McLaren Vale Prescribed Wells Area – Groundwater salinity investigation

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Summary

In the McLaren Vale Prescribed Wells Area, preparation of groundwater salinity distribution maps for the years 1980, 1990, 2007 and 2014 has identified ‘hot spots’ of rising salinity in the Pirramimma Sands and Maslin Sands aquifers. The main driver for these increases appears to be extraction, with water level data suggesting the sources of the increased salinity are underlying aquifers/aquitards which contain higher salinity groundwater. These findings are consistent with previous studies carried out by the National Centre for Groundwater Research and Training. Salinity trends in the Port Willunga Formation aquifer are stable or showing a gradual decline which may be explained by downward leakage from the overlying Quaternary sediments and the lower volumes being pumped from individual wells than in the other aquifers. Data logger water level and salinity data from selected irrigation wells has been consistent with observed regional trends and confirms the leakage processes causing changes in salinity.

The significant rises in groundwater salinity in some areas raises some questions about the local sustainability of the resource and whether a management response is necessary. The broad correlation between rises in salinity and increases in extraction from the monitoring evidence suggest that a reduction in extraction in the ‘hot spot’ areas may stabilize or even reduce salinities.

To a certain extent, this sustainability issue could be self-managing – as salinity levels rise above 1500 mg/L, irrigators may reduce using groundwater and revert to alternative sources (such as the Willunga Basin Water Company). This voluntary reduction in pumping may lead to positive salinity outcomes.

Irrigators in the ‘hot spot’ areas could minimise the risk of salinity increases by reducing the drawdown caused by pumping during the irrigation season. This could be achieved by pumping any bore at a lower rate over a longer period of time to achieve the same volume of output. If several irrigation bores are used on any property, spreading the pumping volume as evenly as possible could also reduce drawdowns during the irrigation season.

On-going salinity monitoring is essential to inform the review of the magnitude and extent of the ‘hot spot’ areas. More detailed investigations and consultation with water users will be required to determine what form the future management responses could take. The next review of the McLaren Vale PWA Water Allocation Plan is planned for 2022-23.
1 Introduction

The McLaren Vale area is one of the major wine producing areas in SA and its development has been highly dependent on the groundwater resources of the Willunga Basin. The McLaren Vale Prescribed Wells Area (PWA) encompasses sedimentary aquifers of Quaternary and Tertiary age within the Willunga Basin and fractured rock aquifers which form the hills to the east of the Willunga Fault and which also crop out to the north. Groundwater occurs in five major aquifers; the Quaternary Aquifer, Port Willunga Formation Aquifer, Pirramimma Sand aquifer, Maslin Sands Aquifer and Fractured Rock Aquifer. Barnett (2018) provides an updated version of the hydrostratigraphy of the Willunga Basin. Imported treated effluent from the Christies Beach Wastewater Treatment Plant provides an alternative water source to groundwater via the Willunga Basin Water Company reticulation scheme.

Figure 1. Location of McLaren Vale PWA and geological cross section
In 2010, the McLaren Vale PWA Groundwater Status Report (Department for Water, 2010) noted significant increases in groundwater salinity associated with the millennium drought. Although higher rainfall since 2010 led to reduced salinity levels in most of these wells, rising trends persisted in a number of them. This technical note provides an interpretation of the salinity trends as well as an analysis of probable causes of the observed salinity increases.

2 Salinity monitoring

2.1 Salinity trends to 2011

The first comprehensive salinity survey in the McLaren Vale PWA was conducted in the summer of 1987-88, and was repeated early in 1989. A more formal monitoring network was established later the same year. This network consisted of equipped wells in the water level observation network supplemented by other private wells, with samples being taken on a monthly basis during the irrigation season. Unequipped observation wells were also sampled in April 1990. Regular salinity monitoring of irrigation wells has been carried out by DEW (and its predecessors) since then.

More widespread monitoring began in 2007 when sample bottles were distributed to all irrigators by Departmental field staff and later collected and analysed. Interpretation of the data revealed that in all three major aquifers, there appears to be a broad correlation between salinity and rainfall patterns. The increases in extraction during the drought from 2007 to 2010 may have also contributed. (Department for Water, 2010).

