Coorong Dryland Salinity Review

Improving Salinity Understanding - June 2019

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*Figure 1* Salinity affected cropping paddock Cooke Plains
2. Salinity Risk Mapping

*Steve Barnett – Principal Hydrogeologist*
*Department for Environment and Water*

These Dryland Salinity Risk Maps were provided by Steve Barnett – Principal Hydrogeologist, Department for Environment and Water in October 2018.

They show areas that have already been salinised together with those areas at risk of salinisation in the future. These areas constitute the lowest topography in the region and were defined using a digital elevation model, depth to watertable information and satellite imagery. Local landholders were consulted to ensure any new areas of salinity were picked up on this new version of the salinity risk mapping.

*Figure 3: Coomandook / Cooke Plains Salinity*

*Figure 4: Meningie East Salinity*
3. Coorong Dryland Salinity Survey

*Tracey Strugnell & Graham Gates*
*Coorong Tatiara Local Action Plan - Coorong & Tatiara District Councils*

A Coorong Dryland Salinity Survey was conducted in late 2018 via direct land owner contact. Here are the results.

<table>
<thead>
<tr>
<th>Coorong Dryland Salinity Survey Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What new areas have been affected by dryland salinity in the last 5 years?</strong></td>
</tr>
<tr>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>1610ha</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>How much land do you think is at risk over the next 5 years?</strong></th>
<th>Coomandook - Cooke Plains</th>
<th>Meningie East</th>
</tr>
</thead>
<tbody>
<tr>
<td>2159ha</td>
<td>130ha</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>How much perennial pasture do you plan to establish in the next 5 years?</strong></th>
<th>Coomandook - Cooke Plains</th>
<th>Meningie East</th>
</tr>
</thead>
<tbody>
<tr>
<td>5857ha</td>
<td>10,550ha</td>
<td></td>
</tr>
</tbody>
</table>

These results confirmed that dryland salinity is increasing in the Coorong District. Since this survey was conducted reports of increases in area have also come through from West of Tintinara / Colebatch area.

The survey questions can be found in Appendix 3.

This data confirmed concerns that had been expressed since 2015/2016 by land managers and agronomists.

Of particular note is; - the larger area of increase, - the belief by land managers that this areas is likely to increase, - the considerable areas likely to be sown to perennial pasture in coming years.

The impact of this increase dryland salinity is causing extreme concern for affected landholders.

They want to understand why it is occurring, and how this increase can be most effectively responded to.
4. Coorong Dryland Salinity Description and Impacts

This section is adapted from:
Natural Resources of the Tatiara – A plan for action. 2013-2018
Recharge Reduction – Reaping the Rewards. March 1997
Tracey Strugnell
Coorong Tatiara Local Action Plan - Coorong & Tatiara District Councils

4.1 Dryland Salinity and the Coorong Landscape

A huge amount of salt is stored in the subsurface soils underlying parts of the Coorong. Historically this salt was accumulated when the area was originally covered with seawater. In the Mallee highland zone the salt is held at depth while on the Coastal plains it is much closer to the surface.

A dryland salinity problem emerges when a rising watertable mobilises salts and carries them upwards close to the ground surface where they are further concentrated by evaporation.

The topography of the region formed by the ancient coastlines has resulted in a landscape of salty flats and range country. Where the summer – autumn watertable is within two metres of the soil surface the effects of dryland salinity are likely to be most severe. Groundwater is drawn up through the soil profile by capillary action, eventually evaporating as it reaches the surface, leaving the salts at or near the topsoil root zone.

Natural expressions of this can be seen at Waltowa Wetlands, Elephant Lake, and the extension of Blink Creek extending inland from Lake Alexandrina though to Cooke Plains.

Historically, the higher elevation areas of the Coorong District have been somewhat immune to the water balance and salinity issues affecting the lower lying areas of the district.

The section above is adapted from ‘Natural Resources of the Tatiara – A plan for action. 2013-2018’.

4.2 Recharge and Discharge Defined

Recharge – is the unused rainfall that percolates down past the root zone of plants and eventually reaches the water table.

Originally the deep rooted native vegetation cover kept the watertables at depth by providing a balance between rainfall recharge and evapotranspiration. However with clearance of scrublands and their replacement with shallow rooted annual crops and pastures, this balance was disrupted and more rainfall reached the watertable causing a general rise bringing the dissolved salts closer to the surface. The widespread sowing of lucerne when the land was first cleared assisted in keeping watertables in check, however the pasture aphid invasions of the late 1970’s and the dramatic loss of susceptible lucerne stands at that time led to a general watertable rise and a rapid spread of dryland salinity in adjacent low lying areas.

Over the 2000’s the spread of dryland salinity appeared to stabilise. However from around 2015 onward increases in the area of affected as covered in Sections 2 and 3 have occurred.

Low lying areas where the groundwater is removed by evaporation are known as discharge areas. These can be associated with very high levels of soil salinity.

As the water table rises, dissolved salts from the soil are carried with it. When the water table rises to within one or two metres of the soil surface, evaporation and use of the water by plants removes the groundwater but leaves the salt behind, which raises the salinity of the remaining groundwater.
In low lying areas where the water table is close to the soil surface, the salt is concentrated at the surface, resulting in dryland salinity which causes; the death of plants that are not salt tolerant, adversely affect soil structure, and reduce the quality of water supplies.

### 4.3 Agriculture & Enterprise Mix Impact

The impact of dryland salinity and agriculture and farm business can include;
- The range of production possible on saline areas is significantly reduced. See Figure 5 below,
- Potential reduction in property values,
- More rapid deterioration of farm improvements such as sheds, fences, roads, vehicles and equipment due to operating in a wet and salty environment,
- Potential drop in farm equity, affecting the ability of farm businesses to access finance,
- The need to restrict livestock access to wet saline areas seasonally,
- Salinisation of farm water supplies sourced from the unconfined aquifer, leading to increased reliance on SA Water mains and an increased cost to the farm business,
- Increased pressure on non saline land. In an attempt to offset the losses from salt affected area, non salinised land may be put under increased pressure,
- Aesthetic impact.

![Relative tolerance of crops and pastures to soil salinity. Source: PIRSA Fact Sheet – Tim Herrmann.](image)

Where discharge are not hyper saline these areas can be appropriate for a range of salt tolerant pastures. Where successful and well managed this can provide good quality feed for sheep and cattle. These options are discussed further in Section 12 – Dryland Salinity Management Recommendations.

Bare salinised land can be at risk of wind erosion. Establishment of ground cover is a high priority to both prevent erosion, but also to reduce the evapo-concentration of salts at the soil surface.

The reduction in ground cover, and health of crops and pastures growing in these low lying areas can further compound the cycle of reduced plant water use, and increased recharge to groundwater.
4.4 Environmental Impact

Increases in the level of the saline unconfined aquifer also has environmental impacts, on low lying native vegetation, mature trees, and wetlands. Groundwater dependant wetlands can also be adversely affected by higher salinity levels.

Impacts include;
- Decline in native vegetation and mature trees,
- Loss of nesting sites and decline in bird populations,
- Loss of food sources for wildlife populations,
- Increased soil and wind erosion,
- Loss of wetland habitat,
- Loss of aesthetic value,
- Reduced species diversity.

The reduction in the health of native vegetation in these low lying areas can further compound the cycle of reduced plant water use, and increased recharge to groundwater.

4.5 Impact on the Built Environment

Some township areas in the Coorong District are located in low lying areas.

Where groundwater levels beneath the soil surface the built environment dryland salinity can impact on;
- Structural damage to houses, sheds, and other buildings,
- Reduced life of water pipes and electrical equipment,
- Decline of quality in unconfined groundwater bores for use on sporting grounds, gardens and domestic uses,
- Damage to pumping and water reticulation equipment,
- Roads, footpaths, pipelines, culverts, septic systems, underground communication cables, and the footings of powerlines and electrical transmission towers
4.6 Social Impact

The main social impacts occur at the farm and local community level. Reduced farm incomes, potentially decreased land values, have a direct flow on impact to the local economy.

Property sizes are likely to increase, leading to flow population decreases impacting local business, schools, volunteer dependant services like CFS and Ambulance, and sporting clubs.

Dryland salinity has a real social impact;
- The stress caused by the expansion and production impact of dryland salinity to land owners and farm businesses,
- Social impact on rural communities due to reduced economic activity,
- Reduction in tourism and recreational activities due to the unattractive damage caused by salt as well as a reduced capacity of resources to support aesthetic, tourism, and recreational based activities.

