Monitoring Mallee Seeps

Project 1498C for the

South Australian Murray-Darling Basin

Natural Resources Management Board

Progress Report Jan-June 2017

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Contents

1 Project Summary

The Mallee Seeps Monitoring Project has shown many significant outcomes over 2016 and 2017 in terms of increasing our understanding of catchment dynamics, including how various seasonal event and management strategies have impacted on recharge, groundwater movement and resulting land degradation.

Key findings include:

- The well above average rainfall year of 2016 has significantly filled soil moisture profiles and recharged all seep catchment groundwater tables to the point where smaller rainfall events of 10-20mm are leading directly to surface discharge.
- Piezometer readings across catchments reveal numerous pulses of lateral ground water flows in the mid-slopes, with water table rises measured between 35 - 135cm.
- Some tops of non-wetting sandhills were shown to steadily contribute to recharge between March and October 2016, despite growing a crop, suggesting they have very limited ability to hold and utilize rainfall.
- Mid-slope sands tended more to contribute to recharge after fewer, more specific rainfall events.
- Lucerne plantation has caused a dramatic reduction in soil moisture throughout the profile (generally maintaining a 60-80mm difference in the top 1m of soil, compared to the cereal rotation, with likely even greater reductions beneath the cereal rootzone) leading to decreased recharge and the lowering of water tables. However, the lucerne hay production appears to also have been diminished after drying out the profile. This will need to be monitored further to ensure the most effective and sustainable lucerne strategies are developed for the future.
- The spading of chicken manure to increase profitable production and higher water use of crops on non-wetting compacted sands continued to show excellent results in its second year. The high initial costs and effort involved and availability of spading equipment and the risks of wind erosion means that this technique, while shown to be highly profitable, is still developing within the farming community.

The role of strategic tree and saltbush plantings, along with the establishment of the salt and waterlogging tolerant *messina* pasture on saturated and scalded areas is set to be assessed in the coming years.

Continual monitoring will also be critical in assessing the ongoing degradations on recovery of the many sites within these catchments in the years following the very high moisture contribution of 2016.

2 Introduction

The growing seep issues in the Karoonda district has led to the establishment of four sites over the last 3 years, involving the monitoring of soil moisture probes, piezometers and various higher water use catchment management strategies. The body of information gathered, in conjunction with associated catchment assessment reports commissioned by the NR SAMDB, is contributing greatly to our understanding of how these seep issues are developing and what strategies may be employed to best manage and rehabilitate the problems.

This is the fifth report associated with monitoring 4 seep sites between Mannum and Karoonda that were originally 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 three following Monitoring Mallee Seeps Progress Reports, dated July-Dec 2015, Jan-June 2016 and July-Dec 2016 are a continuation of monitoring of soil moisture readings, water table levels and the progress of various treatments at these 4 established sites. These NR SAMDB reports also provide some recommendations for future seep management.

The findings from these four sites are providing valuable information for seep management across the Mallee and are often referred to at various farmer meetings, field days and site visits about soaks, their causes and management strategies that may be employed that fit in with different farming systems and needs.

3 Sites Monitoring

3.1 Martin’s Site (formally Pope Site), Karoonda

Seep site at Martin’s property, south west of Karoonda, has 2 main areas of monitoring. There is the southern paddock in the upper catchment area, directly feeding into 2 soaks, as well as the lower catchment area surrounding a major salt scald and seep area. A network of strategically placed piezometers and moisture probes have been placed throughout to monitoring moisture levels, ground water flows within the landscape as well as the impacts of seasonal factors, farming systems influences and spading treatments.

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

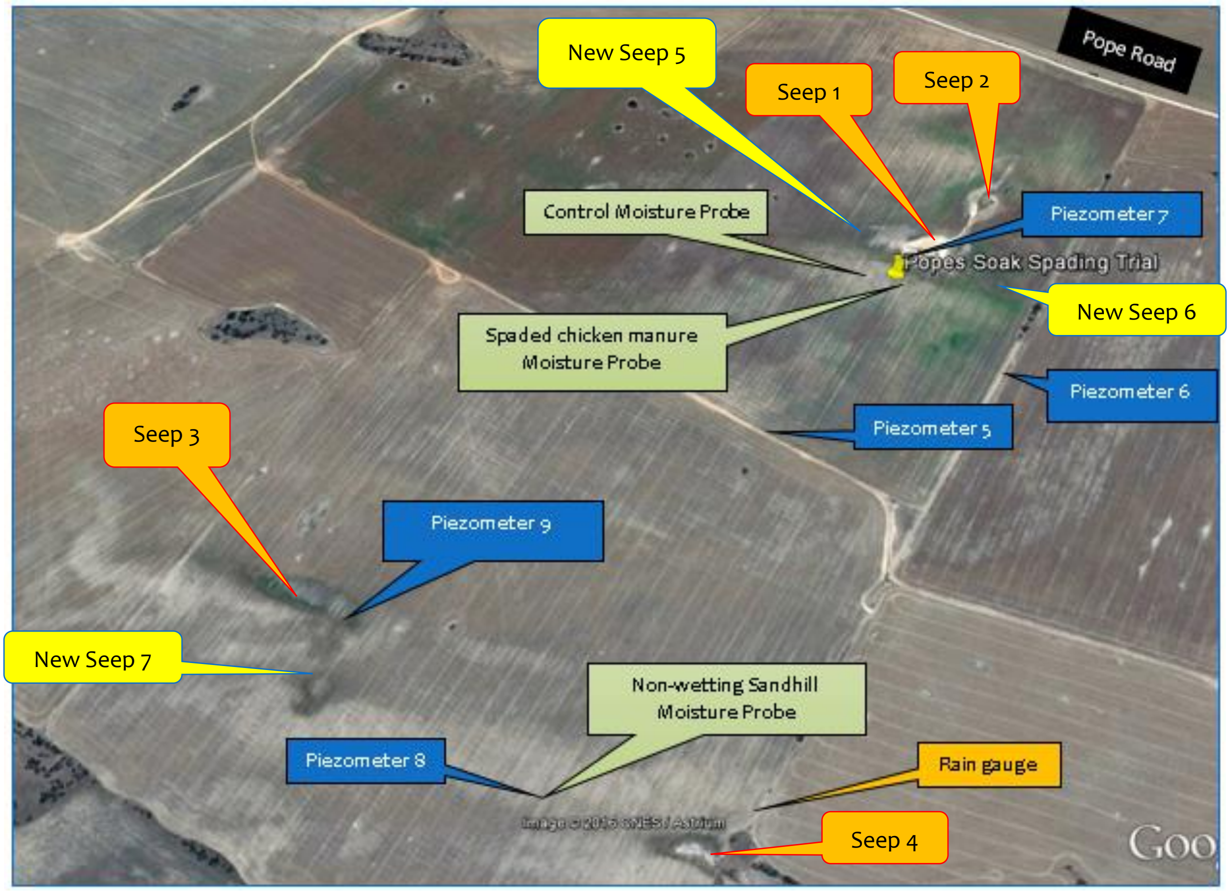


Table 1. Karoonda 2016 and average annual rainfall

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	18.2	19.9	17.7	24.7	35.5	35.1	35.2	38.3	35.6	31.9	23.9	25.1	343.2
2016	35.2	6.8	53	8.8	54.2	31.2	57	70.4	119.3	*34*	*28.2*	*83.8*	*581.9*
2017	29.2	35	18.2	40	12.2*								

****rainfall recorded up until May 29th 2017***

3.1.1 Site Summary

This site has shown a concerning rises in water table levels throughout the catchment in the first half of 2017. This is due to:

1. the high rainfall year of 2016 (Over 200mm above average), where the Spring rainfall was too great to be fully utilized by the crops (unable to draw soil moisture down to the usual crop lower limit), followed by…
2. a large rainfall event in late December (well after crop senescence, with soil moisture preserved through summer weed control).

This appears to have caused large lateral movement of groundwater down to lower areas of the catchment, while filling localized basins and saturating specific areas where subsoil impervious clays are closer to the soil surface.

With subsoils already largely at a level of field capacity or saturation, a 30mm rainfall event in late April was enough to significantly raise water tables, cause lateral water flow through the landscape, form large saturated areas where crop was successfully grown in 2016, as well as fill and increase the size of existing seep areas.

While the crops and pasture growth will begin to use up soil moisture stored within the top 1-1.5m, it is likely that the effects of this wet season will remain and possibly increase soil degradation into the future unless specific management involving deep rooted perennial vegetation is applied. This could include the strategic establishment of lucerne or possibly trees along fencelines. This has been discussed with the farmer is currently considering establishing a 40m lucerne strip along the east-west fenceline between the two monitoring paddocks.

While the spading of chicken manure is encouraged, as it has proved to greatly increase crop production and profitability on non-wetting sands over 2 seasons, with the benefit of higher moisture utilization. However, it does have high up-front costs to establish, and can only have limited impact on the subsoil moisture contribution of high summer rainfall events.

Some hand seeding of the new salt and waterlogging resistant pasture variety *messina* has taken place on and surrounding lower scald and seep areas to help establish soil cover that will reduce evaporation and surface salinization, as well as help establish the potential for this pastures establishment and use at such sites.

3.1.2 Moisture Probe and Piezometer Results

Upper catchment area.
The upper catchment to the south of the monitoring area in the southern paddock (Fig 1.) has a moisture probe and 2 piezometers around 2 large growing seep areas (Seeps 3 & 4) that contain water almost continuously, and at least one newer developing seep area.

This paddock was sown to both lupins and peas in 2016, which generally grew thickly and yielded well. Table 1 shows that Karoonda received approximately 240mm above average rainfall in 2016 and well above average rainfall to May 2017. The previous monitoring report suggested that these soils are more vulnerable to recharge this year due to the high soil moisture levels at the end of the wet 2016 season. Any rainfall event around 25-30mm or more in 2017 would likely lead to recharge.

This predictive statement based on the summed soil probe moisture data appears to have been very accurate, as the data gathered from Piezometer 8 near Seep 3 (Fig 2.) had risen by 25cm after large rainfall at the end of December (48mm) and then by another 25mm after 25mm in April. This is clearly shown by the water still seeping out of the sandhills and clearly flowing above the ground into the lakes in Photos 2, 4 & 5 taken on May 23rd.

Fig 2. Groundwater level for Piezo 9, high southern seep, Feb - Sept 2016

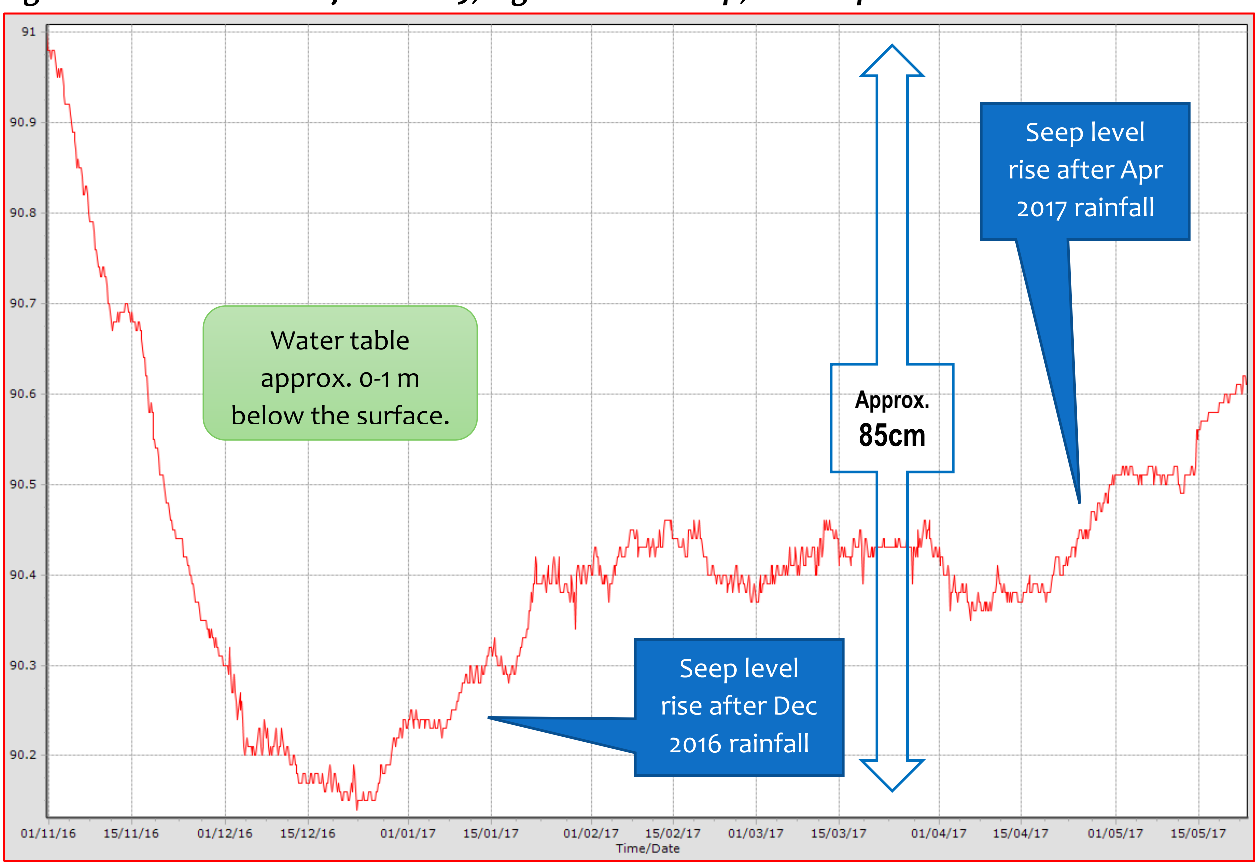


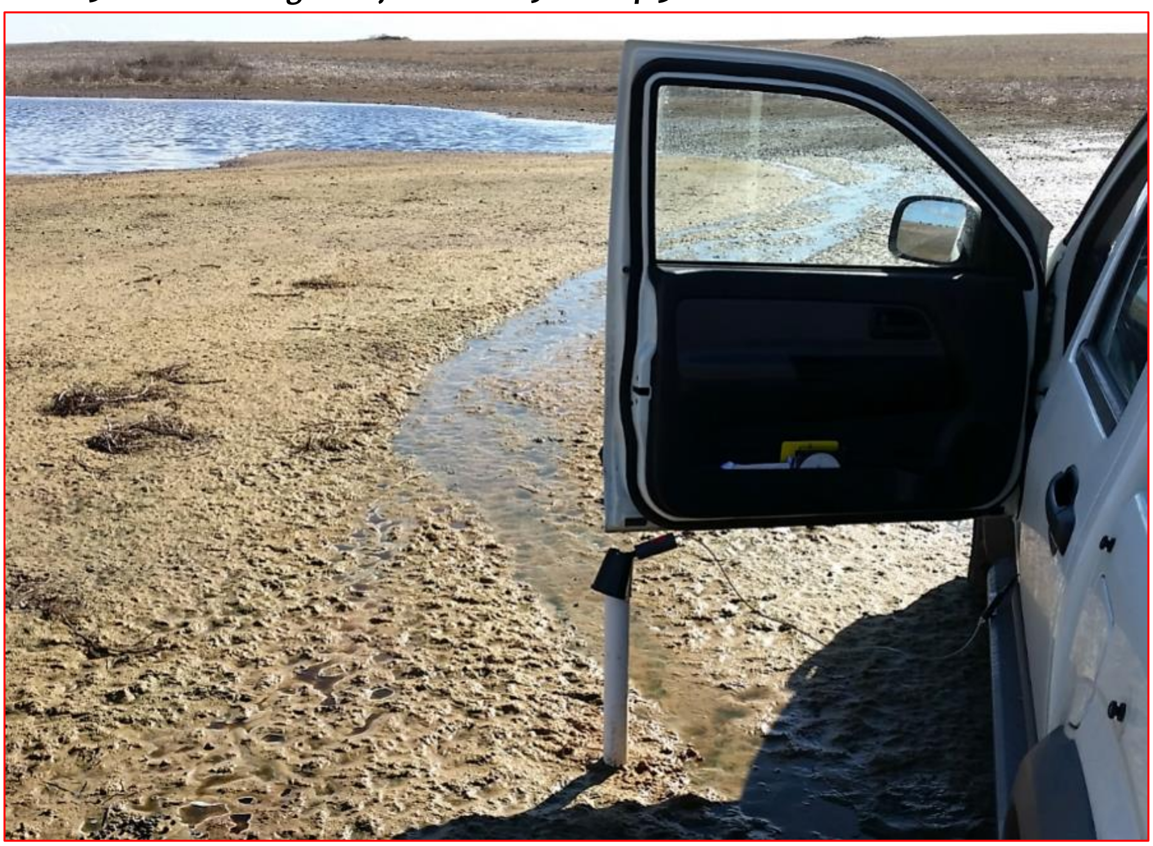
Photo 1. Full Seep 4, east of Piezometer 8.

