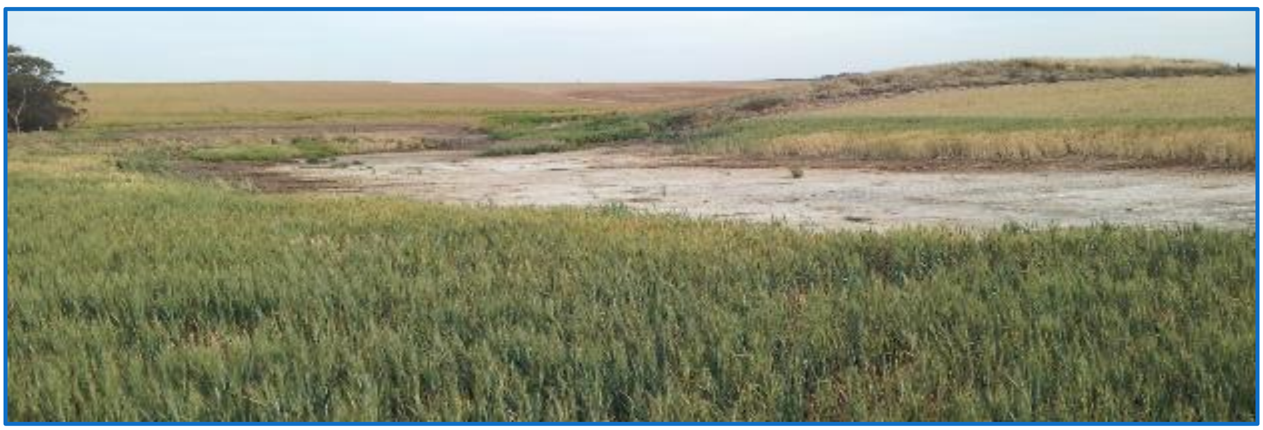
Monitoring Mallee Seeps

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

Progress Report July-Dec 2015



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

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

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Contents

1 Project Summary

This report involves the monitoring of 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, and undertaken by Rural Solutions SA. Background to each site, EM38 mapping, soil tests and initial monitoring are contained in an earlier report by Chris McDonough, Rural Solutions SA in July 2015.

This report is a continuation of the site progress and monitoring at these 4 established sites. It provides some analysis of monitoring results, while further and fuller analysis with recommendations will be provided in the final report.

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.

The highlight has been the amazing impact of spading chicken manure at Popes' farm, showing 3x the crop yields over the control, while also accessing and using much higher subsoil moisture which should help reduce the growing soak impact. About 25 Agricultural Bureau representatives from across the State visited this site in August at their annual conference, while a further 65 farmers and industry representatives were shown the crop growth and comparative root growth with pits at a field day in September. It will be important to monitor the ongoing improved crop benefits and moisture use at this site to determine the longer term impacts of this treatment.

The Rose / Thomas site has seen a detailed catchment analysis carried out, and has recently had data loggers placed on the three piezometers at the site. This will provide vital information about catchment dynamics, particularly after any major rainfall events at the site. It would be good if soil cover could be established at these soak areas to help reduce the evaporation and accumulation of surface salts at this site.

The tree and perennial fodder shrub plantings at Arbons to both intercept and utilize subsoil moisture flows is providing some practical information about these strategies despite a very difficult year for plant establishment. It will be very interesting to see the growth and fodder production from the surviving tagasaste and saltbush in the soak basins over the coming years. Some replanting of trees along fence line above one soak will be needed to fill in gaps, along with tree guards and an improved strategy for seedling survival in these difficult non-wetting sands.

The lucerne establishment at Bonds has been very successful, and should encourage may other farmers (including continuous croppers) to give this a go for hay production. There has been poorer growth on the deep non-wetting sands, but generally reasonable seedling establishment there. Already clear differences in moisture use between the lucerne and the adjacent wheat crop can be seen, which could be very interesting when a large summer rainfall event is experienced, particularly after the lucerne is more fully established. Ongoing monitoring should provide key information about the soil moisture dynamics of the different systems, and how they may impact of the growing soak problems on the farm. The establishment of a few hectares of Sulla pasture was also interesting. It will be important to test this salt tolerant variety much closer to, or even on the scalded soak areas in the future. Data loggers were also placed on the 2 piezometers at this site as well, and although it is early days yet, it will be very informative to see the water table impacts within this catchment after some significant rainfall events occur.

Kevin Bond discussing monitoring results with Chris McDonough

2 Site Monitoring

2.1 Pope Site, Karoonda

Figures 1- 3 show the active problem of the growing seep issue at Popes' property. The subsoils of the large catchment area must be either very saturated, or highly impermeable for such small rainfall events to lead to such moisture discharge into the seep area from the surrounding non-wetting sands. Soil moisture graphs and rainfall data (Figures 33 – 35) show how poorly these sands retain moisture in their natural state, with every rainfall event showing a sharp spike in gained moisture, then returning quickly to previous levels. In some cases the 90cm sensor (which sits right at the top of the subsoil clay) has shown a large rise after rainfall that does not easily correlate with moisture rises on sensors above it, suggesting that this may have been due to lateral moisture movement from higher up the slope.

Figures 5-14 show clear growth differences between the 3 different treatment areas of:

- chicken manure (at both 6 and 9t/ha) spaded into 40cm depth,
- spaded only to 40cm
- control.

From crop establishment, crop growth, tillers produced (see Table 1.), right through to head size, numbers and finally yield and quality, the spaded chicken manure has been far superior to other plots, well beyond expectations. Table 1 shows a slight improvement in seedling establishment, but an incredible increase in tiller numbers per m^2 that has carried through to yield. This must be a result of both extra moisture availability, and vastly improved soil nutrition.

There was little difference this season between the high rate of 9t/ha chicken manure, and 6t/ha which therefore proved to be the most economic in this first year. Time will tell as to how long these benefits will last for each treatment.

The spaded only area showed growth and yields superior to the control areas, but well below that of the spaded chicken manure areas. This shows that just breaking through the compacted layers of sand, which has been shown to greatly impede root growth between 20-40cm depth, provides only part of the benefit. The high levels of nutrition (N, P, K and trace elements) as well as organic matter for improved water retention and CEC, is the key to achieving the best results, and not only broke through the compacted layer, but helped crop roots explore subsoil layers beyond 1m depth (see soil pit Figures 15-23).

Table 2 shows the yield results and economic analysis of each treatment, showing average yields rising by 1.5-2.5t/ha over and above the comparative control areas, or essentially 100%-

250% yield increases. The spaded only areas were more in the order of 50%-60% yield increases. By yield it could be estimated that a 2t/ha increase would require an extra 100mm water to achieve this, but this would assume that the control is already producing at 100% water use efficiency (which it definitively isn't) to start with. The comparative sums of the moisture probe readings to 90cm suggest that the crop in the spaded chicken manure area has drawn soil moisture down by about 40mm more than the control area, which is still very significant, and would surely be enough to reduce significant flows into the soak area.

It will be interesting to see how much this subsoil moisture is replenished over summer, or whether there will be significantly less plant available water next season, now that he roots have broken through the compacted layers. This could greatly impact on whether such substantial yield increases are experienced into the future.

2.1.1 Pictorial progress of site activities at Popes

Figure 1. Soak area seeping water a from crop area after only 10mm rainfall (photo Aug 10).

Figure 2. Moisture accumulation in soak after 10mm rain event

Figure 3 Evidence of soak area expanding further into cropping land

Figure 4. Assessing crop growth at nearby clay spread area above soak to the west of site

Figure 5. Thick crop growth in spaded chicken manure area (photo Sept 10)

Figure 6. Thick crop growth in spaded 9 t/ha chicken manure spread area

Figure 7. Medium crop growth at spaded only area showing less green with less nutrition

Figure 8. Monitoring crop growth in spaded only area

Figure 9. Very poor crop growth in control area (photo Sept 10)

Figure 10. Very poor crop growth in control area showing nutrient deficiencies

Figure 11. Amazing crop growth and heads of spaded chicken manure area (photo Oct 23)

Figure 12. Amazing crop growth and yield potential of spaded chicken manure area

Figure 13. Medium crop growth in spaded only area

Figure 14 Sparse crop growth and fewer, smaller heads control with earlier senescence

Figure 15. Digging soil pit in spaded chicken manure area

Figure 16. Farmer showing the depth of visible root growth after spading chicken manure

Figure 17. Field day, 60 farmers at spaded only / control pit with contrasting crop growth