4.7 Dryland Salinity and Climate Variability

Both dryland salinity and climate change have the potential to reduce the agricultural production options available where they have an impact. The reduction in the production options increases business vulnerability in response to commodity market fluctuations and seasonal variability.

The relationship between dryland salinity and climate variability also needs to be considered as an additional risk factor looking forward in the Coorong District.

Climate Variability in the Coorong

There is empirical evidence that the climate within the Coorong District is not the same as it was fifty or more years ago. Analysis of local rainfall data suggests that annual rainfall has been steadily decreasing since the 1950s, resulting in annual rainfall of up to 60mm less than they were in the earlier part of the 20th century. These trends are supported by long-term, high quality data from the Bureau of Meteorology.

Looking at local daily data, the autumnal break appears to be arriving later and with less regularity. The spring months appear drier and the total number of months without rain appears to be increasing.

There is limited long-term temperature data for the Coorong District, however long term (50-120 year) temperature data from Robe, Nhill, Lameroo and Murray Bridge suggest that there has been an increase in extremely hot days (>40° C), a decrease in frost events and an increase in average night-time temperatures. This is supported by shorter term (20-50 yr) temperature data from the Coorong District.

A range of government agencies (CSIRO, Australian Bureau of Meteorology, South Australian Research & Development Institute) have looked at these long term trends in climate. The tables below show the results.
of their more sophisticated extrapolation of climate data, done for four other towns within or near the Coorong District.

Projected changes from current (<2000) conditions by 2030 (CSIRO, 2009)

<table>
<thead>
<tr>
<th>Town</th>
<th>Temperature increase (°C)</th>
<th>Rainfall reduction (%)</th>
<th>Rainfall reduction (mm)</th>
<th>Evaporation increase (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lameroo</td>
<td>0.74 – 0.98</td>
<td>2.1 – 12.6</td>
<td>8 - 49</td>
<td>33.2 – 48.6</td>
</tr>
<tr>
<td>Tailem Bend</td>
<td>0.72 – 0.91</td>
<td>2.5 – 12.0</td>
<td>12 - 56</td>
<td>32.9 – 47.6</td>
</tr>
<tr>
<td>Meningie</td>
<td>0.69 – 0.86</td>
<td>2.7 – 11.5</td>
<td>10 - 43</td>
<td>39.4 – 50.8</td>
</tr>
</tbody>
</table>

Number of days likely to experience high or low temperatures (CSIRO, 2009)

<table>
<thead>
<tr>
<th>Site</th>
<th>Minimum below 0°C Present</th>
<th>Maximum above 35°C Present</th>
<th>Maximum above 40°C Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>2030</td>
<td>2070</td>
</tr>
<tr>
<td>Tailem Bend</td>
<td>3</td>
<td>1-2</td>
<td>0-1</td>
</tr>
<tr>
<td>Keith</td>
<td>4</td>
<td>1-3</td>
<td>0-2</td>
</tr>
</tbody>
</table>


The relationship between dryland salinity and climate

As discussed further in Sections 5 – 9 groundwater and dryland salinity trends are influenced by climatic and seasonal factors in the following ways;

- Intense rainfall events can cause a spike in levels of recharge,
- Intense rainfall events can cause a spike in groundwater levels,
- Evapotranspiration causes ‘wicking up’ from the shallow saline groundwater leaving the salt behind,
- Long hot and dry conditions further concentrate salt at the soils surface,
- Rainfall is essential at the start of the growing season to ensure salts are flushed from the top soil to allow seedlings to successfully establish.

Long dry periods such as the millennium drought, 2015-16 drought, and 2018-19 drought would have significantly impaired the health, vigour, density and water use potential of perennial pastures on both saline and non saline land. In particular the summer active perennial pasture base that prevails in this region of dryland lucerne, perennial veldt grass and primrose. When rainfall did return after these dry periods, these pastures would have not been in optimum condition to ‘use the rain where it fell’, and hence reduce recharge to groundwater.

In Section 9. Watertable Trends and Graphs, it is shown that the watertable rose by up to 1 m following high rainfall episodic events in 2010/11, 2013 and 2016.

Saltland areas could still expand into the future, due to increased evapotranspiration causing ‘wicking up’ from the shallow saline groundwater leaving the salt behind, and lower rainfall leading to less leaching of salts down through the soil profile.

Improved awareness of the interactions between climatic variations and groundwater trends could inform farm management decisions that respond to episodic rainfall events.
5. Local Watertables Explained

Chris Henschke—Senior Consultant Hydrogeology
PIRSA Rural Solutions

5.1 Hydrogeological Overview

There are two groundwater flow systems occurring in the Upper SE; a local unconfined aquifer and a deeper regional confined aquifer. The shallow unconfined system lies on top of the confining clay layer which separates it from the underlying confined aquifer. The whole area can be likened to a big ‘bucket’ that has now filled up to capacity beneath the low-lying Coastal Plain See Figure 10 below. Refer to Aquifer Maps in Appendix 7.

Local groundwater recharge from rainfall is the cause of the rising watertable in the shallow unconfined aquifer. The deeper confined regional system which is recharged in Western Victoria, does not contribute to dryland salinity as it is confined by a clay layer which only allows very small amounts of flow between the two aquifers.

The impacts of clearing native vegetation are no longer a major driver of rising watertables and the expansion of dryland salinity. Long term monitoring data indicates that groundwater levels respond strongly to changing rainfall patterns.

The influence of climate change is difficult to predict because any beneficial impacts are counterbalanced by negative influences. For example, decreases in rainfall and recharge are conflicting with increasing evapotranspiration (ET) and more intense rainfall events.

The patterns of groundwater trends can be related to landscape, topography, and elevation. Continuously rising watertables are often associated with higher elevation land because the large depth to the watertable results in a delayed cumulative response to rainfall with any seasonal variations smoothed out. On flat lower lying land, the shallow watertable responds rapidly to rainfall in winter and evaporative discharge in summer, resulting in fluctuating watertables (seasonal highs and lows).

Saltland areas could still expand into the future, due to increased evapotranspiration causing ‘wicking up’ from the shallow saline groundwater leaving the salt behind, and lower rainfall leading to less leaching of salts down through the soil profile.
5.2 Previous Research

The local effect is stronger than any regional input, so the adoption of high water use crops and pastures at a large scale can have an impact, especially in dune-swale topography where local water flow cells overlie the regional flow system.

Groundwater flow modelling suggested that a 50% recharge reduction in the Coorong District would be required to limit the spread of land salinisation. This would not prevent salt from spreading entirely, as it would not cause watertables to fall significantly, but it could slow down the rate at which salinity would expand.

There was some scepticism by CSIRO scientists in the early 1990s that recharge reduction could be achieved to control dryland salinity in landscapes underlain by regional groundwater flow systems. This is because a large proportion of the landscape needs to be planted to perennial vegetation and realistically, 100% adoption is unlikely to be achieved. For example, lucerne needs to be well managed to be effective in recharge reduction. An analysis by CSIRO in 2004 suggested that possibly 10-20% recharge reduction had been achieved, far short of the 50% recharge reduction goal.

Because the local groundwater flow system dominates the regional flow system, land management at the local scale can have an impact. However watetable monitoring of a Coomandook Landcare Network trial site (see Appendix 4) suggests that even if the watetable is lowered under the sandhill, it does not have an immediate impact on the salinised area down slope. Because the limestone aquifer has a large through-flow and is highly transmissive (i.e. very porous to groundwater flow), small scale treatments at the farm scale (i.e. hundreds of hectares) will not have a significant impact.

Recharge reduction needs to be carried out on a very large scale (i.e. thousands rather than hundreds of hectares). Individually, farmers undertaking recharge reduction management on a single paddock will not make a difference, but collectively, many farmers doing the same thing can make a difference.

Saltland agronomy was considered to be the most cost effective solution. Living with salt is being revisited as the best option in dealing with the long term impacts of climate change. A surface drainage network is not considered to be a viable option in the undulating dune topography occurring in this area because of the excavation difficulties associated with sandy terrain, the very low hydraulic gradients which would result in very small flows in any drain that was constructed.

5.3 Watetable Trends Analysis

Watetable monitoring wells (also called boreholes, observation wells or piezometers) completed in the unconfined limestone aquifer in the Coomandook and Meningie East areas, were selected for trend analysis.