Photo 2. Water draining from paddock into Seep 4 in the upper catchment May 23, 2017.

Photo 3. Rills through paddock, evidence of surface water flow after 48mm late Dec or 25mm April rain.

Photo 4. Paddock water flowing into Seep 3 at Piezo 9

Photo 5. Downloading data from Piezo 9 at Seep 3.



Despite this, the probe readings at the top of the catchment (Figs 4 & 5) did not show clear signs of recent rainfall events causing recharge (although some causing a slight rise in the 90cm moisture probe sensor, but not a sharp spike as in previous occasions). The total (or summed) moisture in the soil profile rose to a very high level after the late December rains, but has only fluctuated slightly in 2017 remained steady with only small reductions indicated by the 50-90cm sensors. It appears possible that this may be indicative of the beginning of the deeper soil moisture moving down the slope, as the paddock was kept from summer weeds that may have otherwise utilized the moisture.

The Piezometer graph (Fig 3) show that water table level (approximately 7.5m below the surface on top of the sandhill) has begun to move down to the lower catchment areas as it has dropped by approximately 18cm. This would then accumulate down the mid-slopes, creating more lateral movement of moisture towards the seep areas. Photo 3 shown that some of this came from water flowing across the surface of the paddock in the larger rain events. This has led to areas of surface saturation where the impervious clay subsoils are shallower, forcing the moisture to the surface, or where water is accumulating at the bottom of hollows (with underlying impervious clay).

Fig 3. Piezometer 8, groundwater level for top of southern sand hill, Nov - Dec 2016

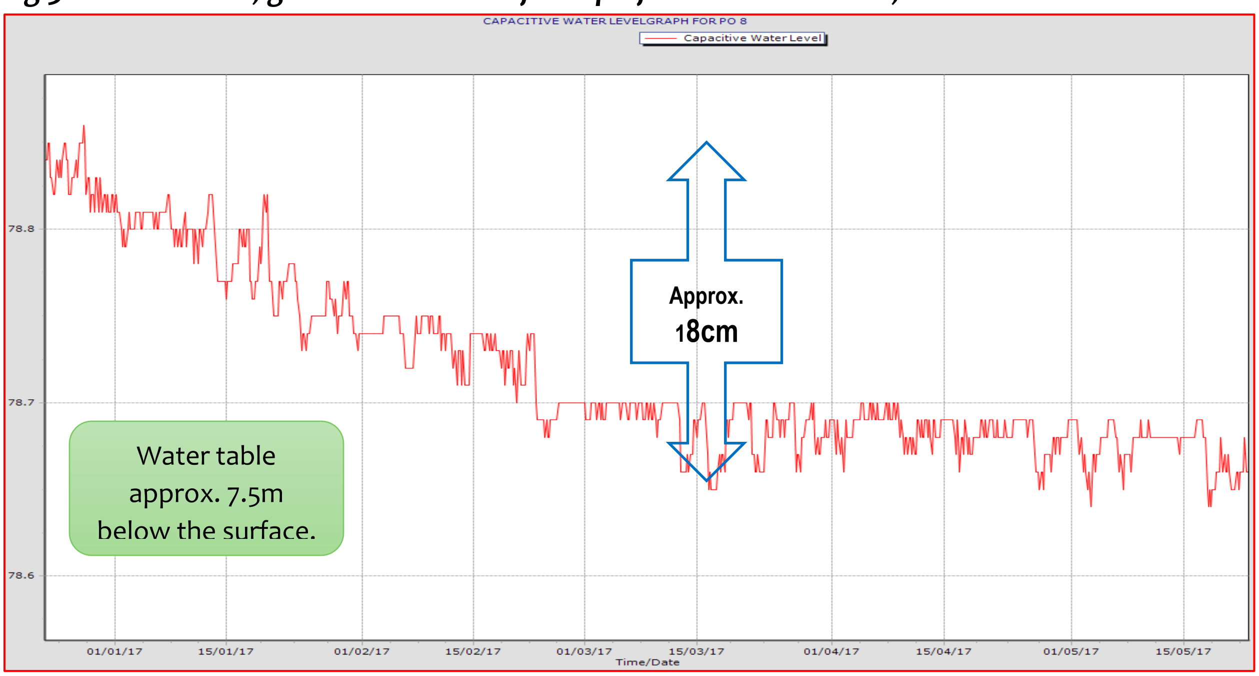


Fig 4. Soil moisture probe readings for non-wetting sandhill site, Jan 2016 – May 2017

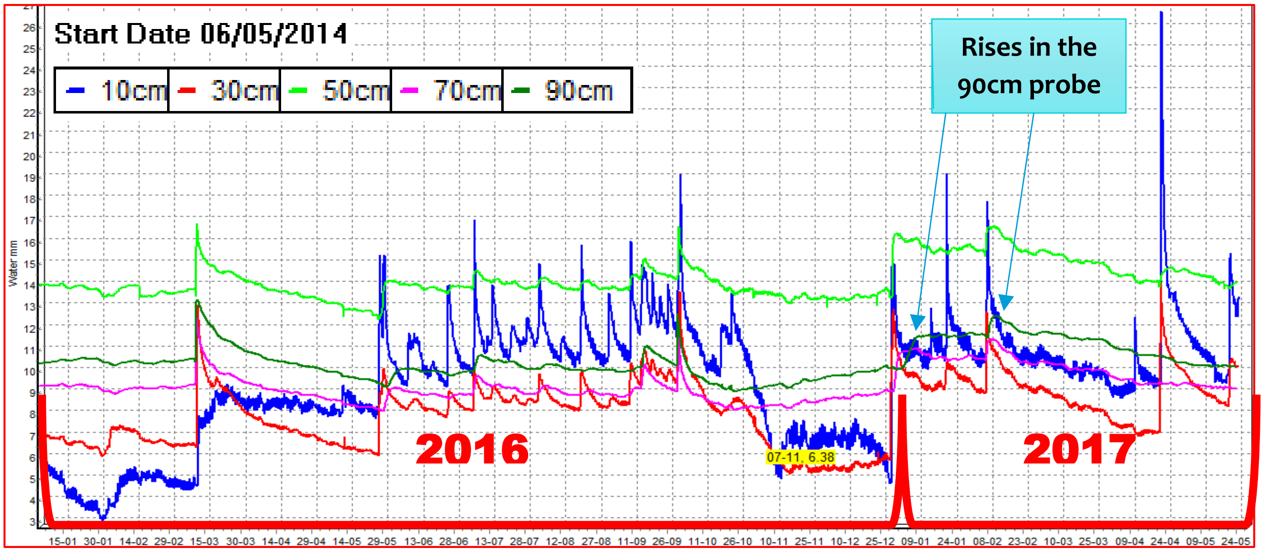


Fig 5. Summed soil moisture probe readings for non-wetting sandhill, Jan 2016 – May 2017

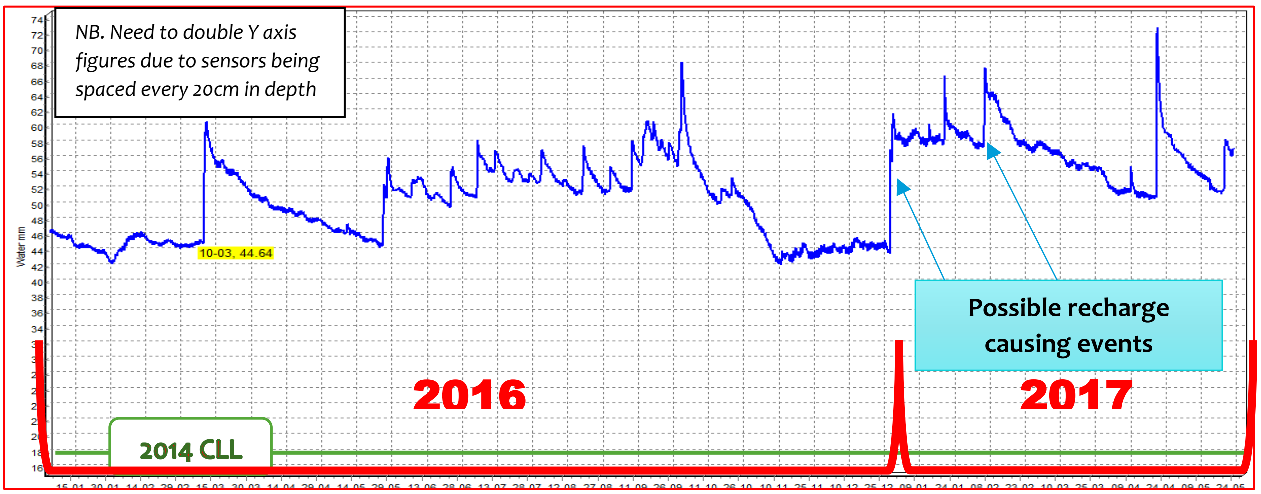


Fig 6. Matching rainfall, Jan 2016 – May 2017

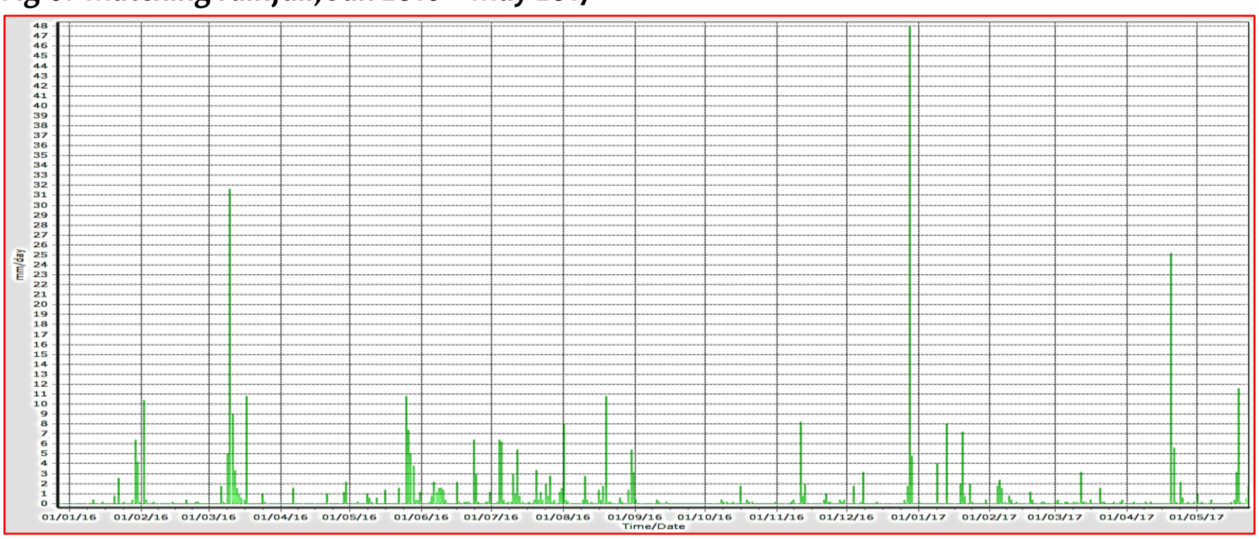
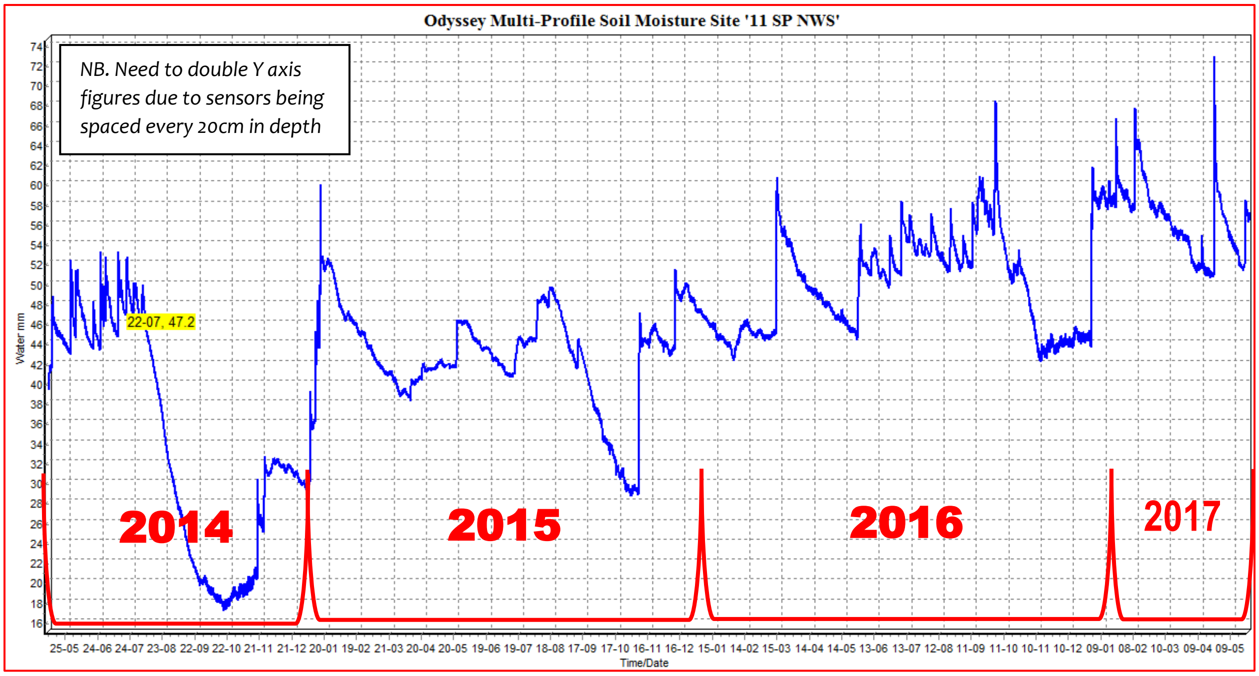


Fig 7. Summed soil moisture, Non-wetting sand hill since probe establishment May 2014



The increase in size of Seeps 3 & 4, along with the clear surface soil saturation of the new Seep area 7 (Photos 6 & 7) is evidence of the high level of soil moisture throughout the soil catchment area. Figure 7 shows a steadily increasing trend of soil moisture within the plant rootzone even on the very top of the rise since 2014.

Photo 6. View from Piezometer 8 looking west toward upper Seep 3 and New Seep 7.

Photo 7. Newly forming Seep 7 above established upper Seep 3.

This clearly indicates that factors contributing to recharge are active even form the very top areas of the landscape, leading to localized seep issues progressively down to the lower catchment areas. While the current increase in water levels and seep affected areas appears substantially due to the very wet year of 2016, there is no indication that there areas are likely to reduce unless higher water use paddock management is able to be applied. Crop growth alone appears to be insufficient to utilize all the soil moisture accumulated in the above average season, and this was greatly exacerbated by the high out of growing season December rainfall event.

This paddock may well benefit from spading chicken manure as has been successful in the lower paddock trial. However, it may also be a more feasible option to sow areas of the paddock to lucerne to utilize the deep soil moisture that is contributing to seep development within this catchment.

This paddock should be tested for evidence of compaction in the sand using either a penetrometer during winter, or using a probe for soil moisture after crop senescence in late October, to assess if this is contributing to the crops inability to utilize available moisture.