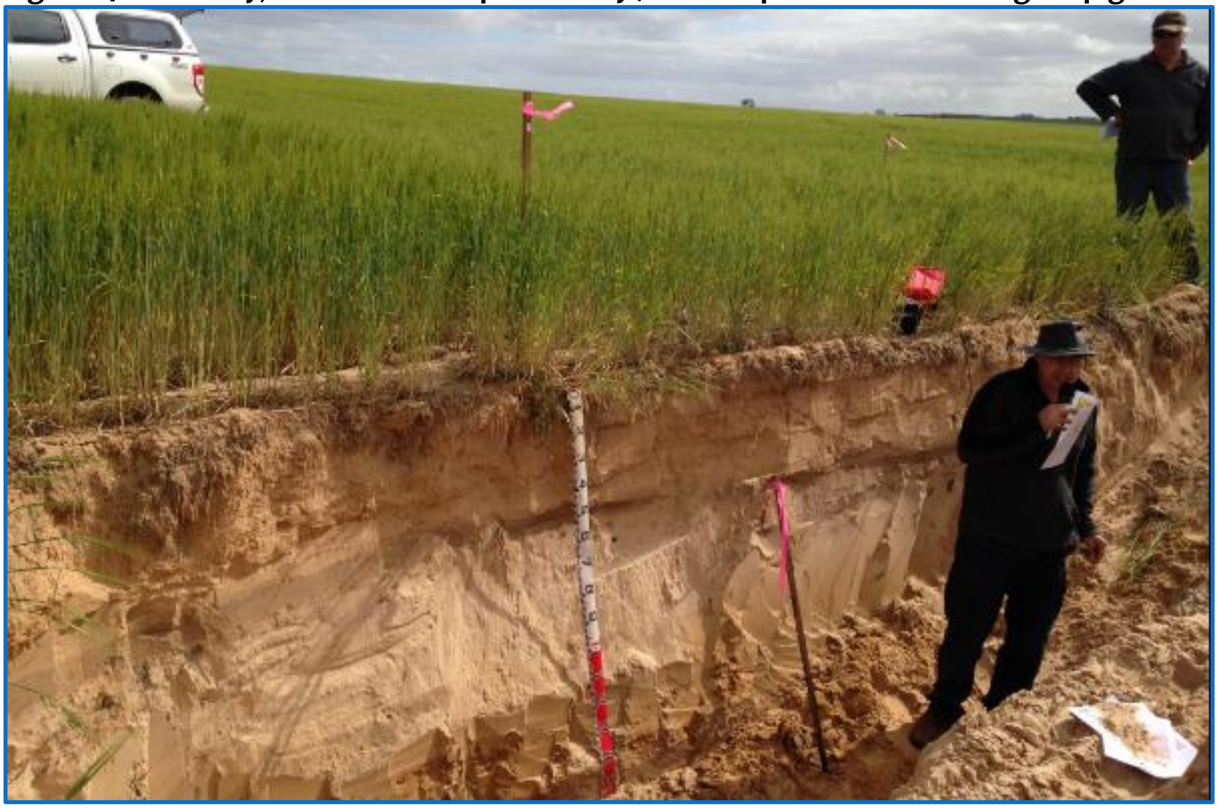


Figure 18. Field day, 60 farmers at spaded chicken manure pit with amazing crop growth

Figure 19. Concentration of surface roots in control area, with few roots below 30cm

Figure 20. Medium crop growth and better root growth through top 40cm in spaded area

Figure 21. **Deeper, bigger root mass growing through top 40cm in spaded area**

Figure 22. **Sparse crop growth and shallow root growth in control area**

Figure 23 Deep and vigorous root growth beyond 100cm in spaded chicken manure area

Figure 24. Harvesting trial area with SARDI plot harvester

Figure 25. Harvesting trial area with SARDI plot harvester

Figure 26. Weighing grain samples in harvesting process

Figure 27. Farmer pulling SARDI truck out of sandy area near plots

Figure 28. Spading effect of reducing skeleton weed on left side of stake

Figure 29. Soak area from northern trial area

Figure 30. Soils consultant James Hall in pit filling with water near soak area

Figure 31. New soil pit with sand over clay at 60cm just above trial site

2.1.2 Data collected from Pope site

Table 1. plant and tiller counts for treatments across site.

Treatment	Count	plants/ m row	tillers/ m row	tillers/ plant	tillers/ m2
Control	1	22	190	8.6	633
	2	23	109	4.7	363
	3	30	113	3.8	377
	4	22	180	8.2	600
	Ave	24.3	148.0	6.3	493
spaded only	1	34	176	5.2	587
	2	17	124	7.3	413
	3	28	151	5.4	503
	4	35	183	5.2	610
	Ave	28.5	158.5	5.8	528
Spaded Chicken Manure 9t/ha	1	32	234	7.3	780
	2	27	186	6.9	620
	3	34	372	10.9	1240
	4	37	215	5.8	717
	Ave	32.5	251.8	7.7	839
Spaded Chicken Manure 6t/ha	1	36	300	8.3	1000
	2	52	278	5.3	927
	3	39	344	8.8	1147
	4	36	267	7.4	890
	Ave	40.8	297.3	7.5	991

Table 2. Yield, grain quality and estimated gross margin results from harvested plots

	Section Area	Rep	Yield (t/ha)	Protein (%)	Weight (kg/Hl)	Screenings (%)	Retention (%)	Ave yield (t/ha)	Ave Protein (%)	Yield Above Control (t/ha)	% Increase over Control	Treatment cost $/ha	GM @ $220/t	GM @ $240/t	GM @ $260/t
Control West	1	a	1.38	10.3	58.1	16%	40%								
Control West	1	b	1.46	10.5	59.6	10%	58%	1.21	10.40			$0			
Control West	2	a	1.06	10.9	54.4	15%	47%								
Control West	2	b	1.10	11.2	55.3	18%	44%	1.06	11.05			$0			
Control West	3	a	2.36	8.6	63.1	4%	69%								
Control West	3	b	1.98	8.5	61.6	4%	67%	1.91	8.55			$0			
Spaded Only	1	a	2.17	10.7	60.1	9%	63%								
Spaded Only	1	b	1.45	11	56.6	17%	54%	1.81	10.85	0.60	49	$100	$31	$43	$55
Spaded Only	2	a	1.68	9.7	56.4	17%	47%								
Spaded Only	2	b	1.53	10.6	53.6	42%	27%	1.61	10.15	0.55	52	$100	$21	$31	$42
Spaded Only	3	a	2.96	9.1	61.9	6%	70%								
Spaded Only	3	b	3.24	9.8	62.0	6%	73%	3.10	9.45	1.19	62	$100	$162	$186	$210
Sp Chicken Man 9t/ha	1	a	2.05	15.1	59.9	18%	62%								
Sp Chicken Man 9t/ha	1	b	3.01	13.5	63.6	13%	70%	2.53	14.30	1.32	109	$415	-$125	-$99	-$73
Sp Chicken Man 9t/ha	2	a	3.03	15	62.7	17%	56%								
Sp Chicken Man 9t/ha	2	b	4.36	15	62.7	17%	56%	3.69	15.00	2.63	248	$415	$164	$217	$270
Sp Chicken Man 9t/ha	3	a	3.78	14.9	61.2	18%	45%								
Sp Chicken Man 9t/ha	3	b	3.57	13.3	62.0	26%	26%	3.67	14.10	1.76	92	$415	-$28	$8	$43
Sp Chicken Man 6t/ha	1	a	2.38	15	61.0	15%	67%								
Sp Chicken Man 6t/ha	1	b	2.90	14	61.1	15%	66%	2.64	14.50	1.42	117	$310	$3	$31	$60
Sp Chicken Man 6t/ha	2	a	3.77	14.2	62.4	14%	68%								
Sp Chicken Man 6t/ha	2	b	3.57	14.1	63.4	11%	71%	3.67	14.15	2.61	246	$310	$265	$317	$369
Sp Chicken Man 6t/ha	3	a	3.63	14.1	62.2	22%	31%								
Sp Chicken Man 6t/ha	3	b	3.51	13.1	64.7	11%	68%	3.57	13.60	1.66	87	$310	$55	$88	$122
Control East	1	a	0.80	12.2	53.1	28%	36%		12.20			$0			
Control East	2	a	1.02	11	53.6	24%	37%		11.00			$0			
Control East	3	a	1.39	10	57.5	7%	57%		10.00			$0			

