Monitoring Mallee Seeps

Project 1403C for the
South Australian Murray-Darling Basin
Natural Resources Management Board

Progress Report Jan-June 2016

by Chris McDonough,

Farming Systems Consultant

Insight Extension for Agriculture

This project is funded through the South Australian Murray-Darling Basin Natural Resources Management Board and the Australian Government's National Landcare Programme

Australian Government | National Landcare Programme

Government of South Australia
South Australian Murray-Darling Basin
Natural Resources Management Board

Prepared by:

Chris McDonough

Farming Systems Consultant, Insight Extension for Agriculture

C/o Post Office, Loxton North, SA 5333

Ph 0408085393

cmcd.insight@gmail.com

The author acknowledges the assistance of farmers Stuart Pope, Peter Rose, Andrew Thomas, Kevin Bond and David Arbon, as well as Scott Gillett of Wisdom Data and various staff from NR SAMDB in the compilation of this document.

Disclaimer

Any advice or information contained in this report has been prepared solely for the use of NR SAMDB. No responsibility to any third party is accepted as the report has not been prepared, and is not intended, for any person other than NR SAMDB. Insight Extension for Agriculture will not be responsible for the effect upon the accuracy, completeness, currency or reliability of the report of any material or information supplied to Insight Extension for Agriculture by NR SAMDB or any other party.

Contents

1 Project Summary

This project has given valuable insight into the dynamics of mallee seeps that compliments the in-depth catchment reports that have recently been commissioned by NR SAMDB.

Three of the four monitoring sites in this project contain a combination of both strategically placed 90cm soil moisture probes within various farming systems, as well as piezometers that reach beyond the perched water tables. This has allowed an examination as to which rainfall events are contributing to recharge and the subsequent effect on the water levels within the catchment.

Piezometer readings across these sites suggest that rainfall events from Nov 2015 through Feb 2016 of up to 15mm did not cause a rise in perched water tables in the catchment. They did, however lead to a replenishing of the root zone to about 40% to 60% capacity.

When 30-40mm rainfall fell around March 10, 2016, many of the moisture probes reported sharp spikes in the subsoil sensors. Each of the piezometers on the edge of seep areas showed a sharp rise and fall of the water table, suggesting a strong lateral movement of surface water. Mid-slope piezometers generally revealed a steady rise on water levels after this event, except for the piezometer at Bonds which is placed on the edge of a lucerne area. Moisture probes at this trial site have revealed there was 34mm less moisture in the soil profile to 90cm in the lucerne, when compared to the cereal cropping systems alongside prior to this major rainfall event. This critical difference identifies why higher water use strategies can go a long way to change the potential spread of mallee seeps.

These and other findings detailed in this report show the importance of ongoing monitoring at these sites, so that a fuller understanding of the catchment moisture dynamics can be captured under a range of seasonal influences, and various management strategies observed and tested for their effectiveness in overcoming the issues of mallee seeps. This will be enhanced by the maintenance of soil moisture probes and placement and monitoring of data-loggers on all of the existing piezometer sites.

2 Introduction

This is the third report associated with monitoring 4 seep sites between Mannum and Karoonda that were established under the "On-Farm Trials and Demonstrations to Address Seeps in the Murray Mallee" project funded through the NR SAMDB.

Background to each site, EM38 mapping, soil tests and initial monitoring are contained in an earlier report entitled "On-Farm Trials and Demonstrations to Address Seeps in the Murray Mallee", by Chris McDonough, Rural Solutions SA in July 2015. The second report, "Monitoring Mallee Seeps Progress Report July-Dec 2015" is a continuation of the site progress and monitoring at these 4 established sites. It provides analysis of monitoring results, with some recommendations for future seep management included.

Each site has and is providing valuable information for the Mallee farming community and beyond about soaks, their causes and management strategies that may be employed that fit in with different farming systems and needs.

February 23rd saw a successful public forum on "Managing Mallee Seeps" held at Karoonda, beginning with an explanation of the history, causes and dynamics of local seeps, by James Hall (Soils and Landscape Scientist), followed by project facilitator Chris McDonough, along with each of this projects 4 site farmers presenting findings and discussing practical management issues with the 35 attendees. The forum concluded with a visit to the seep site at Popes, showing the growing scald, moisture movement, soil pits and Chicken Manure Spading trial (see Appendix for flier of day). Evaluation of this day showed an extremely high rating for people saying they would implement the new information gained form the day into their decision making.

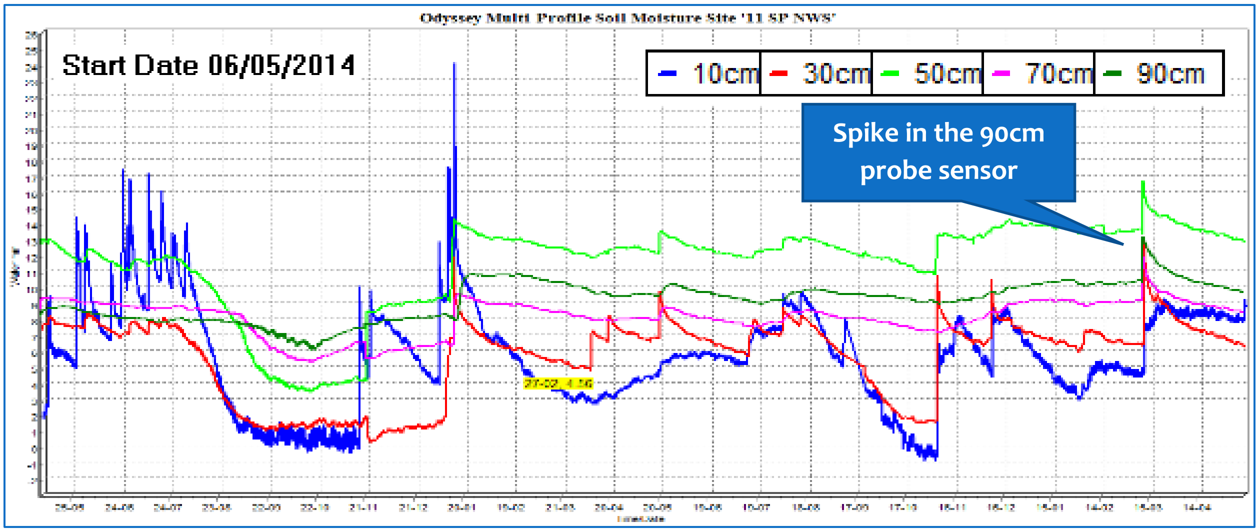
3 Site Monitoring

3.1 Pope Site, Karoonda

Since the harvest of the Spading trial last year, the site monitoring has been focused around the soil moisture probes and piezometers. Figure 1 shows the general locations of all of the monitoring points including moisture probes, piezometers and the tipping bucket rain gauge. Only 2 of the 5 piezometers have data loggers attached at present. It will be important that the remaining piezometers are fitted with data loggers as soon as possible to maximize data gained to better understand the soil moisture dynamics of the catchment.

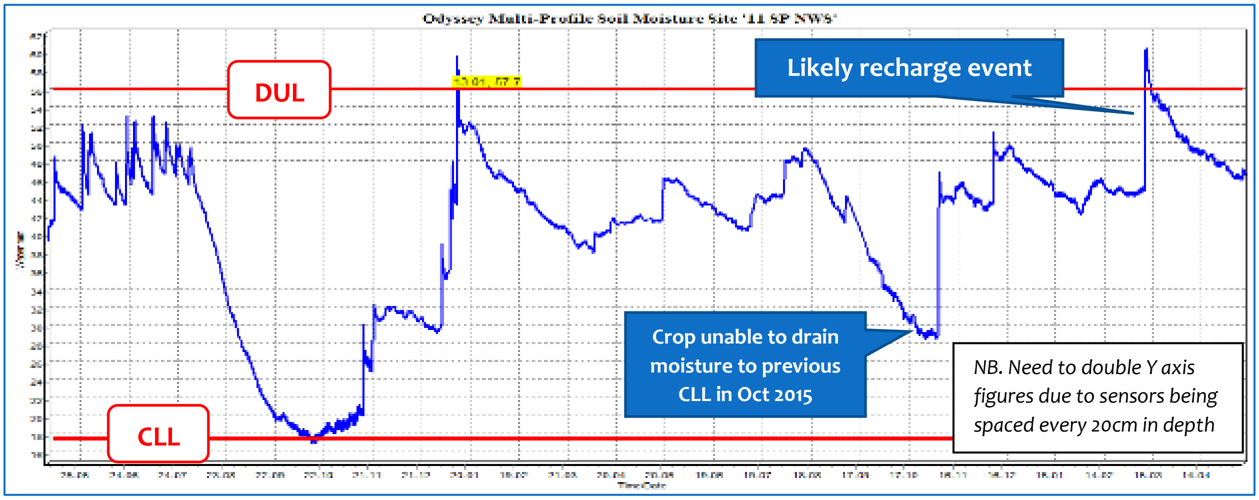
Fig 1. Pope soak site with monitoring equipment approx. locations

Fig 2. Soil moisture probe readings for non-wetting sandhill site, May 2014-May 2016



Spike in the 90cm probe sensor

Fig 3. Summed soil moisture probe readings for non-wetting sandhill, May 2014-May 2016



Likely recharge event

Crop unable to drain moisture to previous CLL in Oct 2015

NB. Need to double Y axis figures due to sensors being spaced every 20cm in depth

Fig 4. Matching rainfall readings, May 2014-May 2016

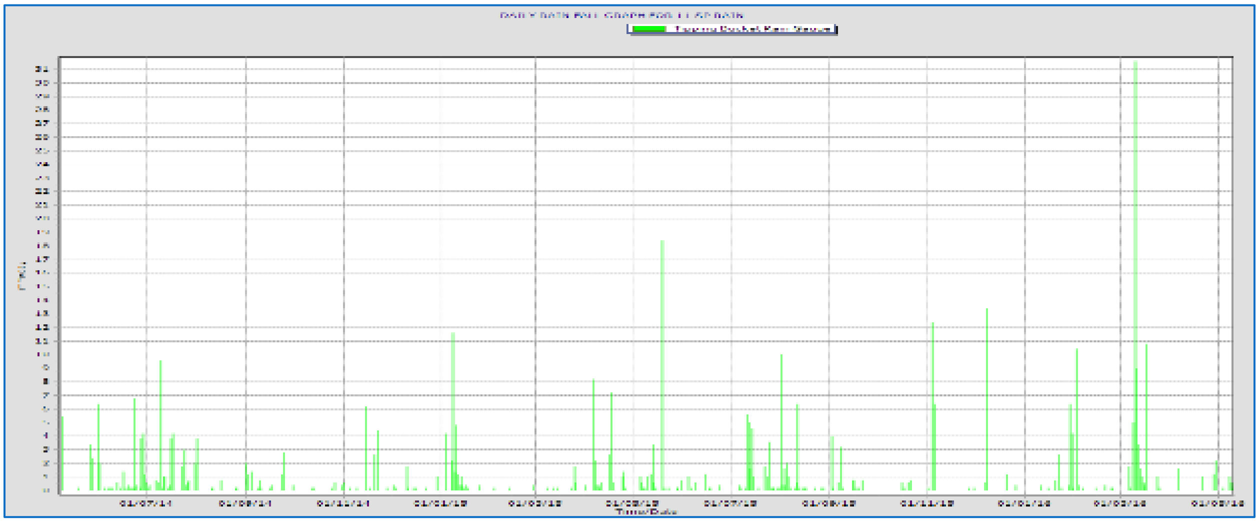


Fig 5. *Soil moisture probe readings for control site, Oct 2015-May 2016*

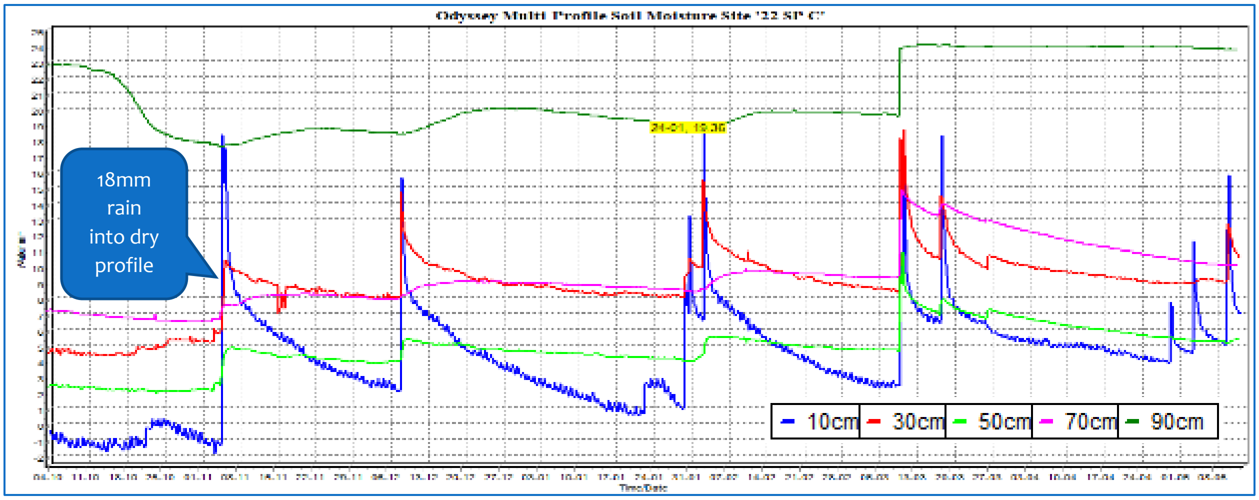


Fig 6. *Soil moisture probe readings for spaded chicken manure, Oct 2015-May 2016*