Lower Catchment Area

The monitoring area of the lower part of the catchment consists of water table data collected from 3 piezometers, as well as readings form 2 soil moisture probes above the main scald from both the spaded chicken manure and control sections of the 2015 Spading Trial (see Figure 1).   The large area features the main historic scald area (Seep 1) which flows into the lower Seep 2, which is consistently holding water and 2 rapidly developing Seep areas 5 & 6 each side of the main scald. The surrounding land consists of non-wetting sands with varying clay depths, as well as patches of shallow stone.

Fig 13. Piezometer 7, groundwater level for main seep, Nov - Dec 2016

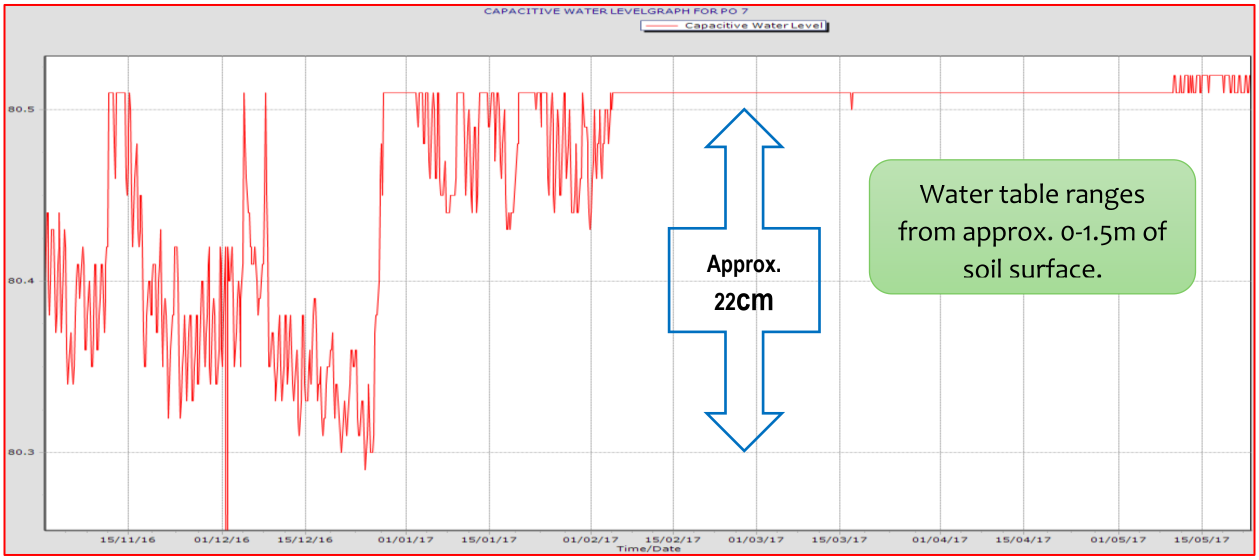


Photo 8. Moisture flowing from the paddock into the scalded Seep 1 area.

Photos 8 & 9 shows water streaming out of the paddock above into the scald area at Seep 1 on 24 May, after 30mm rainfall 20th-21st April and a further 14mm on the 13th-14th May. Piezometer 7 (visible in Photo 8) shows a sharp rise in the in water level at the 48mm December rainfall event to above the level of the moisture sensors, where is has been for most of 2017. This sensor has now been raised by 26cm, slightly above ground level, so that fluctuations in water level can still be measured. Photo 10 shows the soil pit just meters from this piezometer almost full to the brim.

Photo 9. Moisture flowing in many small streams from the paddock into the Seep 1 area.

Photo 10. High water level in soil pit area near scald site piezometer 7

It is therefore clear that water table has risen and remained high at the lower region of the catchment, since the end of 2016. Moisture probe data from the spaded chicken manure treatment site (Figs 14-15) shows little change in moisture level at the 90cm sensor which is just in the top of the clay layer beneath the sand, and appears to be at a level nearing field capacity. All other sensors in the sandy layers to 70cm depth saw a sharp rise in moisture levels after the 48mm December rainfall, and then each rainfall of 8mm or more after this. Summer weeds have generally been controlled on this paddock, although there were some patches of skeleton weed observed. It is possible that the lowering of soil moisture levels after each rainfall event may have been due to some recharge to lower layers, however there are no obvious sharp spikes in the 90cm sensors.

Recordings from the nearby control treatment area shows very similar soil moisture trends (Figs 16-17), although there is 20mm more moisture within the rootzone. This can be attributed to the crop on the spaded chicken manure area reducing the summed soil moisture levels to about 72mm, while the control area with lower nutrition and high soil compaction levels could only reduce moisture summed soil moisture levels to 100mm, a difference of 28mm. The main issue is that the soil profiles appear fairly close to field capacity (Fig 18), and therefore highly vulnerable to recharge of underlying water tables leading to lateral flows towards seeps.

Fig 14. Soil moisture probe readings for spaded chicken manure, Jan 2016 –May 2017

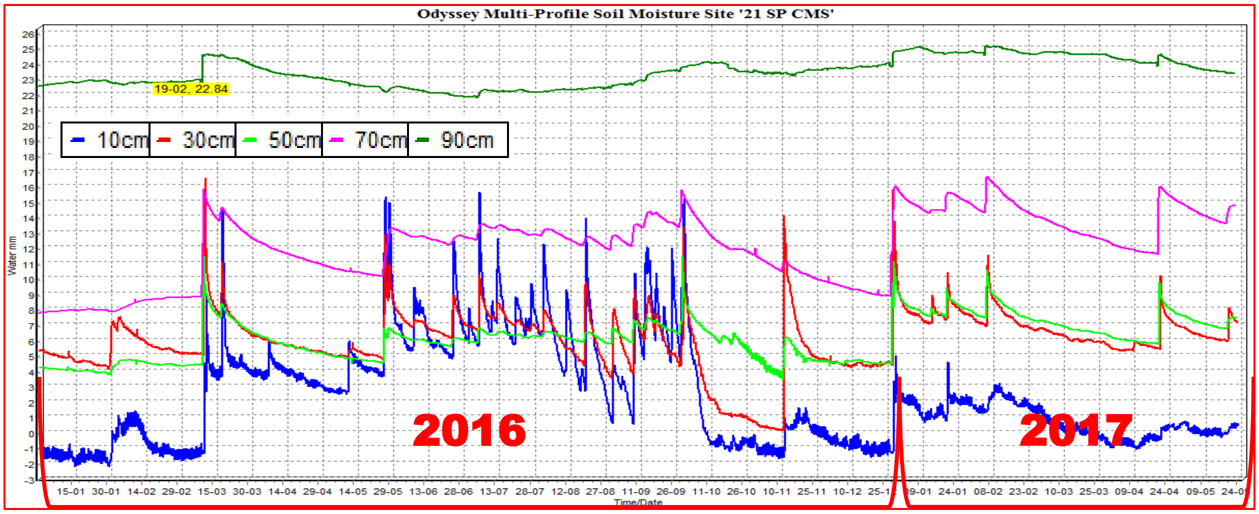


Fig 15. Summed soil moisture readings for spaded chicken manure site, Oct 2015-May 2016

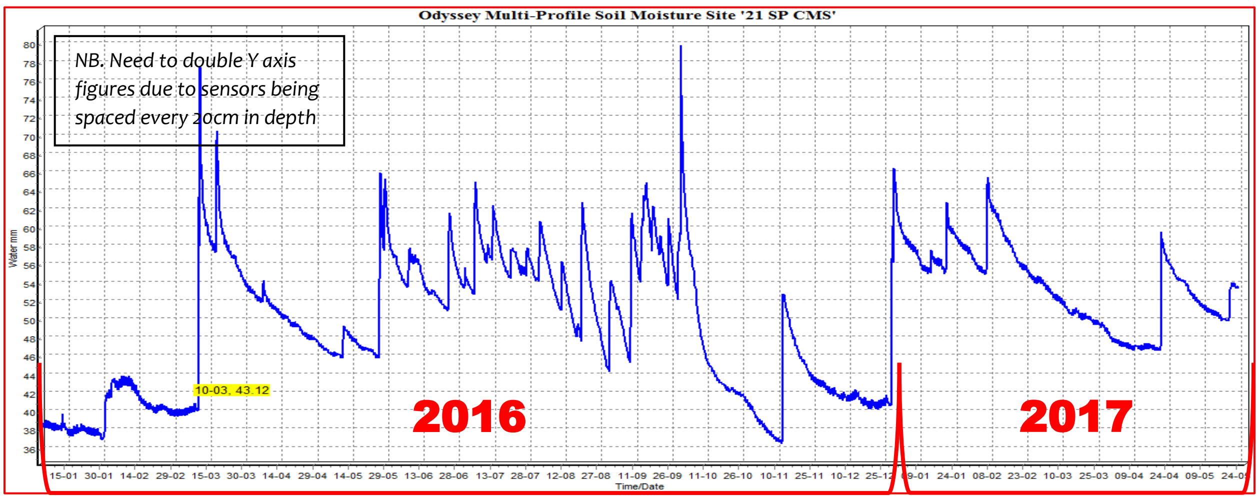


Fig 16. Matching rainfall readings, Jan 2016- May 2017

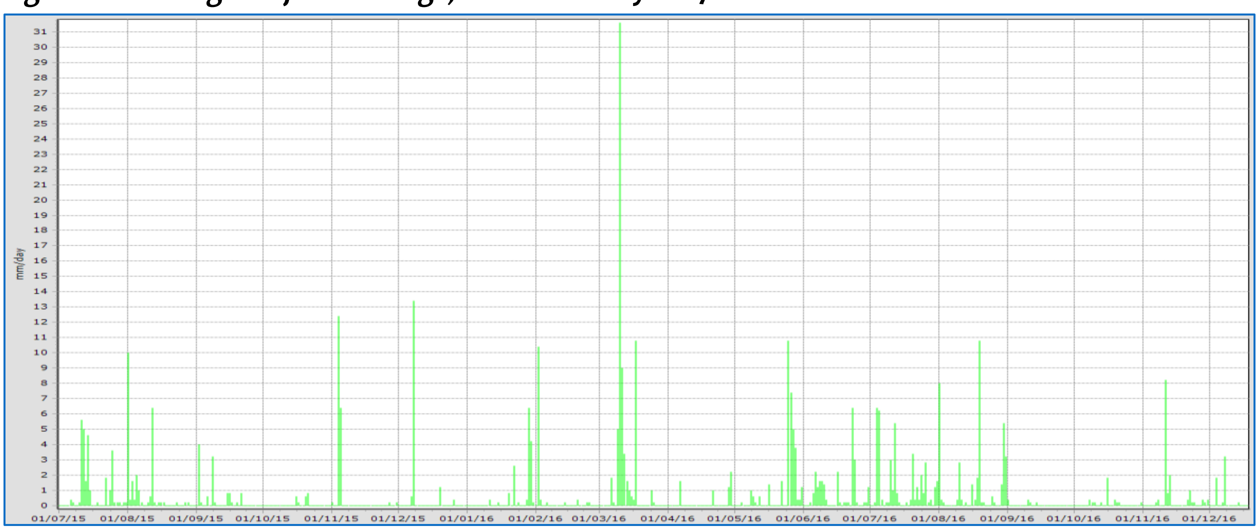


Figure 17. Soil moisture probe readings, control site are above Seep 1, Jan 2016- May 2017

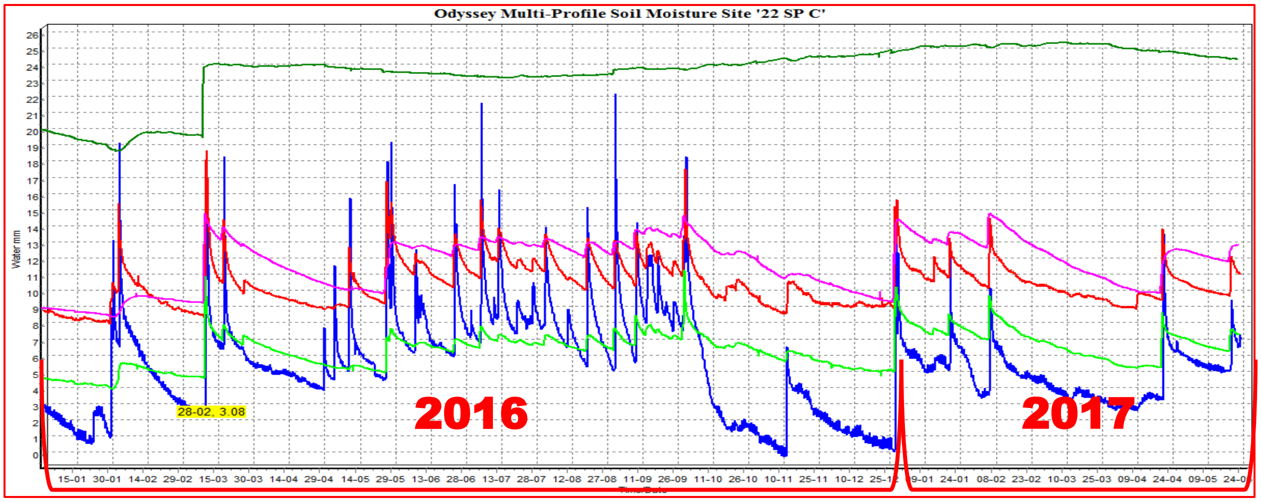


Fig 18. Summed soil moisture readings for control site, Jan 2016- May 2017

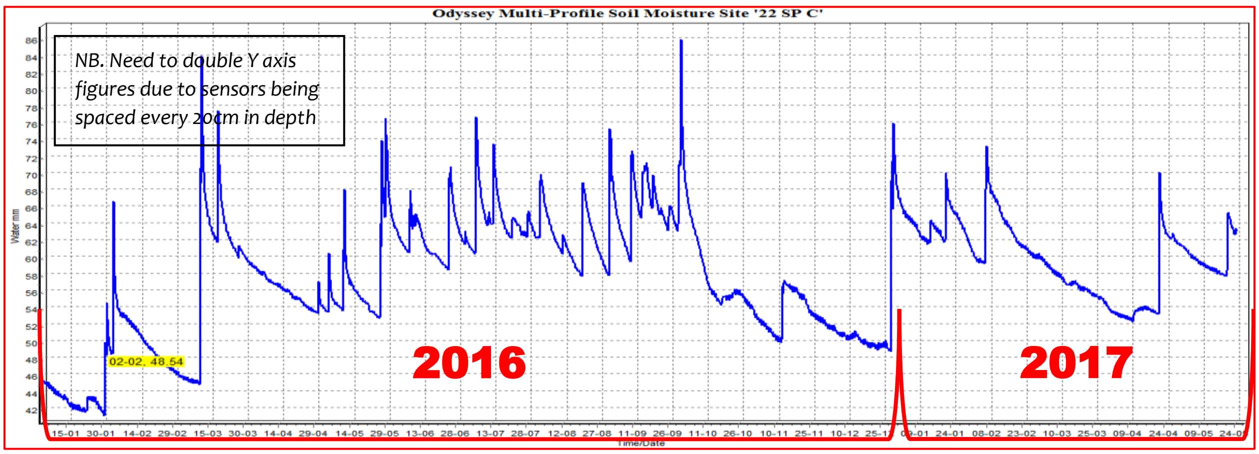


Fig 19. Summed soil moisture readings for spaded chicken manure site, July 2015-May 2016

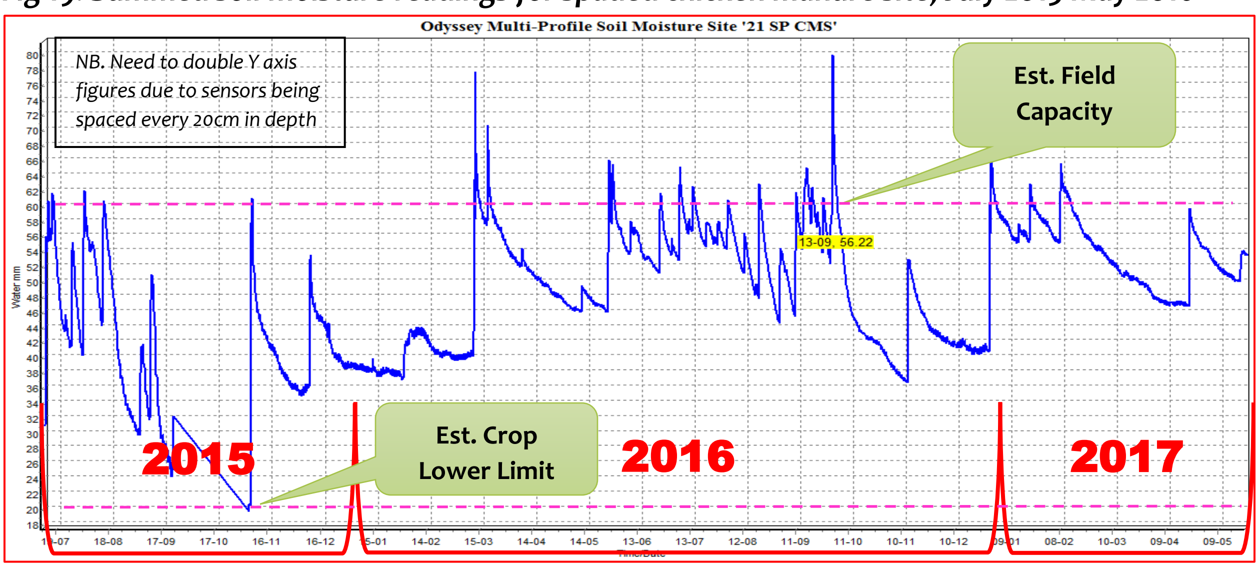


Photo 11. Spaded sand with chicken manure plot above scald and seep areas

Photo 11. Water flowing through scalded area to seep 2 area below.

