Kimba Mallee Seeps Sites Establishment Report



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1 Project Aims and Activities

Sites on two farmer's properties were established to investigate and demonstrate the dynamics and potential strategies to manage mallee seeps in the Kimba district. This was set up to compliment the spread of activities, findings and extension of the larger recently funded Eyre Peninsula Seeps Management Project.

Having a number of sites established with high water use options, salt tolerant grasses and strategically placed monitoring equipment from seeding time in 2020 means that the new project can hit the ground running and in some ways provide an extra season of key information and outcomes to discuss and share with the Eyre Peninsula farming community.

The continuous measurement of water table levels, soil moisture and rainfall using specialised equipment along with soil and water testing and satellite NDVI mapping, will be invaluable for helping to understand the local EP situations, the most effective strategies and build the best messages for the EP farmers. This data will also be matched against MSF Mallee Seep Project findings and outcomes. The sites will continue to be monitored, analysed and demonstrated as a part of the EP Seeps Project.

This project has taken an "on ground participatory approach" to working with the farmer, to ensure the specific and most appropriate management strategies to be demonstrated will be decided collaboratively, and in line with what are practical solutions for them to employ at their own cost. This is a vital component of ensuring local project ownership and to increase the likelihood of adoption by EP farmers and beyond, based on sound technical information. Satellite NDVI Maps have already been made of the various sites, and this report highlights key applications from these.

With any seeps management, there are 3 key zones to address, being the **Recharge, Discharge and Interception Zones**. Given the short timeframe for site analysis and establishment with farmers, it was expected that the **Recharge Zone** sandhills would already be sown, meaning the opportunity for any major subsoil amelioration work to be undertaken (such as deep ripping or spading) had already passes this season (if it hasn't already happened). The main areas to be addressed would be the **Interception Zone** mid-slopes (through strategic lucerne strips, tree or pumping water out for other farm use), and the **Discharge Zones** (such as spreading sand on top and re-cropping, establishing salt tolerant pastures, and the preparation and summer cropping to maintain soil cover and reduce surface salinisation over the dry season), with chosen strategies depending on initial site assessment, including landscape, water, soil/salinity measurements and farmer preferences.

2 Background and context of EP Seeps

The Eyre Peninsula has two types of water table related saline land degradation. The first are associated with established creek lines though very large catchment areas with highly saline shallow water tables. These cannot be easily managed or rehabilitated by individual farmers at a local paddock level, as problems of water flows need to be addressed on larger and co-ordinated scale, with significant ground works required to change water flows and discharge impacts.

The EP mallee seeps project is more focussed on the second scenario of localised seeps developing as perched water tables, usually associated with excess water passing through deep sandhills with poor water holding capacity. Many of these sites have appeared more recently as a direct result of farming system changes. The advent of more intensively managed No-till farming systems has led to the reduction and control of the vast majority of deep rooted summer weeds (such as skeleton weed) which had previously been responsible for using up summer rainfalls before the moisture could accumulate and move down through the soil profiles. This results in the formation of perched water tables above areas of essentially impervious clay layers and water moving laterally toward lower lying areas (as demonstrated in Figure 1) to find surface expression where the clay comes close to the soil surface in mid-slopes or at the base of swales. This leads to waterlogging, capillary rise, evaporation and a process of surface salinisation over time.

These seeps generally begin as areas inundated with too much fresh water but this will lead to permanent salinisation and land degradation if no remediation takes place. It would appear that many perched water tables have existed and become quite saline over a longer period, but have only more recently found surface expression due to changes in recent years. The key to managing seeps is to identify the problem early, assess and apply appropriate management into the three key zones of Recharge, Intercept and Discharge areas (Figure 1).





3 <u>Demonstration Site Locations, Descriptions and Progress</u>

3.1 EP Seep Site 1: Baldock Farms (Tola AG), Kimba.

"Establishing Sandhill to Lucerne Pasture to Bring Recent Seep Scalds back to Cropping"

3.1.1 Purpose

The aim of this demonstration is to test whether planting a sandhill to lucerne can utilise sufficient excess water to prevent the spread of surface degradation at two very different seep areas on either side and possible bring them back to cropping within 3-5 years.