Analysis of watetable data combined with rainfall trend data helps to determine the major driver of groundwater responses and hence the causes of expanding dryland salinity.

Of some concern is the number of sites that have been removed from the monitoring network in recent years. This has contributed to wells becoming lost or destroyed due to the vulnerability of PVC riser tubes not being adequately protected, or new landholders being aware of their significance. Also of concern is the reduction of funding and resources to monitor dryland salinity and the unconfined aquifer.

For each region, key strategic sites should be identified for consistent long term monitoring. Key watetable monitoring wells need to be adequately identified, labelled and protected from damage by stock, farming operations etc.
6. Coorong Hydrogeological Systems

There are two distinct groundwater flow systems: a shallower unconfined sandy limestone aquifer and a deeper confined limestone aquifer. They are separated by a layer of confining clay which does not transmit water between the two systems. Refer to aquifer maps in Appendix 7.

6.1 Shallow Local Unconfined Watertable Aquifer

The Quaternary Limestone (QL) aquifer is an unconfined groundwater system comprising two main geological units which sits on top of the deeper regional system. In the Coomandook area, the unconfined aquifer occurs in the Bridgewater Formation (Qbp) which is made up of sandy and shelly limestones being derived from beach and coastal dune deposits. This formation is usually capped with calcrete.

Further south around Tintinara, the unconfined aquifer occurs in the Padthaway Formation, a shallow highly permeable Quaternary limestone that can be seen outcropping in inter-dunal flats.

In some places the Bridgewater Formation directly overlies the Murray Group Limestone (MGL) (Tml) which consists of a fossiliferous sandy limestone. This aquifer is recharged in south west Victoria and forms the unconfined aquifer in the highland areas to the east where the watertable occurs at much greater depths (>20m). The low permeability grey clays of the Ettrick Formation (Toe) then forms the base of this unconfined system and separates it from the deeper confined aquifer.

6.2 Deep Regional Confined Aquifer

The confined aquifer consists of the Renmark Group (Ter) comprising interbedded sands, clays and limestone units. This aquifer is very well confined with minimal upward leakage into the watertable aquifer. This suggests that the deeper system does not contribute to the recent expansion of dryland salinity.

![Figure 11 Cooke Plains Transects](image-url)
6.3 Basement rocks of the Padthaway Ridge

The Padthaway Ridge is a north-south trending basement formation comprising of metamorphic rocks and granite intrusions. It runs through the middle of the salinity focus area, outcropping at sites such as Binnie Lookout west of Coonalpyn. The ridge forms an impermeable localised barrier to the lateral flow of groundwater which needs to flow around the barrier. To some extent, this isolates the groundwater between the eastern and western parts of the region and differences in processes have been observed between east and west.

![Image of the Padthaway Ridge and groundwater flow](image)

**Figure 12:** Unconfined aquifer movement around the Padthaway Ridge

Some areas directly to the western down-gradient side of the Padthaway Ridge have been affected by dryland salinity between the Range and Meningie. This area is likely to be influenced by a more localised groundwater system as opposed to the more regional nature of groundwater in the Coomandook area.
7. Rainfall Trend Graphs

Chris Henschke – Senior Consultant Hydrogeology
PIRSA Rural Solutions

Monthly rainfall data is available on the Bureau of Meteorology website. Records for Coomandook only have a minor number of data gaps in the period from the late 1980s up until the present.

Rainfall trend analysis is calculated using the cumulative variation / deviation from the mean rainfall (also called a residual rainfall or residual mass curve). In periods where mostly above average rainfall occurs, graphs show a positive or increasing variation from the mean. A falling curve represents periods receiving below average rainfall.

*Figure 13* below shows annual rainfall since 1890 for Meningie and the calculated ‘Residual Mass Curve’ (i.e. residual accumulative rainfall trends). In broad terms, more recent trends indicate a rising trend (wetter cycle) during the 1950s and again in the 1970s up until the early 1990s. This was followed by a drying trend until the 2000s which included the ‘Millennium Drought’ extending from 2006-09. A rising trend then resulted from the wet summer of 2010/11 and the wet spring of 2016.

*Figure 13: Rainfall Trend Graph*
8. Rainfall Deciles

Chris Henschke– Senior Consultant Hydrogeology
PIRSA Rural Solutions

8.1 Dry Periods 1990 to 2018

The table below highlights some of the very dry periods that have occurred since 1990 at Coomandook. This is for the time period since regular watertable monitoring commenced in this region. It shows the months that have experienced Decile 1 and 2 monthly rainfall (i.e. the lowest 20% of rainfall totals on record). These dry periods if sustained over time, can produce a falling trend in the watertable record.

8.2 Wet Periods 1990 to 2018

The table highlights some of the wetter periods that have occurred since regular watertable monitoring commenced in the region. Months with decile 9 and 10 rainfall after 1990 are shown for Coomandook (i.e. the highest 20% of rainfall totals on record). These wet periods are likely to have an impact on local groundwater flow systems producing a rising trend over time.

<table>
<thead>
<tr>
<th>Year</th>
<th>DRY Month</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>April</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>19.8</td>
</tr>
<tr>
<td>1994</td>
<td>March</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>12.6</td>
</tr>
<tr>
<td>2002</td>
<td>February</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>21.4</td>
</tr>
<tr>
<td>2006</td>
<td>June</td>
<td>15.2</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>10.2</td>
</tr>
<tr>
<td>2008</td>
<td>February</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>2.8</td>
</tr>
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<td>2009</td>
<td>January</td>
<td>0.8</td>
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<td></td>
<td>February</td>
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<td>2014</td>
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<td>October</td>
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<table>
<thead>
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<th>Year</th>
<th>WET Month</th>
<th>Rainfall (mm)</th>
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<tbody>
<tr>
<td>1991</td>
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<td>1992</td>
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<td>90.6</td>
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<td></td>
<td>September</td>
<td>78.4</td>
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<tr>
<td>2017</td>
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</tr>
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9. Watertable Trends and Graphs

*Chris Henschke – Senior Consultant Hydrogeology*
*PIRSA Rural Solutions*

### 9.1 Background

The groundwater monitoring localities focussed on in this report are:

<table>
<thead>
<tr>
<th>Location</th>
<th>Watertable Trend Graphs Appendices</th>
<th>PAGE</th>
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<tr>
<td>1. Coomandook-Cooke Plains</td>
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<td>2. Coomandook Landcare Network</td>
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<td>3. Meningie East</td>
<td>4.2 Meningie East Site Location Information and Hydrographs</td>
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<td>4. Tintinara West / Colebatch</td>
<td>4.3 Tintinara West Hydrographs</td>
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Water level data is available on the Department of Environment and Water (DEW) website. The address is [www.waterconnect.sa.gov.au](http://www.waterconnect.sa.gov.au). The Obswell tab on the Groundwater Data page can be used to find records for each water well.

Each site has an Obswell Number based on the Hundred in which the bore is located (e.g. SHK003) and may have a field number that was used to identify the site when the bore was being drilled.

![Figure 14: Screen shots of the Water Connect Groundwater Data pages – computer and smart phone](image)

Obswell sites were selected in each focus area based on the reliability of the record. Unfortunately there is very limited data available in the Tintinara West / Colebatch area.

In the northern areas, the shallow wells are completed in the Bridgewater Formation (Qpbc unconfined aquifer). The formation is described as an aeolian calcarenite with palaeosol horizons often capped with calcrite. In southern areas, shallow wells are completed in the Padthaway Formation.
Watertable trends fall into the following categories:

- Continuously rising trend
- Episodic rise (rises and falls, but each rise is higher than the previous one)
- Seasonal trend (strong seasonal peaks and troughs which correlates with winter rainfall and summer evaporative discharge)
- Static / stable (has rises and falls but no overall change in the longer term)
- Falling trend

The data is summarised in Appendix 4 which displays graphs of water level with time (groundwater hydrographs) for observation wells installed in the unconfined aquifer for each of the three focus areas, against rainfall.

Figure 15 Location of Watertable Monitoring Wells, Coomandook / Meningie below shows the location of 21 obswell sites that were selected based on the continuity of water level records over a reasonable period of time.
9.2 Results

The patterns of groundwater trends can be related to landscape, topography, and elevation. Rising watertables are often associated with higher elevation land while fluctuating watertables (seasonal highs and lows) can be correlated with rainfall on flat lower lying land.