The question remains as to how much the local surrounding paddock areas are contributing and how much is coming from higher in the catchment. This can be partially assessed by the 2 remaining piezometer results. Piezometer 6 lies 300m south east of the main scald, and 7m higher in the landscape (Hall 2016). This shows a steady rise in the water table of 85cm after the December rainfall to mid-February, followed by a drop of 25mm until late April, suggesting a strong bulge of water is moving through the landscape (Fig 20). The 30mm rainfall in late April has then lead to another 40cm rise in water table at this point, which is has stabilized since early May. This surge of subsoil moisture would also explain the rapid formation of highly waterlogged area (New Seep 6) which may be too saturated to produce a crop this season (Photos 12-14). Photo 15 shows the growing Seep area 5 on the western side of the main scald.

Fig 20. Piezometer 6, groundwater level for eastern fence line, Nov - Dec 2016

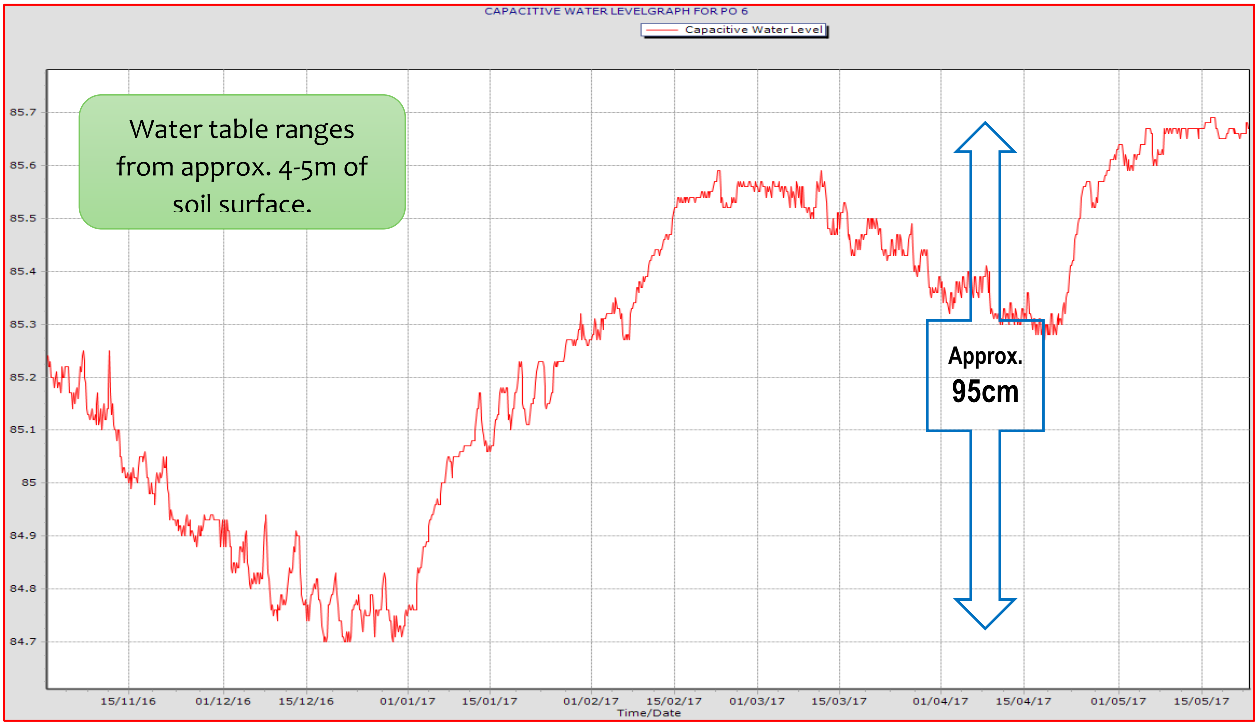


Photo 12. Veiw from Piezometer 6 toward Seeps 1 – 2, showing area becoming waterlogged

Photo 13. Waterlogged New Seep 6 areas showing strong stubble growth form 2016 crop

Photo 14. Close up of water and saturated soil in waterlogged area.

Photo 15. Expanding bare area immediately west of main scald (New Seep 5)

Fig 16. Piezometer 5, moisture readings for southern fence line, Nov - Dec 2016

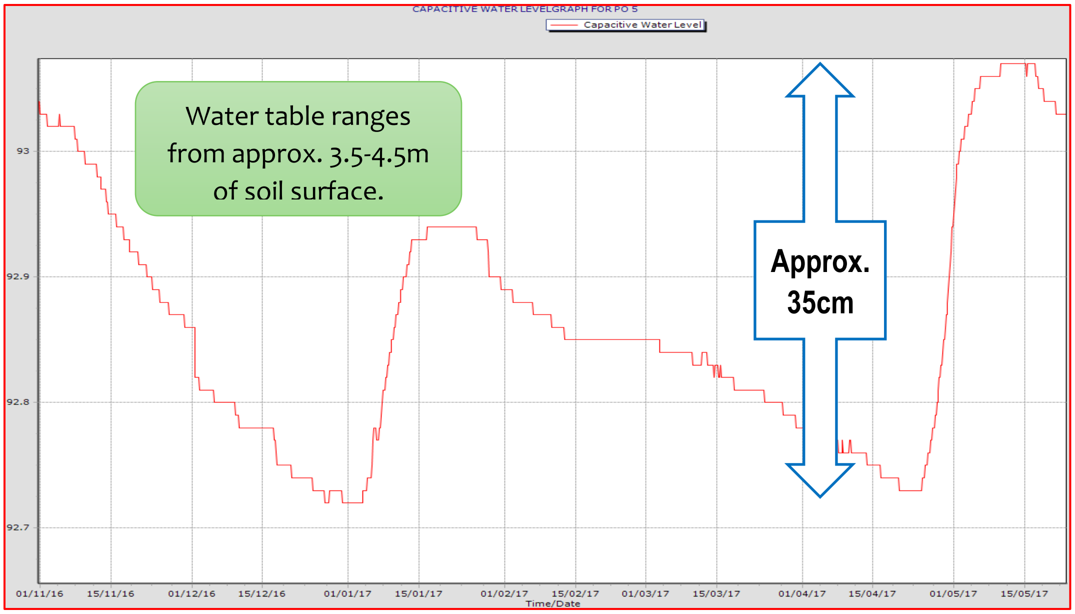


Photo 16. Fenceline Piezometer 5 showing surrounding crop weed growth on 31st Oct 2016

Piezometer 5 is located along the fenceline of the southern side, between the upper and lower and areas, approximately 500m south of Piezometer 7 at the main scald area and 15.5m higher in the landscape. It appears to be fed by the large upper catchment area above it. Fig 16 shows this site to have reduced its water table level through spring by about 30cm after the strong September rainfall period. This may be partly due to fenceline weed growth through this period (Photo 16), but is more likely an indication of a surge of lateral moving ground water, since the water table sits about 4m below the surface, and well below the root growth of these plants.

The 48mm December rainfall has led to recharge, rapidly raising the water table by 22cm, which gradually dissipated until late April. It is likely that much of this rainfall events moisture stayed within the soil profile, as evidenced in the top moisture probe (Figs 4 - 5) where the 50, 70 and 90cm sensor rose sharply and lowered only slightly over the following months. This meant that with an already wet soil profile, the 30mm late April rain event led to a much larger 35cm rise in the water table. Again this bulge of water appears to be moving further down the landscape, given the slight downward trend in the water table in late May (Fig 16). This water is reaching the surface at and around the main scald area at Seep 1 (Photos 8-10), and then flowing through to Seep 2 (Photos 11-13, which has been full of water for over 12 months) and then channeling out into the paddock (Photo 17-18).

It is clear from this data that there is a great deal of perched water table ground water flowing through this catchment and presenting a the surface around the main seep area. While the high rainfall year of 2016 has led to a swift expansion of waterlogged area, it is necessary to employ higher water use catchment strategies to combat further degradation of productive cropping land. While the spading of chicken manure has been shown to greatly increase yields on non-wetting sands by 1.8t/ha in year 2, using an estimated 90mm more water to produce this crop, this is still restricted to a small area of the catchment. While producing very high gross margins there is still high upfront costs and effort required to establish this over the whole catchment area. It essentially uses the rootzone moisture and has reduced ability to impact high summer rainfall events and much of the deeper lateral water movement below the top 1.5m depth.

Growing a 40m strip of lucerne along the east/west fenceline separating the 2 catchment paddocks has been discussed with the farmer. This could potentially intercept and utilize much of the water through the mid-slopes before they cause discharge lower down. It is less likely that the lucerne would completely dry out the profile to the extent that it would soon diminish its growth and production, as it will be fed from the large catchment area above. The lucerne could be cut for hay or be used as a fodder reserve for livestock over summer months, as well as create a race for stock movements through the farm.

Photo 17. Overflow water channelling out of Seep 2 area.

Photo 18. Overflow water channelling out of Seep 2 area.

Photo 19. Water channelling out of New Seep 6 where meesina seed was scattered by hand.

Photo 20. New luping growth yellowing due to waterlogged soil on edge of New Seep areas.

Messina plantings

After seeding the *messina* salt and water tolerant pasture at Arbons property, there was approximated 5kg of inoculated seed left over that needed to be used immediately. It was decided to hand sow this remaining seed at the lower salt scalds and seep areas that were not growing crop at the Martin Seep Site. This was achieved by dragging some garden rakes across the scald areas to roughen the surface and help catch and bury seed. Some weed was also thrown onto saturated soil on the scald and the newly forming seep areas either side. The farmer was planning to drive a stone roller over much of this area the next day to press the seed into the ground, but there were some areas either inaccessible or too saturated to safely drive the tractor through. Photos 21-28 show all the areas where the *messina* seed was scattered and will become photo points to monitor where and how the *messina* establishes and grows in the future. The farmer is planning to sow other larger seep affected areas to *messina* in 2017 that are to the west of the current seep monitoring area.

Photo 21. New Seep 6 where messina seed was scattered by hand on June 5.

Photo 22. New Seep 6 where messina seed was scattered by hand on June 5.

Photo 23. Raked main salt scald area where messina seed was scattered by hand on June 5.

Photo 24. Close up of raked saturated salt scald area where messina seed was scattered.

Photo 25. Raked crusty salt scald area where messina seed was scattered by hand.

Photo 26. Main salt scald area where messina seed was scattered by hand on June 5.

Photo 27. New Seep 5 where messina seed was scattered by hand on June 5.

Photo 28. New Seep 5 where messina seed was scattered by hand on June 5.

3.2 Rose / Thomas Site, Wynarka

This catchment site west of Wynarka consists of a main scald and soak area that largely appeared after the wet 2010 season, which now sees a narrow stream of water regulalry flowing through to a newer rapidly growing seep area to its south east (Fig 17). The swale area north of this area is also developing significantly on Thomas (western side) paddock as well as the Rose (eastern side) paddock.

The catchmetn received well above average rainfall in 2016, but appears missed out on the large rainfall event in late December that greatly impacted the Karoonda site results (Fig 18). It did, however, recieve a 33mm rainfall event in early Feb 2017 and less than 10mm in the late April event.

At present the monitoring involved gathering data from 3 strategically placed piezometers, one moisture probes and the rain gauge, along with visual assessmetns of seep areas, to gain a better understanding of the water flows and recharge causing events within the landscape

Fig 17. Site map showing seeps and monitoring equipment locations (Google Earth Oct 2016)

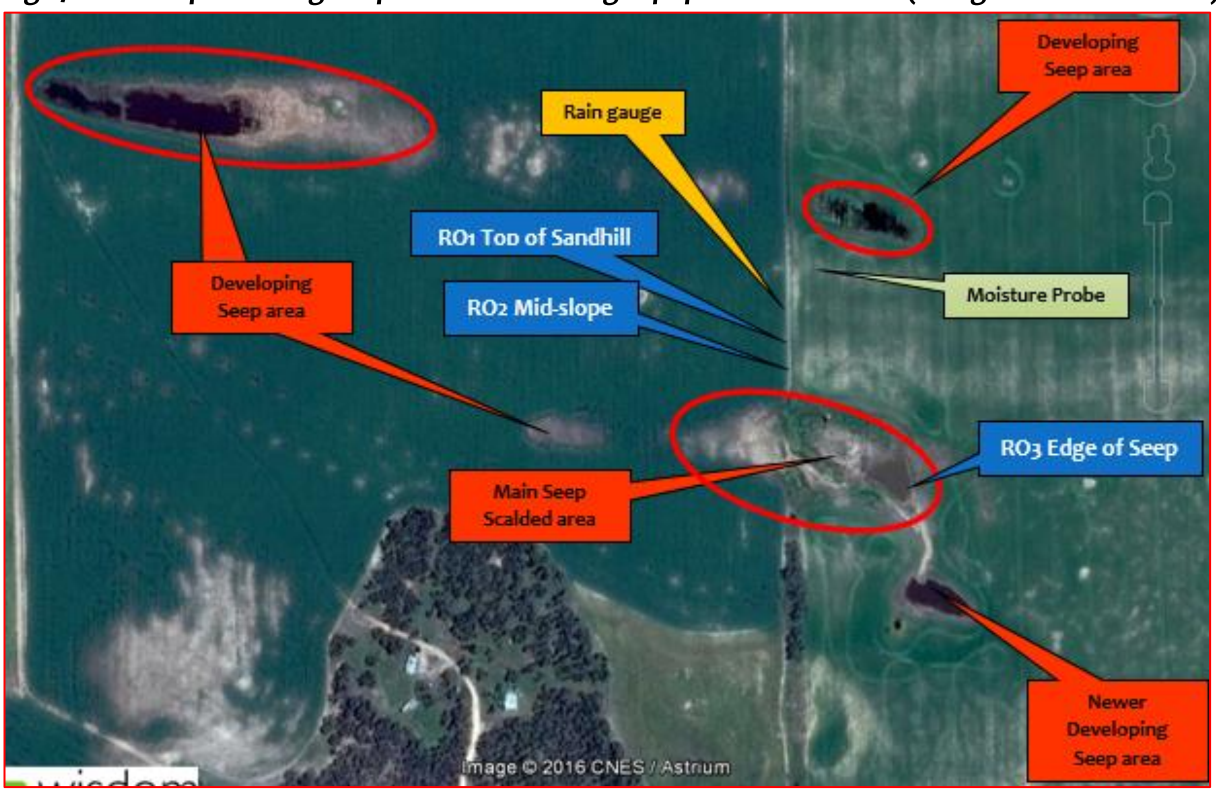
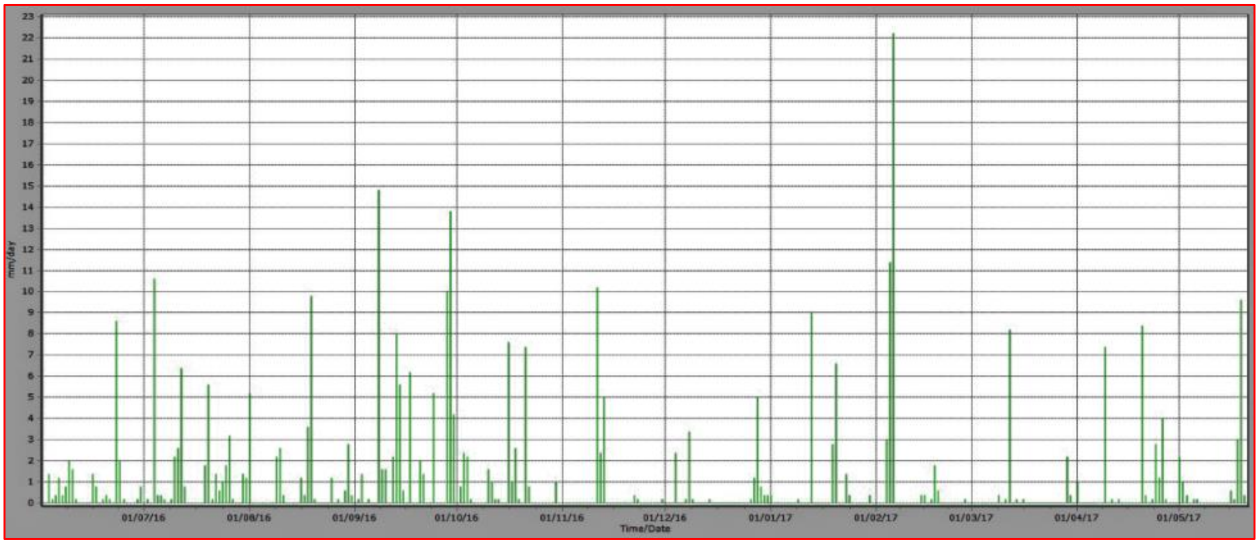