Table 1 summarises the observed rises in salinity due to drought which were discussed with Flinders University and the AMLR NRM Board. The groundwater salinity response for all three aquifers was surprisingly consistent. Between 70 and 80 % of all irrigation wells were affected by 12 to 14 % increases in salinity. This represented average rises of between 117 and 182 mg/L in the various aquifers.

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>No. wells sampled</th>
<th>No. showing rise</th>
<th>Rise (mg/L)</th>
<th>% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port Willunga Fm</td>
<td>96</td>
<td>71 (74%)</td>
<td>153</td>
<td>13</td>
</tr>
<tr>
<td>Pirramimma Sand</td>
<td>86</td>
<td>68 (79%)</td>
<td>117</td>
<td>12</td>
</tr>
<tr>
<td>Maslin Sands</td>
<td>57</td>
<td>43 (75%)</td>
<td>182</td>
<td>14</td>
</tr>
<tr>
<td>Fractured rock</td>
<td>62</td>
<td>44 (71%)</td>
<td>155</td>
<td>12</td>
</tr>
</tbody>
</table>

Higher rainfall during 2009-10 resulted in rising trends stabilising or actually decreasing in about half of the wells, however some were still rising in 2011 after the drought ended.

2.2 Recent monitoring

In 2015, another assessment of observed trends delineated about 70 wells that were still showing a consistent rising trend based on the limited data collected since 2011. These wells were targeted by a new monitoring approach whereby 500 ml sample bottles and labels were mailed out to licensees in December 2016 with instructions on sampling procedures and where to deliver the samples for collection and analysis by DEW. About 60% of these samples were returned to the McLaren Vale Visitor Centre for collection, with the remainder collected during three half day field visits. The results were emailed out to the irrigators with a link to the salinity graph for their well on the Waterconnect website. Another successful mail out occurred in 2018.
Targeted monitoring has continued in 2018 and 2019. In addition to salinity monitoring of targeted wells, a broader program was established in 2018 to offer the testing of salinity samples provided from any licensed irrigation well in the McLaren Vale PWA. This program supports groundwater users to identify any local salinity issues and provides more comprehensive regional data for monitoring salinity trends across in the McLaren Vale PWA.

3 Previous investigations into salinity rises

The Willunga Basin is one of the focus sites for research activities of the National Centre for Groundwater Research and Training (NCGRT) which include groundwater – surface water interactions, seawater intrusion risk, regional groundwater flow and inter-aquifer leakage. In response to the findings outlined in Table 1, the NCGRT carried out an investigation to further examine the rising trends, with the most up to date salinity sampling results, and investigate their spatial distribution and possible relationship to water level and bore depth (Villeneuve and Harrington, 2012). It found a possible relationship between increasing salinity and the proximity of well screens to the Blanch Point Marls aquitard. The report therefore suggested that isotope sampling for helium and carbon-14 in wells with increasing salinity and well screens close to the aquitard be undertaken. This could provide information on possible aquitard contributions to increasing salinity.

Judd (2016) utilised rigorous statistical tests to determine both the existence of salinity trends and relationships with key parameters. The analysis was applied to data collected up until 2014 from 383 wells distributed across the Willunga Basin. The statistical tests identified 87 wells with salinity trends that are rising with time (22.7% of the total 383 wells), and 28 wells (7.3%) with ‘probably rising’ trends. 19 wells (4.0%) have falling or ‘probably falling’ trends, with the majority (249, or 65% of wells) having either stable salinity or no significant trend.

Having established which wells have rising and falling salinity trends, the relationships with different hydrogeological parameters and well construction and usage information were then examined to investigate possible reasons for rising trends. The results from Judd (2016) are summarised below:

- There is no relationship between salinity trend and geology, with the proportion of wells with increasing trends being similar in Port Willunga, Pirramimma Sand, Maslin Sands and Fractured Rock aquifers.
- Most wells with rising salinity have screens that are more than 10 m below the watertable, which suggests that irrigation drainage is not the cause of most salinity.
- There is no relationship between salinity trend and the age of the well, which suggests that poor well construction is unlikely to contribute significantly to salinity trends.
- No relationship between salinity trend and the age of water (determined using carbon-14) was found, which supports the conclusion that irrigation drainage is not the cause of rising salinity trends.
- There is no significant difference in salinity trends between wells that are used for irrigation and those that are not.