3.1.2 Background and site assessment

The mallee seep sites in the Outlook paddock have essentially formed from the ongoing impacts of the wet season of 2016. This is evident from the NDVI images in Figures 4 & 5, showing strong green plant growth in the November after the 2017 season, with this effect still clearly visible mid-2018. This site was inspected on June 2nd 2020 to find a large, long sandhill running in a north-westerly direction that was thought to be the main source of water table recharge with bare scald areas evident on the eastern and western sides (Figure 3).



Figure 2. Demonstration Site 1, Google Earth Image 2015, before mallee seeps present.

A test hole was dug in the middle of a seep scald on the eastern side to a depth of 1.8m, which has developed since 2016. A perched water table was found at a depth of 55cm with wet clay to a depth of about 160cm, and the dryer impervious clay layer beneath. The water flowed quickly into the hole. A piezometer (AB Pz1) was established here (Photo 1). The water quality was measured at a low salinity level of 1.8 dS/m. The area of bare scald and affected crop growth at this site is approximately 0.3ha. Soil test results (Table 1) show low levels of soil salinity in the top 20cm, but with medium levels at 20-30cm. The high pH levels and possible water logging appear to be the

most threatening impediment to crop growth at the present time. A bare area of about 1ha lies immediately east of this scald (Figure 3), which was initially thought to have not grown due to the heavy clay and the dry season opening, but this may need further investigation.

A second test well was dug 20m up the sandhill, to a depth of 2.8m, and a water table at approximately 1.2m to 2.6m depth and a similar water quality. The water seeped more slowly into the hole at this site. A second piezometer (AB Pz2) was established here (background of Photo 1). The top of the sandhill was another 40m up the sandy rise (Photo 2).

This site appears to have a clearly defined Recharge Zone, being the sandhill to the west, Discharge Zone, being the growing scald area and surrounding crop affected area at the base of the hill (although further investigation should be made of the clay flat to the east of this), and a potential Interception Zone, being the crop growing area at the lower edge of the sandy rise, where there is a clear water table underneath.

On the south-western side of this sandhill there is a large developing scald area (0.7ha, Photo 3), which although many test wells were dug, there was no clear evident of a defined water table. After returning to these sites 6 hours after there was no water available to be sampled. Table 2 shows that the soil salinity levels within the top 30cm of soil at this site was very low at around 0.2 dS/m, and that pH levels were also good for crop growth. While it is expected that the Recharge Zone is the same sandhill as for the other seep, the sand depth is not as great on this western side. With no clear water table evident, both the Discharge and potential Intercept Zones are not as easily defined. Further investigation will need to be done at this site to see what has been the driver of this bare site. It may be possible that the scald may be seep related, but the waterlogging periods may have been transient, leading to crop failure and ongoing impacts. However, there is no clear reason why the crops have not established at this site this season, as evident in Figure 3.



Figure 3. June 2020 NDVI image showing mallee seep bare scald areas and planned lucerne area

Figure 4 Nov 2017 NDVI image showing strong post season growth at eastern base of sandhill



Figure 5. 2018 NDVI image still showing effects of 2016 rainfall at eastern base of sandhill



Table 1. Soil test results from Baldock Farms Sites 1 and 2.

	units	AB Outlook	AB Pines	AB Pines	AB Pines					
SampleName		East Seep 1	East Seep 1	East Seep 1	West Seep 2	West Seep 2	West Seep 2	Seep 3	Seep 3	Seep 3
SampleDepth	cm	0-10	10-20	20-30	0-10	10-20	20-30	0-10	10-20	20-30
pH 1:5 water	рН	9.82	9.82	10.2	8.64	9.12	9.1	10.1	10	10.2
pH CaCl2	рН	8.92	9.79	9.42	8.16	8.45	8.43	9.32	9.23	9.4
Gravimetric	0/									
moisture	/0	8.5	12.3	11.1	4.1	5	6.5	11.7	12.3	11.3
Salinity EC	dC /m									
1:5	us/m	0.33	0.28	0.58	0.22	0.15	0.21	0.49	0.2	0.32