Fig 18. Rainfall records from site June 2016 -- May 2017.



3.2.1 Site Summary

The Rose / Thomas catchment has become progressively wetter after the well above average rainfall year of 2016. This has left much of the soil profile (above the perched water tables) close to field capacity which has led to recharge and surface water accumulation after relatively small rainfall event in 2017. All seep and bare scald areas within the catchment are increasing in size and beginning to cut channels through to newer seeps in some areas.

The water table on the very top of the sandhill rose steadily from early March to late October 2016, suggesting this sand has very little capacity to hold, store or utilise moisture. These areas appear to be a major contributor to recharge within the catchment. A 65cm water level rise at the top became a 135cm rise in the lower midslope (where the lower rootzone 50-90cm appears to be now continually holding water at around field capacity), with regular discharge into the surface seep scald areas through most of 2016.

There is a need for high water use strategies within the non-wetting sand areas as well as nearby the seep areas, otherwise it likely that each well above average season will lead to the expansion of land degradation. Since both farmers are continuously cropping these areas, there is an immediate opportunity to plant trees along the fenceline separating the 2 properties in the swale areas that would at least intercept some water flowing into the Rose seep areas. While the establishment of salt and water tolerant pasture species on bare scalds will reduce evaporation and surface salt accumulation, a consideration should be made of strategic lucerne establishment along the sandy slopes that appear to be contributing the majority of recharge water. Lucerne areas must designed to minimise impacts on cropping operations, while still providing opportunities for hay production.

3.2.2 Moisture Probe and Piezometer Results

Main Seep area

The piezometer RO3 readings from the edge of the main soak (Fig 19) saw a sharpe rise in the seep water level, despite the rain gauge only recording 5mm. It is possible that parts of the catchment may have received more rainfall. Interestingly, a much larger Feb rainfall of 33mm caused a smaller and only brief rise in the seep levels. An 8mm rainfall on Mar 12 then saw a larger and sustained rise in the seep level of 40cm, and the scalded areas to fill with surface water. Two 7mm rainfall events in April then brought the seep water level to capacity and overflowing into the lower seep area (Fig 19, Photo 32) and surround Piezometer RO3. This water has coninued to overflow and seep down to the newer seep areas shown in Photos 33 & 34.

This site has been quite volatile in its filling, draining and refilling in recent times. While there is not a clear correlation between the amount of rainfall and the immediate imapct on the size and height of the seep, it is very clear that when the water level is just below the main seep surface (Photo 29), even a relatively minor rainfall can lead to very large rises in water levels above the surface (Photos 31 & 32).

Once the water level subsides an attempt to establish the salt and water tolerant *messina* will be made to try and maintain soil cover and reduce the accumulation of salt at the surface.

Fig 19. Piezometer readings for Bottom edge of seep site (RO3), Nov 2015 - May 2017

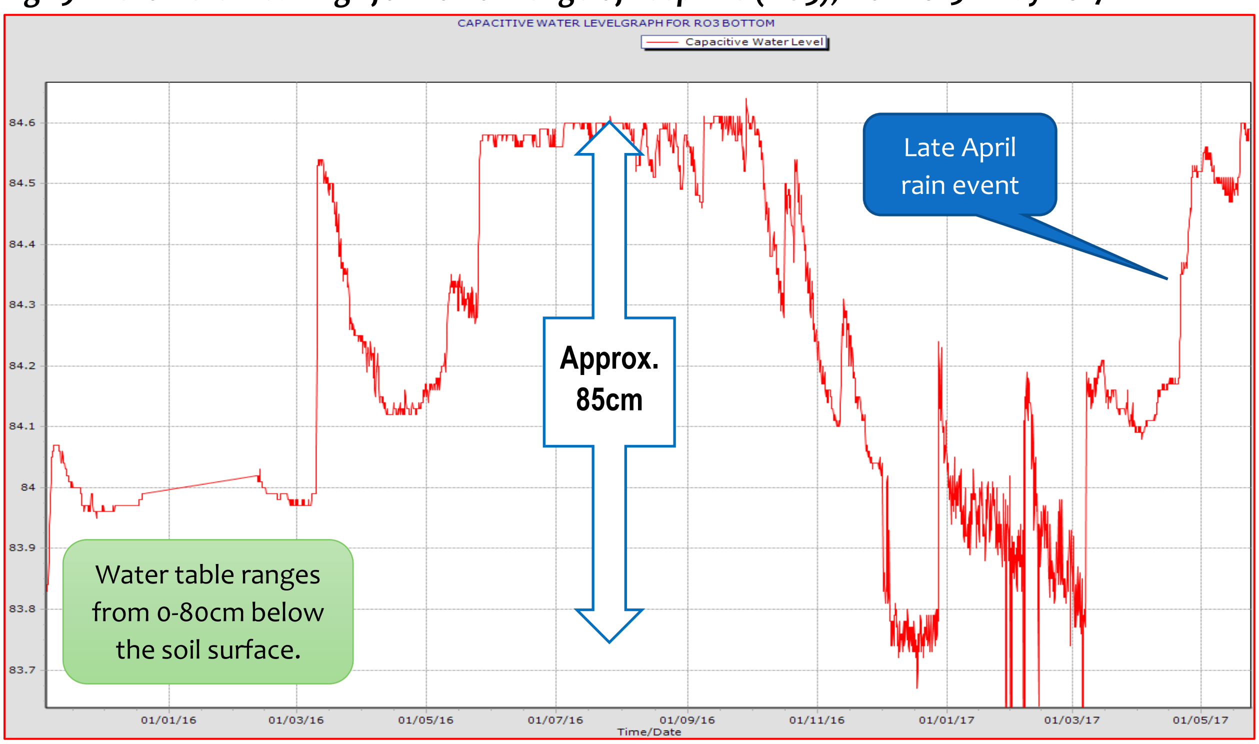


Photo 29. Pit full of water on the edge of main soak on March 7 prior to March rainfall.

Photo 30. Strong ryegrass growth between scald and fence suggesting not fully saline yet.

Photo 31. Main seep empty of water on March 7

Photo 32. Main seep full of water enveloping Piezometer RO3 on March 23

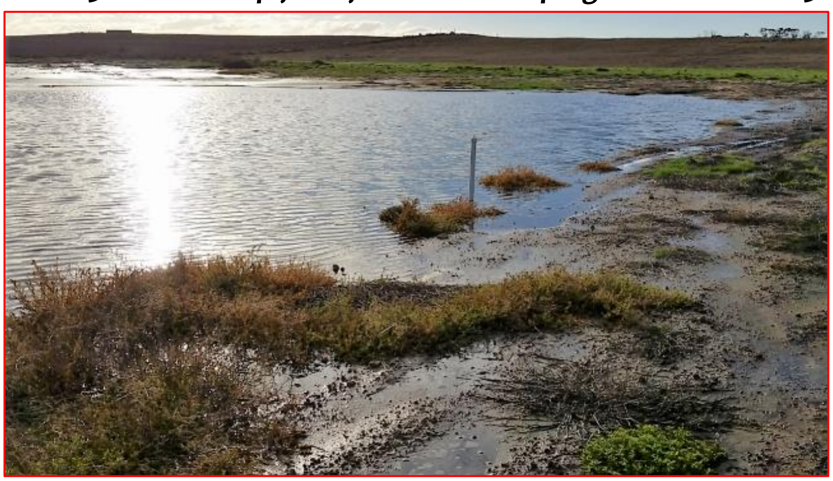


Photo 33. Water flowing from main seep down to rapidly devloping new seep below.

Photo 34. Recently cropped area, now filled with water, surrounded by seep vegetatoin

Midslope Area

The Piezometer RO2 in the midslope above the seep shows a slightly more consistent response of larger rainfall events (Fig 21) contributing to a rise in water table levels (Fig 20). After the high point following the very wet Sept 2016, there was a steady drop of approx.1m until the late Dec rainfall, which caused a 17cm rise. This is likely due to to both the crop and fenceline weed growth utilising this soil moisture, as well as bulge of laterally flowing water moving down to the surface seep water below.

The soil moisture probe placed in the midsope on the northern side of this same sandhill (Fig 22-23) clearly shows that this December rainfall went mostly into refilling the rootzone (mainly the top 40cm, as the 50cm-90cm appear to be at a constant level of field capacity or possibly saturation), even though this rainfall only lead to a small rise in the water table. This could be likened to water filling up a dry sponge (ie the soil above the water table) which made the soil more succetible to recharge for the following rain event. This was evidenced with the 33mm Feb 2017 rainfall which caused a sharp 23cm rise to the water table, even though there is only a relatively small catchment area above this piezometer.

Photo 35. View of Main seep on Rose side from Piezometer 1 (Top of sand hill)

Fig 20. Piezometer readings for Mid-slope (RO2), Nov 2015 – May 2017

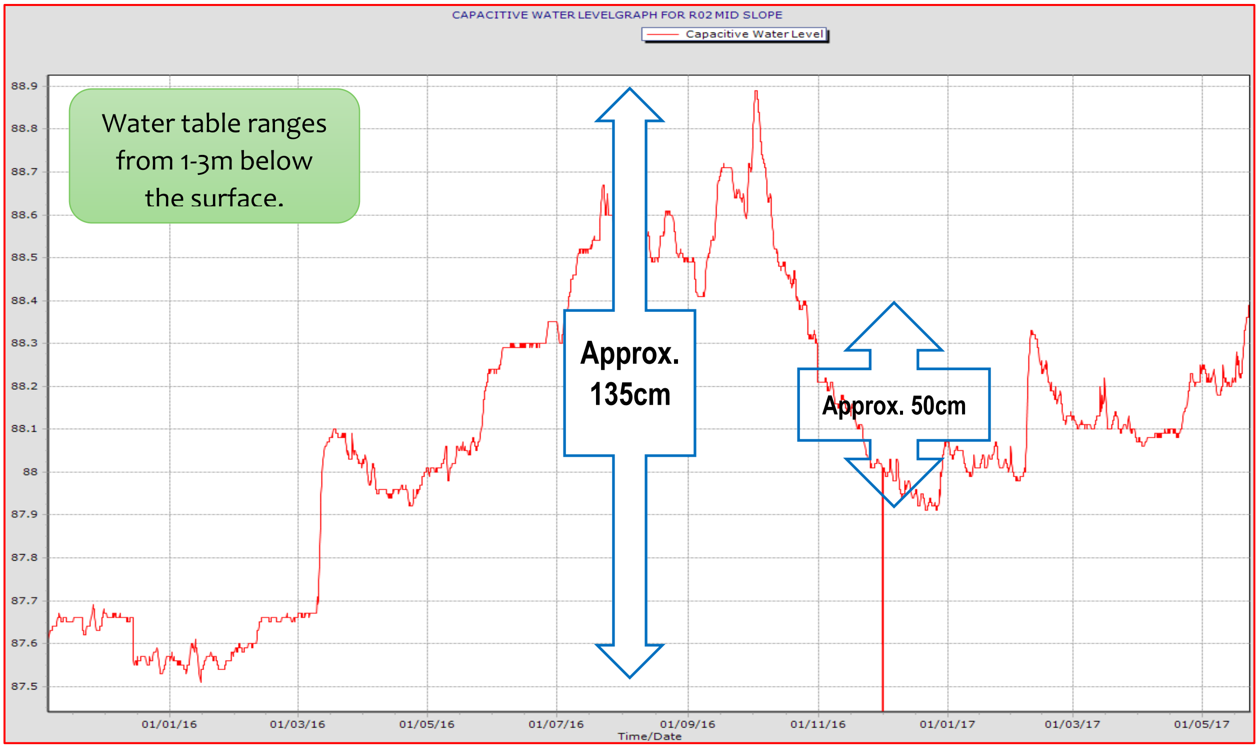


Fig 21 Rainfall records from site Nov 2015 -- May 2017.