Although there is no relationship between the average pumping rate of a well and the existence of a rising salinity trend, a relationship between annual extraction rate and annual change in salinity is apparent for a number of wells (Fig. 2). Statistical analysis found that the probability of pumping increasing and salinity increasing together, is considerably higher than the probability of pumping increasing and salinity decreasing. More importantly from a management perspective, the probability of pumping decreasing and salinity decreasing together is even higher than the probability of both increasing (Judd, 2016).

A statistical analysis of years when significant changes in salinity occurred (change-points) demonstrated that there is an indirect relationship between salinity trends and climate (largely rainfall), with the majority of the
change-points identified within the salinity datasets correlating with the 2006 drought (Fig. 3). The more direct relationship is between salinity trends and annual extraction volumes which are controlled by climate. Extraction increases during dry years which can in turn, lead to salinity increases in some areas.

Other work carried out that informs salinity processes involved obtaining drill core of the Blanche Point Marls aquitard at five locations and measuring salinity within the pore water (Irving, 2016). The results has shown that the aquitard is not a major source of salinity, and aquitard pore water salinity is mostly low (less than 2000 mg/L).

![Figure 2. Example of the relationship between extraction rate and salinity (after Judd, 2016)](image)

![Figure 3. Frequency of change-points (after Judd, 2016)](image)

## 4 Spatial distribution of salinity trends
A time series of salinity distribution was prepared for each aquifer for the first time. This enables a spatial analysis of where salinity changes are occurring which can provide a focus for determining the process that is driving those changes. The selection of the years for which the salinity maps were created was determined by the availability of monitoring data. The changes in salinity will be discussed for each aquifer in turn.
4.1 Port Willunga Formation

This aquifer, composed of Tertiary limestone, is confined throughout its extent with groundwater flow toward the coast in a south-westerly direction. Figure 4 shows a trend of increasing salinity toward the west with the lowest salinity of below 800 mg/L observed in the northeast near McLaren Vale township. The salinity legend displays relatively small increments of 100 mg/L which is necessary to show the relatively small changes in salinity over time. Some freshening occurs around 2007 before the drought, with some modest increases showing in 2007 which are probably caused by the drought.

![Figure 4. Changes in salinity distribution in the Port Willunga Formation aquifer](image-url)
4.2 Pirramimma Sands

This sand aquifer is hydraulically connected to the Port Willunga Formation aquifer. Groundwater flows in a south-westerly direction. The lowest salinities below 600 mg/L occur in the McLaren Vale area (Fig. 5) with increases toward the north-east. A continuous rise in salinity over time can be observed in the area to the east of McLaren Flat to levels higher than the salinity tolerance for wine grapes. This on-going rise does not appear to be related to drought impacts and represents a major sustainability issue for irrigators using this aquifer.

![Figure 5. Changes in salinity distribution in the Pirramimma Sandstone aquifer](image)

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4.3 Maslin Sands

This sand aquifer is generally only utilised to the north of the McLaren Vale to McLaren Flat road because elsewhere, it is too deep and shallower aquifers can be developed. As with the other aquifers, groundwater flows in a south-westerly direction. There is also a general rise in salinity in this direction also, as shown in Figure 6. The time series data shows reasonable consistent values over most of the area, with the exception of the area north of McLaren Flat where continuous rises are occurring where Maslin Sands outcrops and overlies basement rocks. These rises do not appear to be drought-related and are reaching levels higher than the salinity tolerance for wine grapes.
Figure 6. Changes in salinity distribution in the Maslin Sands aquifer
5 Salinity processes

There are several processes that can lead to salinity increases in an aquifer. These include lateral movement of saline groundwater within any given aquifer, downward flushing of salt from the overlying unsaturated zone and vertical movement of more saline groundwater from overlying or underlying sedimentary layers. The salinity trends for each of the aquifers and possible drivers for salinity changes are discussed below.