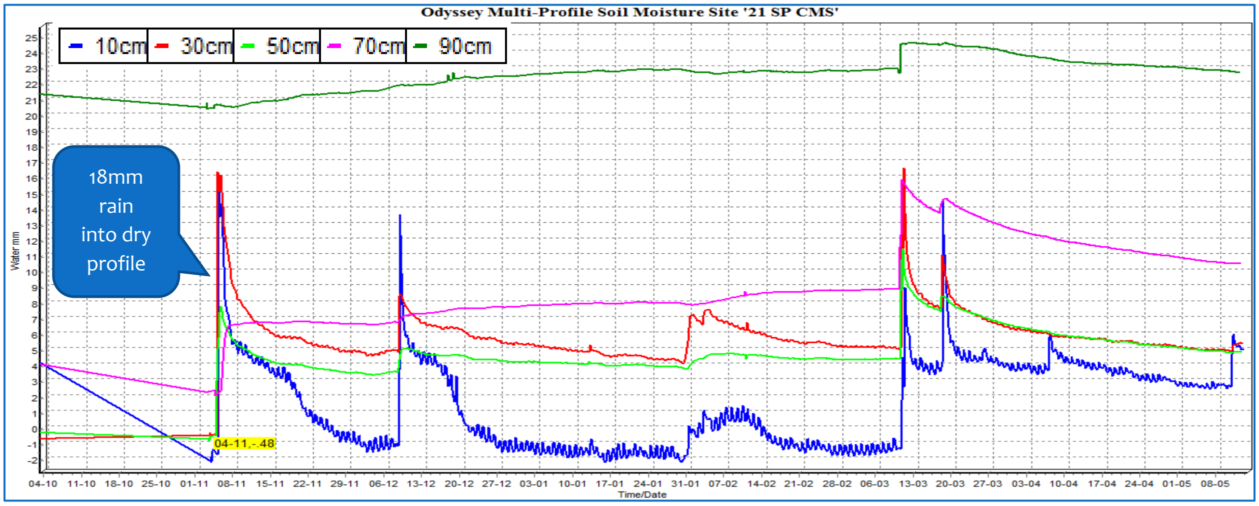


Fig 7. *Matching rainfall readings, Oct 2015-May 2016*

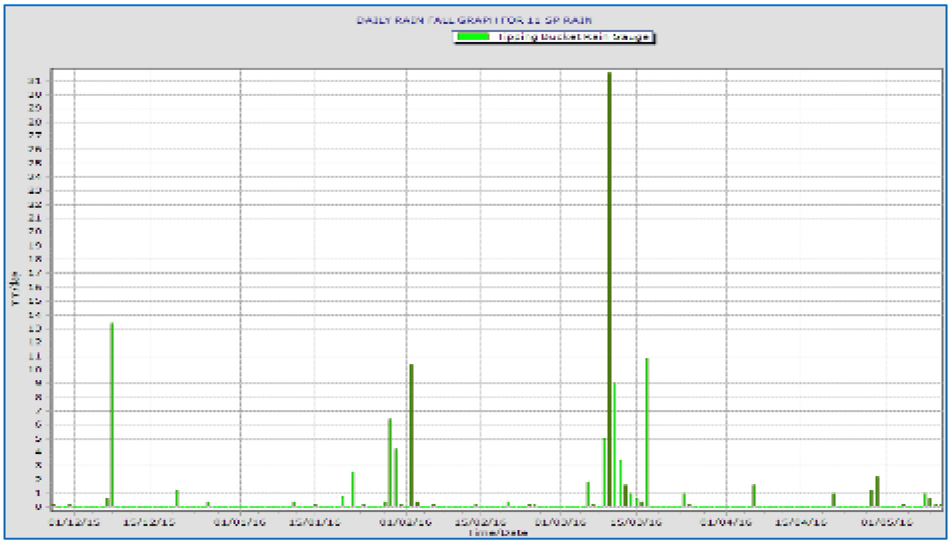


Fig 8. Summed soil moisture readings for spaded chicken manure site, Oct 2015-May 2016

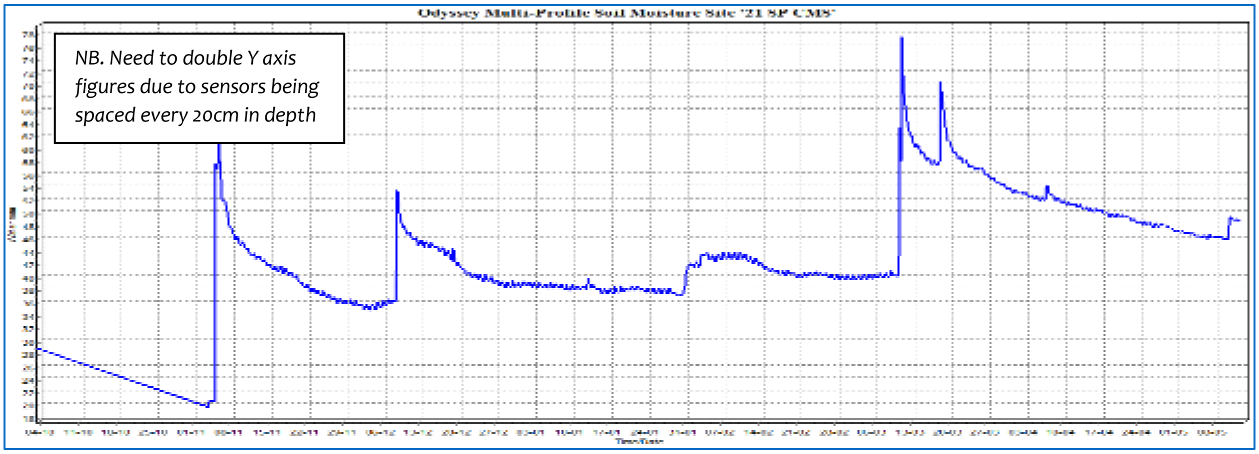
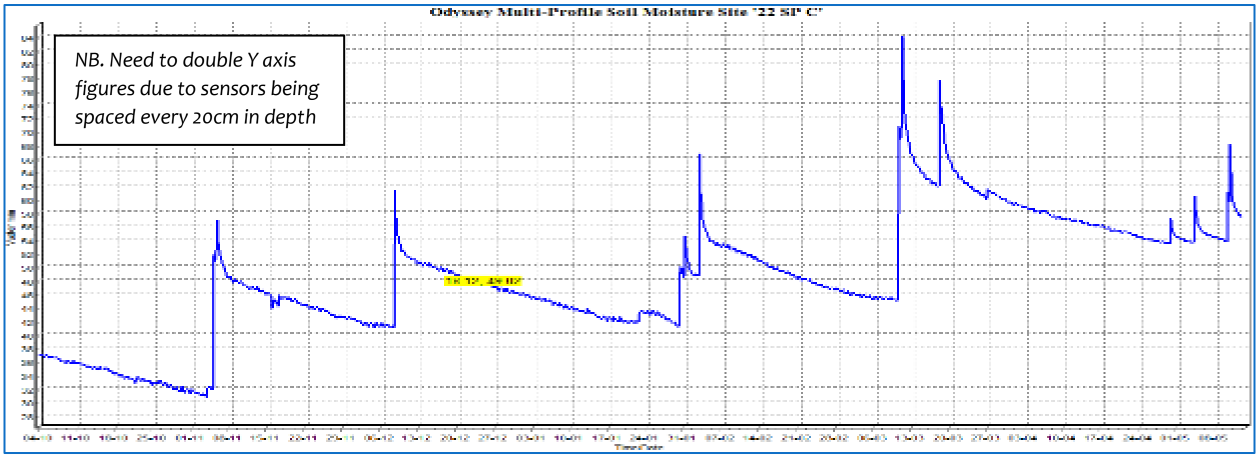


Fig 9. Summed soil moisture readings for control site, Oct 2015-May 2016



The moisture probe on the non-wetting sandhill (Fig 2) appears to have only shown one moisture spike at the 90cm sensor which may have contributed to recharge in March 2016. Figures 3 and 4 suggest that the 2015 crop on this sandhill was unable to utilize all plant available water (PAW), leaving 24% behind. This was partly due to the unusual heat and fast season finish that cut the crop off.

Rains in Nov, Dec and Jan all helped to refill the "bucket" to being bout 65% full. A 32mm rainfall event that fell in March was then enough to reach saturation at all levels and allowing moisture to pass through to recharge. This clearly corresponds to the sharp rise and fall of the nearby piezometer at the edge of a nearby soak area in Fig 11. It rises quickly with a surge of water flowing from the surrounding non-wetting sandhill filling the soak area, and causing some surface flow and lateral drainage past the piezometer.

All the other rainfall events since May 2014 appear to have held the moisture within the rootzone to be used by the crop. There has not previously been the combination of moderately high root zone moisture and a large rainfall event to cause such recharge and groundwater rise.

The 2 moisture probe sites close to the main seep area are represented in Figs 5, 6, 8 & 9. There are some important differences in the 2 sites. There is some variations in the 90cm sensor, which may be hard to directly compare. Both are clearly sitting in the top of the clay layer, as they have distinctly higher moisture content. However, the control 90cm appears to be more affected by lateral moisture movement through the top of this clay, which may be partly due to the greater recharge happening in the lower water use control area, or could also be that this is an area of the clay that the moisture naturally flows through.

The advantage of the chicken manure spaded area is that is has completely dried out the top 70cm after the crop, whereas the control area didn't, and left approximately 24mm more moisture behind. Close examination of the graphs show that the spaded chicken manure site has about 20mm larger bucket site in the top 70cm due to its improved water retention. This would suggest that it should be able to absorb an extra 20-30mm rainfall event without resulting in recharge, whereas the control area is likely to fill up quickly and then contribute to recharge more quickly. This appears to be evident in the differences in the rise of the 90cm sensor probe between each treatment site.

There is clearly more stubble and soil cover from the spaded chicken manure site, which may have reduced evaporation in the topsoil. It can be seen that the moisture recorded at the 10cm sensors seems to be maintained for longer than the control area.

Figure 10 shows a steady rise in the water table, beginning about 5 days after the large March rain, and appearing to rise approximately 40cm to mid-June. There was very little rain after this event, suggesting that the water table rise was due to lateral water movement from higher in the catchment.