Figure 32. Soil moisture probe spaded chicken manure area

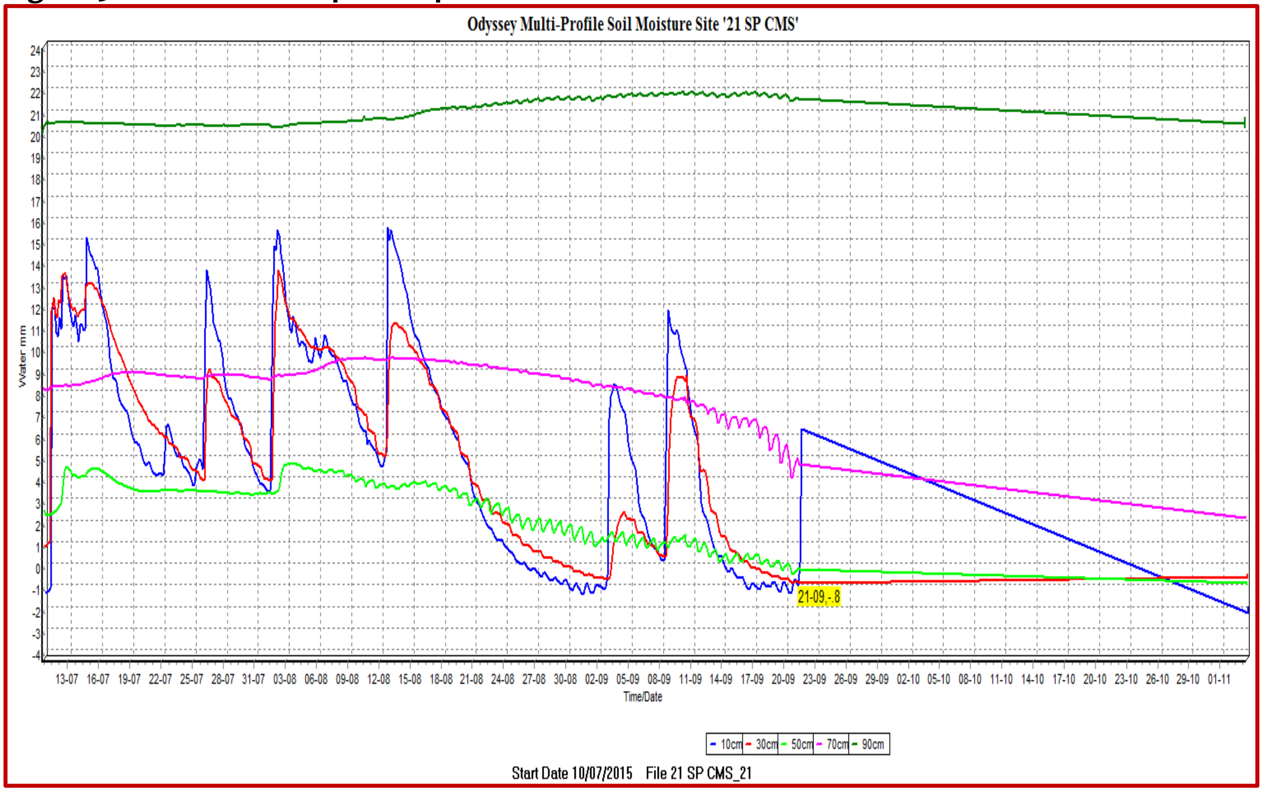


Figure 33. Summed moisture to 90cm from spaded chicken manure area

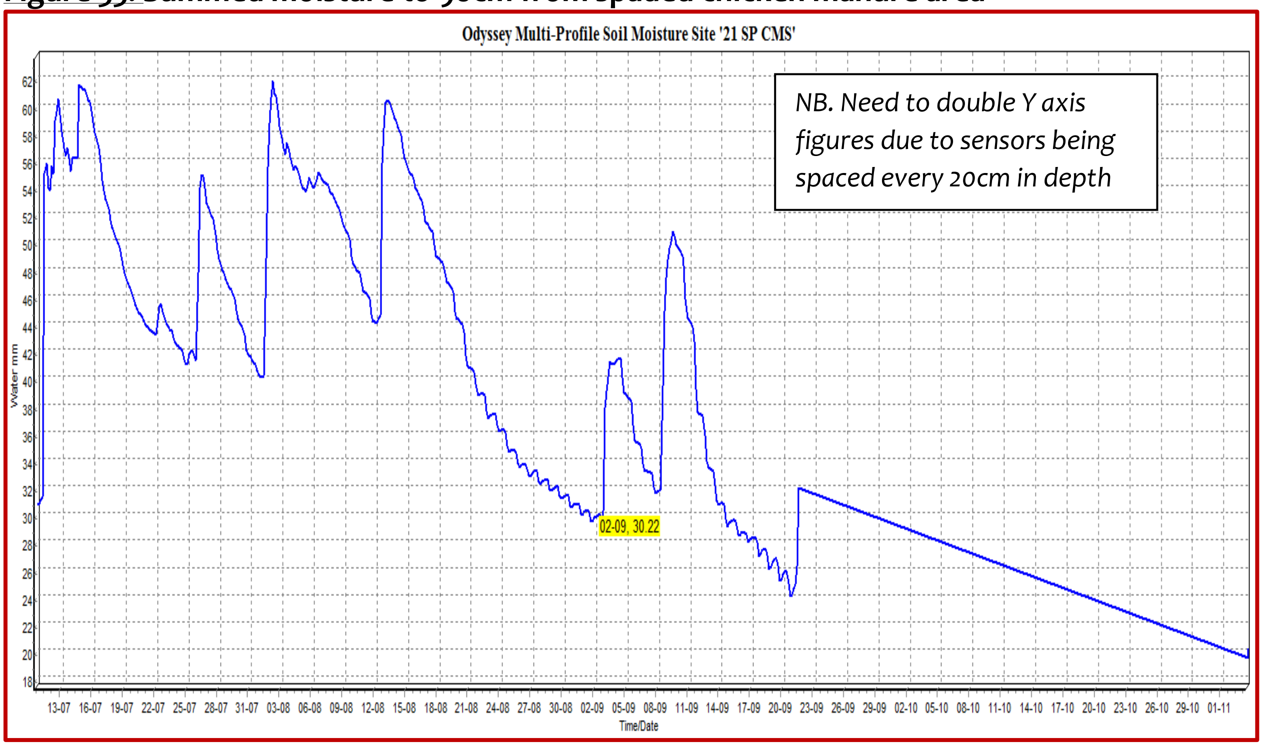


Figure 34. Soil moisture probe readings form the control area to 90cm

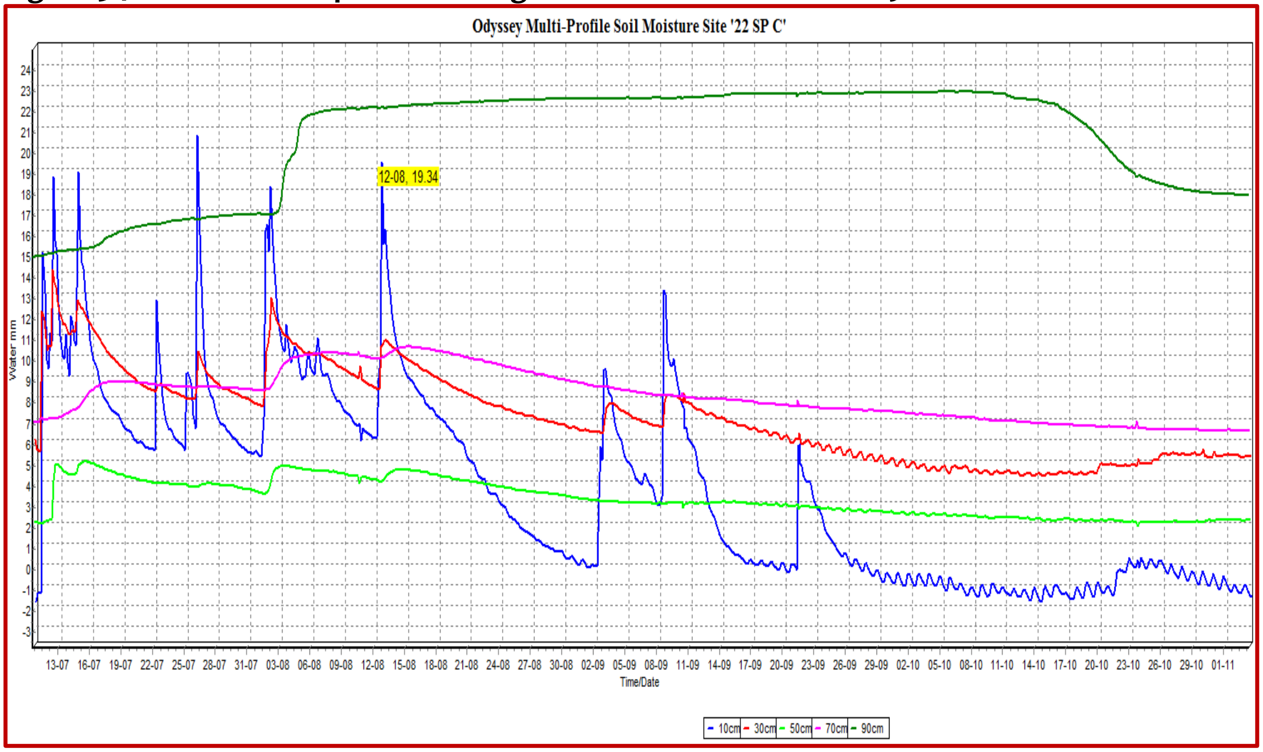


Figure 35. Summed moisture to 90cm from control area

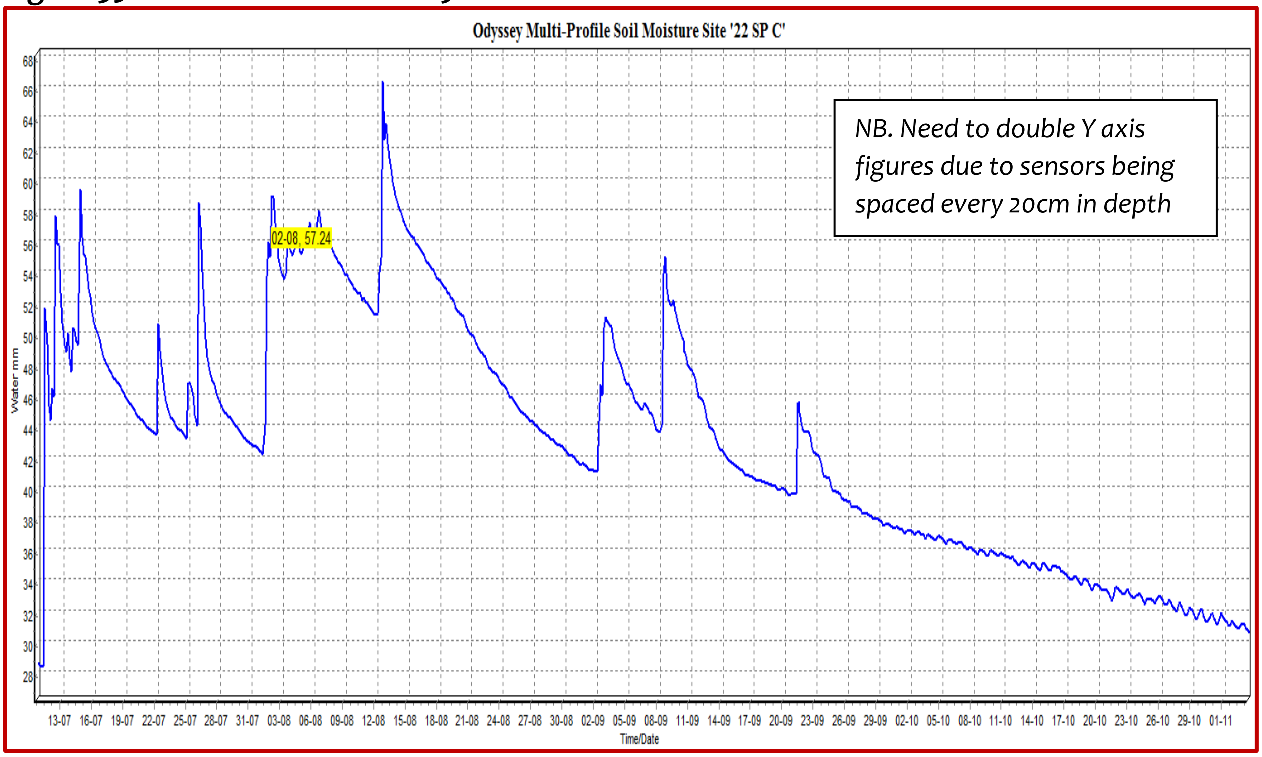
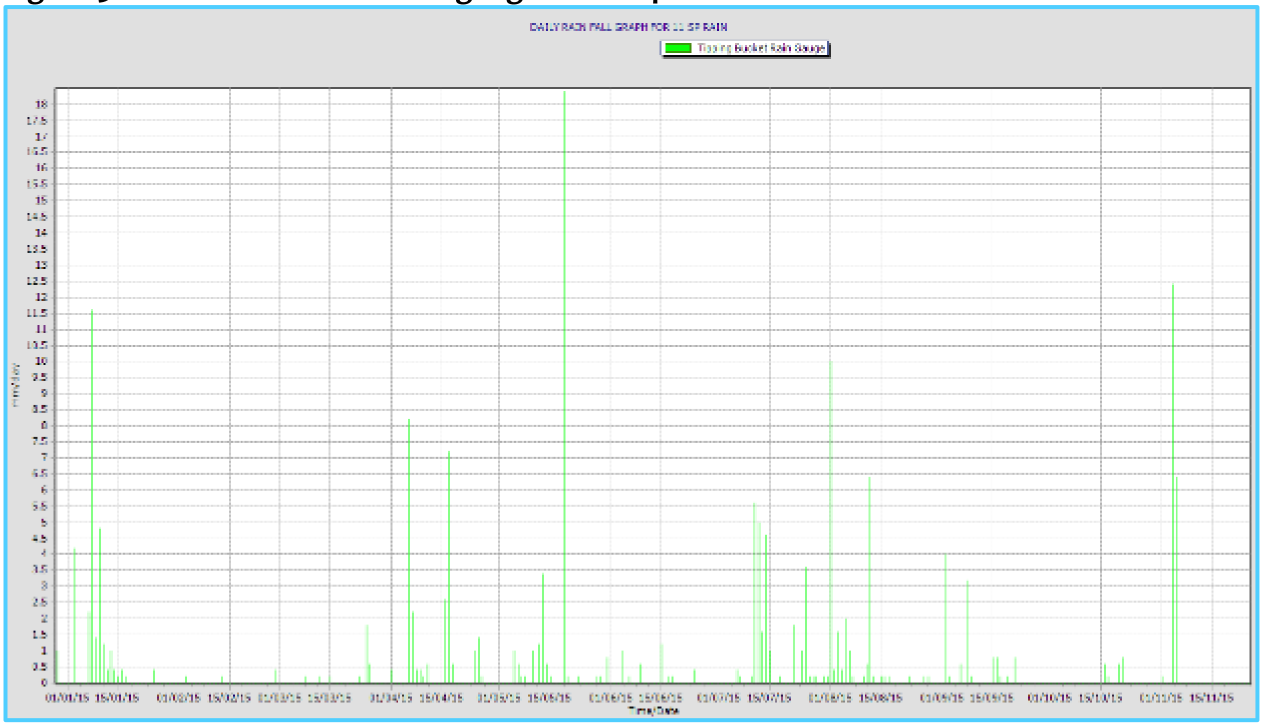


Figure 36. Rainfall data collected gauge near Pope site



2.2 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. While initial readings from some loggers (see Figures 51-53 show 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.

2.2.1 Pictorial progress of site activities at the Rose / Thomas site

Figure 37. Piezometer data logger installation at mid-slope site

Figure 38. Piezometer data logger installation at bottom, soak site

Figure 39. Developing site on northern side of sand hill.

Figure 40. Problematic strong dense ryegrass growth around developing soak.