Given that earlier investigations found a possible relationship between salinity increases and extraction, the history of metered extractions for the areas of interest was examined and graphed against salinity trends. Metered extractions are only available continuously since 2002, with earlier data from the period 1997 to 1999. The recognised maximum salinity level that can be tolerated by wine grapes (1500 mg/L) is also shown on the graphs.

5.1 Port Willunga Formation

As mentioned, the changes in the salinity for the Port Willunga Formation confined aquifer (PWF) are relatively minor. Figure 7 shows long term trends from four representative irrigation wells which are generally stable, or showing slightly declining trends, apart from the well showing a slight rising trend which is located in a higher salinity zone of the PWF aquifer. Also shown in the graph is the extraction from the PWF aquifer which has been reasonably consistent over the years. There appears to be a close relationship with extraction, as shown by the decline in both salinity and extraction between 1998 and 2006, and the following increase in both to 2010 during the drought.

Although the salinity trend does appear to also follow the rainfall trend, the fact that this aquifer is confined would result in a considerable lag time for rainfall recharge to infiltrate down to and freshen the aquifer.

![Figure 7. Long term salinity trends in the Port Willunga Formation aquifer](image)

Salinity tolerance for wine grapes
Figure 8 presents the frequency distribution of the annual extraction from each irrigation well. This graph shows that the majority of extraction from individual wells is below 5 ML/yr, with a steady decrease in the number of wells pumping higher volumes during the irrigation season.

![Figure 8. Frequency distribution of extraction volumes from the Port Willunga Formation aquifer](image)

When extraction occurs from the confined PWF, a drawdown in the potentiometric surface will occur. Whether or not any adverse impacts occur as a result of this drawdown depends on the water level and salinity of groundwater in the overlying Quaternary sediments. There is a low risk of upward leakage from the Blanche Point Marls because the base of the PWF aquifer is well below the bottom of the irrigation wells (averaging greater than 50m).

Figure 9 shows a view of the Willunga Basin from the south-west corner near Sellicks Hill, looking northeast toward McLaren Vale. It shows the approximate Quaternary watertable elevation surface (in grey) that is up to 40m higher than the PWF potentiometric surface (in blue), indicating that there is potential for downward leakage at all times.

![Figure 9. Water level elevation surfaces for the Quaternary and Port Willunga Formation aquifers](image)
Figure 10 presents the salinity distribution for the Quaternary aquifer which indicates large areas of low salinity groundwater that is most likely recharged from streamflow in the numerous drainage lines emanating from the range and flowing in a north-westerly direction. This indicates that the groundwater leaking downwards into the PWF aquifer is most likely to be of low salinity.

In summary, there may be several reasons why salinity trends in the PWF aquifer are stable. The extractions from individual wells are relatively low, which minimise the potential for any downward leakage from the overlying Quaternary sediments. Even if such leakage did occur during periods of high extraction, the generally low salinities in these sediments would not cause significant increases in salinity the PWF aquifer.
5.2 Pirrama Sands

The previous section highlighted areas of rising salinity in the Pirramimma Sands (PS) aquifer to the east of McLaren Flat. Figure 11 presents salinity trends and extraction data for three ‘hot spots’ in this aquifer. There appears to be a good correlation between a rising salinity trend and increasing extraction since 2002 in areas B and C. However the meter data for the period 1997-99 shows higher extraction than after 2002 in areas A and B. This indicates a possible lag time between pumping and the resultant salinity impact. Some wells however, show a stabilisation or even decline in recent years which could be associated with a decrease in extraction.
Figure 11. Salinity trends and extraction for the Pirramimma Sands aquifer
Figure 12 presents the frequency distribution of the annual extraction from each irrigation well in Areas A, B and C. This graph shows that although most of the extraction from individual wells is below 5 ML/yr, there is a larger proportion of wells with higher extraction rates than was observed for the PWF aquifer.

![Figure 12. Frequency distribution of extraction volumes from the Pirramimma Sands aquifer ‘hot spots’](image)

As the PS aquifer is unconfined to the east of McLaren Flat, there is no groundwater in the overlying clays which could contribute to the salinity increases. These clays are generally over 20 m thick which would most likely preclude drainage of irrigation water as a possible source of salt. Lateral flow of more saline water is not feasible due to the slow lateral movement of groundwater (metres per year) and the absence of a nearby source.