Fig 10. Piezometer 2, moisture readings for midslope fence, Feb - May 2016

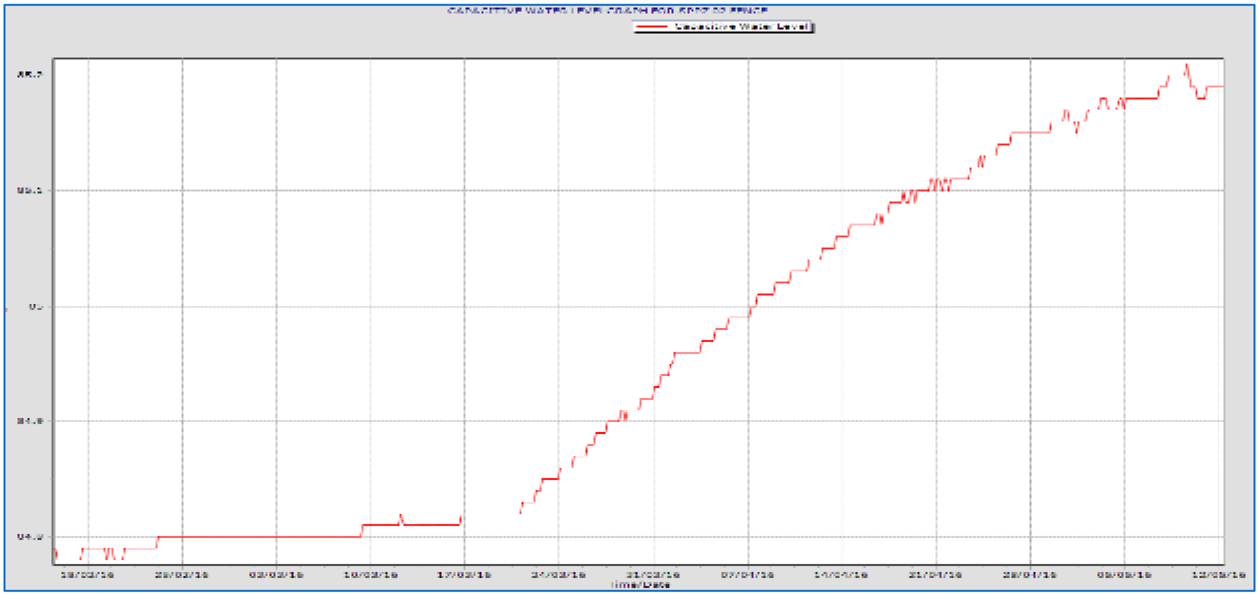


Fig 11. Piezometer 4, moisture readings for upper catchment soak, Feb - May 2016

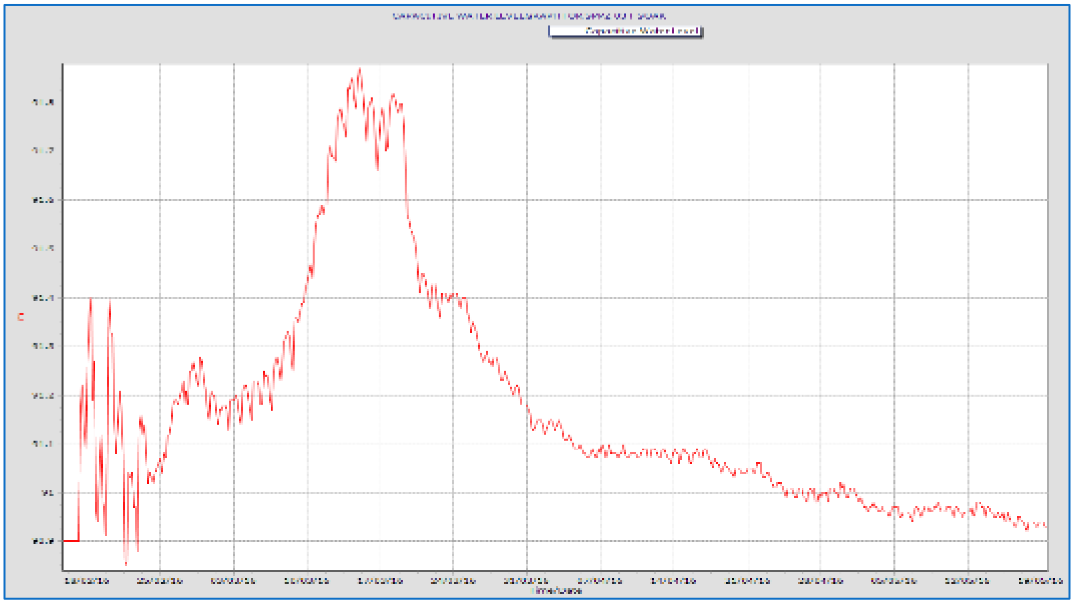


Fig 12-13. Small seep at base of main seep area after summer rain, Feb 10, 2016

Fig 14. Seep in the upper catchment showing Piezometer 4, May 19 2016

Fig 15. Evidence of moisture rise and fall at Piezometer 4 seep, May 2016

Fig 16. Piezometer 2 on fence line near main soak, May 12, 2016

Fig 17. Soil pit above main seep, filled with water after March rain, May 12, 2016

Fig 18. Soil pit above main seep, filled with water after March rain, May 12, 2016

Fig 19. Moisture flowing still draining out of sand into soak, May 12, 2016

Fig 20. Moisture flowing still draining out of sand into soak, May 12, 2016

Fig 21. Barley root growth fully between stubble rows on spaded chicken manure plot

Fig 22. Sandy soil profile on trial plots above main seep area

Fig 23. Soil testing chicken manure site above soak

Table 1. 2nd year soil testing at spading site for changes & carry over nutrition (SARDI funded)

Apal	Mg	Na	Nitrate NO3	Ammonium	Avail N	Colwell K	Organic Carbon	Colwell P	PBI	CL Sulfu	Exch K	Exch Ca	Exch Mg	Exch Na	ECEC	Exch K	Exch Ca	Exch Mg	Exch Na	Ca:Mg
	mg/kg	mg/kg	mg/kg	mg/kg	kg/ha	mg/kg	%	mg/kg		mg/kg	c.mol/kg	c.mol/kg	c.mol/kg	c.mol/kg	c.mol/kg	%	%	%	%	ratio
POPE CONTROL 0-10	43.9	8	7.5	8	26	72	0.48	30	13.3	5.2	0.144	1.372	0.361	0.035	1.93	7.47	71.00	18.70	1.80	3.80
POPE CONTROL 10-40	38.1	24.2	2.2	3.7	30	48	0.11	17	12.8	4.3	0.103	1.747	0.314	0.105	2.27	4.52	77.01	13.83	4.64	5.57
POPE CONTROL 40-60			0.5	0.5	3															
				Total	60															
POPE 6TCM 0-10	39.3	8	5.5	5	18	81	0.31	25	10.8	9.2	0.166	1.072	0.323	0.035	1.61	10.32	66.76	20.14	2.17	3.32
POPE 6TCM 10-40	30.4	8	2	5.3	37	72	0.11	15	11.5	3	0.174	1.022	0.250	0.035	1.49	11.65	68.57	16.78	2.33	4.09
POPE 6TCM 40-60			0.5	0.5	3															
				Total	58															
POPE 9TCM 0-10			17.1	4.9	37															
POPE 9TCM 10-40			3.8	0.5	22															
POPE 9TCM 40-60			1.6	1.1	9															
				Total	69															
POPE SPADED 0-10			3.8	2.3	10															
POPE SPADED 10-40			3.3	0.5	19															
POPE SPADED 40-60			0.5	0.5	3															
				Total	33															

In May 2016 funding was made available to retest some of the 2015 Spading Chicken Manure treatment areas to see if there has been a clear improvement in subsoil characteristics, and how much nitrogen may have carried over from the first year. With limited funds, only 1 test could be made at each plot, with limits to full analysis. Table 1 shows the results, showing an increase of 25kg/ha of N where 6t/ha chicken manure was spaded in, when compared to spading alone, and 36kg/ha extra N where 9t/ha chicken manure was spaded.

It is interesting that the control area also showed the soil with high N similar to the chicken manure plots. While it is possible that this is just be an anomaly that may be corrected with more intensive testing, it is more likely related to the levels of N extraction from 2015. In the area of testing through the middle of the plots:

- the 6t/ha and 9t/ha Spaded chicken manure plots yielded approximately 3.6t/ha with high protein, exporting about 240kg/ha N,
- the control area yielded 1t/ha and low protein, exporting only 54kg/ha N in yield
- the Spaded only area averaged about 2.6t/ha exporting about 75kg/ha N.

It is estimated that the 6t/ha and 9t/ha chicken manure contains about 160ka/ha and 240kg/ha N respectively. It therefore makes reasonable sense that the control area has about 20kd/ha N more than the Spaded only area, and that the majority of the excessive N applied in chicken manure has already been used up in last year's extraordinary yield. It is hoped that the longer term improvements to the soil will still lead to more N mineralization and higher yields, but the reality is that there will not be the same level of N available to reach these yields, without higher N application.

Other soil measurements comparing the control area sand to the 6t/ha spaded chicken manure plot showed slightly higher levels of phosphorus, organic carbon and cation exchange capacity in the control soil. This however could be due to natural soil variation within these sands, as the 2 testing areas were about 80m apart. There would need to be more intensive testing, using the eastern side control, before any meaningful conclusions could be reached.

3.2 Rose / Thomas Site, Wynarka

While this site currently has no specific trial work treatments, there are many points of interest to be monitored. The dataloggers now established on the 3 piezometers should be extremely informative in understanding the water dynamics of the catchment in the future, particulary after significant rainfall events. Google Earth images over time also show the change in the landscape, particularly since the wet season of 2010.

Fig 24. Site map showing monitoring equipment locations

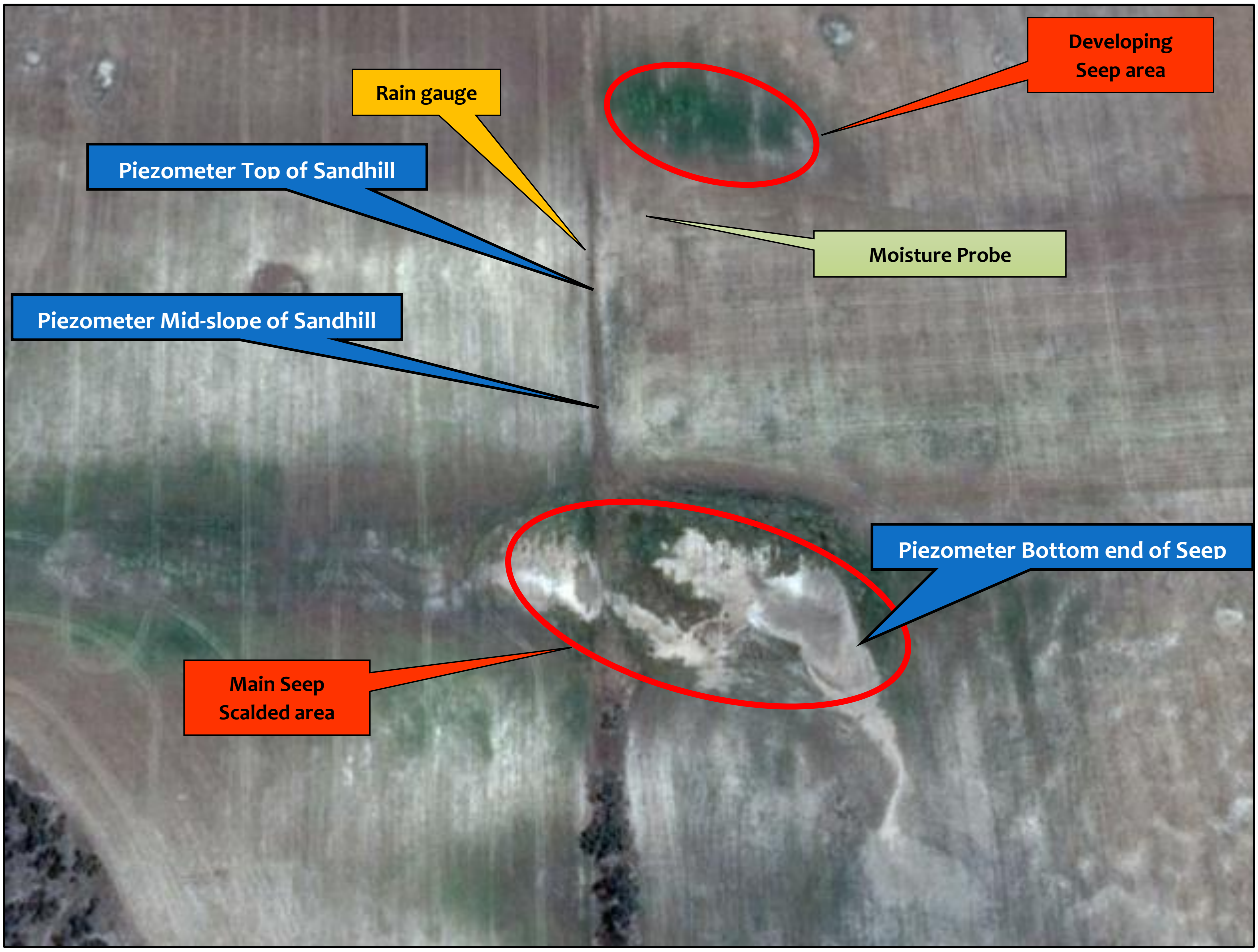


Fig 25. Immediate catchment area 2006 still being cropped through.

Fig 26. Immediate catchmanet area 2013 Google Earth

Fig 27. Google earth comparisons of main seep area showing extensive spread of scald

Figures 25-27 show s the developemnt of the seeps in this immediate catchment between 2006 and 2013, accorinding to Google Earth imaging. The farmers said that the most dramatic change happened after the wet season of 2010.

Readings from piezometer data loggers (see Figures 51-53) suggest an increase in water levels of approximately 20cm on the top of the sand hill, how some movement, the reality is that this is only a fraction of a millimeter. The initial rainfall events have not been big enough to significanlty seep throught o the water table.

Other Figures reveal significant differences in skeleton weed control from the different farmers. It is possible that leaving this deep rooted summer growing weed could use more moisture and imporve the soak situation. It may however have little impact and lead to greater cropping isssues.

The mid-slope moisture probe has again shown that little moisture has penetrated below 40cm from any rainfall events in 2015, suggesting that this area has not been contibuting moisture into the growing soak area below.