Figure 41. salt tolerant grass and salt accumulation at bare surface through evaporation

Figure 42. High skeleton weed infestation on Rose side of fence

Figure 43. Limited control of deep rooted summer growing skeleton weed on Rose side

Figure 44. Excellent skeleton weed control on Thomas side of fence

Figure 45. Very little skeleton weed in crop on Thomas side of fence

Figure 46. Growth of unproductive soak area towards road

Figure 47. South view showing sand-hill and mid-slope piezometers and soak

Figure 48. Soak piezometer in scalded area at base of sand hills

Figure 49 Bare soak area with salt crystals accumulating

Figure 50. Differences in skeleton weed growth between farmers may affect moisture flow

2.2.2 Data collected from Rose / Thomas site

Figure 51. Top sandhill piezometer readings from Nov 2015 (essentially no change)

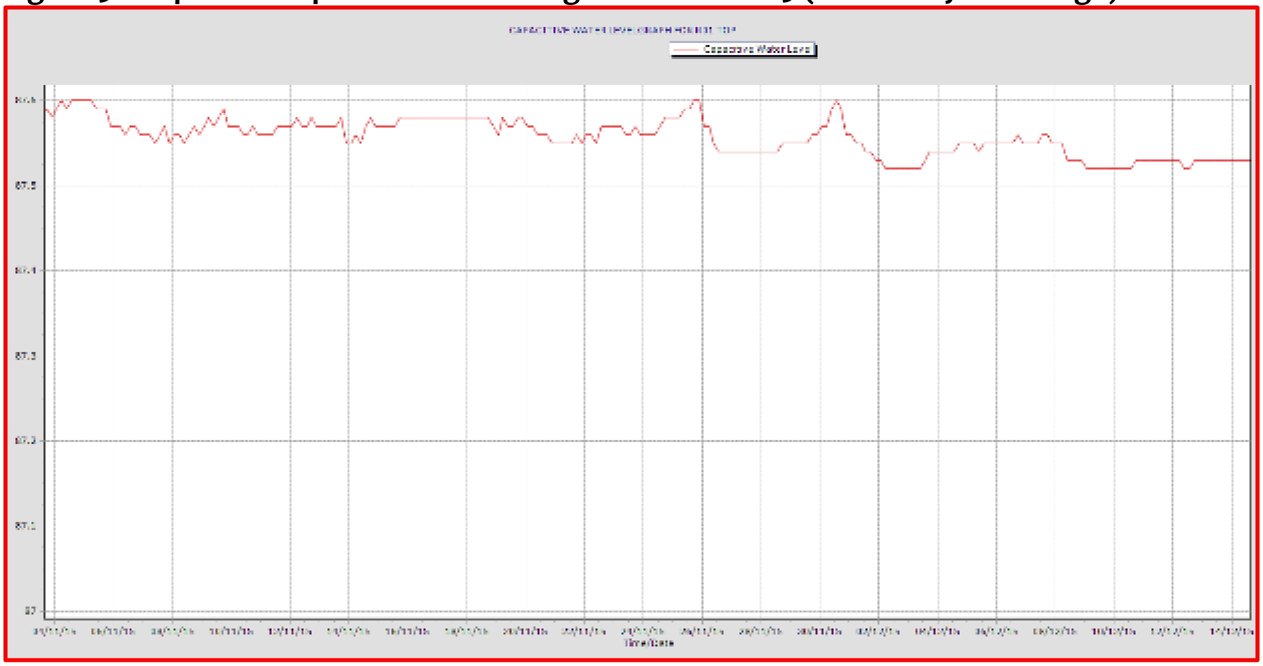


Figure 52. Mid-slope piezometer readings from Nov 2015 (essentially no change)

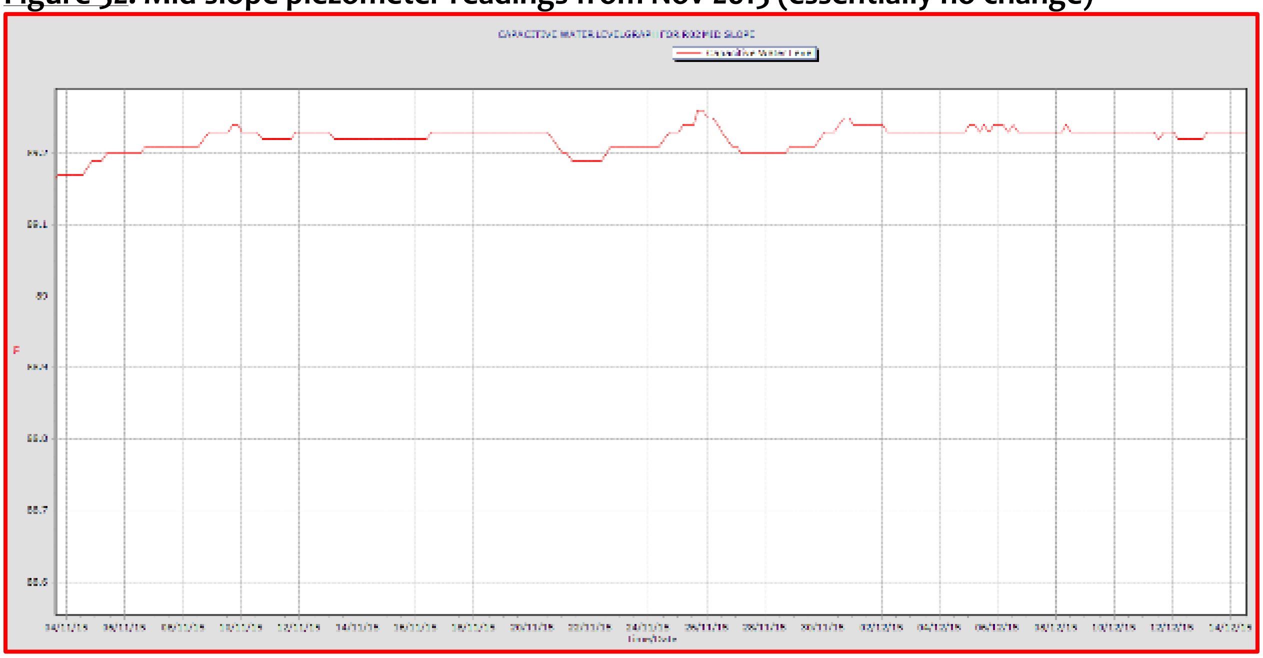


Figure 53. Bottom soak piezometer readings from Nov 2015 (very little change – 0.25mm)