The only other possible source of more saline groundwater is the underlying Blanche Point Marl (BPM) confining layer. Although this layer consists predominantly of low permeability marls, there are occasional limestone layers that could readily transmit groundwater. A limited number of wells are completed in these layers and reveal salinities of the same order of magnitude as the adjacent aquifers, with potentiometric heads higher than the overlying watertable aquifers. In addition, the chloride content of pore water samples taken from cores across the BPM are below 1000 mg/L in the vicinity of the ‘hot spots’ (Irvine, 2016). The irrigation wells near McLaren Flat are completed to a depth within 10 – 20 m of the underlying BPM confining layer.

Figure 13 presents a schematic cross section and the probable mechanism for salinity increases in the PS aquifer. The fact that salinities in the BPM confining layer are not too dissimilar to those in the PS aquifer could help explain the stabilisation of the rising trends seen in Figure 11.

The apparent lag time between extraction and salinity response is consistent with the relatively slow flow rates associated with vertical leakage.

![Figure 13. Probable source of salinity increase in the Pirramimma Sands aquifer](image)
5.3 Maslin Sands

Areas of rising salinity in the Maslin Sands (MS) aquifer previously highlighted occur to the north of McLaren Vale and McLaren Flat where the MS aquifer outcrops and overlies basement rocks. Figure 14 presents salinity trends and extraction data for two ‘hot spots’ in this aquifer. Area A is showing a stabilisation in recent years in response to extraction rates showing a gradual declining trend which is probably a result of a lag time existing between pumping and salinity impact. There appears to be a good correlation between a rising salinity trend and increasing extraction since 2002 in Area B even though extractions are slightly lower than 1997-98. Area B is also displaying an on-going rising trend.

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**Figure 14. Salinity trends and extraction for the Maslin Sands aquifer**
Figure 15 presents the frequency distribution of the annual extraction from each irrigation well in Areas A and B. This graph shows that most of the extraction from individual wells is between 5 and 15 ML/yr, which is generally higher than was observed for the other two aquifers.

![Frequency distribution of extraction volumes from the Maslin Sands aquifer ‘hot spots’](image)

**Figure 15. Frequency distribution of extraction volumes from the Maslin Sands aquifer ‘hot spots’**

As the MS aquifer is outcropping and unconfined to the north of McLaren Flat, there is no groundwater in the overlying clays which could contribute to the salinity increases. These clays are generally over 20 m thick which would most likely preclude drainage of irrigation water as a possible source of salt.

The only other possible source of more saline groundwater is the underlying confined basement fractured rock aquifer (FRA). Examination of water levels in the confined FRA shows that the pressure level is higher than the watertable in the MS aquifer, which would cause upward leakage especially when pumping from the MS aquifer causes local drawdown.

Of more significance is Figure 16 which displays the salinity of the FRA to the north of McLaren Vale and McLaren Flat. These salinities are higher than those in the overlying MS aquifer in the ‘hot spot’ Areas A and B and range up to 6000 mg/L. This could explain why the rising trend in Area B is continuing above 2000 mg/L with the potential for further increases up to this 6000 mg/L level.
Figure 16. Salinity distribution in the basement fractured rock aquifer

Figure 17 presents a schematic cross section and the probable mechanism for salinity increases in the MS aquifer.

Figure 17. Probable source of salinity increase in the Maslin Sands aquifer
6  Telemetry Pilot Project data

The McLaren Vale Groundwater Telemetry Pilot Project was established in 2014 with the support of seven irrigators to provide ‘real time’ logger data of water level, salinity and meter readings. The aim was to assist irrigators to make prompt management decisions and to provide a better understanding of the groundwater system response to extraction. The logger data was downloaded from the Water Data Services website and plotted on graphs, with the only parameters analyzed for this report being the water level and salinity values. The water level shown on the graph is the depth of water in the irrigation well above the data logger, and not the depth of water below ground level which is normally used. Table 1 presents the list of wells equipped with the loggers and their completion details.