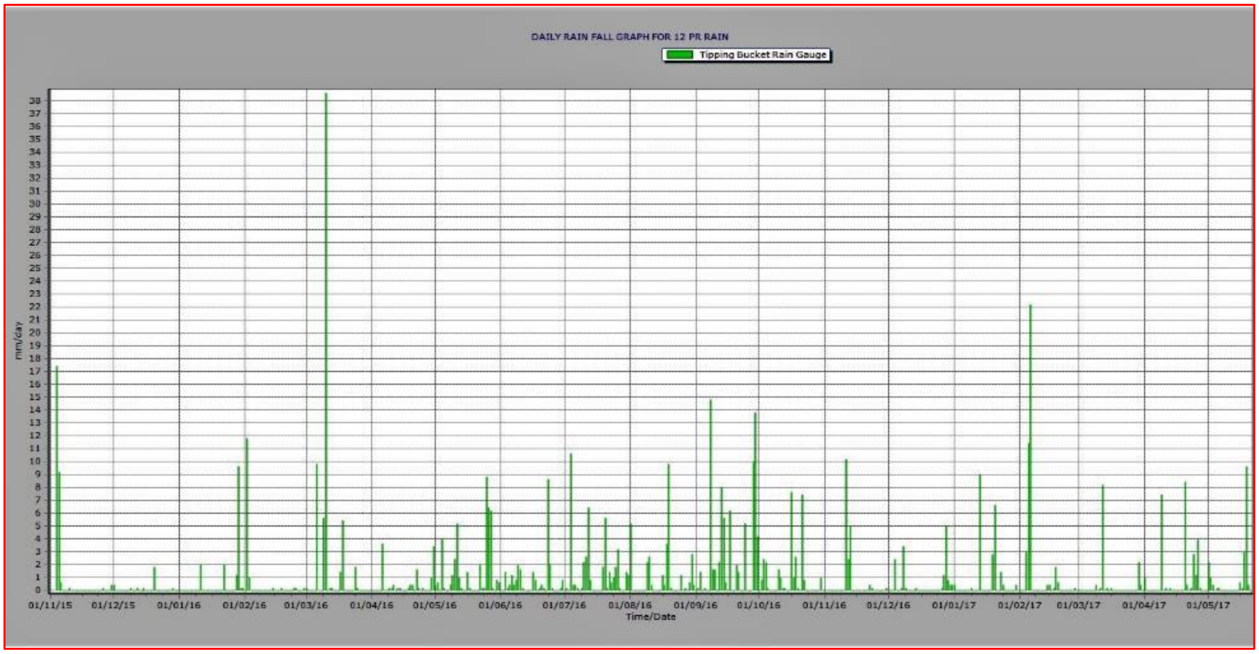


Fig 22. Soil moisture data from midslope probe above northern seep (Jan 2016 – May 2017)

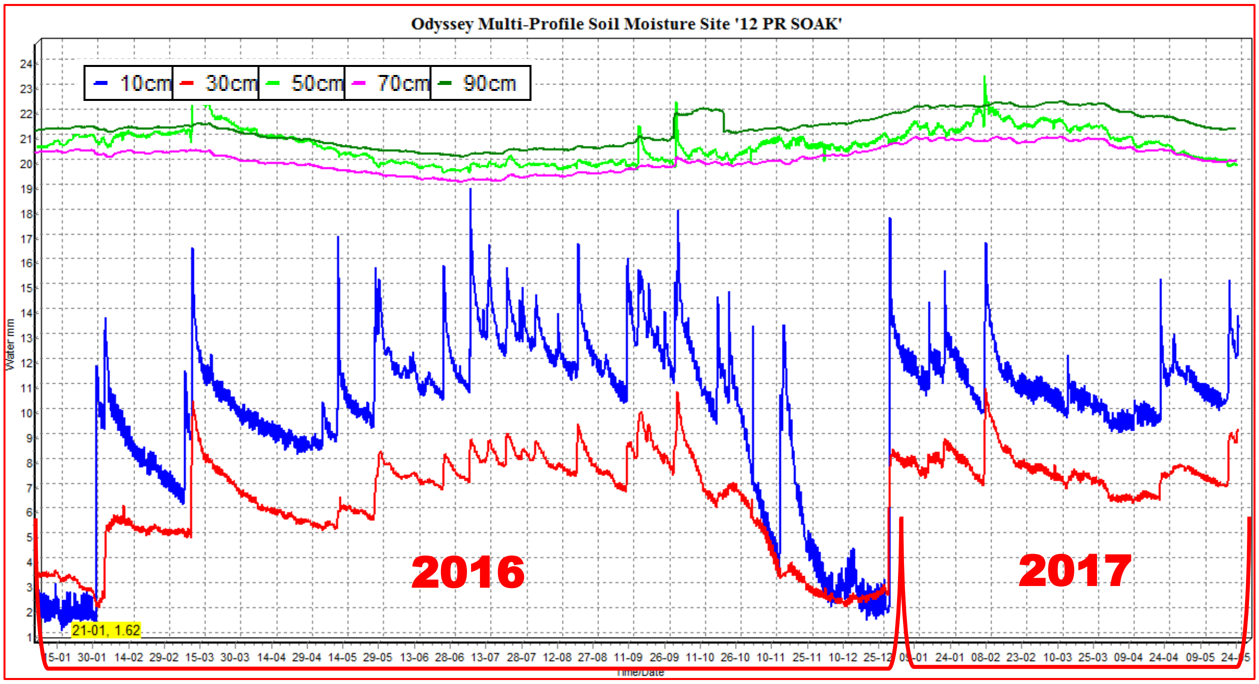


Fig 23. Matching cumulative moisture data from midslope probe (May 2014 – Nov 2016)

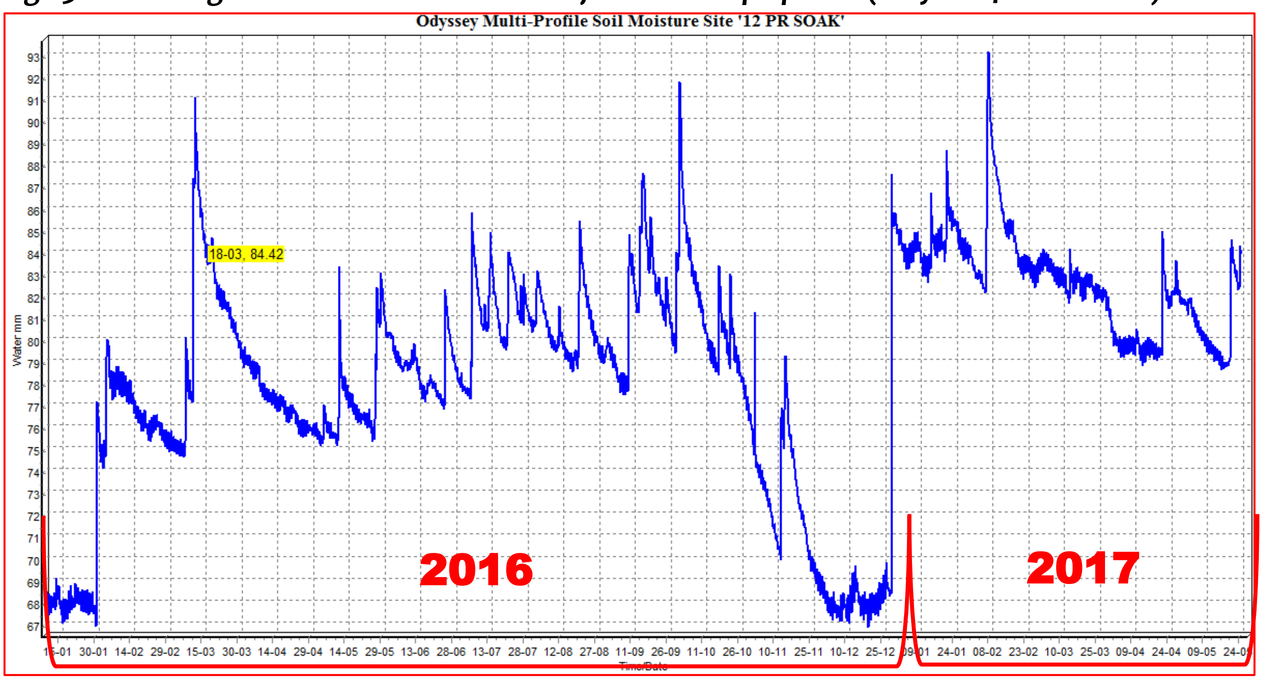
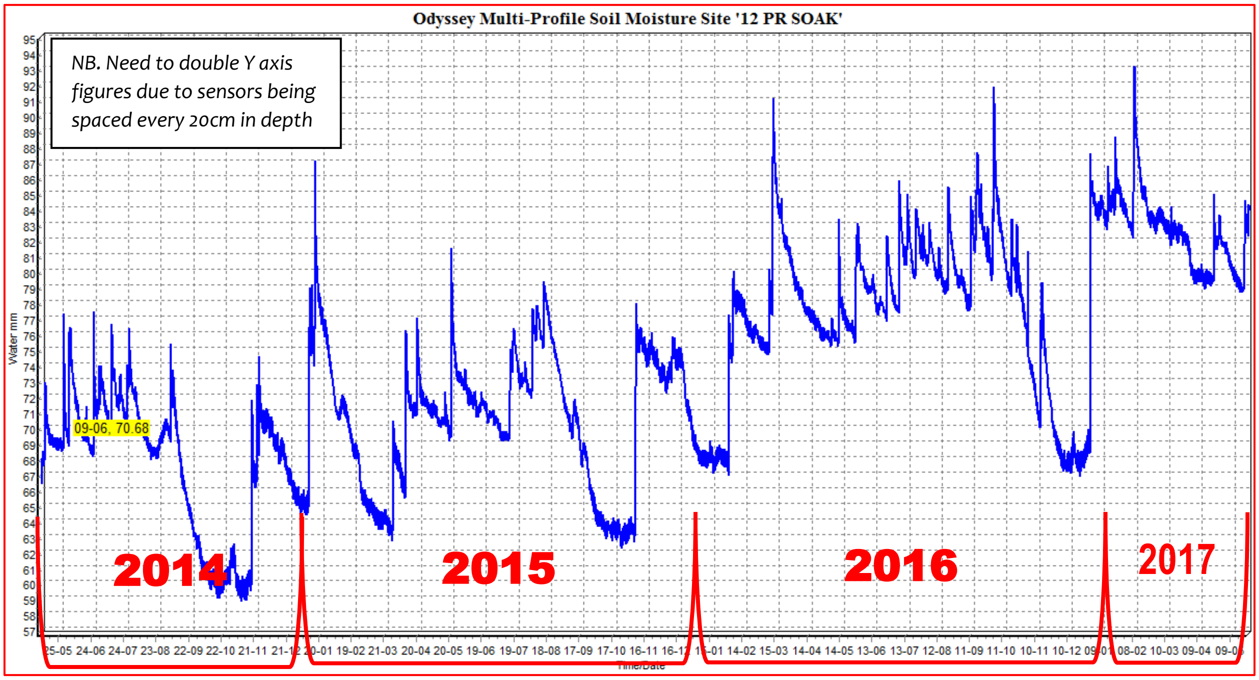


Fig 23. Long term cumulative moisture data from midslope probe (May 2014 – Nov 2016) showing a general upward trend, corresponding to trending wetter 50, 70 & 90cm readings



Top of Sandy Rise

Unfortunately, the piezometer data from this site on top of the sandhill has given erronious readings in 2017 and will aim to be rectified as soon as possible. The piezometer readings up until early Dec 2016 are shown in Fig 24 revealing a steady rise in of 70cm since the March 2016, followed by a drop from November 2016.

Fig 24. Piezometer readings for top of sand hill (RO1), Dec 2015 - Dec 2016

Photo 36. Seep development on Thomas side, north of monitoring sandhill

3.2.3 Other Developing Seep Areas

The wet season of 2016 has lead to the clear growth of developing seep areas within the catchment, many of which have been cropped in recent years. Photo 37 shows the seep directly north of the main seep which was holding surface water in May 2017. There is still a lot of grassy growth around this seep, suggesting that it is mainly suffering form waterlogging at present, rather than surface salinty. This area appears to have doubled in size over the last 3 years.

Photo 37. Water in basin of expanding seep area in the swale directly north of the main seep

Further east in the same loamy swale but within the Thomas paddock there has been a large collection of surface water in areas that were clearly cropped last season, as can be seen in Photos 38-39. The water may well be collecting from the large sandy rises on both the northern and southern sides of this seep area. There is a very strong concern that this seep will continue to grow and degrade many hectares of good cropping land unless high water use strategic management is taken. *Messina* is likely to be planted in this area this season once the water subsides to at least maintain soil cover and limit evaporation.

Photo 38. Rapidly developing seep in swale on Thomas side of catchment

Photo 39. Water on surface and bare scald devloping on Thomas side of catchment, May 2017

3.3 Arbon Site, Wynarka

The Arbon site north of Wynarka consist of 4 recently forming seep areas. These sites are mainly affected by waterlogging at present, while there is some evidence of salt scalds beginning at 2 of the seeps. In 2015, 3 seep areas were planted with fodder shrubs saltbush or tagasaste to help utilize the water forming in the seep while providing excellent livestock feed, but there were many plant losses do vermin.

A 5 row block of native trees was also planted along sandy fence line area above a developing soak to intercept the lateral flow of water, which also suffered heavy plant losses. These areas are have recently been replanted, with tree guards and improved watering strategies to greatly improve establishment.

Fig 25. Google Earth from Oct 2016 showing main sand areas that contribute to seeps.

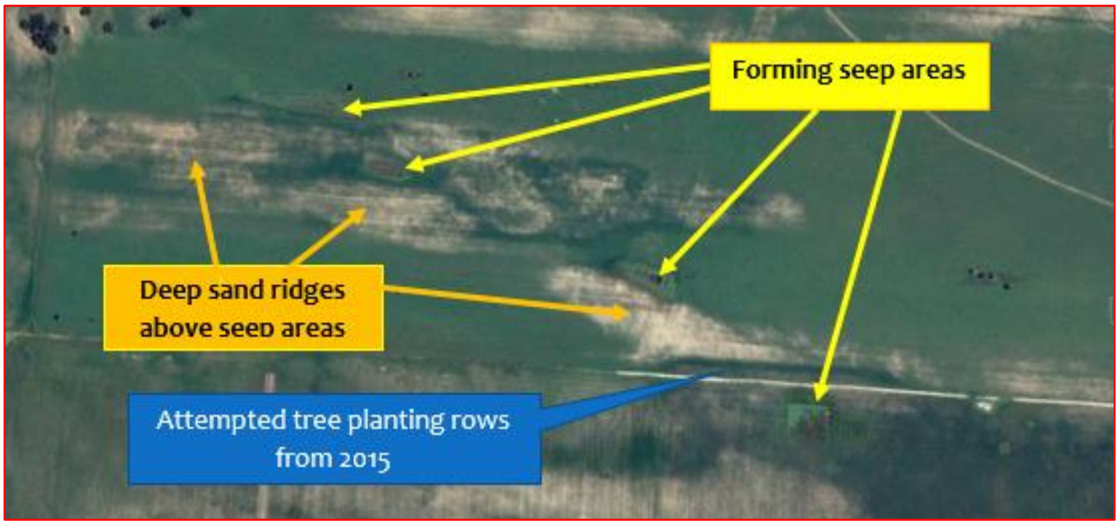
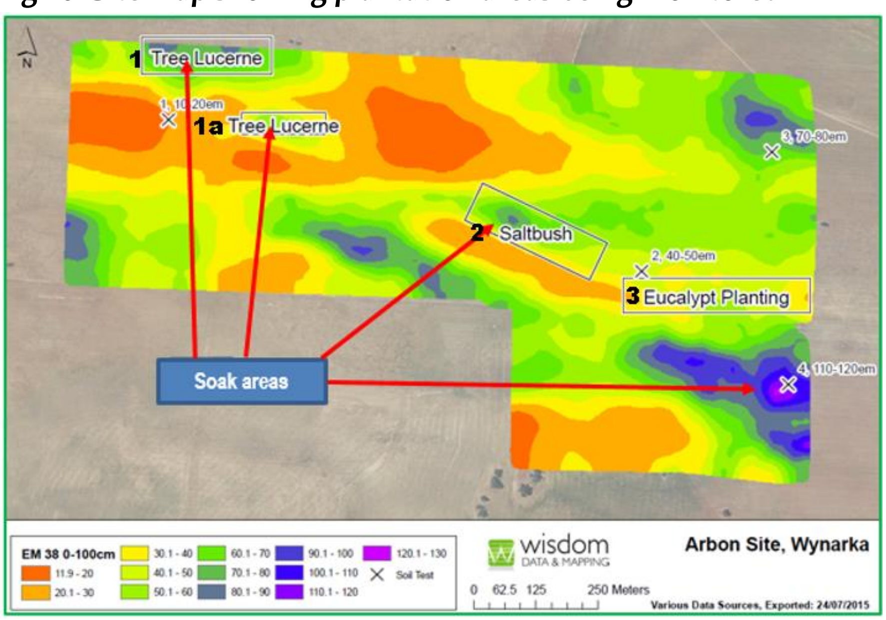


Fig 26. Site map showing plantation areas being monitored.



3.3.1 Catchment Snapshots

The following photos and descriptions provide pictorial evidence of the progress and issues at this site. These seep areas do not appear to be strongly saline at this point, as is evidenced by the strong growth of ryegrass in developing wet areas. However, maintaining soil cover to prevent evaporation and capillary rise concentrating salts at the surface will be an important management strategy, and the use of waterlogged and salt tolerant grasses or other pastures in the developing scalded areas should be an important strategy.