Reading the Hydrographs:
The top blue line in each graph is the rainfall trend.
The bottom red line in each graph is the depth to watertable trend line.

*Figure 16* below is an example of a rising watertable under elevated land. *The sudden’blip’ in the watertable trend line is due to a change in datum/reference elevation point.*

*Figure 17* below is an example of a seasonally fluctuating water table on low lying land.
9.3 Discussion

The hydrographs of rainfall vs depth across the project area are shown in Appendix 4. These graphs show that over a large area the water level in shallow unconfined system is highly responsive to winter recharge, particularly in wetter years and where the groundwater is relatively shallow. This indicates that the recharge process is very local in nature (i.e. in the immediate vicinity area surrounding salinity hotspots).

Short term water level trends are superimposed on longer term trends. For example the watertable rose by up to 1 m following high rainfall episodic events in 2010/11, 2013 and 2016. In the longer term (since 1987), there has a general rising trend of +0.002 to +0.015m/year in the unconfined aquifer in this region.

*Figure 18.* Graph illustrating long term rising trends

Of greatest relevance to the sudden appearance of dryland salinity in 2018 is the rapidly rising watertable trend from 2015/16 until late spring of 2017. This brought the watertable at many sites to its highest recorded level. The large episodic rainfall events as noted appears to coincide with the sudden increase in salinised area in 2018.

*Figure 19* shows an example of the highest ever water level in 2017 following record rainfall in 2016
10. Coorong Dryland Salinity Mythbusting

Steve Barnett—Principal Hydrogeologist
Department for Environment and Water

These questions have often been raised at meetings and field days and require a scientific explanation.

- Is the unconfined aquifer pressurised?
- Why isn’t there an immediate response to high rainfall events?
- Why do the best crops occur in the year before ground goes saline?
- What is the effect of raised Lower Lake levels on the watertable and dryland salinity
- Impact of gypsum mining in the Cooke Plains area?
- Why does dryland salinity get worse in a dry year?
- Are there ‘underground rivers’ pushing down from the Mallee groundwater system?

10.1 Is the unconfined aquifer pressurised?

The shallow aquifer is not pressurised as it is an unconfined groundwater system. Water moves through the aquifer under gravity at slow speeds (i.e. 5 - 10 metres per year). The water level at any point is responding to processes occurring locally (i.e. recharge that occurs on a nearby sandhill in the order of less than 1km in distance). Therefore processes occurring 10km away from a saline patch is not relevant.

Direct rainfall is the issue, for example, a 20 mm recharge event will produce a 100 mm rise in the watertable due to the porosity of the aquifer.

An unconfined aquifer is not a pressure system.

10.2 Why isn’t there an immediate response to high rainfall events?

This question arose from the observation by some farmers that they are seeing higher watertable levels in their dams and pits in what has been a very dry year. For example, with less than 10mm of rain being received, water level rises of up to 1m were being observed.

There is a time lag for rainfall to infiltrate down through the soil to the watertable and then for the watertable to rise. The deeper the watertable, the longer it takes to respond. This is shown in hydrographs comparing rainfall with depth to watertable response. Watertables that are near the surface (e.g. 0 to 2m) show almost instantaneous response to rainfall events (an example includes site RBY 4 with very spiky responses to significant rainfall events). Hydrographs of deeper watertables (e.g. 5 to 10m) show lag times of months or even years to respond to large rainfall events (an example is site FID 2 where the 2010/11 rainfall event produced a large response in 2015/16). It is useful to obtain the landuse history at each site to further help interpret depth to water trends. Furthermore, it takes time for evaporation to remove the water and concentrate the salt. The salt is often concentrated in dryer years (see below).

10.3 Why do the best crops occur in the year before the ground goes saline?

A better crop is usually the result of a wet year. A wet year means higher recharge and consequently greater watertable rise. As the watertable rises, the crop may benefit from a freshwater lens on top of the rising groundwater creating ‘sub-surface irrigation’ in the root zone, in the first year or two after the water table has risen. Once this freshwater lens has depleted, salinisation can then occur in the following year.
10.4 Impact of lake levels on watertables and dryland salinity

The schematic diagram Figure 20 below is a cross-section through Lake Albert and Alexandrina to the left, samphire swamps (such as Pink Lake) in the centre and the Coomandook area to the right of the cross-section (which is across a distance of approximately 40km). The water in the Lakes is held at 0.75m AHD since the barrages were constructed in the 1940s. The Lakes are surrounded by low-lying samphire swamps. The watertable in the swamps is at minus 1.0m AHD (i.e. below sea and lake level).

The watertable in the Coomandook area is at a higher elevation (2.0m AHD) than the lake level and samphire swamps. The groundwater moves slowly westwards under gravity (downhill) to discharge in low-lying areas such as Pink Lake. The low-lying saline swampy areas around the Lakes also intercept any groundwater leaving the Lake and behave as ‘natural salt interception schemes’. As the shallow groundwater is not pressurised (see previous question), it cannot move uphill against gravity to the higher areas around Coomandook. It is therefore concluded that the Lake levels do not affect groundwater levels inland.

Figure 20: Coorong District cross section

10.5 Impact of Gypsum mining around Cooke Plains

The Cooke Plains embayment contains estuarine, lagoonal and lacustrine clays, sands and carbonates. In areas of groundwater discharge, evaporite gypsum beds occur and these have been mined for gypsum. The mining excavations in the Cooke Plains area have exposed the watertable in some of the deeper excavated pits. The effect of gypsum mining is considered to have minimal effect on surrounding saline areas.

10.6 Why does dryland salinity get worse in a dry year?

Salinity may get worse in a dry year as there is less rainfall to flush salts down the profile. With less rain to flush salt out of the profile and higher evaporation rates, there is more time for evaporation to concentrate the salts, even if the watertable does not rise. This has been observed in the drier years of 2017 / 2018. Although the watertable is dropping in 2019, the recent saline areas will not disappear quickly as a good salt flushing event (wetter winter) will be required.

Figure 21: Salt concentrated on the soil surface at Cooke Plains
10.7 Are there ‘Underground Rivers’ pushing down from the Mallee groundwater system?

There is no influence from the Mallee since groundwater movement is from east to west as shown in the watertable contour map. The map indicates contours of the height of the watertable with the arrow showing the direction of groundwater flow. The Murray Group Limestone (MGL) forms an unconfined aquifer and originates from the Dundas Tablelands in SW Victoria. The MGL aquifer discharges into the River Murray or in low-lying swamps around the Lakes. The aquifer is 140m thick in the central Mallee, but gets thinner (40m) toward Tailem Bend due to shallow granite basement in this area.

Figure 22: Map showing the direction of groundwater flow in the unconfined MGL aquifer. The flow originates in SW Victoria and flows toward the Murray River. The Cooke Plains / Coomandook area is highlighted as the red square.
11. Land Use Change and Vegetation Cover

Data provided by Natural Resources SA Murray-Darling Basin
Tracey Strugnell

Coorong Tatiara Local Action Plan - Coorong & Tatiara District Councils

A gradual change in land use can be observed in the following series of maps, showing an increase in the area of dryland cropping over time, particularly around the greater Coomandook area.

Figure 23: Land Use Change Maps 2003 2008 2014
This gradual change is further extrapolated in the following tables.

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<th>Hectares</th>
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<tr>
<td>Irrigated modified pasture</td>
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### Land Use 2008

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This data does illustrate an increase in area under continuous and mixed cropping farming systems, particularly around the northern area shown on the map. This land use does have a lower plant water use than perennial pastures. When coupled with summer weed control techniques, the level of water use on these areas would be low relative to well management dryland lucerne pastures [http://www.abc.net.au/science/articles/2001/08/14/345557.htm](http://www.abc.net.au/science/articles/2001/08/14/345557.htm)

It is difficult to quantify what the actual change in plant water use across the landscape could be as a result of shifts in the coverage, health, and density of perennial pastures, and increases in areas land under annual cropping. Additionally this land use change data does not quantify annual vs perennial pastures, or the quality of these pastures across the areas defined as having grazing land use.

It is widely accepted and proven through past studies that healthy perennial pastures or other perennial vegetation, when paired with ground cover, provides the greatest plant water use option and hence greatest potential in recharge reduction to saline groundwater. This remains the best option we have for reducing recharge to groundwater at both the local and regional level.