Photo 1. Establishment of Scald (AB Pz1) and Midslope (AB Pz2) piezometers



Photo 2. 40m of Recharge Zone sand above midslope piezometer



Photo 3 Bare scald area west of sandhill showing poor crop germination



3.1.3 Treatments

After discussion with the farmers about how to increase the water use on the Recharge and Interception Zones of this site, and given the significant livestock enterprise within their business, it was decided that the whole sandhill (which has been of limited crop production value in recent years) would be sown to lucerne (Figure 3). Once established, this perennial, deep rooted pasture will utilise all water moving within these zones and prevent excess water entering the Discharge Zones on both sides of the sandhill, which should prevent them from land degradation and increasing in area. It was also decided that the current bare scalded areas be sown to puccinellia to establish soil cover immediately to prevent capillary rise and evaporation that could lead to rapid increase in surface salinisation. While this action was decided when the expectation was that the topsoil was more saline (prior to soil tests results being available) it is still felt that puccinellia is still a good option, as the crops sown through these bare scalds have failed to germinate. More investigation of these soils will need to take place to better understand these issues.

It is possible that once the lucerne has stopped the excess water, then the addition of some sand to the Discharge Zones may be required to bring these areas back to cropping. This could prove to be a critical demonstration trial for the differing scald areas both sides of the sandhill.

While some puccinellia seed was roughly sown over the eastern site to see if it would easily establish, the farmer went on to order some seed and sow it using a baitlayer and scratching it in. He also purchased lucerne seed to be sown at the next opportunity after suitable rainfall.

3.1.4 Ongoing Monitoring

This site will be monitored by assessing the establishment of both the lucerne and the puccinellia and its effectiveness at achieving its desired outcomes. The success of the lucerne will be monitored in coming years be measuring the drop in the perched water table at both the scald (AB Pz1) and midslope (AB Pz2) piezometers which are both equipped with continuous data loggers. This will also be analysed against rainfall events.

Further investigation into the soil factors that are actually preventing crop growth on these various bare areas needs to be made, as it is not clear at present. This should greatly improve our understanding of the driving forces associated with mallee seep formation on the Eyre Peninsula.

Successful outcomes for the farmers at this site will depend on their ability to:

- 1. gain valuable grazing and/or haymaking production from the sandhill;
- 2. stop the rapid spread of land degradation in the discharge areas;
- 3. restore these bare scald areas back to cropping in the coming years.

3.2 EP Seep Site 2. Baldock Farms (Tola AG), Kimba.

"Pumping Out Perched Water Table for Productive Farm Use & Seep Scald Rehabilitation"

3.2.1 Purpose

The aim of the demonstration site is to test how seep water can potentially be pumped out and used on farm and how effective this can draw down perched water tables to help restore degraded land back into production.

The unknown questions include:

- What rate of water extraction can take place?
- How quickly with the water refill the sump?
- How far will the pump extractions draw the water from?
- Will lateral drains be required to direct more water into the sump area?
- How quickly and effectively can this draw down the perched water table over time?
- Can this lead to a permanent rehabilitation of the seep scald area?
- What can the water be successfully used for, and will the water quality vary over time?
- Will the current local farm water use requirement be enough to use all this excess water, or will the farmer need to look at alternative water uses (such as irrigated lucerne for hay production) to keep up with the water extraction rates.

3.2.2 Background and site assessment

Since 2015 (Figure 6) this site has formed from a waterlogged area (Figure 7 & 8) to a large bare scalded area (Figures 9-11) after the very wet 2016 season. It appears from landscape observation and confirmed from NDVI images (Figure 7) that a large mass of water flows from the sandy catchment above to be concentrated through the sandy surface area where the scalded seep has appeared. The drilling of numerous test wells and placement of piezometers (Photos 4-6) showed a saturated sandy soil layer from 10cm to at least 2.5m depth with water quality tested at 2.8 dS/m. The sandy nature of this soil profile meant that water inflow into each hole was rapid. This suggests that there is a very large volume of water present which appears suitable for stock water and could possibly be used for tank spraying with the blending of some rainwater. This could prove to be a very valuable farm resource given the cost of purchasing water for farm use on the Eyre Peninsula.