The forming seep area south of the track and tree plantation was planted to *messina* which is salt tolerant and able to withstand waterlogging (photos 46-48). This should help maintain soil cover to reduce evaporation and salt acculation at the surface, while also providing excellent liveshock fodder. Seed was also be spread amongst the saltbush plantation seep areas.

While this site does not have moisture probes or peizometer data recording, it is clearly experiencing similar issues as the other catchment monitoring sites of high subsoil moisture levels, lateral water movement and the accumulation of water surface water and waterlogging. The rainfall would be similar to both the Martin and Rose / Thomas sites.

Photo 40. Fenceline where trees were planted and recently replanted above develpoing seep

Photo 41. Few surviving eucalypts from 2015 planting

Photo 42. Developing seep in midslope below tree planting rows

Photo 43. Developing waterlogged seep area surrounded by dry ryegrass

Photo 44. Surface water ponding in the developing seep

Photo 45. Farmer considering messina pasture planting through devloping seep

Photo 46. Ground preparation for messina pasture planting through devloping seep

Photo 47. Innoculated messina seed loaded into rabbit bait layer ready for spreading

Photo 48. Farmer spreading messina seed through devloping seep

Photo 49. Tree planiting along fenceline to intercept water above developing seep

Photo 50. Tree planiting along fenceline in non-wetting sand above developing seep

Photo 51. Inproved tree planting technique with basin and guard to protect from vermin.

Photo 52. Seep with original saltbush that has been both grazed and rolled in 2017.

Photo 47. Seep with original saltbush that has been both grazed and rolled in 2017.

Photo 48. Seep with original saltbush that has been both grazed and rolled in 2017

Photo 49. Surviving tagasaste in western seep area

Photo 50. Surviving grazed saltbush in western seep area

Photo 51. Saltbush and tagasaste established in 2015, in the western seep area.

Photo 52. Farmer Dave Arbon assessing grazed tagasaste in western seep area

Photo 53. Grazed saltbush and tagasaste in western seep area May 24th 2017

Photo 54. Surface water in the western seep area, May 24th 2017.

Photo 55. Saturated 0range/yellow with some stone at 40cm in western seep area

Photo 56. Scraping between saltbush rows for messina establishment, prior to replanting

Photo 57. Small developing seep area with some surviving grazed saltbush near western seep

Photo 58. Small developing seep area being sown with messina between saltbush

3.3.2 Recommendations

This is a very dynamic system with growing seep concerns. It is also the only site using trees and perennial fodder shrubs to intercept and utilize excessive soil moisture. It will every important to continue to monitor this site in coming years, as it will take time for the vegetation to establish to a level that will maximize its water use.

There are two key strategies being used here:

1. To allow the water to flow into the basins where the saltbush can use it, grow well and provide strategic fodder over summer months for livestock, while continuing to crop the surrounding non-wetting sands as usual,
2. To intercept the lateral flow of moisture with trees between the non-wetting above and within the tree line, as well as through the contours of the landscape.

It is still uncertain as to how effective these strategies will be and how well the vegetation will impact on the actual water table levels. It would be very beneficial to the assessment of this site if there were strategically located moisture probes and piezometers located at this site with continuous monitoring using data loggers, as has been used and vital to the understandings gained at the other monitoring sites.

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 paddock area being monitored adjacent to the lucerne has been cereal cut for hay in both 2015 and 2016.

The main monitoring at the Bond site has revolved around three main aspects:

1. the measurable differences in soil water dynamics using moisture probes between the 2 different farming systems at the site (lucerne for hay with deep rooted perennial growing all year verses continuous annual cropping system active only in growing season, with clean summer and autumn weed control),
2. the water table levels at the seep and on the sandy rise, using piezometers,

Mannum received well above average rainfall in 2016 recording 427mm, 132mm higher than the annual average, as can be seen in Table 6. However, the catchment site on Bonds property received 370mm for 2016, still 75mm above average. This site only received 28mm rainfall in Dec 2016, and largely missed out on the large rainfall event at the end of the year that was featured at the other locations. The site rainfall gauge shows above average rain for Jan-Feb this year, and well above average rainfall for April.

Table 6. Rainfall data for Mannum, 2016, and Bond Site for 2017 until May 23.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Apr-Oct
Mannum 2016	21.4	12.4	48.4	9.4	31	28.8	49.1	24.2	79.1	*18*	*31.8*	*73.8*	*427.4*	240
Site 2017	*24.2*	*24.6*	9.6	45.4	11.6*									
Mean	15.9	17.2	18.4	25	29.9	31.9	28.6	30.6	29.9	26.6	21.1	21.6	295.5	203

Fig 27. Rainfall records for site, Jan 2016 to May 2017

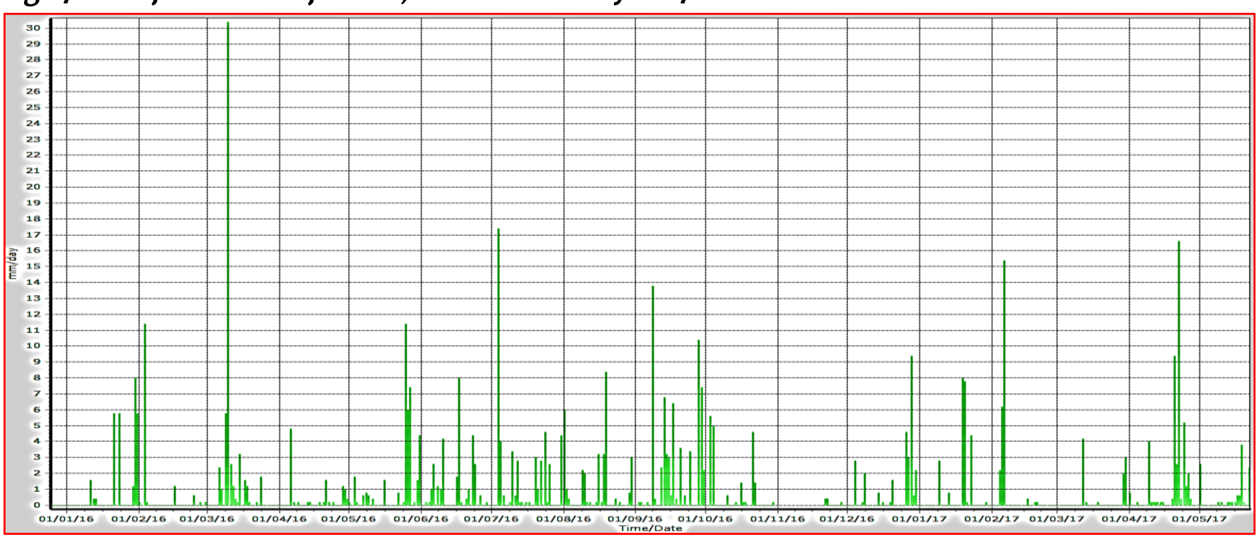


Fig 28. Map of Bond Lucerne Trial showing monitoring zones and equipment sites

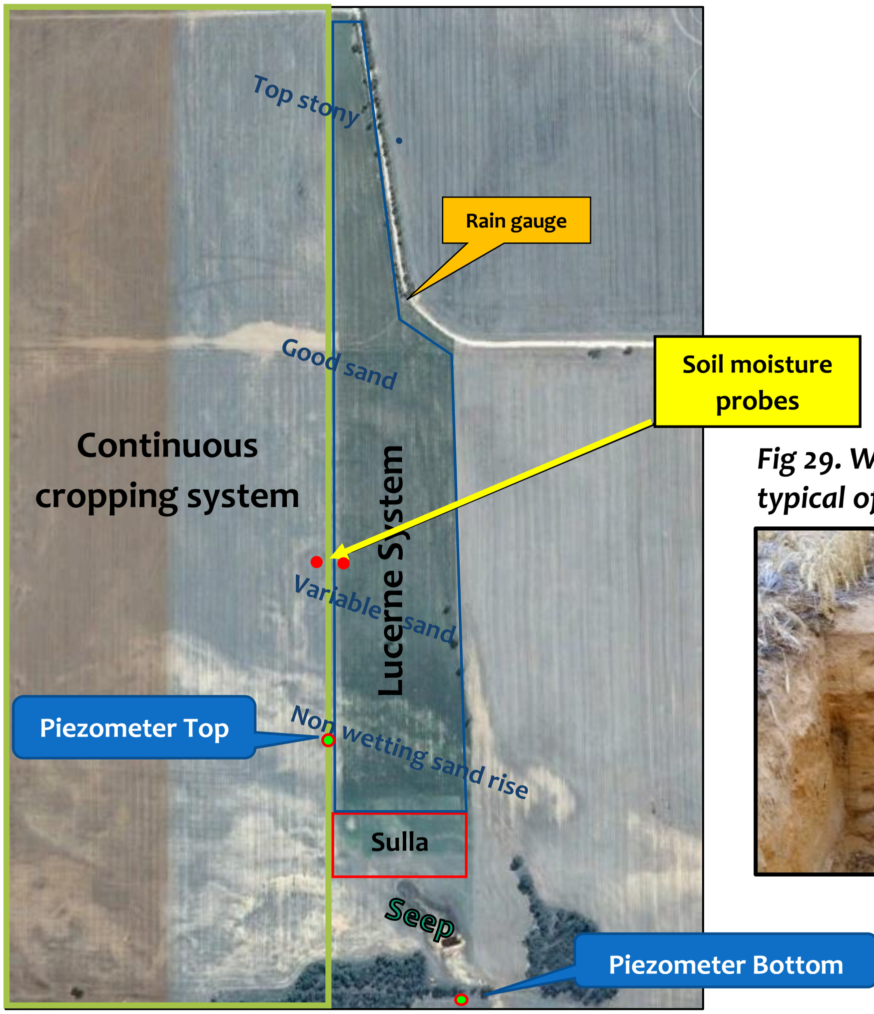


Fig 29. White sand over clay profile typical of this site

3.4.1 Site Summary

The Bond site has continued to show the value of establishing lucerne to reduce subsoil moisture and recharge. Soil moisture probes have shown that they have effectively halved the soil moisture levels within the top 1m (reduced by approx. 60-80mm). This level may be even higher in the soils below the rootzone of the cereals, where the deep rooted lucerne may still be accessing moisture.

There is however some concerns rising in the ongoing productivity of the lucerne, which was surprisingly not able to be cut for hay in 2017. It is possible that as the lucerne has dried out the excess subsoil moisture, it may now just be relying on rainfall to produce its top growth, which may lead to fewer, more opportunistic hay cutting opportunities. This will continue to be monitored over time to assess this. If this is the case it may have important implications for other farmers wanting to employ this high water use strategy. It may be more sustainable to target the lucerne plantings to the sandy areas closer to the seeps, so they can protect the catchments from surface recharge, while still intercepting enough lateral moisture flow from higher areas to remain productive.

As with the other sites, the above average rainfall year of 2016 has led to increases in seep area within the catchment, and relatively small rainfall events in 2017 have resulted in strong surface moisture discharge.

3.4.2 Moisture Probe and Piezometer Results

May 2017 saw the dam at the base of the main soak catchment full of water (Photo 59) showing signs of recent overflows to the growing seep areas beneath (Photo 60). The Piezometer readings (Fig 30) from near the main seep area show that the water level rose sharply after the Mar 2016 rains, and rose further with the above average rainfall year. However, at the end of the growing seasonit was unable to return to its previous lower level. Instead, it appears that the amount of moisture throughout the soil profiles after the above average rainfall year has meant that small rainfall events (10-20mm) have contributed to recharge, indicated by sharp piezometer rises in BO1 of about 20cm through Feb March 2017. This was followed appproximately 30mm rainfall event in April that raised the water table by about 60cm.

The water table at the non-wetting sandhill just north of the main seep area (Fig 31) shows a very different shape. This piezometer is situated between the lucerne and the continuous cropping treaments. It would appear that the level has been most influenced by the lucerne side, as it has shown a steady decline since the lucerne reached maturity in late 2015, with some leveling out through the high rainfall season of 2016. It is interesting that there has been some rise again in 2017 which may be due to some lateral water movement form higher in the catchment and the slightly poorer growth of the lucerne this year.

The *Sulla* that was planted in a small area at the base of the lucerne area has grown well and regenerated in patches, but less so on the deeper sand. It was not planted on any scald areas. As these farmers do not have grazing livestock, this is not considered a long term option for their farm.

Photo 59. Dam area at main seep at bottom of paddock

Photo 60. Developing seep area in cropping ground beneath the main seep area

Photo 61. Main Seep scalded area at bottom of paddock, where messina may be planted

Photo 62. Northern view from sandhill piezometer showing sown crop left and lucerne right

Fig 30. Piezometer Bo1 readings for Bottom soak area, Jan 2016 - May 2017

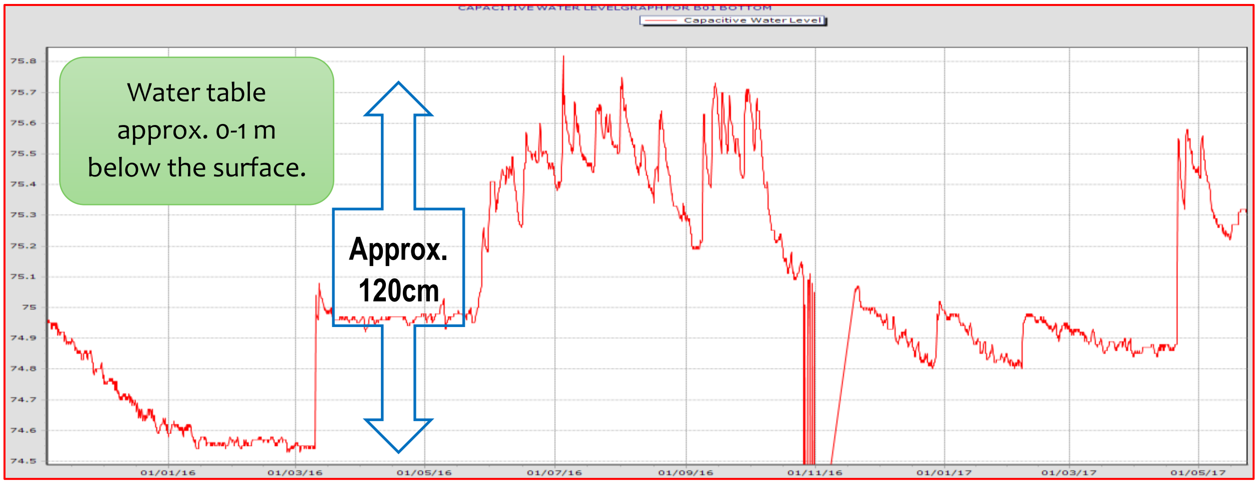


Fig 31. Piezometer Bo2 readings from the top of non-wetting sandy rise, Nov 2015 - Nov 2016