Table 1. Irrigation wells equipped with data loggers

<table>
<thead>
<tr>
<th>Well</th>
<th>Owner</th>
<th>Aquifer</th>
<th>Production zone (m)</th>
<th>Logger depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6627-7037</td>
<td>Chalk Hill</td>
<td>PWF</td>
<td>63 - 80</td>
<td>Unknown</td>
</tr>
<tr>
<td>6627-7240</td>
<td>D’Arenberg</td>
<td>MS</td>
<td>72 - 75</td>
<td>75.6</td>
</tr>
<tr>
<td>6627-8065</td>
<td>Dowie Doole</td>
<td>PWF</td>
<td>31 - 45</td>
<td>22.8</td>
</tr>
<tr>
<td>6627-8072</td>
<td>Gemtree</td>
<td>PS</td>
<td>98 - 110</td>
<td>56.0</td>
</tr>
<tr>
<td>6627-9467</td>
<td>Penny’s Hill</td>
<td>PS</td>
<td>121 - 133</td>
<td>Unknown</td>
</tr>
<tr>
<td>6627-10042</td>
<td>Hedonist</td>
<td>FRA</td>
<td>5.5 – 99.5</td>
<td>57.8</td>
</tr>
<tr>
<td>6627-10720</td>
<td>Paxton</td>
<td>PS</td>
<td>46 - 55</td>
<td>22.0</td>
</tr>
</tbody>
</table>

6.1 Well 6627-7037 - Chalk Hill

This well is completed open hole in the confined PWF aquifer with the logger installed at an unknown depth. It is located 1.5 km north of Willunga. Figure 18 presents the groundwater level and salinity trends for this well.

Figure 18. Groundwater level and salinity trends – 6627-7037
Prior to May 2015, the logger was set at a shallow depth which allowed the water level to fall below it during periods of pumping. It was subsequently lowered by about 22 m which allowed a better appreciation of the pumping drawdown which averages about 7 m. The pressure level trend shows a seasonal variation of about 3 m between summer and winter and a slight recovery in pressure level of about 1.5 m from the end of the 2016 irrigation season, to the end of the 2017 season. This is more than likely a reflection of the wet 2017 summer which would have resulted in reduced extraction for irrigation.

The salinity trends are showing a gradual decline which is consistent with the observed regional trends for the PWF aquifer. There also appears to be a relationship between salinity and pumping whereby salinity values tend to decrease during the irrigation season when drawdown occurs. This trend supports the suggestion made earlier in this report that the salinity decreases in the PWF aquifer are caused by downward leakage from the overlying Quaternary sediments which is driven by pumping drawdowns.

6.2 Well 6627-7240 - D’Arenberg

This well is screened in the unconfined MS aquifer with the logger installed just below the production zone. It is located 2.7 km north of McLaren Flat near the northern extent of the MS aquifer. Figure 19 presents the groundwater level and salinity trends for this well.

![Figure 19. Groundwater level and salinity trends – 6627-7240](image)

Similarly to the previous well, the logger was set at a shallow depth which allowed the water level to fall below it during periods of pumping. It was subsequently lowered in November 2014 by about 3 m which allowed a better appreciation of the pumping drawdown which averages about 6 m. The water level trend shows a seasonal variation of about one metre between summer and winter with a longer term stable trend.

Of more interest is the salinity trend for this well which is located in area of rising salinity in the MS aquifer identified earlier in this report. A gradual rising trend in the irrigation season salinities can be seen, but more importantly, there appears to be a difference of about 150 mg/L between the irrigation season salinities and the values recorded during winter. This evidence supports the suggestion that the salinity increases are caused by upward leakage from the underlying FRA which is driven by pumping drawdowns. The large variations in salinity data of ~300 mg/L during the 2015-16 irrigation season are suspicious.

This mechanism is the complete opposite of the processes observed in the previous PWF well 6627-7037.
6.3 Well 6627-8065 - Dowie Doole

This well is completed open hole in the confined PWF aquifer with the logger installed 10 m above the production zone. It is located 3.7 km southwest of McLaren Vale. Figure 20 presents the groundwater level and salinity trends for this well.