The bare areas of accumulating salt crystals at this site are of major concern, and should be adressed in the coming year by establishing salt tolerant ground cover species to minimise evaporation effects.

Fig 28. Rainfall records from site Nov 2015 -- May 2016.

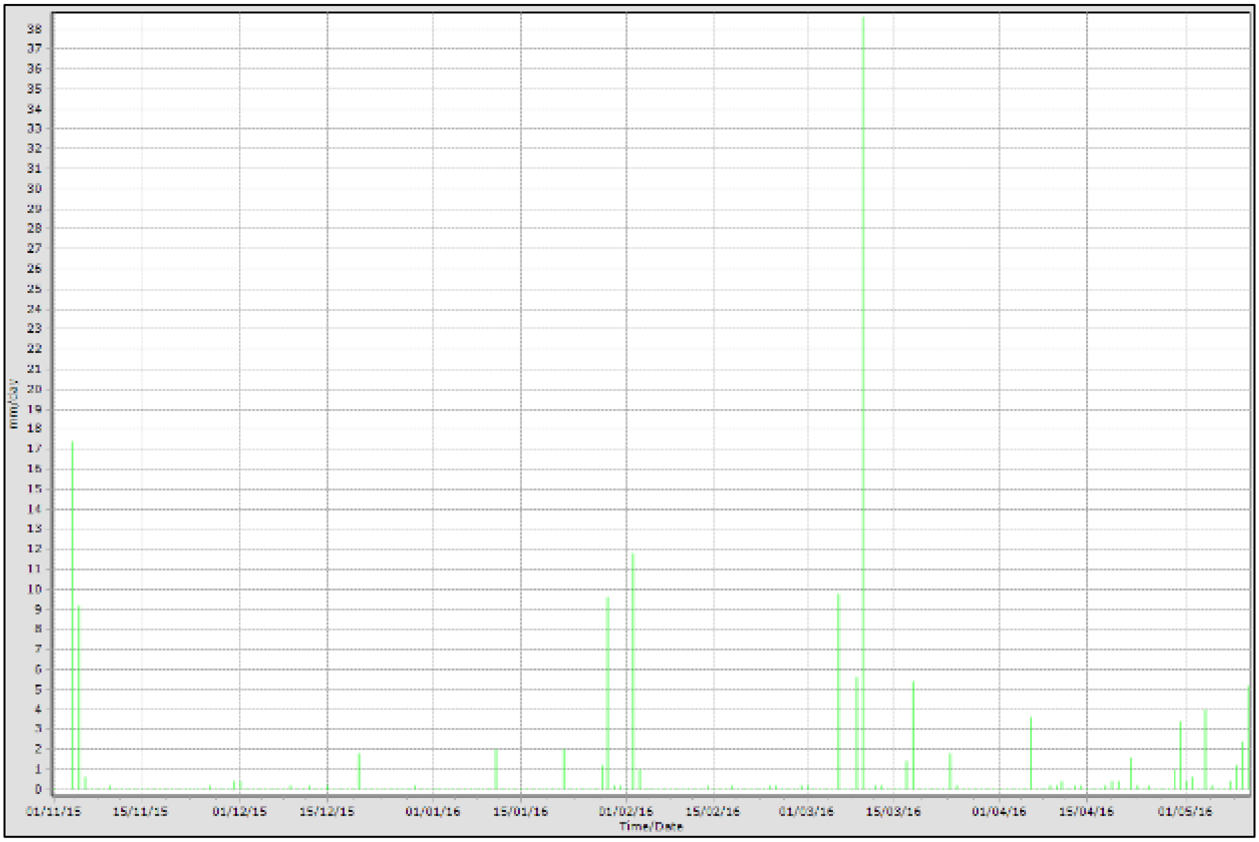


Fig 29. Piezometer readings for Bottom edge of seep site, Nov 2015 - May 2016

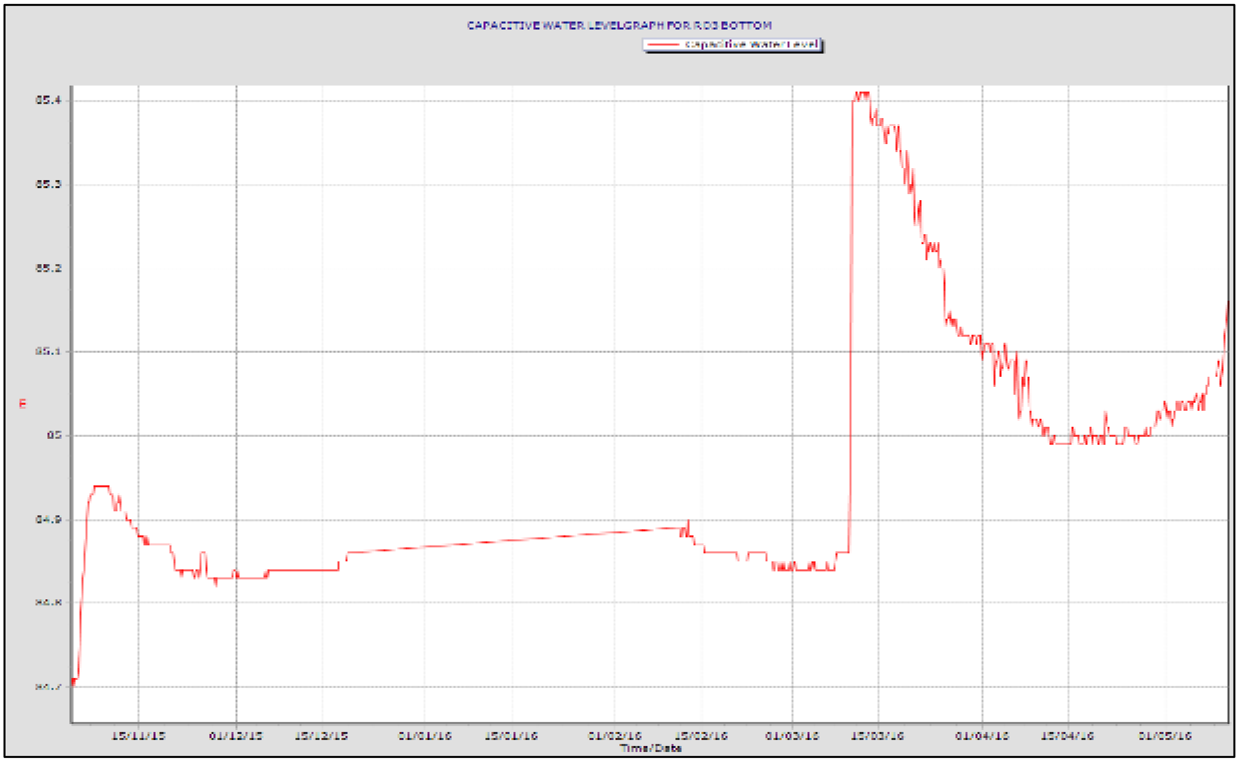


Fig 30. Piezometer readings for Mid-slope, Nov 2015 - May 2016

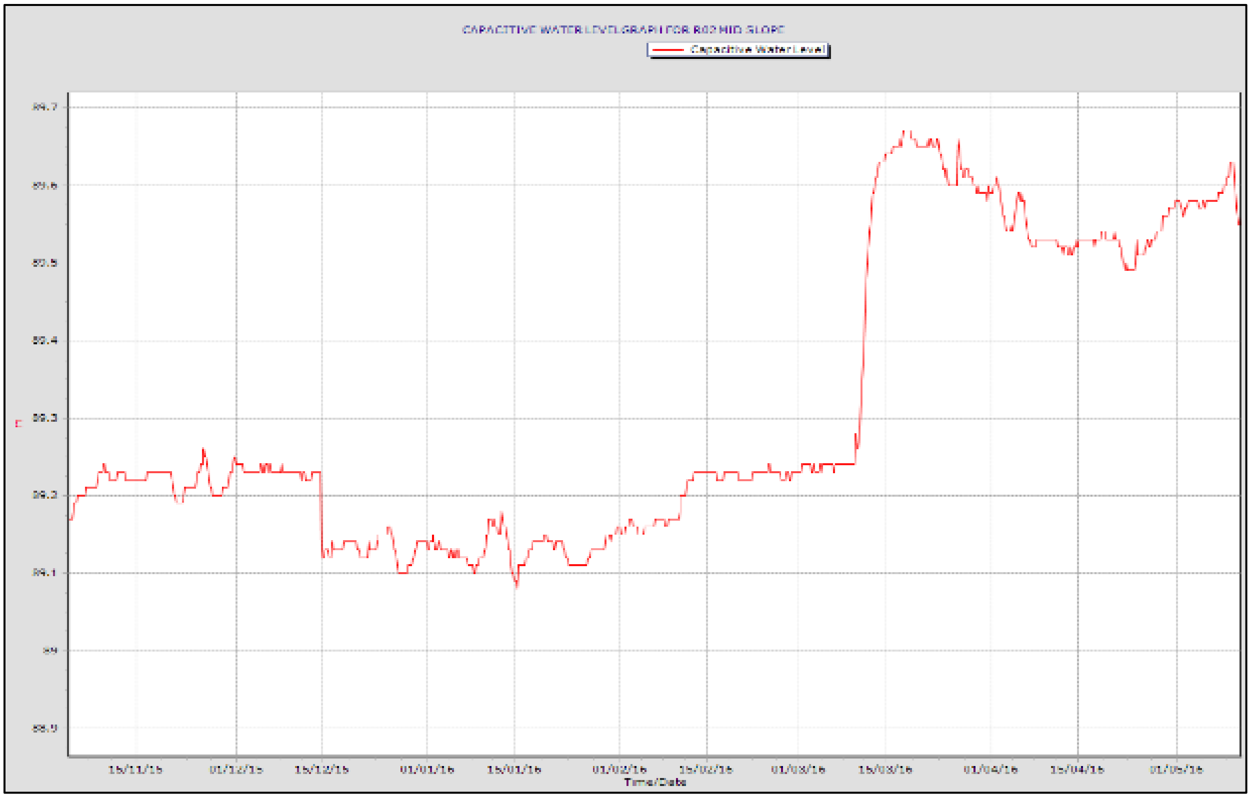


Fig 31. Piezometer readings for top of sand hill, Nov 2015 - May 2016

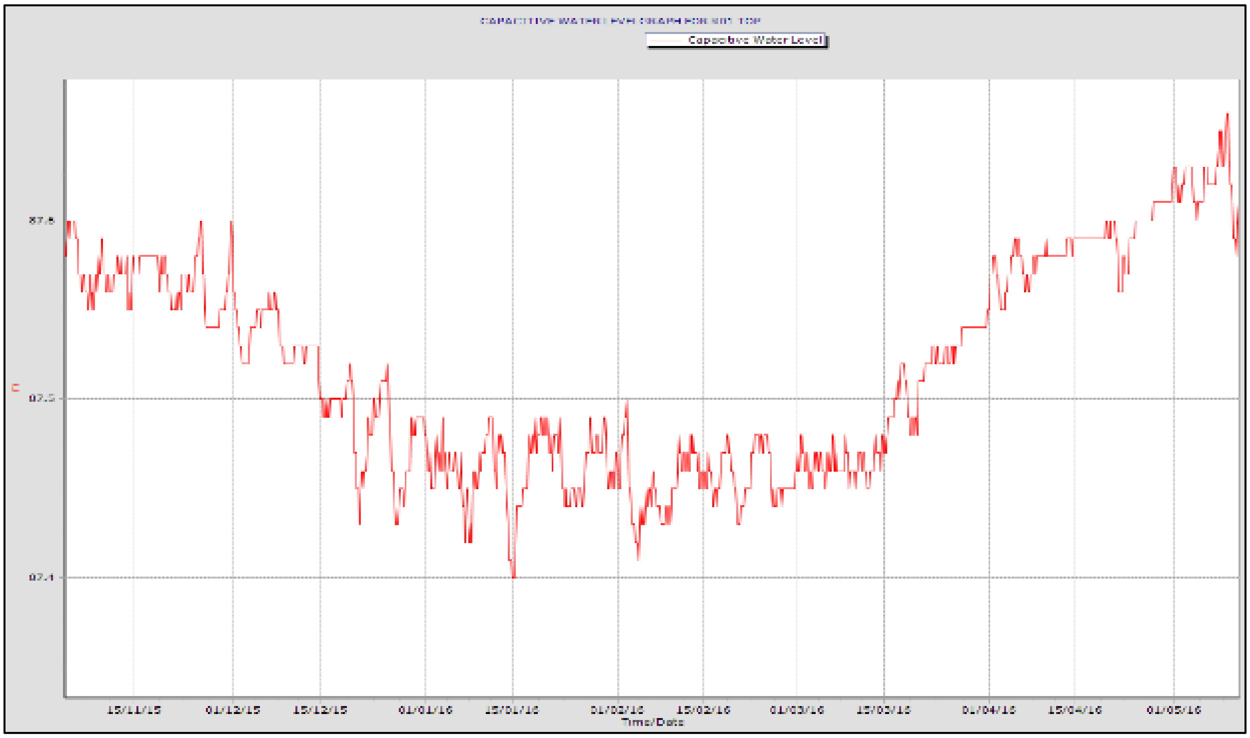


Fig 32. Soil moisture probe readings, midslope near emerging seep area north of main seep.