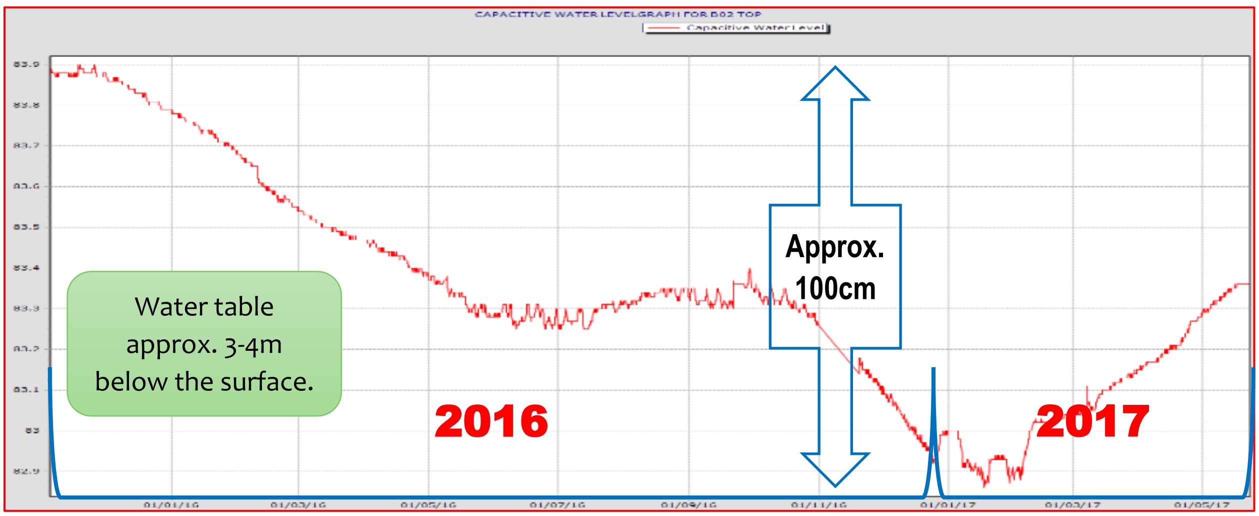
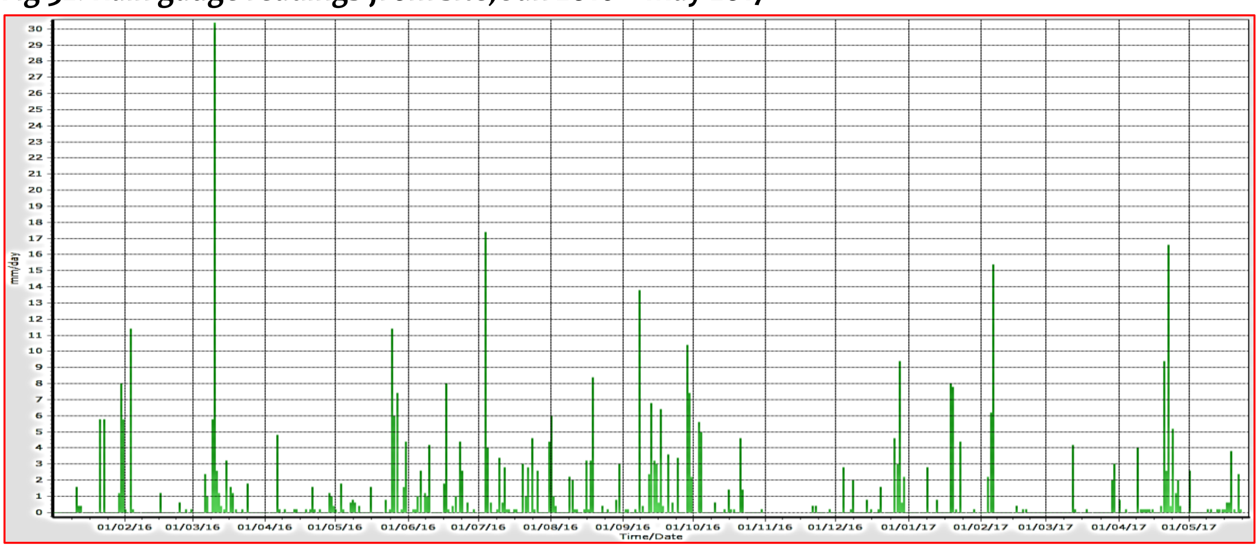


Fig 32. Rain gauge readings from site, Jan 2016 – May 2017



3.4.3 Farming system water use.

The moisture probe results continue to show a large difference in soil moisture levels and water use between the 2 farming systems. Since Nov 2016, the cereal cropping side has generally hovered between 140-160mm within the top 1m soil in the period of summer weed control and not crop growth (Fig 36). By contrast, the lucerne side has generally maintained levels of 70-80mm within the top 1m (Fig 35), with only brief spikes of refill after rainfall events. This 50% reduction of soil moisture in the top meter would likely be much higher just below the crop rootzone, where the deep rooted lucerne plants would continue to draw moisture from, particularly if they have been able to penetrate into the perched water table.

These probes are located approximately 30m apart, 15m inside their treatment areas in sand over clay soils, where the clay begins at the about the 90cm sensor. It may be possible that the 90cm cereal sensor (Fig 37) may be measuring more of the clay layer (originating at 22mm) when compared to the lucerne side 90cm sensor (originating at 14mm), however, this would only account for an approximate 16mm difference in the top meter moisture comparisons. The key factor is that all sensors have reduced moisture levels on the lucerne side, while they have all increased at the cereal side.

This confirms that the lucerne plantation has definitely achieved its desired outcome of significantly reducing recharge since its establishment 2015. This is confirmed in the overall reduction in the mid-slope water table (Fig 31) which borders the lucerne area, despite the well above average rainfall year. The main soak piezometer (Fig 30) would only partially be influenced by the lucerne plantation.

One critical factor is that despite the wet Spring in 2016, some significant summer rains and good events in 2017, the lucerne has not achieved high foliar production, and the expected hay cut in 2017 was not able to be achieved. At seeding time, some barley was sown within the lucerne stand. Photos 63-37 reveal far inferior growth than the previous season.

This may be explained if the lucerne has significantly dried out the initial subsoil moisture reserves and is now much more reliant on rainfall events to grow well. The long term cumulative soil moisture trend for the top meter (Fig 25) provides some evidence towards this. It shows initial soil moisture levels of between 100-120mm for the first 5 months while the lucerne became established within the top 1m. Since then the level has generally been pulled back to 70-80mm, apart from periods of intense rainfall events. If the subsoil clays have also greatly reduced in moisture and the perched water table lowered, then this is likely to lead to reduced lucerne production.

The key question is whether this could make the lucerne become unproductive economically. If this was the case it may be worth considering reducing the lucerne area to the lower sandy portion of the site, which may allow some lateral moisture feed from above, which still allowing for the year round deep moisture use closer to the seep areas.

Fig 34. Long term soil moisture sensor readings, lucerne site, July 2015 – May 2017

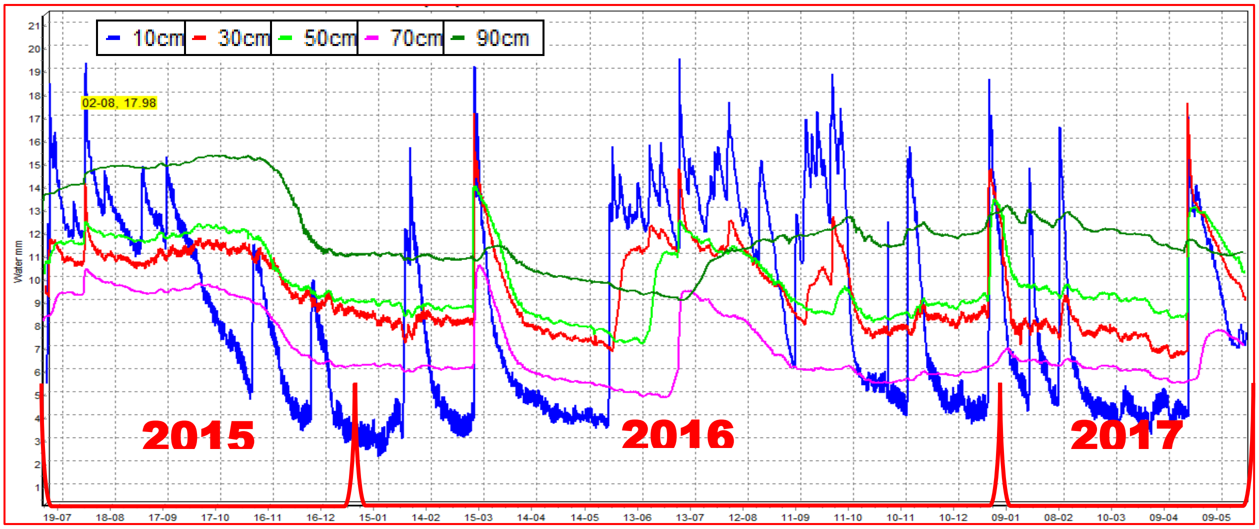


Fig 35. Long term cumulative soil moisture readings, lucerne site, July 2015 – May 2017

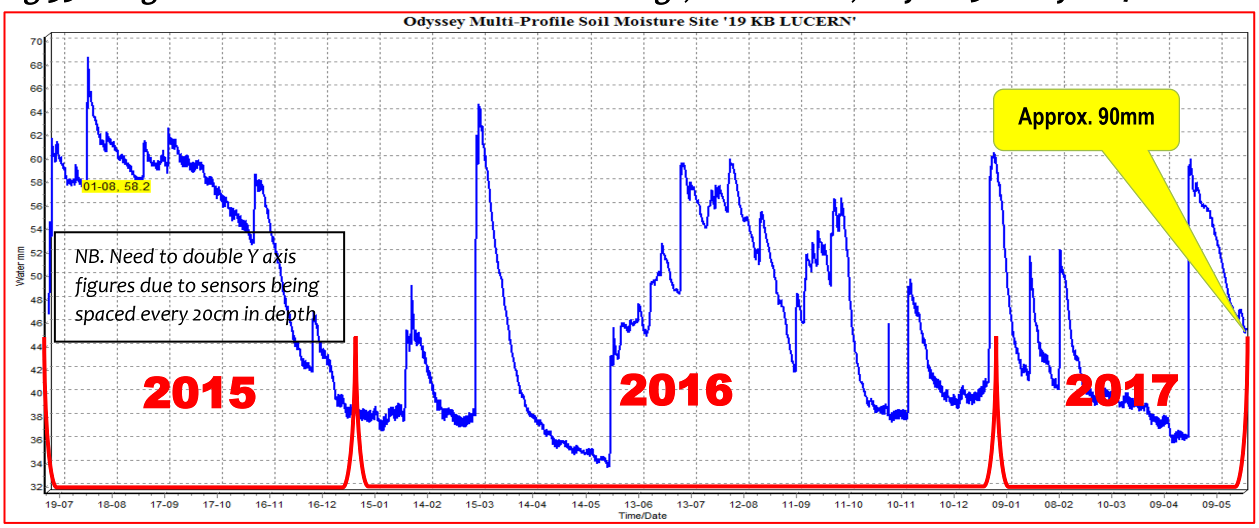


Fig 36. Long term cumulative soil moisture readings, cereal site, July 2015 – May 2017

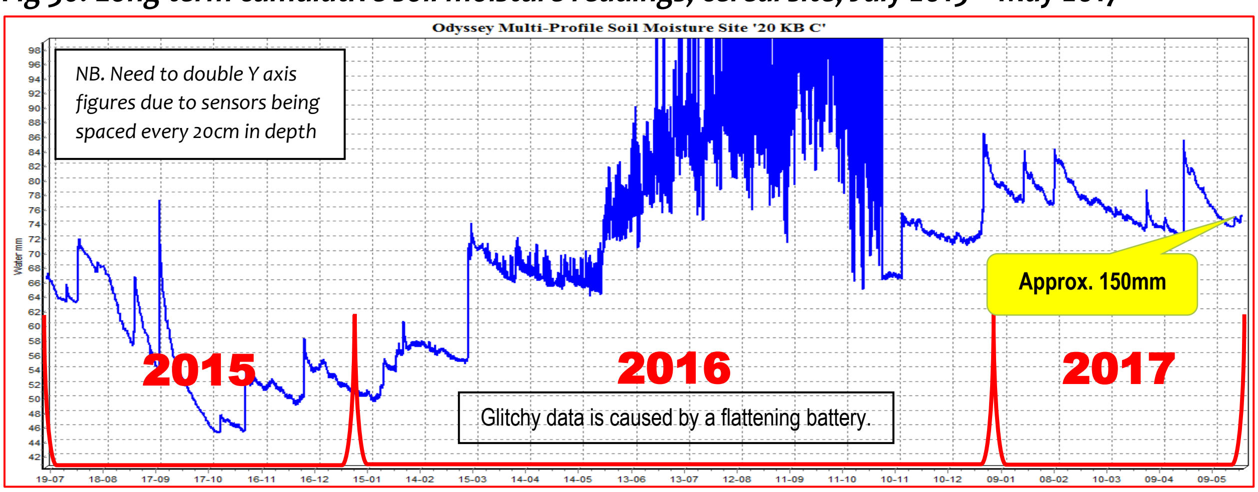


Fig 37. Long term soil moisture sensor readings, cereal site, July 2015 – May 2017

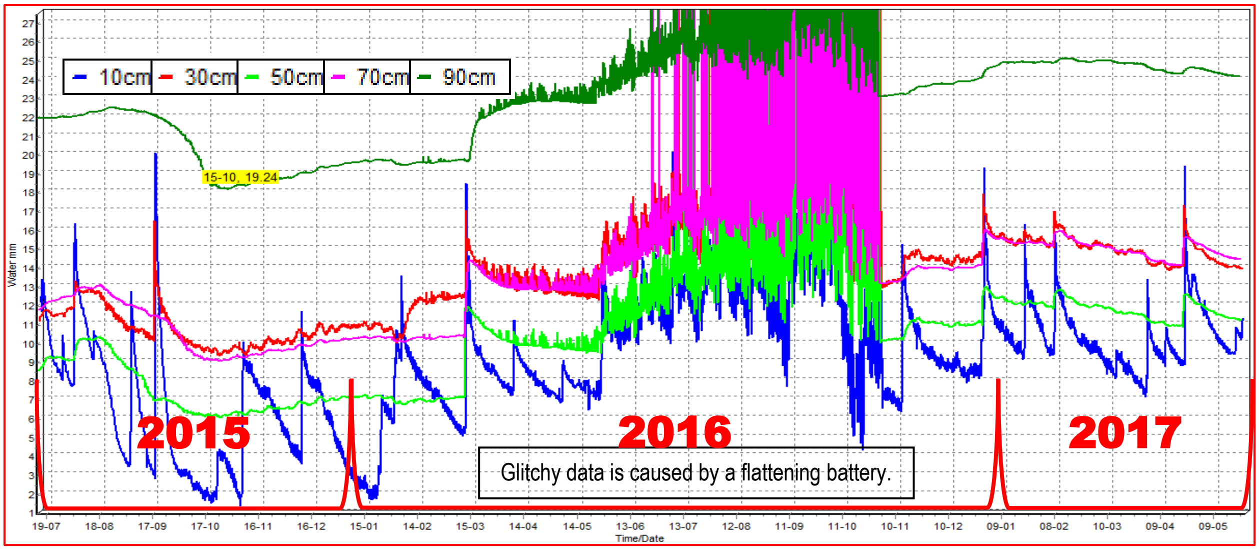


Photo 63. Lucerne growth at sandhill piezometer showing showing poor vigour, May 2017

Photo 64. Lucerne growth at sandhill piezometer showing showing poor vigour

Photo 65. Lucerne growth near moisture probes showing showing poor vigour

Photo 66. Lucerne growth at moisture probe showing relatively poor vigour

Photo 67. Lucerne growth at stony top end also showing relatively poor vigour

Gaining meaningful gross margin comparisons between the 2 farming system areas has proved difficult, in that the farmers were unable to accurately assess how many bales of hay were attributable to each site area and land type. The wet season of 2016 also lead to a glut in the hay market generally, result in a significant reduction in price. The storage and marketing of the hay then becomes a very strong influence on its gross margin. However, while the lucerne continues to grow well and provides two good cuts of high quality hay per year, it remains viable and is considered well by the farmer, particularly as it is protecting the catchment against further seep degradation. However, if after initially drying out the deeper soil moisture the lucerne production potential becomes diminished, then this strategy may need to be revised.

3.4.4 Catchment Snapshots

The following photos and descriptions provide pictorial evidence of the progress and issues at this catchment site.

Photo 68. Seep site west of main seeps site. Possible messina planting site

Photo 69. Nearby seep forming at base of a non-wetting sandhill, southeast of main seep

4 Acknowledgements

The author of this report acknowledges each of the famers involved in the monitoring sites, including Stuart Pope, Simon Martin, Peter Rose, Andrew Thomas, David Arbon as well as Kevin, Geoff and Rodney Bond. The author also thanks Tony Randall of NR SAMDB for his ongoing support and assistance in the operations of this ongoing project.

5 References

Hall, J. (2016). Mallee Dune Seeps, Drilling and Well Installation Report, Pope Subcatchment, Juliet Creek Consulting Pty Ltd.