![Graph showing groundwater level and salinity trends for Well 6627-8065](image)

**Figure 20. Groundwater level and salinity trends – 6627-8065**

This well has a more complete record than the previous PWF well 6627-7037 and the processes suggested by that earlier data are more clearly defined in Figure 20. There is a good correlation between water levels and salinity values which supports the downward leakage process. The pressure levels show a seasonal variation of about a metre with pumping drawdowns of about 11-12 m. The longer term pressure level trend is stable.

Salinity values show a gradual decrease during the irrigation season to a maximum fall of about 100 mg/L. The longer term salinity trends are stable up until December 2016 when the conductivity sensor appears to drift or malfunction.

6.4 Well 6627-8072 - Gemtree

This well is screened in the unconfined PS aquifer with the logger installed at a depth of 56 m. It is located 1.7 km southeast of McLaren Flat close to the Willunga Fault. Figure 21 presents the groundwater level and salinity trends for this well.

The data for this well does not look as ‘clean’ as the other wells. The water level data is ‘noisy’ but nonetheless shows seasonal variations of up to a metre with a longer term gradual decline which is consistent with the regional monitoring network. The logger appears to be set too high in the well.

Although the overall decreasing salinity trend is not inconsistent with observed regional trends, the large variations in salinity data of up to 1000 mg/L suggest a faulty probe. A possible cause is the large distance of 40 m between the logger and the well's production interval where groundwater enters the well. If possible, the logger should lowered to just above the pump to ensure more representative salinity monitoring and also allow capture of the full pumping drawdown.
Figure 21. Groundwater level and salinity trends – 6627-8072

6.5 Well 6627-9467 – Penny’s Hill

This well is screened in the unconfined PS aquifer with the logger installed at an unknown depth. It is located 5 km east of McLaren Vale close to the Willunga Fault. Figure 22 presents the groundwater level and salinity trends for this well.

Figure 22. Groundwater level and salinity trends – 6627-9467

The water level data shows seasonal variations of about 0.5 m with a longer term gradual decline which is consistent with the regional monitoring network. Pumping drawdowns range up to 3 to 4 m.

The salinity data is again somewhat contradictory like the previous PS well 6627-8072. There is a longer term gradual rise in salinity which is also consistent with the local trend identified by the regional salinity network. However the unusual seasonal variations with a decline observed during the irrigation season may also be
explained by a large distance between the logger and the well’s production interval which is quite deep at 120 m below ground. EC data is presented for this well because the conversion to mg/L in the data download was inconsistent.

6.6 Well 6627-10042 – Hedonist

This well is completed open hole in the FRA with the logger installed at a depth of 58 m within a large production zone from 6.5 to 99.5 m. It is located 3.5 km northeast of Willunga along the fault scarp. Figure 23 presents the groundwater level and salinity trends for this well.

![Graph: Groundwater level and salinity trends – 6627-10042](image)

**Figure 23. Groundwater level and salinity trends – 6627-10042**

The water level trend appears to be predominantly driven by rainfall recharge with seasonal variations of about 4 to 5 m and a rise of almost 2 m during 2016-17 due to the very wet spring and summer. The pumping drawdowns amount to only a metre or so.

The complex nature of fractured rock aquifers makes interpretation of salinity trends problematic. The overall declining trend is once again, consistent with regional salinity trends which after widespread rises caused by the millennium drought, show a general decrease in salinity due to higher rainfall and recharge since 2009. The main fracture zones encountered during drilling were below a depth of 90 m, resulting in another large distance between the logger at 58 m and the production zone. There appears to be some freshening during the irrigation season, which could indicate that the deeper fractures could be contributing lower salinity groundwater than those higher in the borehole closer to the logger.

6.7 Well 6627-10720 – Paxton

This well is screened in the unconfined PS aquifer with the logger installed at a depth of 22 m. It is located 2.5 km east of McLaren Vale. Figure 24 presents the groundwater level and salinity trends for this well.

The water level data shows seasonal variations of about 0.5 m with a longer term gradual decline which is consistent with the regional monitoring network. Pumping drawdowns range up one metre.