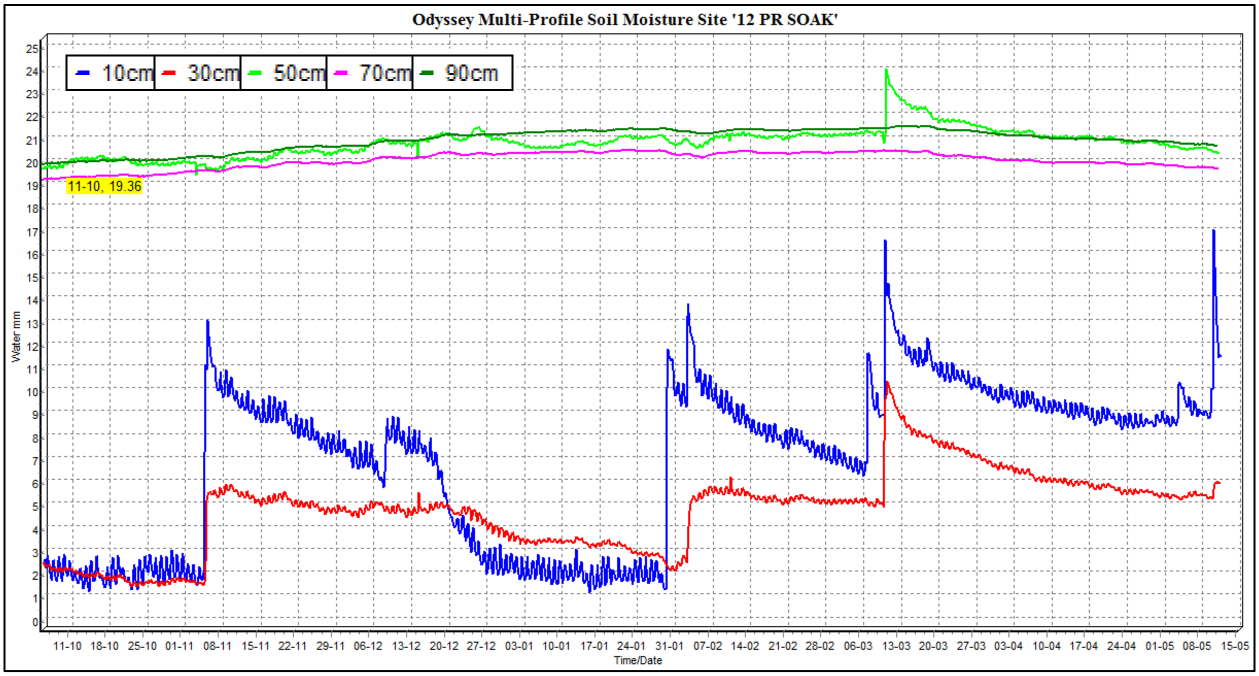


Figure 28 shows the rainfall at the site since November 2015, with only one significant event of around 45mm recorded in mid-March 2016. It should be noted that while this event did cause rises in the water table at all of the 3 piezometers, it did not appear to register in the 70cm or 90cm sensor of the moisture probe on the northern sideof the sandhill (Fig 32.) after spiking at 50cm. It does not appear that the rainfall at this particular site has contributed to recharge. This would indicate that the actual recharge is comeing from further up the sandhill. This means that location of this probe is not in a preferred area of lateral flow, or more likely, it is occurring in lyer of clay below the 90cm sensor. When drill piezometers at this trial site it was found that the saturated perched water table sat in a clay slurry just above the impervious Blanchetown clay.

The piezometer graphs at the base of the seep area (Fig 29) showed that the water level rose approximately 20cm after 26mm in early November, and then quickly settled down by 10cm to a level that remained at the same level until the mid march rainfall (although there appears to be some missing data in summer. The 55mm that feel in a few days in March then lifted the water table by about 55mm, causing a breif stream of water to pass through the area before it settled down by 40cm to a level that has left the seep area with surface through to winter.

The GPS readings suggest that the water line on the Mid-slope piezometer is 4-5m higher than at the seep, which seems a little higher hthan expected. It also has a higher reading than the top of the sandhill reading, which does suggest that this site may need recalibration for a more accurate elevation baseline. However, the relative changes in the water levels represented in Figure 29 appear accurate, and reveal a small rise after the November rain, but then a 40cm rise after the March rain. This level decreases far slower than at the seep area, and by only about 15cm over 4 weeks. The water level the appears to rise again slightly without any obvious ranifall event to trigger this.

The top of the sand hill piezometer appears to slightly drop its water level by 10-15cm from November to January, and then remain steady until after the March rain. This causes the level to rise by 15-20cm over a period of 6 weeks. It must be remembered that the piezometer depth is in the order of 8m.

Fig 33. South view from top of sandhill piezometer toward main seep. Feb 10, 2016

Fig 34. South view from top of sandhill piezometer toward Thomas side seep. Feb 10, 2016

Fig 35. Seep pit area clsoe to fence, May 11, 2016

Fig 36. North view from main seep near piezometer, toward sand hill, May 11, 2016

Fig 37.Water overflow area from main soak after March rain.

Fig 38.No sloppy clay for at least 30cm depth in scald at end of the overflow area

Fig 39. South view from top of sandhill piezometer toward Thomas side seep. May 11, 2016

Fig 40. South view from top of sandhill piezometer toward Thomas side seep. May 11, 2016

Fig 41. Dry sand under surface sand crust, Sandhill, May 11, 2016

Fig 42. Evidence of water running across top of sand rather than soaking in, May 11, 2016

Fig 43. North view from top of sandhill toward emerging seep. May 11, 2016

Fig 44. Sloppy red clay evident at 20-30cm at emerging seep scald. May 11, 2016

The main features of the photographs is the ponded water at the main seep which remains after peaking soon after the March rain. The overflow area shown in Figures 37 and 38 has not maintained saturated soil near the surface due to its sandy nature. This is in contrast to the emerging seep area on the north side where the soil moisture appears to be maintained due to the red clay base at 20-30cm depth.

The non-wetting sandhill appears to be strongly contributing to the seep moisture from the piezometer readings, but also shows surface runoff as well. It would be interesting to further explore and better understand the moisture dynamics of this sand, so that improved management techniques can be employed to improve water use.

3.3 Arbon Site, Wynarka

At Arbons', three areas were targeted to assess the value of using native trees, saltbush and tree lucerne to use and intercept water, dry up soaks and provide strategic grazing opportunities (Fig 47). Figures 45 and 46 show how 4 areas have developed to become to wet for cropping since 2010.

Fig 45. Google Earth 6/10/2010 toward end of wet season before soaks appeared.

Fig 45. Google Earth 1/11/2013 toward end of wet season before soaks appeared.

Fig 45. Site map showing plantation areas being monitored.

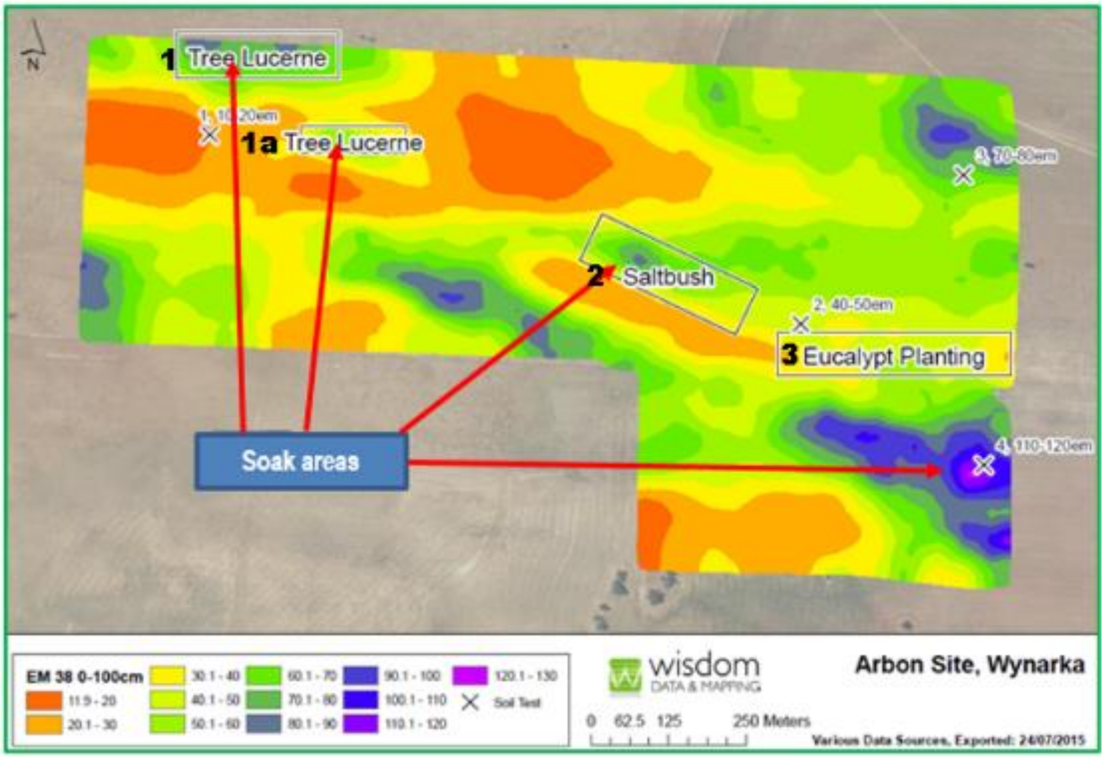


Table 2. Plant survival rates after first summer and autumn.

Site	Site plantings	Sept 15 survival counts	May 16 survival counts	Comments
1,1a Tagasaste through soak	Approximately 400 tagasaste 70 saltbush	281 38	4 50	1% tagasaste survival, very poor most likely due to vermin, quality and dry conditions 71% saltbush survival, planted about every 4 to 5th plant. Many of these were not seen in the Sept 15 count
2 Saltbush through soak	Approximately 270 saltbush	98	119	44% saltbush survival, very poor on the southern side going up the sandhill. There were no recorded dead saltbush in Sept 15, but hard to find in long grass
3 Fence line above soak, 5 rows, mainly eucalypts	Approximately 275 Eucalypts 20 Saltbush	147 7	28 2	10% survival of both eucalyptsand saltbush, mostly at the eastern end where sand is not as deep. High plant death most likely due to very dry conditions in non-wetting sands, and possibly vermin.

The tree and fodder shrub program that was initiated in 2015, has been fairly unsuccessful, as is evidence in Table 2. The tagasaste has only seen a 1% survival rate (see Figs 46 and 47) due to a number of factors, most notably the presents of hares in the area that appear to have eaten the tops off of most plants. There is also evidence of kangaroos and rabbits which may have also eaten many plants. Heat and moisture stress would have also been issues on land out from the edge of the soak areas during the dry spring and summer. It is recommended that these sites be replanted with saltbush, as the saltbush planted amongst the tagasaste have generally survived and established quite well over this period (Fig 48).

The main saltbush area has shown about a 44% survival rate, growing reasonably well through the scalded and edge of seep areas, but poorly on the strips moving up the sandhill (Figs 49 and 50). This strongly supports the decision to target the activity where the water is accumulating in the soak (to maximize growth and grazing), rather than the sandhill, which although may be contributing much of the moisture, is very difficult to establish. This site could benefit from replanting of saltbush seedlings in some of the gap areas.

While fencing was commenced around this area, the farmer is not likely to carry through with this, and rather focus on grazing in summer months with crop stubbles.

The five rows of tree planting along the fence line has been fenced (Figs 51-53), but has also suffered from very poor survival rates. While the farmers did water trees during winter and spring, they said it was very difficult to get the water to soak in, rather than run off. This may have been improved with a better basin created around each tree at sowing (which did happen to some extent, but was not easily sustained), and possibly the use of tree guards. Plant establishment is very poor at the western end deeper sandy rise.

The farmer is hoping to replant trees through this area, but would benefit from any assistance in achieving this. It is hoped that this tree plantation will help to intercept the movement of water across the perched water table and surfacing at the seep area below, which is now full of thick ryegrass for much of the year, due to the extra moisture. This is nowhere near the bottom of the catchment. If more trees can be used to replace the dead seedlings in 2016, it would require more attention to strategic watering and tree guards to ensure a higher rate of plant establishment. The weed population of melons, lupins, capeweed, turnip and thistles will need to be controlled.