Figure 6. 2015 Google Earth image showing plant growth through most the current scald area

Figure 7. March 2017 large area of plant growth where seep formed following wet 2016 spring



Figure 8. Seep area orange due to surface ponding and flow most of the 2017 growing season



Figure 9. Sept 2018 NDVI image showing bare scald forming within high growth area



Figure 10. Aug 2019 NDVI image of scald with strong plant growth west.



Figure 11. Jun 2020 with strong surrounding growth despite dry season start.



Photo 4. Digging test well at site of proposed sump and solar pump location AB Site 2.



Photo 5 Digging for AB Piezo 3, 40m north of pump site.



Photo 6. AB Site 2 scald showing sump and monitoring sites



Photo 7. Moisture probe in deep sand above AB Site 2 to assess plant/soil/rainfall dynamics



3.2.3 Treatments

This site is being set up with a sump at a key location at the top edge of the scalded area near the fence, close to a small open dam that was dug in 2018. It is very important to set up a properly constructed, deep covered sump to collect the water, as the water quality in open dams will deteriorate very quickly. The site needed to be in a place that would have maximum impact, being not too high in the catchment to miss significant inflows from either side below the site, and not too low to prevent degradation above. The water will be pumped up to a large tank which already sits at the top of the hill to the south.

For a sump the farmer has acquired a large tuna pipe (5m diameter) to be dug in to the ground to 2.5m depth. This is to be set up with a solar pump and floatation switch and flow meter to allow for the measurements of water extraction. A water level monitor with continuous data-logging will be placed within the sump which should give a good indication of the very localised water table changes. Two piezometers have already been strategically placed, one 20m to the south and one 40m to the north, and will have data-loggers attached to measure the corresponding changes to water table levels as water is pumped out. It may also be good to place a further piezometer and water table data-logger 60cm below (southeast of the sump) to test the treatments effectiveness.

The Site 2 bare scald is also in the process of being sown to the salt tolerant puccinellia to provide perennial soil cover and grazing and reduce topsoil salinisation because of capillary rise and evaporation of this waterlogged landscape. Topsoil (0-10cm) salinity was measured at 0.49 dS/m, 0.2 dS/m (10-20) and 0.34 dS/m at 20-30cm depth, which is not considered too saline to grow crops at this stage (Table 3). However, the high pH levels of 10 at this site may well be the most toxic factor inhibiting rehabilitation to cereal growth. It may also be that waterlogging in the rootzone may also be the main driver of this bare patch, which hopefully will be changed through this sites water use strategy. All these factors will need to be progressively monitored over time.

A soil moisture probe has also been placed in the deep sand toward the top of the side to the north of the seep scald to help assess how compacted this sand may be (measuring profile moisture extraction by crop roots) as well as which rainfall events may be contributing to recharge (Photo 7).

3.2.4 Ongoing Monitoring

This site will be assessed by:

- downloading and analysing all water dynamic information from piezometers, sump and tank flows to test how much water is being drawn out and utilised and what the direct effects on the seep landscape are;
- 2. recording the success of puccinellia the establishment to fully cover the bare scald area in coming years;
- 3. measuring any changes in water and soil quality at the site
- 4. reporting on the value of the water use by the farmers

The ultimate success of this site will be the rehabilitation of this whole scald site back to cropping in time by reducing the water table and water logging issues, as well as the gaining of critical information to support how this innovative strategy can be employed by other farmers across the EP, Mallee and across Australia.

3.3 Site 3, Jericho Farm, Kimba.

"Using strategic narrow lucerne strips to intercept lateral water flows & rehabilitate scalds"

3.3.1 Purpose

The aim of this demonstration trial is to test whether strategic narrow strips of lucerne surrounding seeps at different stages of development can successfully reduce perched water tables, as the first step towards their rehabilitation back to cropping or productive pasture. If proven successful, this technique may prove advantageous to farmers who wish to minimise changes and impacts to paddock operations while halting further land degradation and restoring seep areas back to productivity. The crucial benefits of establishment of salt tolerant pastures within this process will also be explored and demonstrated at this site.

3.3.2 Background and site assessment

The Jericho Trough Paddock was visited on June 3rd 2020. The paddock has many jumbled sandy rises, loamy flats and 3 seep areas of varying stages of development as shown in Figures 12 and 13.