Long dry periods such as the millennium drought, 2015-16 drought, and 2018-19 drought would have significantly impaired the health, vigour, density and water use potential of perennial pastures on both saline and non saline land. In particular the summer active perennial pasture base that prevails in this region of dryland lucerne, perennial veldt grass and primrose. When rainfall did return after these dry periods, these pastures would have not been in optimum condition to ‘use the rain where it fell’, and hence reduce recharge to groundwater.
Larger versions of Land Use Maps can be found in Appendix 5.

Change in vegetation cover over time can be observed in the following series of maps, showing change in Fractional Vegetation Cover.

Fractional cover refers to estimating the proportion of an area that is covered by a pre-defined set vegetation or land cover types.

The data used to compile these maps has been sourced from satellite remote sensing data.

These maps also show real shifts in vegetation cover, with a large increase in ‘very low’ cover in the summer 2008. The 2014 map still indicates lower cover than 2003.

There is some correlation between areas of ‘very low’ cover and areas with a high prevalence of cropping.

However the ‘very low’ cover indicated in the 2008 map would also be picking up non cropping areas, likely to be bare ground and areas of poor quality annual or perennial pastures on sandy soils.

Areas of ‘very low’ cover would be providing very little to no plant water use, or recharge reduction potential at the time this data was captured.

**Figure 24:** Fractional Vegetation Cover Maps 2003 2008 2014
12. Dryland Salinity Management Recommendations

Information adapted from Coorong & Districts Soil Conservation Board, Coorong & District Local Action Plan
Tracey Strugnell & Graham Gates
Coorong Tatiara Local Action Plan - Coorong & Tatiara District Councils

This section discusses the accepted best land management practices over the last several decades to reduce recharge, address dryland salinity, and establish salt tolerant plants. All of these practices are still very relevant.

The management of dryland salinity can be divided into two sections
1) Attacking the cause
2) Treating the effects

12.1 Attacking the cause of dryland salinity
The main management strategy is attacking the causes of salinity is to make better use of water where it falls, in order to prevent this water from entering the groundwater system (as recharge).

This was confirmed in research undertaken by CSIRO Land and Water over the 1990’s and early 2000’s. The relationship was modeled between different crops and pastures and the “water balance” on a farm, presenting a breakthrough in the management of dryland salinity. The research confirmed that growing lucerne for a minimum of two years in rotation with other crops had a measurable effect in combating salinity. The researchers used huge underground “flower pots”, called lysimeters, to accurately measure plant water use.

Lysimeters are steel containers 2 metres deep and 1.6 metres square, sitting on scales and were buried in the middle of the test farms. The researchers measured the weight of the container at various times to calculate the amount of water falling on and being used by the crops.

They found that planting lucerne in rotation with canola, wheat and triticale crops used more water, as did native vegetation. The study also found that other options for minimising salinity includes developing crop varieties that use more water during the growing season, and introducing companion crops into the farming system. http://www.abc.net.au/science/articles/2001/08/14/345557.htm

The recommended strategies to achieve this are:
1. Establish Perennial Pastures
   - Perennial pastures have the advantage of being able to respond quickly to rain whenever it falls. They are also often able to make use of spring and summer rains, where annuals cannot. The deep rooted systems of perennials are able to then use more water from deep in the profile for longer periods during the year. Deep rooted perennial pastures can use up to double the water used by annual plants.
   - Lucerne is a deep rooted, summer active, high water using perennial species which has productive and economic value when grown on recharge areas.

2. Consider higher water use or longer season cropping alternatives
   A key recommendation of this report will be to improve our local understanding of cropping alternatives to improve plant water use under cropping rotations. Options that could be more carefully analysed include;
   - Pasture Cropping, use of cover crops over Lucerne, use of Lucerne in cropping rotations,
   - Increased use of summer crops such as Sorghum and Millett,
3. Increase crop and pasture water use
- Increase the health and productivity of crops and pastures so they are growing at their optimum production levels ensures that they are using the maximum amount of water.

4. Improve soil health by identifying soil constraints and ameliorating them.
   - This improves the capacity of healthy plants to use rainfall where it falls.
   - Treating non wetting sands with clay spreading and spading
   - Treating soil acidity through spreading lime
   - Improving soil fertility through targeted application of nutrients, trace elements, or biological treatments
   - Treatment of hard pans, or nutrient poor layers in the soil through ripping, Yeomans Plough or other mechanical techniques

5. Establish trees and shrubs
   - Trees (particularly eucalypts) and shrubs have an annual evaporation rate of up to seven times that of surrounding annual pastures. This is due to the evergreen canopy, large leaf area and the fact that they may have their roots directly into the groundwater. Annual crops and pastures lack these features.
   - The density of trees and/or shrubs required to minimise groundwater recharge will depend on species, age and health of trees, climate, soil and position in the landscape.
   - There are a number of ways that trees and shrubs can be incorporated viably into farming systems.
   - Farm Forestry is a productive option to reduce recharge, provide stock shelter, valuable windbreak and have the potential for an economic return when harvested.

6. Fodder Shrubs
   - Fodder shrubs such as saltbush or tagasaste are also productive options that reduce recharge, provide shelter as well as being valuable stock feed, particularly in times of drought.
   - Perennial forage plantings that include native shrubs can extend ground cover to consolidate fragile, easily eroded soils. The use of forage shrubs for many livestock producers coupled with unfamiliarity of their advantages and short comings can limit the productivity of these plants, their effective use by grazing livestock and their contribution to soil protection. Skilled management of these plants and grazing livestock can buffer feed shortages and protect the environment.
   - Experimental work carried out by the CSIRO in the Cooke Plains region demonstrated that these strategies need to be carried out over a large scale to be effective. A reduction in recharge of at least 50% and preferably 90% is needed over thousands of hectares.

12.2 Treating the effects of dryland salinity
The second approach to the dryland salinity problem is to tackle directly the salt affected soils that result from rising water tables. Following are some strategies for rehabilitating, or at least preventing the spread of these salt affected areas.

1. Understand your Soil
   - How saline is your soil? Ensure that your soil is tested. This is the first step to understanding what your options are.

2. Management of Cropping Land (land with low to moderate salinity)
   - Use salt tolerant crops such as barley or canola.
   - Sow salt tolerant pasture cultivars, e.g. Balansa Clover or Puccinellia.
- Grow high yielding crops and pastures to maximise plant water use.
- Aim to overcome other limiting factors ie. low fertility, disease control, weed control and seed bed preparation.
- Maintain crop and pasture residues to ensure the soil surface is covered at all times.
- Stay abreast of developments in salt tolerant cereal alternatives.

3. Management Strategies for Saline Land (land which is too saline for broad acre crops)

Salt Tolerant Pastures
- Fence off to enable the control of grazing pressure. Where possible keep this separate from annual crop and pasture land.
- Establish salt tolerant perennial pastures e.g. Puccinellia, Tall Wheat Grass, Saltbush, salt tolerant legumes.
- Encourage and maintain surface cover at all times to reduce evaporation and prevent salt from concentrating at the soil surface.
- Graze perennial pastures in Spring and Autumn and allow them to set seed on a regular basis to maintain stand density.

Revegetation
Establish salt tolerant native trees and shrubs around the edge of salt affected sites to increase water use and halt or slow down the rate of spread.

Bare Patches
- Rip area with single tyne ripper to roughen up the soil to promote the leaching of salt.
- Where possible, cover any bare patches with hay, straw, or similar material to;
  - Reduce salt concentration at the surface due to evaporation,
  - Encourage natural regeneration,
  - Reduce risk of topsoil loss.

On Farm Desalination
High SA Water mains prices are a challenge in the project area for livestock producers wholly dependent on mains water for stock. On Farm Desalination Plants are becoming more common in the project area. If technology becomes available to desalinate high salinity water economically on a small scale. It would be interesting to test if this could provide a localised draw down effect on the unconfined aquifer.
12.3 Factoring in rainfall and climatic variability

Consideration must be given to variability in rainfall and climate. Success of the plant based options discussed above is based on the assumption that there will be sufficient growing season rainfall, and in the case of summer based perennial pastures, at least some rainfall over the spring and summer.

Long dry periods such as the millennium drought, 2015-16 drought, and 2018-19 drought would have significantly impaired the health, vigour, density and water use potential of perennial pastures on both saline and non saline land. In particular the summer active perennial pasture base that prevails in this region of dryland lucerne, perennial veldt grass and primrose. When rainfall did return after these dry periods, these pastures would have not been in optimum condition to ‘use the rain where it fell’, and hence reduce recharge to groundwater.