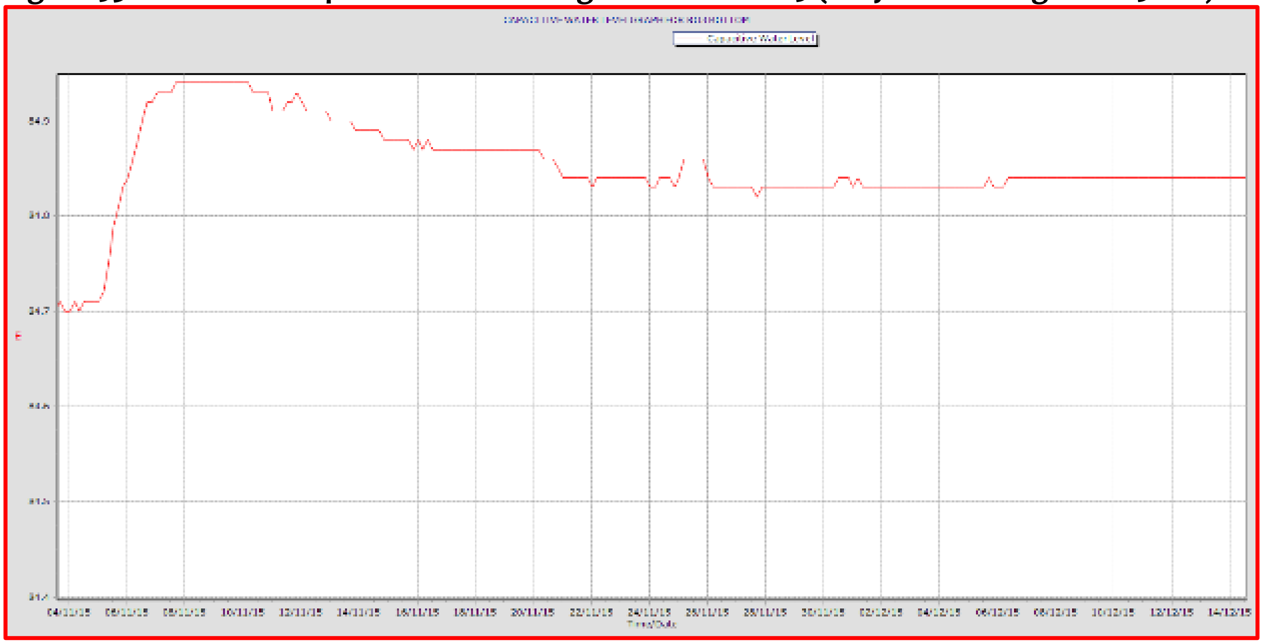


Figure 54. Rainfall recordings from Rose soak site in 2015

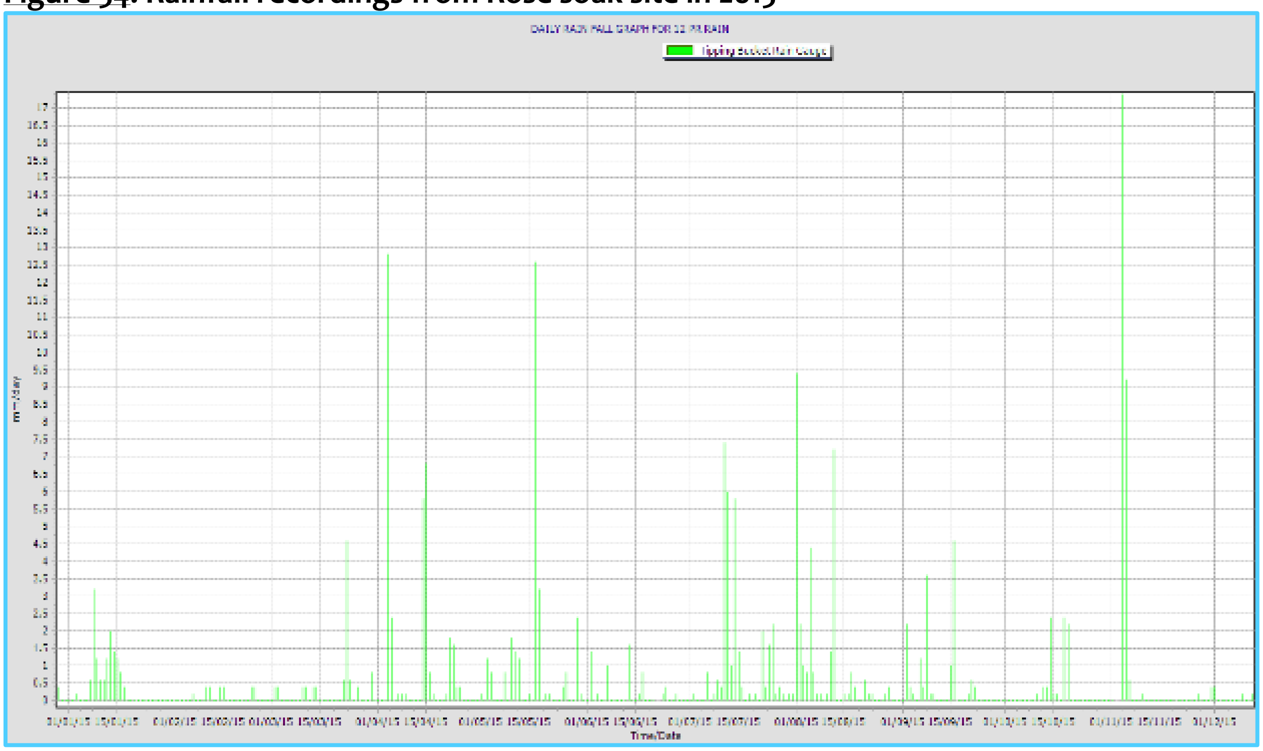


Figure 55. Mid-slope moisture probe showing little moisture penetration blow 40cm depth