The first site is a large white scalded area that has been present since before 2000 but in recent years has begun to extend in an easterly direction (Photos 8 & 9). It has a large sandy rise to the northwest, the northeast and southeast that could all be contributing recharge water (Figure 13). The scalded area has had most of the sand eroded from the topsoil over the years, exposing the slippery wet clay to the surface. Interestingly, a bore hole drilled to over 2m depth in the middle of the scald revealed no clear water table (Photo 10), with just enough water seeping in to test after 6hrs, reading at a very high 15 dS/m. It was thought that the essentially impervious clay layer was now very close to the eroded surface. However, in the northern edge water was found at a shallow depth at only 2.9 dS/m and at the western edge at 6.3 dS/m. The lower reading edge levels gave confidence that lucerne planted close to the seeps could successfully intercept water moving into this scald area.



Figure 12. 2015 Google Earth image of the demonstration "Trough" paddock

Figure 13. Nov 2018 Satellite NDVI image highlighting deep sand (orange) and loamy (blue) areas



Soil Tests from the centre of the Seep 1 showed levels salinity above cereal toxicity at 1.2 dS/m through the top 30cm (Table 2), but this should be suitable for establishing Puccinellia. The high pH affects may need to be monitored if there are some initial variations in establishment. The surface salinity drop by over 50% to a more moderate 0.62 dS/m at the northern edge of the scald.

SampleName	units	SJ Trough Seep 1 Mid	SJ Trough Seep 1 Nth Edge	SJ Trough Seep 2	SJ Trough Seep 2	SJ Trough Seep 2	SJ Trough Seep 3	SJ Trough Seep 3	SJ Trough Seep 3				
SampleDepth	cm	0-10	10-20	20-30	50-80	140-160	0-10	0-10	10-20	20-30	0-10	10-20	20-30
pH 1:5 water	рН	10.2	10.2	10.2	9.99	9.73	10.1	10.2	9.97	9.93	9.85	9.83	9.88
pH CaCl2	рН	9.5	9.59	9.57	8.99	8.7	9.03	9.2	9.35	9.37	9.18	9.2	9.24
Gravimetric moisture	%	12	16	14.5	20.3	15.8	19	12.1	14	15.2	7.7	15.3	17.8
Salinity EC 1:5	dS/m	1.2	1.4	1.2	0.59	0.62	0.49	0.79	0.26	0.21	0.45	0.87	0.95

Table 2. Jericho Trough Paddock scald areas soil test results.

Photo 8. Jericho Seep 1 scald in middle of paddock



Photo 9. Clear indications of water seeping out of the sandy rise to the north of scald.



Photo 10. Deep test hole revealing no sloppy clay layer.



The second (Seep 2) site has a sandy rises to the north (Figure 13, Photos 11 & 12) which appeared to be contributing water to the seep. This was confirmed by the piezometer established approximately 30m up the slope that had a water table at 2.2m, and a salinity level of 3.3 dS/m. A piezometer was also placed in the middle of the scald, showing a water table at 30cm with a salinity level of 4.5 dS/m. This has given confidence that a ring of lucerne established around this scald could utilise the water and reduce the water table. Data loggers were set in each piezometer so that continuous monitoring of the perched water table levels can be analysed in response to both rainfall events and management practices undertaken. A probe containing 5 soil moisture sensors at 20cm, 40cm, 60cm, 80cm and 1m was also set up in the midslope to assess how this soil retains loses water throughout the seasons, as well as there is a compacted layer preventing root access.

Soil tests from the middle of the scald show a high salinity level concentrated in the surface of 0.79 dS/m, with low salinity levels of 0.21 dS/m at 10-20cm and 0.21 dS/m at 20-30cm depth within this sandy profile (Table 2). This is indicative of a recently formed scald (since the wet season of 2016) with capillary rise bringing slightly saline water to the surface where it evaporates, but leaves the salt behind to gradually concentrate. This scald should initially establish well with Puccinellia, and may well be restored back to cropping if management strategies prove successful. Some Puccinellia seed was thrown over the site to see if it would germinate, and some germinated seed samples were also planted around the scald piezometer.



Photo 11. Jericho Seep 2 showing mid-slope piezometer and moisture probe in foreground.