This site has been good in concept of both intercepting and utilizing the excess water in ways that will most support this farmers farming system with minimal inconvenience, and maximum grazing opportunities. However, more attention was required to help maximize plant survival, mainly through protection form vermin, ongoing weed control and improved watering. It is hoped that this site can still be supported into the future to help achieve these goals and measure the impact on the seep areas.

Fig 46. Surviving tagasaste plant, although being grazed by vermin.

Fig 47. Surviving tagasaste plant, May 2016

Fig 48. Thriving saltbush through tagasaste plot (planted about every 5th plant)

Fig 49. Good establishment through most of the saltbush planting, May 2016

Fig 50. Good establishment through most of the saltbush planting, edge of sandhill, May 2016

Fig 51. Tree planting area along fence above seep area with very poor survival, Feb 2016

Fig 52. Good establishment through most of the saltbush planting, Feb 2016

Fig 53. Poor sand making plant survival very difficult, Feb 2016

Fig 54. Trees surviving through summer on sandy soil

Fig 55. Trees surviving through summer on sandy soil

3.4 Bond Site, Mannum

There are numerous seep areas developing throughout the Bonds property south east of Mannum. In 2015 a 19ha strip of lucerne was established over a long sandy rise above a main seep area. This is surrounded by well managed Notill continuous cropping of cereals, pulses and canola. The main monitoring at the Bond site has revolved around three main aspects:

1. the survival of the lucerne after establishment in 2015,
2. the measurable differences in soil water dynamics between the 2 different farming systems at the site (lucerne for hay and continuous cropping), from moisture probes.
3. the water table levels at the seep and on the sandy rise, from piezometers.

It is expected that this will provide excellent insight into how and when recharge is occurring and to what extent, and what management strategies are best to minimize this.

Fig 56. Map of Bond Lucerne Trial showing monitoring zones and equipment sites

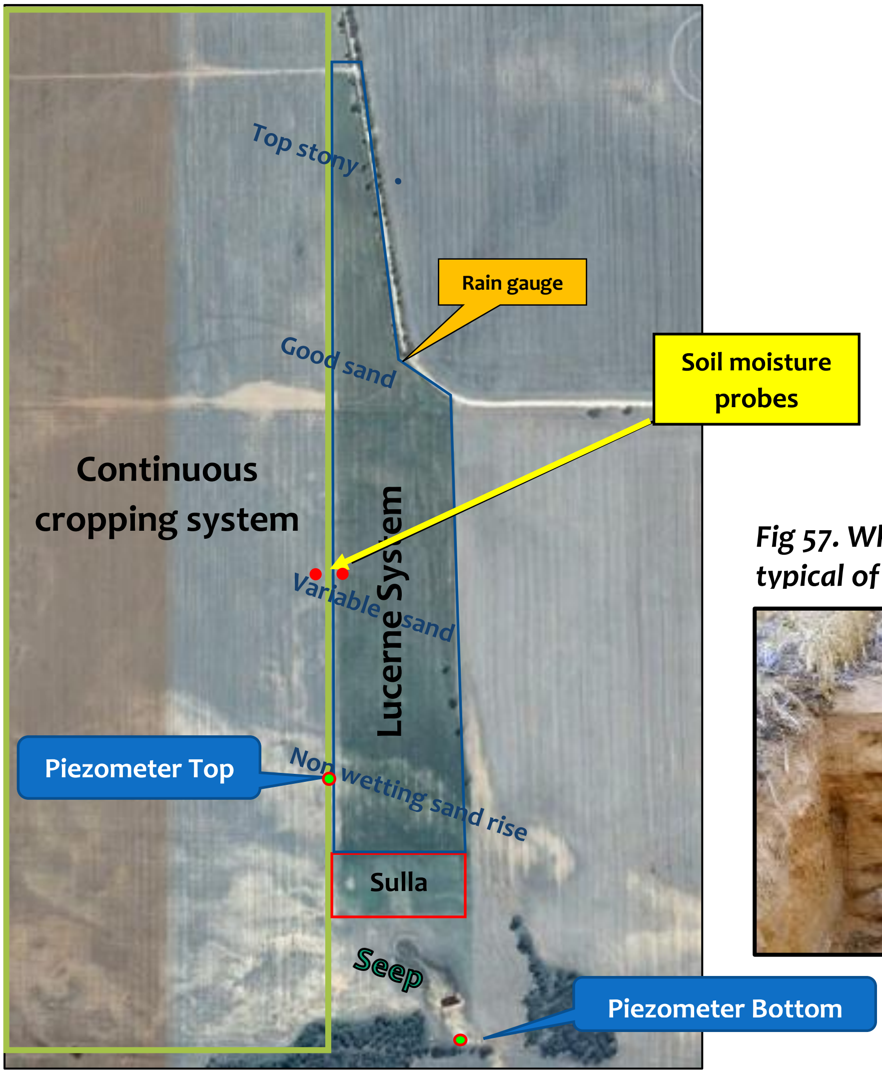
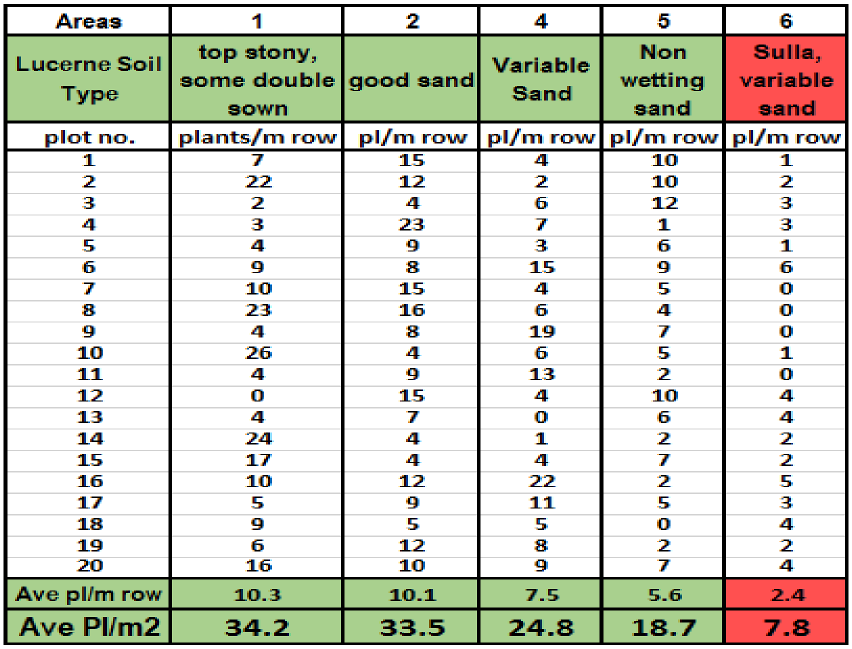


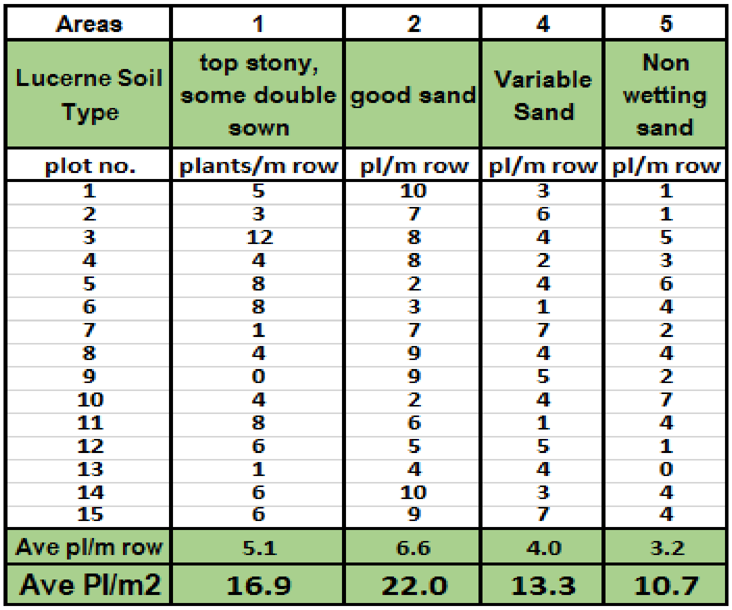
Fig 57. White sand over clay profile typical of this site

Table 1. Lucerne and Sulla counts (Sept 2015)



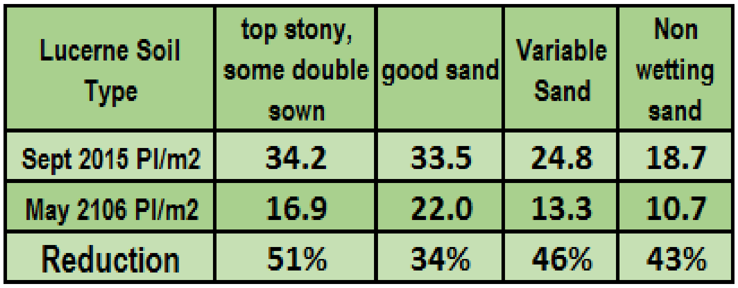
Areas	1	2	4	5	6
Lucerne Soil Type	top stony, some double sown	good sand	Variable Sand	Non wetting sand	Sulla, variable sand
plot no.	plants/m row	pl/m row	pl/m row	pl/m row	pl/m row
1	7	15	4	10	1
2	22	12	2	10	2
3	2	4	6	12	3
4	3	23	7	1	3
5	4	9	3	6	1
6	9	8	15	9	6
7	10	15	4	5	0
8	23	16	6	4	0
9	4	8	19	7	0
10	26	4	6	5	1
11	4	9	13	2	0
12	0	15	4	10	4
13	4	7	0	6	4
14	24	4	1	2	2
15	17	4	4	7	2
16	10	12	22	2	5
17	5	9	11	5	3
18	9	5	5	0	4
19	6	12	8	2	2
20	16	10	9	7	4
Ave pl/m row	10.3	10.1	7.5	5.6	2.4
Ave Pl/m2	34.2	33.5	24.8	18.7	7.8

Table 4. Lucerne and Sulla counts (May 2016)



Areas	1	2	4	5
Lucerne Soil Type	top stony, some double sown	good sand	Variable Sand	Non wetting sand
plot no.	plants/m row	pl/m row	pl/m row	pl/m row
1	5	10	3	1
2	3	7	6	1
3	12	8	4	5
4	4	8	2	3
5	8	2	4	6
6	8	3	1	4
7	1	7	7	2
8	4	9	4	4
9	0	9	5	2
10	4	2	4	7
11	8	6	1	4
12	6	5	5	1
13	1	4	4	0
14	6	10	3	4
15	6	9	7	4
Ave pl/m row	5.1	6.6	4.0	3.2
Ave Pl/m2	16.9	22.0	13.3	10.7

Table 5. Lucerne survival by area summary



Lucerne Soil Type	top stony, some double sown	good sand	Variable Sand	Non wetting sand
Sept 2015 Pl/m2	34.2	33.5	24.8	18.7
May 2106 Pl/m2	16.9	22.0	13.3	10.7
Reduction	51%	34%	46%	43%

Lucerne was established well by the Bonds in May 2015, and plant density counts were conducted in Sept (Table 3.). This showed an average of 34.2 pl/m^2 on the stony northern and similar numbers in the good sand just below this area, near the rain gauge. 24.8 pl/m^2 were counted at the variable sands near the soil moisture probes, while the non-wetting sands (while still having reasonable coverage) was the lowest density at only 18.7 pl/m^2.

The Sulla density was measured at 7.8 on the loamy sand and sandy loam areas, but was almost non-existent on the deeper sand areas. It had begun to re-establish in 2016, assisted by March rains (Fig 71, 95 & 96).

Table 4 shows the lucerne plant counts made in May 2016, while Table 5 indicates the % reduction in plant numbers over the summer season. This was as high as 51% in the northern shallower stony soil end, which may be due to the high initial establishment density at this site, combined with the shallower rooting zone due to the stone, which would have greatly reduced plant available water through the dry summer periods. This area still has good plant density numbers to produce enough bulk for hay cutting.

While the non-wetting sand has the lowest establishment, this is still quite a reasonable density and coverage for this soil type. It is hoped that lucerne densities will stabilize this season. There is no grazing pressure as it will be cut for hay as regularly as seasons allow.

The Bonds are now strongly considering sowing more of their non-wetting sands to lucerne, because they "aint making any money form chickpeas or other pulse crops there!" This may be a very significant outcome for the project.

The area described as good sand, adjacent to the rain gauge, has shown a 34% reduction in lucerne plants and has the highest density of areas monitored at an average of 22pl/m^2. This area of midslope sand is expected to continue with excellent lucerne hay production in to the future (Figs 76 and 79).