12.4 Dryland Salinity Management Resources

Over the 1980’s through to the early 2000’s there was a wealth of salinity management resources produced on; soil and water testing, perennial pastures, saltbush, and more.

Links to many of these resources that are relevant to this region have been compiled at;

Recent findings from the Saltland Pasture Redemption Project can be accessed at www.coorong.sa.gov.au/saltlandredemption A focus of this project has included exploring how the salt tolerant legume Neptune Messina grows in local conditions.

An excellent resource that is is still extremely relevant is the ‘Saltland Pastures for South Australia Manual’. A summary of the contents of this document can be found at Appendix 6, or at http://www.coorong.sa.gov.au/webdata/resources/files/salt-land-pastures-SA-manual_%20(2).pdf

12.5 Current Projects

Information on the Saltland Pasture Redemption Projects can be accessed at www.coorong.sa.gov.au/saltlandredemption A focus of this project has included exploring how the salt tolerant legume Neptune Messina grows in local Coorong District conditions, and use of mulching to reduce evapo-concentration of salts at the soil surface.

A series of Mallee Seeps Projects have and are being delivered in the Mallee to better understand this landscape phenomena. More information and access to Mallee Seeps resources can be found at https://www.naturalresources.sa.gov.au/samurra ydarlingbasin/land-and-farming/soils/mallee-seeps

Coorong Tatiara Local Action Plan will be delivering a National Landcare Program 2 project developing new dryland salinity resources for land managers over 2019-2021.
13. Report Summary

This is what is occurring

Dryland salinity began to reappear on a number of farms in the latter part of the 2010 decade in the Coomandook / Meningie West area.

An examination of groundwater trends for the shallow unconfined aquifer indicates that significant rises in watertable levels have occurred since 2010. Subtle depressions in the landscape are high risk areas for salinity to appear following watertable rises.

Even though watertables are starting to fall again under dry conditions, salinity is getting worse due to higher evaporation rates and less rainfall to flush salt out of the soil profile once the salt has accumulated.

This is why it is occurring

Dryland salinity is the result of groundwater discharge occurring from the unconfined watertable aquifer and not from the deeper regional system.

Long term groundwater records from numerous monitoring bores/wells/piezometers indicate that a close relationship exists between calculated rainfall trends and depth to watertable trends.

Recharge to groundwater occurs across the whole landscape when the soil profile cannot hold all of the stored moisture which then drains down to the watertable. This occurs to a much greater extent following large episodic (especially out of season) rainfall events. These events are becoming more common under a ‘climate change’ scenario.

Some sites do not follow the rainfall trend (e.g. rising watertables with decreasing rainfall). Broader issues are influencing the watertable trend. The longer term increase in the level of the unconfined aquifer levels, overlaid with spikes after rainfall events, may partly reflect this trend. Increases may also be linked to the changes in land use and vegetation cover. This reflects the increase in: -area cropped, -very effective summer weed control, -and potentially areas of poor quality annual or perennial pastures with a low capacity for plant water use. These changes may partially explain the trend of rising groundwater.

This is what we can do about it

Because of the characteristics of this unconfined aquifer (i.e. highly transmissive sand/limestone), high water use strategies to prevent excess recharge need to be carried out over a broad area of the region to be successful. In practice, this is required over large areas, not just one farm.

Under current technology, smart soil moisture monitoring can be an early warning alert for potential high recharge events.

Flexible farming practices may be required to deal with extreme climatic patterns.

Saltland agronomy will always have a role to play and needs good demonstration sites of successful productive alternatives to broad scale cropping.

Recommendations going forward

- Further targeted monitoring after large and intense rainfall events, & to understand the relationship between dry conditions, evaporation and groundwater rise.
- The need for a technical and land manager panel to review outcomes arising from this report
- Government commitment to fund consistent groundwater, land use, and climatic monitoring in non-prescribed high risk salinity regions of the state,
- More research is required to determine the impact of changed farming practices, climate and rainfall variability on groundwater recharge and the expression of dryland salinity in the landscape.
### 14. Key Recommendations

<table>
<thead>
<tr>
<th>No</th>
<th>Section</th>
<th>Government / Funding Body Recommendations</th>
<th>Land Manager Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Salinity Risk Mapping</td>
<td>Consult with landholders in affected localities to ensure the accuracy of the maps. Establish options to undertake salinity risk mapping in the Tintinara West area. Do not put the Salinity Risk Maps on line or release publically.</td>
<td>If you have dryland salinity occurring on your land, and it is not shown on the maps in Section 2 please contact the Coorong Tatiara Local Action Plan.</td>
</tr>
<tr>
<td></td>
<td>Coomandook – Cooke Plains</td>
<td></td>
<td></td>
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<td></td>
<td>Meningie East</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Coorong Dryland Salinity Survey</td>
<td>Consider expanding the survey catchment to encompass the Tintinara West area. Ensure that these results are actively promoted to relevant agencies and funding bodies, to ensure they understand the current impact of dryland salinity.</td>
<td>If you have dryland salinity occurring on your land, and you do not believe that you have been included in the Dryland Salinity Survey please contact the Coorong Tatiara Local Action Plan for your data to be captured.</td>
</tr>
<tr>
<td>4</td>
<td>Coorong Dryland Salinity Description and Impacts</td>
<td>Improve awareness of the interactions between climatic variations and groundwater trends could inform farm management decisions that respond to episodic rainfall events. Consider putting together projects that measure soil moisture after episodic rainfall events, and agronomic options to use up soil moisture after episodic rainfall events.</td>
<td>Improve awareness of the interactions between climatic variations and groundwater trends could inform farm management decisions that respond to episodic rainfall events. Consider trying out agronomic options to use up soil moisture after episodic rainfall events.</td>
</tr>
<tr>
<td>4.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Watertable trends Coomandook – Meningie</td>
<td>Provide clear explanations of this relationship in updated dryland salinity information updates. Continue recommendation and pursuit of landscape scale projects that promote; high water use perennial vegetation, soil and farming management techniques that promote the concept of using maximum rainfall where it falls in the landscape. Promote management of existing perennial pasture stands to maximise plant water use and production. Advise current and and new landholders of the existence of Recharge reduction needs to be carried out on a very large scale (i.e. thousands rather than hundreds of hectares. Individually, farmers undertaking recharge reduction management on a single paddock will not make a difference, but collectively, many farmers doing the same thing can make a difference. Continue implementing saltland agronomy and mulching options post flushing events to decrease concentrated salinisation through evapo-concentration / ‘wicking up’</td>
<td></td>
</tr>
</tbody>
</table>
### No Section

<table>
<thead>
<tr>
<th>No</th>
<th>Section</th>
<th>Government / Funding Body Recommendations</th>
<th>Land Manager Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2</td>
<td>Previous Research</td>
<td>piezometers on their land and their significance&lt;br&gt;Consider ways to protect the piezometers&lt;br&gt;Consider finding ways to support land owners to collect groundwater level data themselves and provide data input&lt;br&gt;Consider restarting the ‘Salt Watch’ flag system to improve awareness&lt;br&gt;Ensure that the concerns in regard to reduced funding and monitoring of groundwater network is communicated clearly to relevant agencies and funding bodies, to ensure they understand the current impact of dryland salinity&lt;br&gt;For each region, key strategic sites should be identified for consistent long term monitoring. Key watertable monitoring wells need to be adequately identified, labelled and protected from damage by stock, farming operations etc.</td>
<td>Advise current and and new landholders of the existence of piezometers on their land and their significance&lt;br&gt;Consider ways to protect the piezometers&lt;br&gt;Ensure that the concerns in regard to reduced funding and monitoring of groundwater network is communicated clearly to relevant agencies and funding bodies, to ensure they understand the current impact of dryland salinity&lt;br&gt;Consider restarting the ‘Salt Watch’ flag system to improve awareness&lt;br&gt;Ensure that the concerns in regard to reduced funding and monitoring of groundwater network is communicated clearly to relevant agencies and funding bodies, to ensure they understand the current impact of dryland salinity&lt;br&gt;For each region, key strategic sites should be identified for consistent long term monitoring. Key watertable monitoring wells need to be adequately identified, labelled and protected from damage by stock, farming operations etc.</td>
</tr>
<tr>
<td>5.3</td>
<td>Watertable Trends Analysis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Coorong Hydrogeological Systems