Photo 12. Jericho Seep 2 scald area rapidly spreading though cropping land.



The third (Seep 3) site is located in the south edge of the paddock at the base of a large sandy rise (Photo 13). It was found to have very wet clay close to the surface containing high transient salinity (Table 2). It would appear that this salinity is beginning to rise into the surface layer. However, if the stem of moisture from above this scald is dried up using a narrow strip of lucerne, it is expected that this relatively small area will be restored back to crop production.



Photo 13. Jericho Seep 3 site that is its early stages of development.

3.3.3 Treatments

The Discharge Zones

The bare scalded areas of Seep 1 and Seep 2 should be sown to the salt tolerant grass Puccinellia to provide soil cover, grazing and water use. This will stop further surface soil degradation by utilising water within the rootzone, rather than allowing it to rise to the surface, evaporate and leave salts to concentrate. In time it may be possible to return Seep 2 to cropping, possibly with the addition of sand to the surface, however, such rehabilitation may take far longer in Seep 1, given the much higher salinity levels of soil and water measured.

The farmer has purchased the Puccinellia seed and is in the process of establishing it on these areas using some light harrows and a bait layer to spread it, and then lightly harrow it in.

The Recharge Zones

The farmer intends to undertake some deep ripping and clay spreading into the sandy rises in this paddock in the future. Deep ripping will help break compacted layers and allow plant roots to access and utilise more soil water before it contributes to recharge. Clay spreading and spading will help improve the soils ability to hold both moisture and nutrients within the crop root zone, resulting in far greater water use efficiency.

Interception Zones

The initial main innovative practice to be tested at this site was to use of strategic 20-30m wide lucerne strips planted immediately around the discharge zones (or just above in the case of Seep 3), to utilise enough excess water to lower the water tables, to stop the spread of the land degradation and, in time, possibly restore areas back to crop production. The farmer has acquired the lucerne seed and will sow these areas as soon as the conditions are deemed to be good to proceed. The advantage of lucerne is that it is very deep rooted, and perennial, meaning that it will utilise all the summer rainfall, which has been identified as a key contributor to seep formation since the success of chemical summer weed control by farmers.

However, after a closer examination of the NDVI satellite imaging since 2016, it appeared to indicate that Seeps 1 and 2 are linked by the water moving through the landscape of the paddock. This is particularly evident in Figure 14, which is taken from Dec 2017, a year after the very wet spring of 2016, showing plant growth continuing in an east-west line when the rest of the paddock was dry. This pattern is repeated in other years, and was certainly a consideration when the paddock was first inspected. So while it is clear that water is flowing into these sites from the surrounding sands to the north in particular, there may also be a significant contribution coming through this water flow from east to west. It has therefore been decided to extend the lucerne strip to the east of Seep 1 to capture this flow, as this may well be the key to drying our both seep areas. This also will show the value and practicality of utilising the NDVI technology, which all farmers can access, to better manage mallee seeps.

The areas targeted for both Puccinellia and Lucerne is indicated in Figures 12, 13 and 14.



Figure 14. Green east/west line indicating water flow connecting sites in summer after wet 2016

3.3.4 Ongoing Monitoring

This site will be monitored by assessing the establishment of both the lucerne and the puccinellia and its effectiveness at achieving its desired outcomes. The success of the lucerne will be monitored in coming years be measuring the drop in the perched water table at both the scald (SJ Pz1) and midslope (SJ Pz2) piezometers which are both equipped with continuous data loggers, as well as observations at the other scald areas. This will also be analysed against rainfall events.

Successful outcomes for the farmers at this site will depend on their ability to:

- 1. establish both lucerne and puccinellia successfully to achieve strategic high water use and soil protection, while gaining some valuable grazing;
- 2. stop the rapid spread of land degradation in the discharge areas;
- 3. restore these bare scald areas back to cropping and/or grazing in the coming years.

3.3.5 Final Note:

At the Jericho's driveway about a kilometre away there is a water course moving through the landscape and causing widespread salinity degradation. The water quality water tested at 75 dS/m which is well in excess of sea water. This highlights the difference between these water course seep issues and the mallee seeps caused by more localised perched water tables that can be rehabilitated if addressed well quickly.