The variable sand around the soil moisture probe area experienced a 46% reduction in plant density, maintaining an average 13.3 pl/m^2. While this is quite lower than the previous areas, the plants are quite larger where densities are lower. This is shown in Figs 75 and 81.

Photos of this area in both Feb 2016 and May 2016 show good lucerne survival at each monitoring area (Figs 81-93). The slightly yellow tinge and poorer looking growth in the May photos are due to some insect attack that was controlled in autumn, along with some chemical weed control. All areas are expected to recover from this, and be ready for the next hay cut soon.

Fig 58. Rainfall records for site, Nov 2015 to May 2016

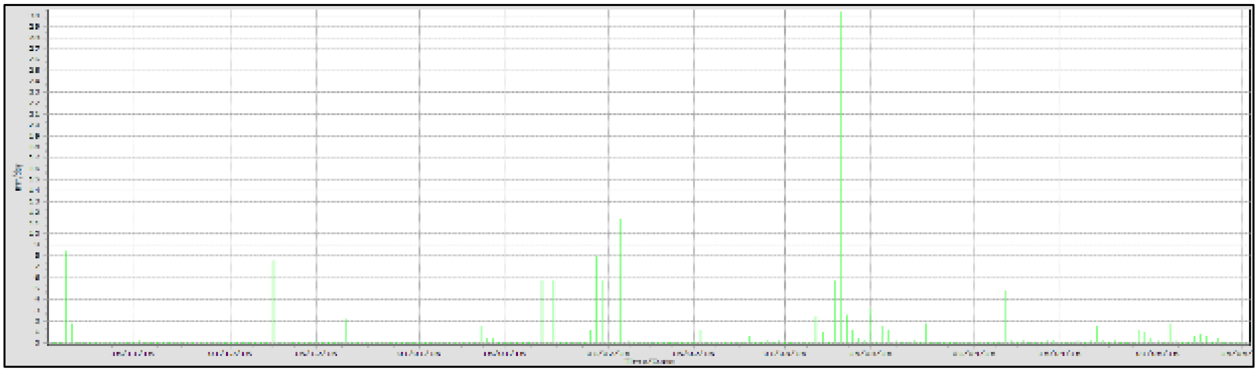


Fig 59. Piezometer readings for Bottom soak area, Nov 2015 - May 2016

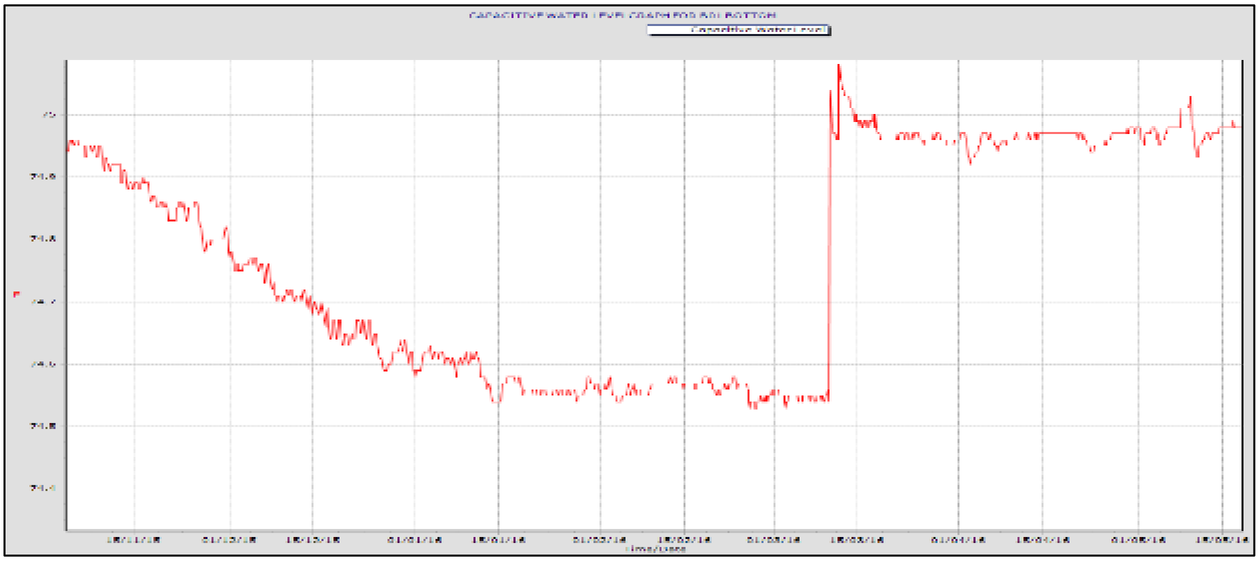


Fig 60. Piezometer readings for Top of non-wetting sandy rise, Nov 2015 - May 2016

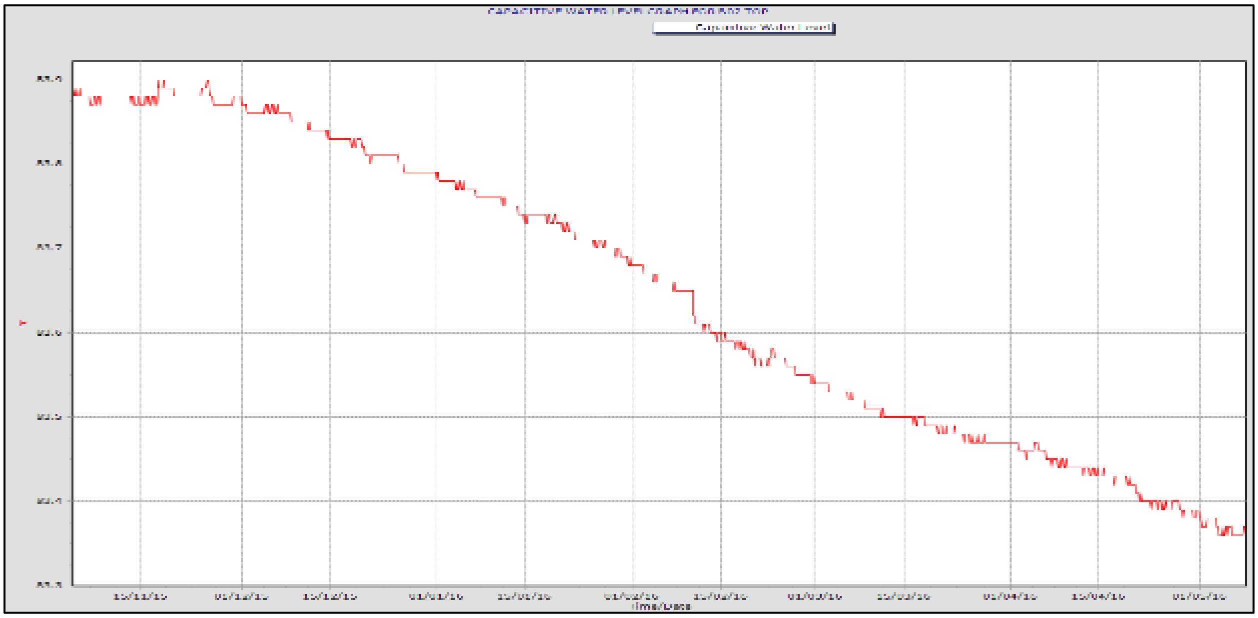


Fig 61. Cereal cropping moisture probe readings, Oct 2015 – May 2016

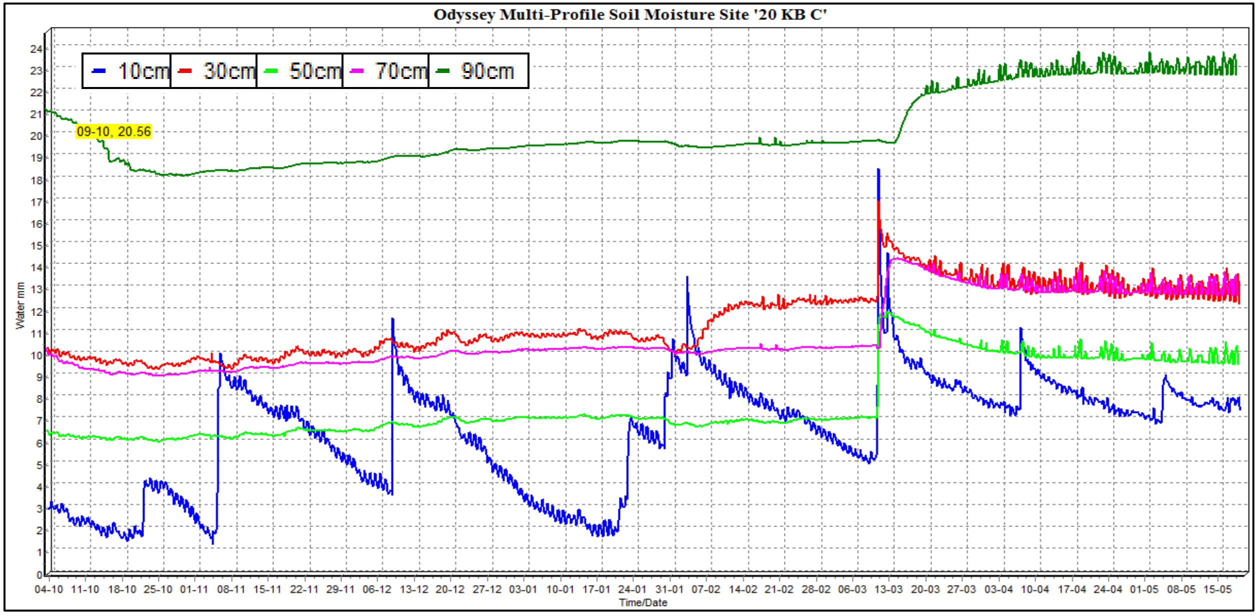
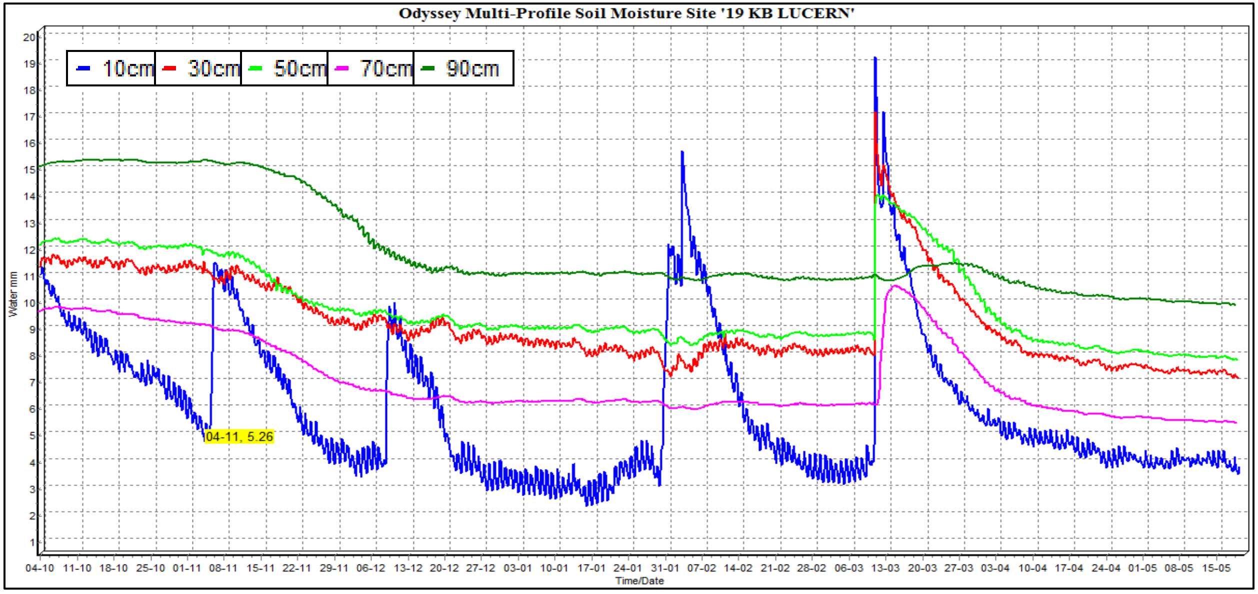