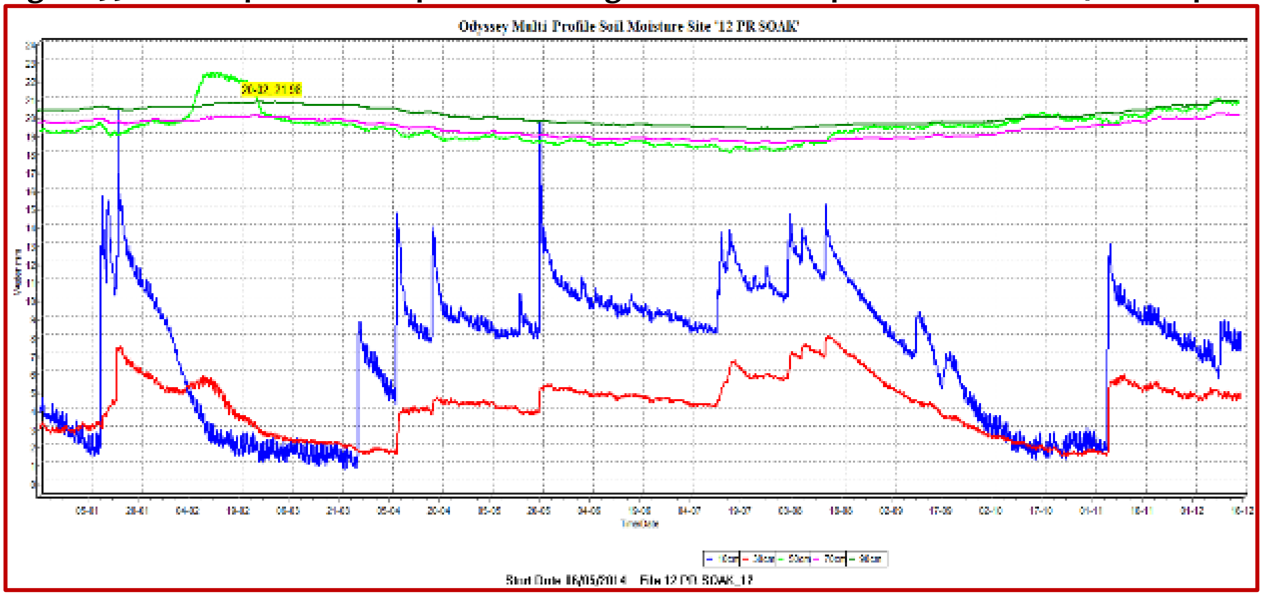
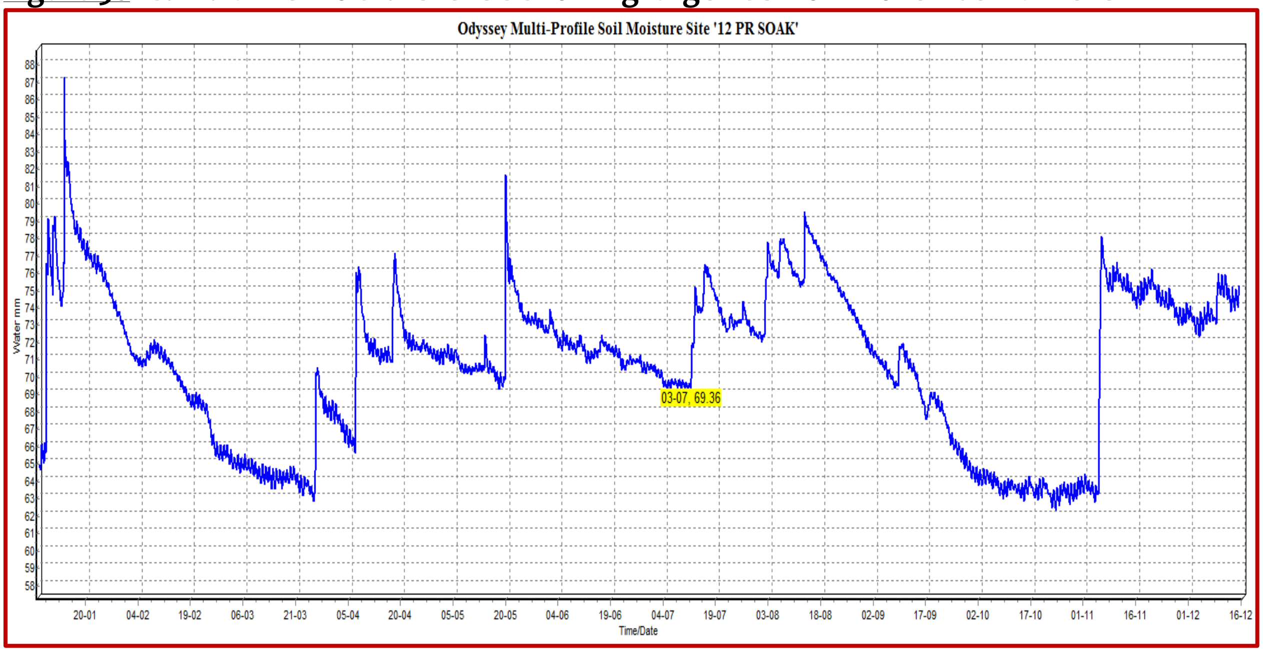


Figure 56. Cumulative moisture levels showing large rise from November rain event



2.3 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.

Trees (mainly local eucalypt species) were planted along an existing fence line on a sandy rise above a soak area. There was very poor survival rates at this site, possibly due to the dry winter and spring and poor moisture retention in this sand. While the farmer used a water cart to water these plants on numerous occasions, he found that the non-wetting nature of the sand lead to high moisture runoff. Some varieties fared better than others. Plant survival numbers were recorded in September and are presented in Table 3, showing about 53% eucalypt survival, mostly on the eastern end where the sand was not as deep or non-wetting.

If more trees can be used to replace the dead seedlings in 2016, it would require more attention to strategic watering to ensure a higher rate of plant establishment. The farmer has also requested that tree guards also be used, as many of the seedlings appeared to be killed by grazing of rabbits or more likely hares and kangaroos.

The saltbush establishment has been much better through the seep areas, possibly due to the extra soil moisture associated, and generally loamier soil types. There is still need for some replanting of dead seedlings through this site. The long grass through the rows made it difficult to find all the

Tagasaste plantings through soak areas has been reasonably successful, similar to the saltbush, but may need some replanting as well. This is despite the seedlings being slightly overgrown and woody when planted. It will be interesting to see how well these grow across the soak area.

These survival numbers will be reported on in more detail after plant counts are made at the end of summer.

2.3.1 Data collected from Arbon site

Table 3. Plant counts of each planting area

1. Large Tagastaste Trial

Variety	Tagastaste			Saltbush			Total	Notes
Condition	Dead	Alive	Thriving	Dead	Alive	Thriving	# plants	
row1	5	18	11	0	0	0	34	
row2	0	2	25	0	0	8	35	row 1 starting closest to seep and row nine
row3	5	5	15	0	1	3	29	starting to move up sandy rise
row4	2	14	17	0	0	0	33	
row5	0	13	20	0	0	4	37	
row6	6	10	18	0	0	5	39	While 252 tagasaste were accounted for at a
row7	5	10	18	0	0	0	33	survival rate of 89%, it is likely that about 100
row8	4	8	9	0	0	6	27	plants are unaccounted for. Survival may be
row9	0	7	5	0	0	4	16	more like 68%. Up to 40 saltbush could also
Totals	**27**	**87**	**138**	**0**	**1**	**30**	**283**	be unnaccounted for, but some possibly

1a. Small Tagastate Trial

Variety	Tagastaste			Saltbush			Total	Notes
Condition	Dead	Alive	Thriving	Dead	Alive	Thriving	# plants	
row1	1	3	3	0	0	0	7	
row2	2	4	9	0	0	1	16	
row3	2	7	4	0	0	2	15	Row 1 starting on the side closest to the
row4	0	4	10	0	0	2	16	eucalypt site/soak
row5	2	5	3	0	0	2	12	
row6	0	2	2	0	0	0	4	88% survival for the tagasaste although many
Totals	**7**	**25**	**31**	**0**	**0**	**7**	**70**	poor, and 100% for the saltbush

2. Saltbush Trial

Condition	Dead	Alive	Thriving	Totals	Notes
row1	0	3	10	13	sandy rise
row2	0	3	8	11	midslope sandy rise, thick grass making it
row3	0	0	2	2	difficult to find plants/ difficult to keep track of
row4	0	1	10	11	line due to grass
row5	0	1	18	19	midslope, very high grass- grass over knee
row6	0	3	15	18	high/ difficult to keep track of line due to grass
row7	0	1	11	12	difficult to keep track of line due to grass
row8	0	1	10	11	passing through soak area
row9	0	0	1	1	While 100% survival shown, up to 64% were
Totals	**0**	**13**	**85**	**98**	unaccounted for.

3. Eucaluptus Trial

Variety	Narrow Leaf			Broad Leaf			Saltbush			Total	Notes
Condition	Dead	Alive	Thriving	Dead	Alive	Thriving	Dead	Alive	Thriving	# plants	
row1	16	10	6	8	2	1	1	0	4	48	no trees from halfway down row
row2	11	13	10	7	14	4	1	0	0	60	
row3	5	6	18	15	7	10	0	0	2	63	It is unsure how many saltbush were planted
row4	8	0	20	17	12	0	0	0	1	58	amongs the trees in the area
row5	5	2	8	5	2	2				24	244 of 275 trees accounted for, 147
Totals	**45**	**31**	**62**	**52**	**37**	**17**	**2**	**0**	**7**	**253**	surviving. Approx 53% survival at Sept 2015.

2.3.2 Pictorial progress of site activities at Arbons

Figure 57. Surviving Eucalypt along fence line (July 10).

Figure 58. Rows of seedllings planted along fenceline.

Figure 59. Saltbush seedlings planted through soak area.

Figure 60. Saltbush seedlings planted through soak area.

Figure 61. Tagasaste established through soak area

Figure 62. Tagasaste survival, despite seedlings being large and woody when planted.

2.4 Bond Site, Mannum

This site has been well managed by the farmers to establish 19ha of lucerne above a soak area in 2015. Figures clearly show some excellent establishment and growth in many areas, although the numbers and growth has been much lower on the deep non-wetting sands. Table 3 shows that densities range from 18 to 46 plants /m^2. There are no areas of no lucerne establishment that are likely to cause a significant erosion threat, at this stage. It is hoped that the poorer areas will improve and thicken up in time, particularly if the plants can get their roots down into the subsoil moisture that may be contributing to the soak issues. Further monitoring will be done in the same areas post summer to assess survival levels.

This site is alongside a continuous cropping zone, and adjacent moisture probes in the mid-slope sands of each farming system should be very revealing as to whether either will be leaching moisture down the slope at particular times of the season. In 2015 the lucerne was only establishing, and it can be seen that it used far less soil moisture throughout the growing season (see moisture probe graphs Fig 85 and 86), compared to the wheat crop that drew levels right down at harvest time (see moisture probe graphs Fig 87 and 88). Since the moisture rise from November rains it is now the lucerne that is drawing the levels down, while the cereal probe is maintaining. Neither site appeared to contribute to subsoil moisture flows in 2015 at any time.

Similar to the Rose site, the piezometer readings are insignificant at this stage.

The Sulla has established well, but has proved unsuitable for deeper sands (see Figs 78, 79 & 80). It will be good to see it established on the actual salt scalded area to see it can survive well.