Basement rocks of the Padthaway Ridge

- Increase land management interventions;
  - Perennial vegetation,
  - Healthier perennial pastures, and
  - Using rainfall where it falls,
- Localised treatments may have a higher likelihood of effectiveness on the western side of the Range in the Meningie East area

#### Watertable Trends & Graphs

Results & Discussion

- Provide clear explanations of this information in updated dryland salinity information updates
- Look for opportunities to establish new piezometers to improve monitoring opportunities in the Tintinara West area
- Ensure that the trend of rising groundwater over time is communicated clearly to relevant agencies and funding bodies, to ensure they understand the current impact of dryland salinity

- Check watertable trends around you by checking the well map in Figure 17 page 15, and the Graphs in Appendix 4
- Ensure that the trend of rising groundwater over time is communicated clearly to relevant agencies and funding bodies, to ensure they understand the current impact of dryland salinity

#### Coorong Dryland Salinity Mythbusting

- Develop a fact sheet series to lay out the key information in this Section 10. Coorong Dryland Salinity Mythbusting, In particular;
  - Impact of lake levels on watertables and dryland salinity

- Consider the information in this section carefully, to inform future land management decisions.
- ‘Underground Rivers’ pressure pushing down from the Mallee
- Why isn’t there an immediate response to high rainfall events?
- Why does dryland salinity get worse in a dry year?
- Why do the best crops occur before the ground goes saline?
- Is the unconfined aquifer pressurised?

<table>
<thead>
<tr>
<th>No</th>
<th>Section</th>
<th>Government / Funding Body Recommendations</th>
<th>Land Manager Recommendations</th>
</tr>
</thead>
</table>
| 11 | Land Use Change and Vegetation Cover | Explore whether any data exists to show improved vs unimproved pasture over time across the study area  
Work with landholder groups to discuss options for improving water use in cropping systems, and improved water use in mixed farming systems | Consider whether plant water use could be improved across your farm enterprise through;  
- Use of more perennial plants in your farming system  
- Improving soil health and reducing limitation to enhance capture of rain where it falls  
- Work with grower groups to explore how to improve water use in cropping systems. Options are discussed further in Section 12. |
| 12 | Dryland Salinity Management Recommendations | Review extension material, update and make accessible to land managers  
Work with grower groups to explore how to improve water use in cropping systems. Options are discussed further in Section 12.  
Work with grower groups to explore how to improve soil health by identifying soil constraints and ameliorating them. Improving the capacity of healthy plants to use rainfall where it falls. Options are discussed further in Section 12.  
Careful consideration must be given to the following paragraph. How will agencies and advisers reconsider the perennial plant based solutions in light of recent climate and rainfall variability? Long dry periods such as the millennium drought, 2015-16 drought, and 2018-19 drought would have significantly impaired the health, vigour, density and water use potential of perennial pastures on both saline and non saline land. In particular the summer active | Consider whether plant water use could be improved across your farm enterprise through;  
- Use of more perennial plants in your farming system  
- Improving soil health and reducing limitation to enhance capture of rain where it falls  
Work with grower groups to explore how to improve water use in cropping systems. Options are discussed further in Section 12.  
Work with grower groups to explore how to improve soil health by identifying soil constraints and ameliorating them. Improving the capacity of healthy plants to use rainfall where it falls. Options are discussed further in Section 12.  
Careful consideration must be given to the following paragraph. How do farmers, land managers, and advisers reconsider the perennial plant based solutions in light of recent climate and rainfall variability? Long dry periods such as the millennium drought, 2015-16 drought, and 2018-19 drought would have significantly impaired the health, vigour, density and water use potential of perennial pastures on both saline and non saline land. |
<table>
<thead>
<tr>
<th>13</th>
<th><strong>Report Summary</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>perennial pasture base that prevails in this region of dryland lucerne, perennial veldt grass and primrose. When rainfall did return after these dry periods, these pastures would have not been in optimum condition to ‘use the rain where it fell’, and hence reduce recharge to groundwater.</td>
<td>In particular the summer active perennial pasture base that prevails in this region of dryland lucerne, perennial veldt grass and primrose. When rainfall did return after these dry periods, these pastures would have not been in optimum condition to ‘use the rain where it fell’, and hence reduce recharge to groundwater.</td>
</tr>
</tbody>
</table>
| **Because of the characteristics of this unconfined aquifer (i.e. highly transmissive sand/limestone), high water use strategies to prevent excess recharge need to be carried out over a broad area of the region to be successful. In practice, this is required over large areas, not just one farm.**  
Consider the place of smart soil moisture monitoring as an early warning alert for potential high recharge events.  
Saltland agronomy will always have a role to play and needs good demonstration sites of successful productive alternatives to broad scale cropping.  
Further targeted monitoring after large and intense rainfall events, & to understand the relationship between dry conditions, evaporation and groundwater rise.  
A technical and land manager panel to review outcomes arising from this report  
Government commitment to fund consistent groundwater monitoring in non-prescribed high risk salinity regions of the state  
More research is required to determine the impact of changing farming practices on groundwater recharge and dryland salinity. | See recommendations above in 12.  
Flexible farming practices may be required to deal with extreme climatic patterns.  
Saltland agronomy will always have a role to play and needs good demonstration sites of successful productive alternatives to broad scale cropping.  
Further targeted monitoring after large and intense rainfall events, & to understand the relationship between dry conditions, evaporation and groundwater rise.  
A technical and land manager panel to review outcomes arising from this report  
Seek Government support for a consistent groundwater monitoring in non-prescribed high risk salinity regions of the state |
Appendix 4: Groundwater and Rainfall Trends continued

Chris Henschke – Senior Consultant Hydrogeology
PIRSA Rural Solutions

4.2 Meningie East Site Location Information and Hydrographs

The table shows a list of eight wells (from the DEW WaterConnect groundwater network) that are currently being monitored in the Meningie east focus area. These are displayed in the WaterConnect website in the following Obswell networks: SAMDB Non-prescribed area (SAMDB_NP), South East Non-prescribed area (SE_NP) and Tintinara Coonalpyn PWA (TINT_COON).

<table>
<thead>
<tr>
<th>Obswell No.</th>
<th>Obswell Network</th>
<th>Field Name</th>
<th>Property /Landholder Location</th>
<th>Date Drilled</th>
<th>Total Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNN004</td>
<td>SAMDB_NP</td>
<td>HA3</td>
<td>Yarindale Road</td>
<td>17/10/2005</td>
<td>6.71</td>
</tr>
<tr>
<td>JEF002</td>
<td>SE_NP</td>
<td>MN1</td>
<td>McIntosh Way</td>
<td>18/10/2005</td>
<td>6.18</td>
</tr>
<tr>
<td>JEF005</td>
<td>SE_NP</td>
<td>MN2</td>
<td>McIntosh Way</td>
<td>18/10/2005</td>
<td>8.14</td>
</tr>
<tr>
<td>JEF007</td>
<td>SE_NP</td>
<td>MN4</td>
<td>McIntosh Way</td>
<td>18/10/2005</td>
<td>12.00</td>
</tr>
<tr>
<td>JEF008</td>
<td>SE_NP</td>
<td>MN5</td>
<td>Scrub land</td>
<td>18/10/2005</td>
<td>9.76</td>
</tr>
<tr>
<td>STB001</td>
<td>SE_NP</td>
<td></td>
<td>Coonalpyn</td>
<td>22/11/1955</td>
<td>15.85</td>
</tr>
<tr>
<td>STB003</td>
<td>SE_NP</td>
<td></td>
<td>McIntosh Way</td>
<td>16/02/1945</td>
<td>17.37</td>
</tr>
<tr>
<td>FID002</td>
<td>SE_NP</td>
<td></td>
<td>Naranga Road</td>
<td>11/08/1954</td>
<td>7.01</td>
</tr>
<tr>
<td>CNB002</td>
<td>TINT_COON</td>
<td></td>
<td>Mt Boothby Cons Park</td>
<td>09/04/1987</td>
<td>16.5</td>
</tr>
</tbody>
</table>

The following sites were not able to be used for reasons as outlined below:

<table>
<thead>
<tr>
<th>Obswell No.</th>
<th>Field Name</th>
<th>Property /Landholder</th>
<th>Last date recorded</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNN001</td>
<td>HA1</td>
<td>Meningie</td>
<td>02/10/2007</td>
<td>This bore had become dry</td>
</tr>
<tr>
<td>BNN002</td>
<td>HA1</td>
<td>Yarindale Road</td>
<td>18/10/2011</td>
<td>Borehole was redrilled in Nov. 2007 but has since collapsed back to 5.75m and is dry</td>
</tr>
<tr>
<td>BNN003</td>
<td>HA2</td>
<td>Yarindale Road</td>
<td>07/04/2014</td>
<td>Destroyed by stock and removed from the network</td>
</tr>
</tbody>
</table>
Photographs have been taken by DEW at each monitoring site in the network and are presented to display the site in context of the surrounding land use.