Fig 62. Lucerne system moisture probe readings, Oct 2015 – May 2016



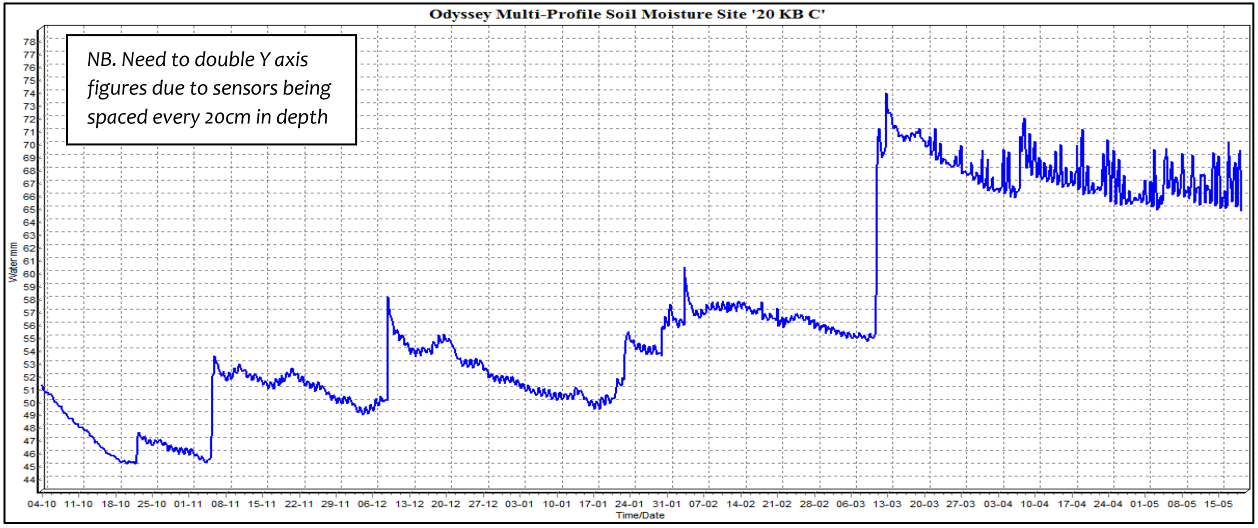
As expected there is large difference in the summer moisture use between the 2 farming systems as measured by the moisture probes set either side of the lucerne line (Figs 83-84). The 90cm sensor on Figure 61 suggests that the cereal crop drew down the deep moisture in mid-October (immediately around the probe the crop grew through to maturity, while the rest of the paddock was cut for hay). This low moisture remained through summer, until the large March rain came, possibly taking this subsoil clay to saturation point leading to recharge and lateral moisture movement. Figure 63 suggests that the crop could draw the moisture down to about 90mm, and could hold approximately 140mm, suggesting a “bucket size” of about 50mm, which was less than half full when the March rain fell. Figure 61 shows that the moisture went all the way to the 90cm sensor and beyond, likely contributing to recharge.

However, on the lucerne side there is no substantial rise in the 90cm sensor after the March rain (Figures 62 & 64). This is because the lucerne had used far more soil moisture up over summer moisture, and continues to with its deep perennial roots. Figures 64 and 63 suggest that the lucerne side had 76mm moisture in the top 90cm, 34mm less than the cereal side. This is why 30-40mm rainfall in March was almost fully absorbed into the top 80cm where the lucerne was growing, rather than causing recharge. It was also very quickly used by the plants returning soil moisture levels back to where they were in a month. This has proven lucerne as an excellent tool for the reduction of recharge and Mallee seep management.

The piezometer reading at the base of the soak area (Fig 59) shows that the perched water table was slowly declining over the summer, and that none of the summer rainfall events of up to 12mm were large enough to cause substantial lateral moisture movement in the catchment. However, the March rainfall lead to a very swift rise in water table of approximately 40cm, as evidenced by the nearby pit water level changed (Figs 66-68).

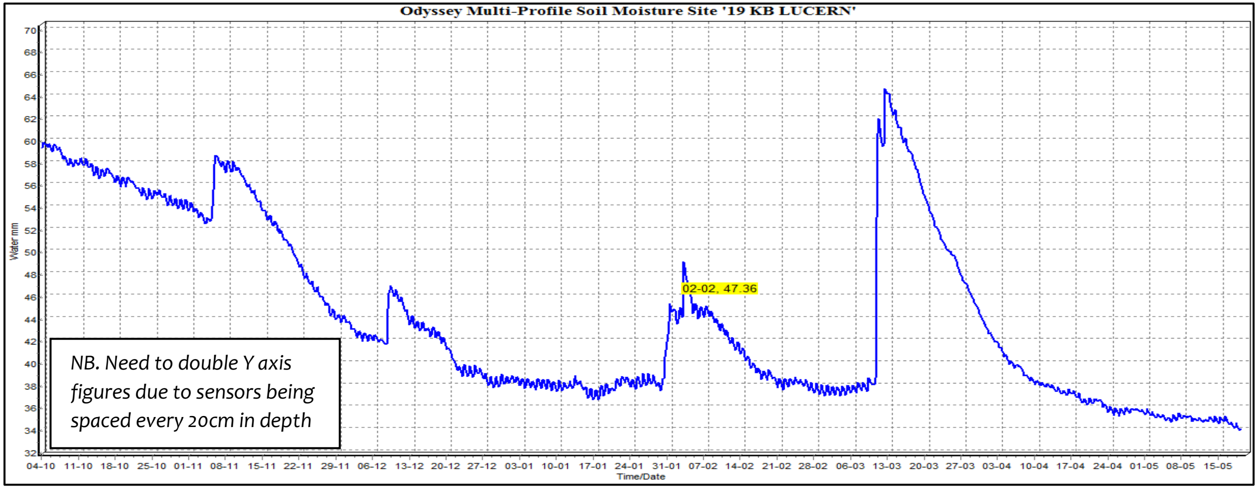
The piezometer at the top of the first non-wetting sandy rise (Fig 60) has surprisingly been steadily declining since the data logger was attached in Nov 2015. The March rainfall had no effect on the water table levels at this site. This is most likely due to the close proximity of lucerne to this piezometer site, reinforcing the positive effects of this lucerne strategy.

Fig 63. Cereal cropping summed moisture probe readings, Oct 2015 – May 2016



NB. Need to double Y axis figures due to sensors being spaced every 20cm in depth

Fig 64. Lucerne system summed moisture probe readings, Oct 2015 – May 2016



NB. Need to double Y axis figures due to sensors being spaced every 20cm in depth

Fig 65. Rainfall records for site, Feb to May 2016

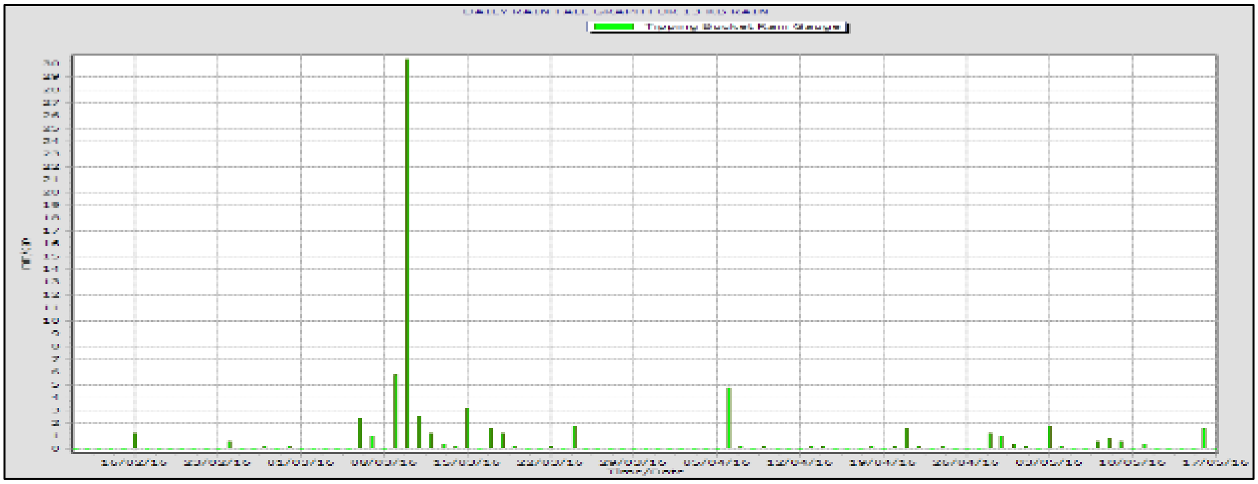


Fig 66. Pit near Bottom Piezometer nearly empty at Feb 2016

Fig 67. Large pit at seep area nearly empty in Feb 2016

Fig 68. Large pit at seep area full at May 2016 after March rain

Fig 69. Seep area above pit, surrounded by salt tolerant growth, Feb 2016

Fig70. Seep area above pit, May 2016

Fig 71. Germinating Sulla, Feb 2016

Fig 72. Reasonable lucerne growth on non-wetting sand above soak, Feb 2016

Fig 73. Lucerne growth on non-wetting sand looking north, Feb 2016

Fig 74. Crop stubble and lucerne above moisture probes, Feb 2016

Fig 75. Lucerne above moisture probes, variable sand area, Feb 2016

Fig 76. Overlooking good sand area from edge of top stone area, Feb 2016

Fig 77. Stony area at top of lucerne plot, Feb 2016

Fig 78. Stony area at top of lucerne plot, May 2016

Fig 79. Good sand area near rain gauge, May 2016

Fig 80. Lucerne soil moisture probe, May 2016

Fig 81. Lucerne growth on variable sand area, May 2016

Fig 82. Lucerne growth on non-wetting sand, May 2016

Fig 83. Lucerne and crop stubble looking north toward moisture probes, May 2016

Fig 84. Lucerne growth on non-wetting sand looking south to Sulla area, May 2016

Fig 93. Lucerne growth on non-wetting sand looking south to Sulla area, May 2016

Fig 94. Established Sulla, May 2016

Fig 95. Established Sulla below non-wetting sand rise, May 2016

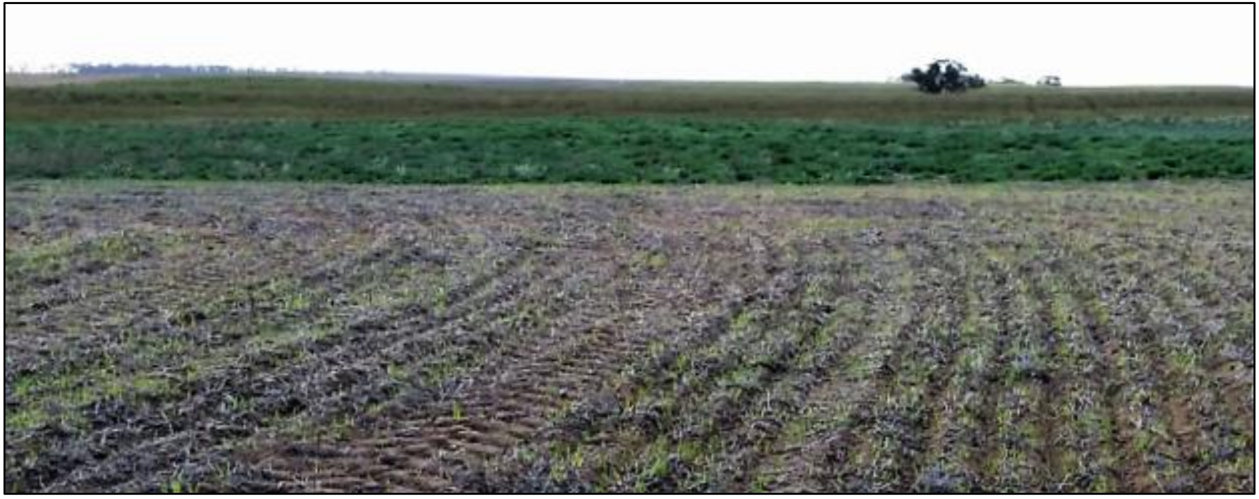


Fig 96. Developing seep area above main seep, May 2016

Fig 97. Developing seep area above main seep, May 2016

4 Appendix

Dealing with Mallee Seeps

Workshop/Field Day

Why are Seeps increasing?
What can we best do to fix them?

Feb 23rd, 9am – 12.30pm

Starting at Karoonda Football Clubrooms

- **Causes, effects and dynamics of Mallee Seeps**
  James Hall, Soil Scientist who has analysed 3 local catchments
- **Local trial work including Chicken Manure Spading, Lucerne Hay establishment, Saltbush and Tree Lucerne for livestock**
  Chris McDonough (Trials consultant) with farmers Stu Pope, Kevin Bond & David Arbon
- **Reclaiming a Saline Seep for Cropping** *farmer David Smith*
- **Visit Seep Catchment at Stu Popes' with moisture probes & soil pits and deep root growth from manure spading trial**
- **Discussion on where and how farmers should target optimal seep management strategies, and where to from here…**
- **Lunch back at Football Clubrooms**

Everybody is Welcome - no cost for the day

Please register with Chris McDonough for catering purposes - 0408085393

Australian Government | National Landcare Programme

Government of South Australia
South Australian Murray-Darling Basin Natural Resources Management Board

NRM Organisations | Production & Environment Partnerships | Grains Industry

Ag Excellence Alliance

Mallee Sustainable Farming

GRDC Grains Research & Development Corporation
Your GRDC working with you

Karoonda Agricultural Bureau