2.4.1 Pictorial progress of site activities at Bonds

Figure 63. Excellent wheat crop growth alongside establishing lucerne looking north

Figure 64. Excellent wheat crop growth alongside establishing lucerne, looking south

Figure 65. Monitoring lucerne establishment with farmer

Figure 66. Lucerne seedling establishment

Figure 67. Soak area showing some cover of salt tolerant grasses

Figure 68. Water table close to surface at dug-out at soak area

Figure 69. Lucerne and cereal farming systems side by side looking north up rise

Figure 70. Lucerne and cereal farming systems side by side looking south towards soak

Figure 71. Excellent lucerne establishment and growth at northern end of trial

Figure 72. Soil moisture probe in lucerne zone of the trial

Figure 73. Soil moisture probe in corresponding cereal zone of the trial

Figure 74. Fitting data logger to mid-slope piezometer

Figure 75. Poor lucerne growth near mid-slope piezometer on non-wetting deep sand

Figure 76. Reasonable plant numbers on non-wetting sand, but poor growth and patchy

Figure 77. Excellent lucerne establishment and growth on midslope sand

Figure 78. Sulla at seedling stage

Figure 79. Sulla flowering (potential for use around soaks as has salt tolerance)

Figure 80. Sulla pasture establishment showing clear non-preference for deep sand

Figure 81. Soil pit close to mid slope showing sand over clay

2.4.2 Data collected from Bond site

Table 3. Lucerne and Sulla counts (Sept 2015)

Areas	1	2	3	4	5	6
Lucerne Soil Type	top stony, some double sown	good sand	Sand Later Germ. Smaller	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	pl/m row
1	7	15	16	4	10	1
2	22	12	16	2	10	2
3	2	4	14	6	12	3
4	3	23	22	7	1	3
5	4	9	17	3	6	1
6	9	8	7	15	9	6
7	10	15	7	4	5	0
8	23	16	16	6	4	0
9	4	8	16	19	7	0
10	26	4	21	6	5	1
11	4	9	21	13	2	0
12	0	15	5	4	10	4
13	4	7	8	0	6	4
14	24	4	12	1	2	2
15	17	4	13	4	7	2
16	10	12	8	22	2	5
17	5	9	9	11	5	3
18	9	5	10	5	0	4
19	6	12	27	8	2	2
20	16	10	14	9	7	4
Ave pl/m row	10.3	10.1	14.0	7.5	5.6	2.4
Ave Pl/m2	34.2	33.5	46.5	24.8	18.7	7.8

Figure 82. Piezometer readings from soak area.

