured in 2009, compared to 1989. What has not changed is the steep gradient in water level from east to west. Although the observation wells are completed at different depths, and there are no operational observation wells within 3.5 km of Baroota Reservoir, these data limitations would not change the regional gradient to any great extent.

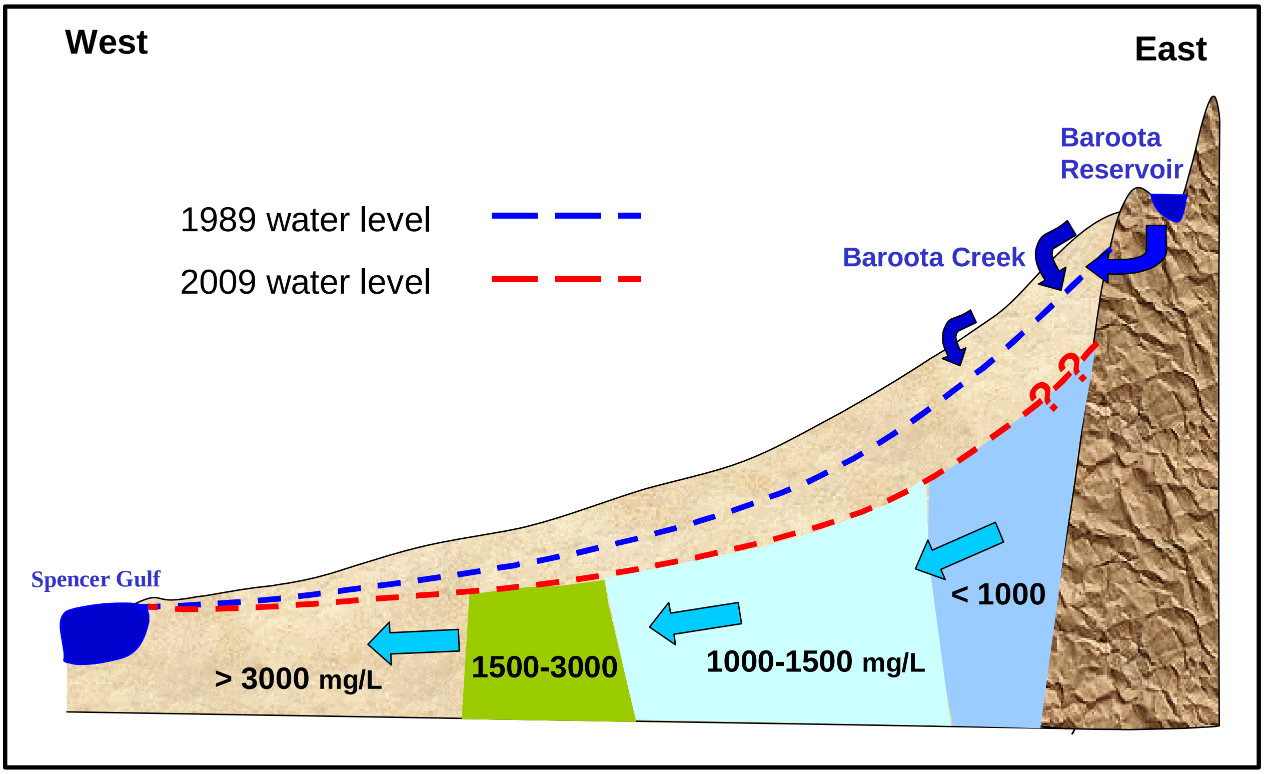

Figure 10. Schematic cross section of Baroota PWRA

The important outcome from Figure 10 is that despite the significant fall in water levels, the strong east-west gradient is maintained with no likelihood in the near future of groundwater flow reversal, that could lead to salinity increases due to more saline groundwater in the west flowing back eastwards into the irrigation area.

There may be a risk of salinity increases due to vertical leakage between sedimentary layers, however there is insufficient information available to quantify this risk, or estimate what changes in salinity might occur.

GROUNDWATER SALINITY TRENDS

As discussed previously, there are no significant trends indicating degradation of the resource, even though groundwater levels are falling consistently.

RECHARGE

The consistent trend of below average rainfall since 1992/93, and especially since 2001, would have reduced diffuse recharge to the Quaternary sedimentary aquifers (and the adjoining fractured rock aquifers in the Flinders Ranges) as shown in Figure 7. With the Baroota Reservoir no longer being used as a balancing storage, the reduced rainfall (and hence runoff), will result in prolonged periods of low reservoir levels as indicated in Figure 8. This will result in reduced recharge to the aquifer from reservoir leakage, and much less frequent dam overflow recharge events.

CONCLUSIONS AND RECOMMENDATIONS

Examination of monitoring trends reveals no adverse salinity impacts, despite water levels falling at about 1 m/y at current extraction rates, due to reduced recharge. A precautionary approach would assume that this period of below average rainfall and reduced recharge will continue in the immediate future. It is anticipated that levels will fall to a new equilibrium reflecting the regional east to west flow gradient, unaffected largely by localised recharge.

In the absence of better information, it is proposed that resource capacity of the groundwater resource for the Baroota PWRA (as required by Sec 155 of the NRM Act), be set at 1500 ML/y. This volume is considerably lower than the authorised volume (3800 ML), and is consistent with the recommendation by Evans (2004). This figure does not include the environmental water requirements which have to be taken into account before the volume available for allocation to water users can be calculated.

Given the uncertainties regarding the estimation of recharge, an adaptive management approach is recommended, which will require consistent monitoring and an upgrading of the network because of the falling water levels. In order to improve the crucial salinity monitoring, a condition should be placed on each licence requiring a water sample be provided from each irrigation well, at least once a year.

To facilitate these monitoring requirements, consideration should be given to imposing a resource management levy on licensed users of the resource.

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