A gradual rising trend in the irrigation season salinities can be seen, but more importantly, there appears to be difference of about 350 mg/L between the irrigation season salinities and the values recorded during winter. This evidence supports the suggestion made earlier in this report that the salinity increases are caused by upward leakage from the underlying Blanche Point Marl which in this case, lies only 5 m below the base of the sandscreen.
Summary and recommendations

Where representative salinity data was recorded, the logger data confirms the mechanisms driving salinity changes discussed earlier in this report i.e. downward leakage causing gradual declines in salinity in the PWF aquifer and upward leakage causing rises in salinity in ‘hot spot’ areas in the MS and PS aquifers. The logger water level trends are also consistent with the observed regional trends.

For resource management purposes, the frequency of water level and salinity data collection is excessive and could be reduced from 10 minute intervals to six to twelve hourly intervals if the project were to continue. No comment is made on the flow data or the usefulness of the data for irrigation management purposes.

Future directions

The significant rises in groundwater salinity in some areas raises questions about the local sustainability of the resource and whether a management response is necessary. The broad correlation between rises in salinity and increases in extraction from the monitoring evidence suggest that a reduction in extraction in the ‘hot spot’ areas may stabilize or even reduce salinities.

To a certain extent, this sustainability issue could be self-managing – as salinity levels rise above 1500 mg/L, irrigators may reduce groundwater use and revert to alternative sources (such as the Willunga Basin Water Company). This voluntary reduction in pumping may lead to positive salinity outcomes.

Irrigators in the ‘hot spot’ areas could minimise the risk of salinity increases by reducing the drawdown caused by pumping during the irrigation season. This could be achieved by pumping any bore at a lower rate over a longer period of time to achieve the same volume of output. If several irrigation bores are used on any property, spreading the pumping volume as evenly as possible could also reduce drawdowns during the irrigation season.

On-going salinity monitoring is desirable to inform the review of the magnitude and extent of the ‘hot spot’ areas.

It is recommended that further salinity monitoring focus on the ‘hot spot’ areas and other locations where long term monitoring has taken place. The methodology of mailing out sample bottles to licensees who would deliver the samples to the McLaren Vale Visitor Centre for collection could be continued, but some follow-up field visits may be necessary.
Figure 18 presents the location of wells proposed for on-going salinity monitoring, together with the aquifer monitored. Table 2 lists the wells and the rationale for monitoring. All the proposed wells are equipped private wells and sampling by portable pump is not required. The network may evolve over time due to changes in access, well use and irrigator cooperation.

Table 2. Proposed salinity monitoring wells

<table>
<thead>
<tr>
<th>Long term</th>
<th>Port Willunga Fm</th>
<th>Pirramimma Sands</th>
<th>Maslin Sands</th>
<th>Fractured rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>WLG 52</td>
<td>WLG 55</td>
<td>WLG 73</td>
<td>KTP 21</td>
<td>KTP 28</td>
</tr>
<tr>
<td>WLG 68</td>
<td>WLG 90</td>
<td>WLG 109</td>
<td>KTP 22</td>
<td>WLG 82</td>
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<tr>
<td>WLG 70</td>
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<td></td>
<td>KTP 30</td>
<td>WLG 112</td>
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<td>WLG 85</td>
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<td>WLG 50</td>
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</tr>
<tr>
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<tr>
<td>6627-10079</td>
<td></td>
<td></td>
<td>WLG 75</td>
<td></td>
</tr>
</tbody>
</table>

| 'Hot spot'         | 6527-1385        | 6627-3545        | WLG 140      | KTP 28         |
|                    | 6627-7874        | 6627-3592        | 6627-7436    | WLG 82         |
|                    | 6627-8258        | 6627-7928        | 6627-9268    | WLG 112        |
|                    | 6627-9594        | 6627-9581        | 6627-9581    |                |
|                    | 6627-11309       |                  |              |                |

More detailed investigations and consultation with water users are needed to determine what form future management responses could take. This could occur in a future WAP review. Specific management areas could be considered and delineated to cover the 'hot spots' so that any management intervention may be targeted to those areas and not affect other areas where salinity trends are stable.
Figure 25. Proposed salinity monitoring network
8 References