**BNN004** in laneway between lucerne paddocks

**JEF002** is an old well and windmill

**JEF004** in laneway next to lucerne paddock

**JEF005** near abandoned well and tank

**JEF007** near old abandoned well

**JEF008** in native scrub land
STB001 is an old rusted bore casing

STB003 is an occasionally pumped bore on a Dairy farm

FID002 is an abandoned bore & windmill

CNB002 near cropped land & conservation park
**BNN004 (HA3):** This obs well was drilled to 9.8m depth in October 2005, but collapsed back to 6.7m due to a very sandy profile. It is on a property off Yarindale Road, Meningie and was located on a raceway adjacent to broadscale lucerne paddocks. There was a notable falling trend (-0.6m) from 2006 to 2010 which is reflected in the decreasing residual rainfall. A rising trend (+0.4m) 2015 to 2018 is similarly reflected in the increasing residual rainfall trend for that period.

**JEF002:** This monitoring site is located almost mid-way between Meningie and Coonalpyn. The borehole was drilled to 5.6m depth in 1951 and the original depth to water was 5.2m from the ground surface. Regular monitoring commenced in March 1990 with a water level depth of 3.48m below ground level. The watertable had therefore risen by 2.1m over the 40 year period. Since then it has shown seasonal fluctuations ranging from 2.8m to 3.7m below ground level. The depth to water trend closely mirrors the residual accumulative rainfall trend. The highest water levels for this site occurred in December 1992, October 2013 and October 2018. This is in response to the extreme rainfall events of the spring/summer of 2010/11 and the spring of 2016. The re-emergence of dryland salinity is not surprising.
**JEF004 (MN1):** This purpose obs well was drilled to 6.2m on private property adjacent to McIntosh Way in October 2005. It was sited near to an existing old well (number ‘16’). It is located at the base of a sand dune and was surrounded by Lucerne at the time of installation. The depth to water level shows a continuously rising trend from 2005 until 2012 (+1.3m) and is a reflection of the rainfall trend for most of that period. Since then it follows a seasonal (sinusoidal) trend with spring highs and autumn lows. The rise of the watertable may reflect the loss of lucerne during the drought.

**JEF005 (MN2):** This purpose observation well was drilled to 8m adjacent to an old existing well (called ‘Rankine’) on private property adjacent to McIntosh Way in October 2005. It is located on sandplain country. It had to be re-drilled in November 2007 due to stock damage (hence the missing records from 2005 to 2007). It displays very similar responses to JEF004 with strong seasonal responses (spring peaks and autumns troughs).
**JEF007 (MN4):** This purpose obs well was drilled to 12m on private property adjacent to McIntosh Way in October 2005. It is sited adjacent to an old well (called ‘*new vivian*’) in an area of jumbled sand dunes. It had to be re-drilled due to stock damage in April 2006. It was removed from the DEW monitoring network in September 2017 (under the DEW Monitoring Optimisation Project). The water level trend mirrors the falling rainfall trend from 2005 to 2009 and the rising trend from 2010 till 2014. Similarly the steep rise from 2015 to 2017 reflects the rising trend in rainfall. The depth to water reached its highest ever level in September 2017.

![JEF 7](image)

**JEF008 (MN5):** The site was drilled to almost 10m in October 2005 in the middle of large remnant scrub patch adjacent to the McIntosh Way. A falling trend (-0.4m) occurred from 2006 to 2008. A rising trend (+0.8m) occurred from 2009 to 2018. There is a close correlation between rainfall and water level trends. The depth to water reached its highest recorded elevation in October 2018.

![JEF 8](image)
STB001: This site is located north west of Coonalpyn and was drilled to 15m in 1955. In 1955 the depth to water was recorded at 14.0m from the surface. Regular monitoring commenced in March 1990 with a water level of 11.7m. This gives a rise of 2.3m between 1955 and 1990. The bore has continued to exhibit a continuously rising trend with a further 1.2m rise between 1990 and 2018.

STB003: This site is located on a dairy farm south of Binnie Lookout and was drilled to 17m in 1945. The bore has a TDS of 1000mg/L and is pumped intermittently. The farm was apparently being renovated to lucerne. There is a large data gap between 2010 and 2016 due to access difficulties. It was removed from the monitoring network by DEW in September 2017 (under the DEW Monitoring Optimisation Project). Although possibly affected by pumping, the water level trend closely mirrors the falling rainfall trend from 1993 up to 2008. Of interest is that the depth to water reached its highest ever recorded level of 9.85m below the surface in March 2017.
**FID002:** This bore was drilled to 7m depth in 1954. Regular monitoring commenced in 1989. The watertable rose by 1.9m between 1954 and 1989. Since then it has mirrored the trends in rainfall, but with a steady decline in the decade from 2000 to 2010. Water levels began to rise again in 2015 and reached their highest level in April 2018, but falling again during the 2018/19 dry spell.

**CNB002:** Located on the margin of Boothby Conservation Park, south of Coonalpyn, this borehole was drilled to 16.5m in 1987. It indicates a continuously rising trend up until 2005 followed by a fall until 2007. The depth to water level is almost a reverse image of the rainfall cumulative deviation up until 2005, suggesting that in this case groundwater is still responding to the clearing of native vegetation. The peak in 2005 indicates a response to the 108mm recorded in June 2005. The falling trend from 2006 to 2008 mirrors the falling rainfall cumulative deviation. Similarly the rising trend from 2009 to 2018 mirrors the rising rainfall cumulative deviation.
Appendix 5: Land Use Change

Data provided by Natural Resources SA Murray-Darling Basin
### Land Use 2003

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Hectares</th>
<th>% of Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropping</td>
<td>70,631</td>
<td>13.2</td>
</tr>
<tr>
<td>Grazing</td>
<td>357,829</td>
<td>66.9</td>
</tr>
<tr>
<td>Irrigated modified pasture</td>
<td>3,109</td>
<td>0.6</td>
</tr>
<tr>
<td>Marsh/wetland</td>
<td>31,186</td>
<td>5.8</td>
</tr>
<tr>
<td>Conservation and Natural Resources</td>
<td>59,291</td>
<td>11.1</td>
</tr>
<tr>
<td>Unclassified/Not Part of project scope</td>
<td>12,922</td>
<td>2.4</td>
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### Land Use 2008

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Hectares</th>
<th>% of Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropping</td>
<td>101,966</td>
<td>19.1</td>
</tr>
<tr>
<td>Grazing</td>
<td>322,968</td>
<td>60.4</td>
</tr>
<tr>
<td>Irrigated modified pasture</td>
<td>3,626</td>
<td>0.7</td>
</tr>
<tr>
<td>Marsh/wetland</td>
<td>30,512</td>
<td>5.7</td>
</tr>
<tr>
<td>Conservation and Natural Resources</td>
<td>63,619</td>
<td>11.9</td>
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<td>Unclassified/Not Part of project scope</td>
<td>12,279</td>
<td>2.3</td>
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</table>

### Land Use 2014

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Hectares</th>
<th>% of Area</th>
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</thead>
<tbody>
<tr>
<td>Cropping</td>
<td>107,171</td>
<td>20.0</td>
</tr>
<tr>
<td>Grazing</td>
<td>318,526</td>
<td>59.5</td>
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<tr>
<td>Irrigated modified pasture</td>
<td>744</td>
<td>0.1</td>
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<tr>
<td>Marsh/wetland</td>
<td>29,441</td>
<td>5.5</td>
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<tr>
<td>Conservation and Natural Resources</td>
<td>63,669</td>
<td>11.9</td>
</tr>
<tr>
<td>Unclassified/Not Part of project scope</td>
<td>15,418</td>
<td>2.9</td>
</tr>
</tbody>
</table>
Appendix 7: Unconfined and Confined Aquifer Maps

Unconfined Aquifer Map

Confined Aquifer Map
Appendix 7 continued: Unconfined Aquifer Water Tables & Salinity Levers

Unconfined Aquifer Water Table

Unconfined Aquifer Salinity Levers