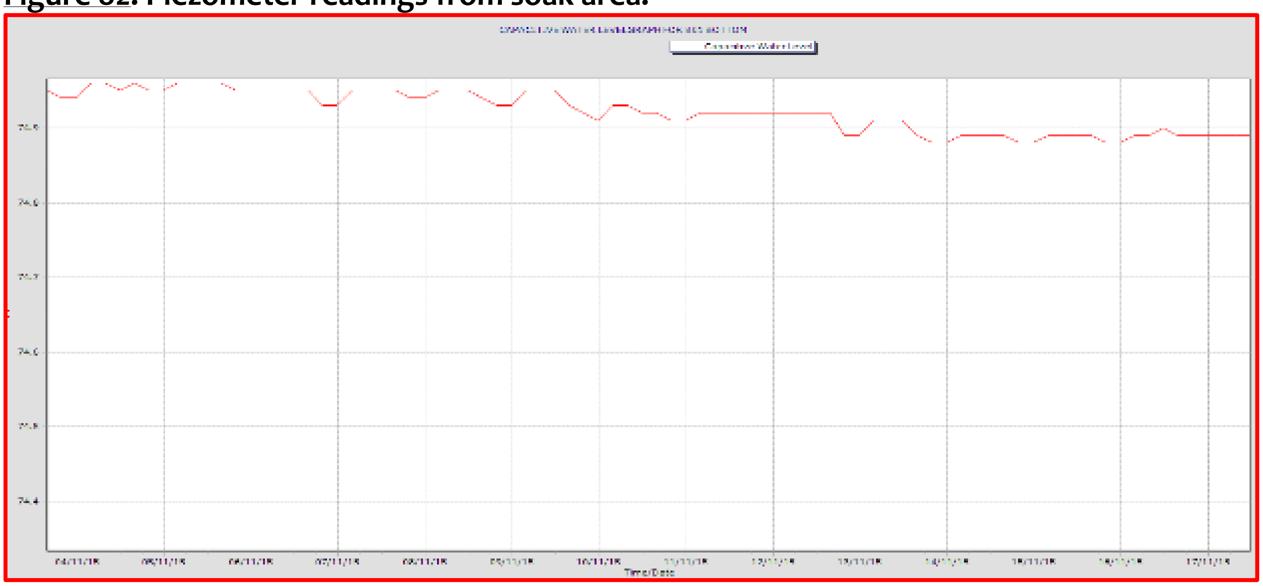


Figure 83. Piezometer readings from mid-slope sand area

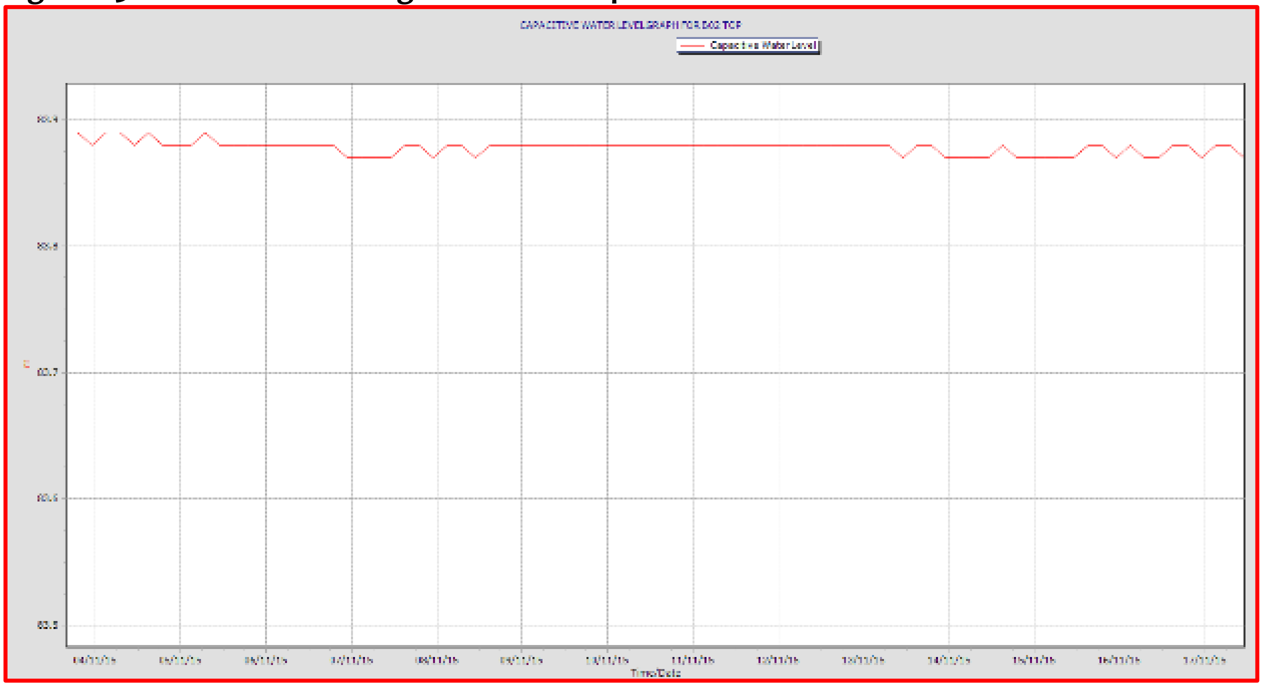


Figure 84. Rainfall data from Bonds paddock

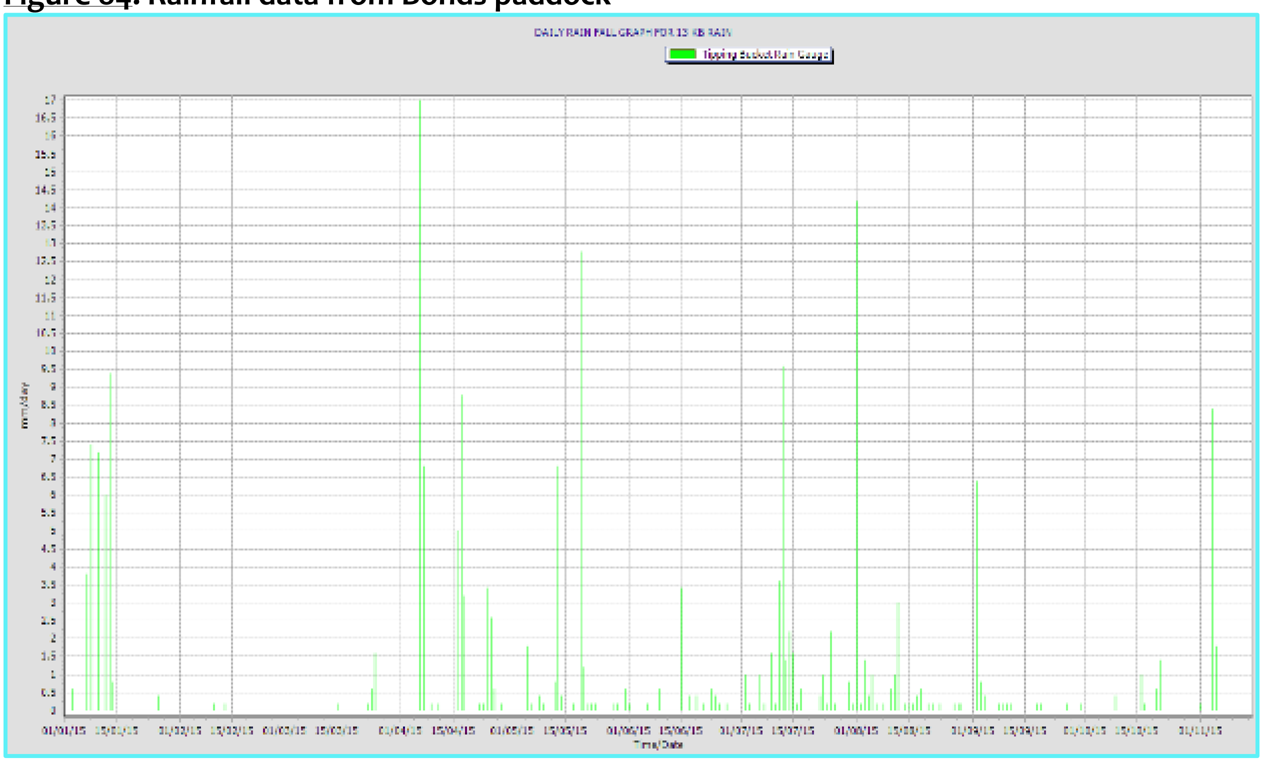


Figure 85. Soil moisture probe data from lucerne mid-slope area

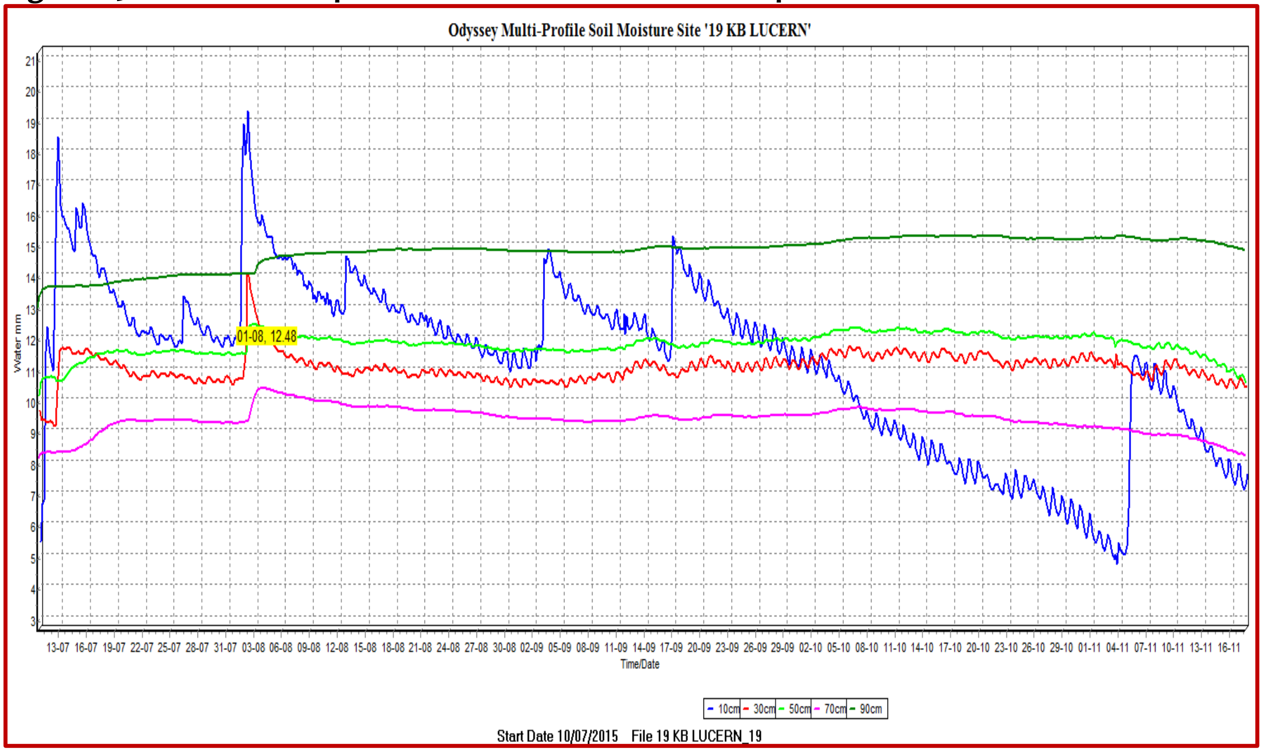


Figure 86. Summed moisture from lucerne area

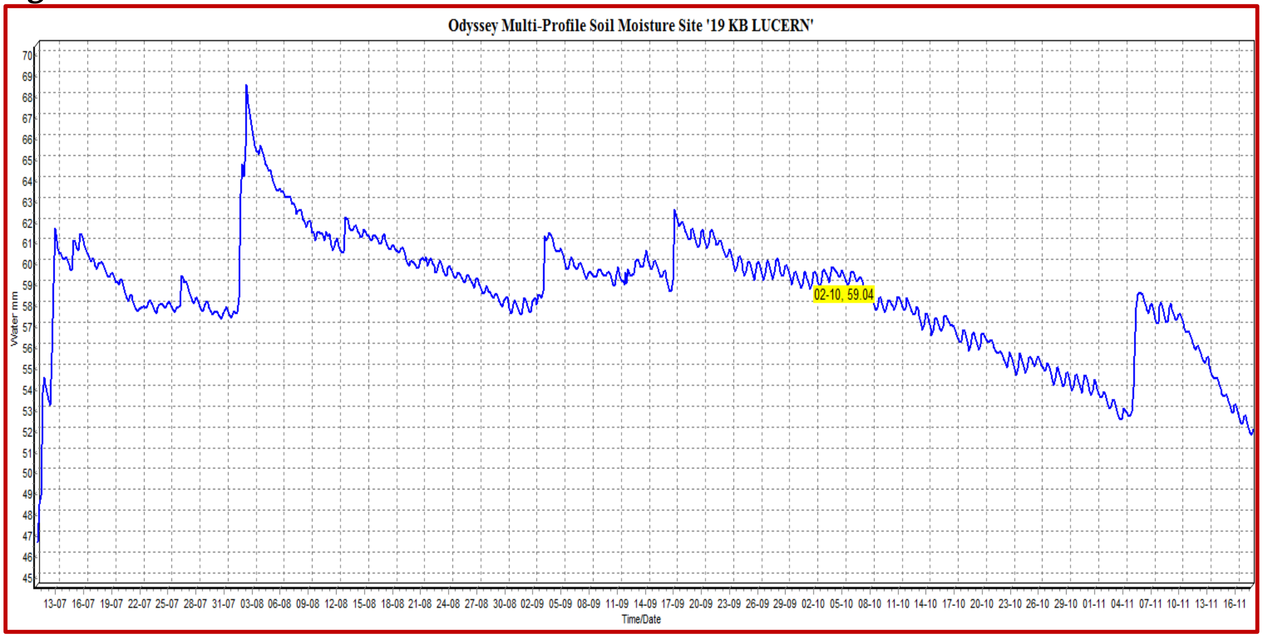


Figure 87. Soil moisture probe data from wheat crop mid-slope area

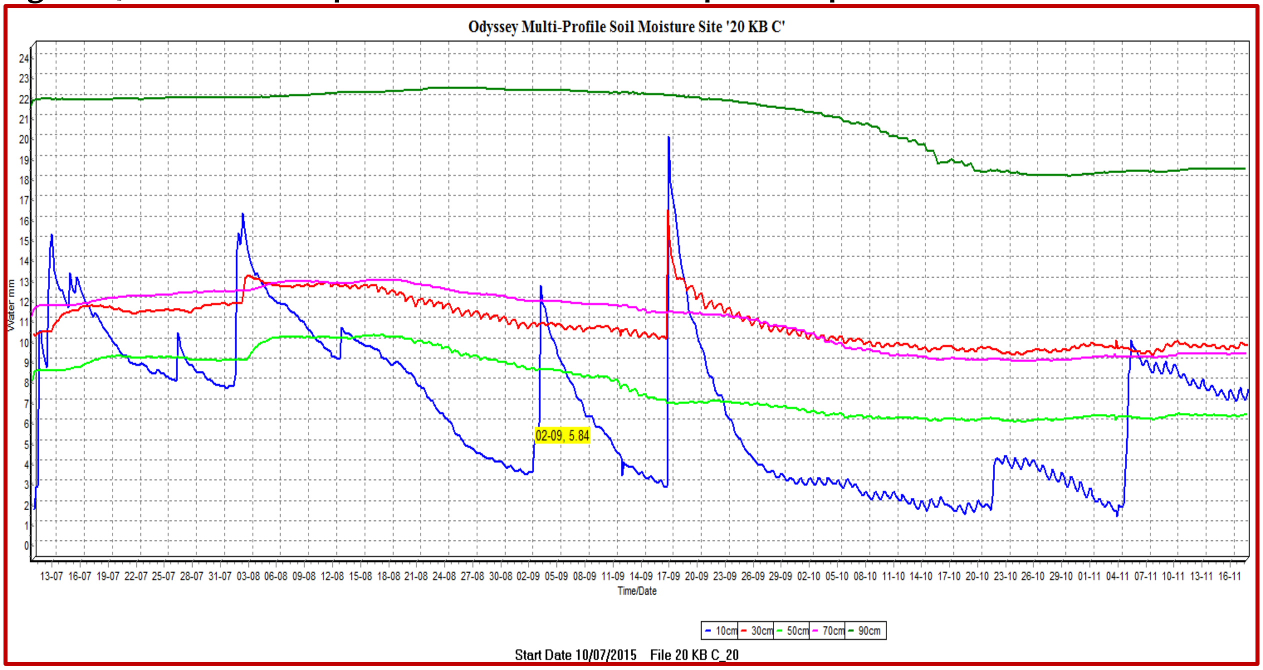


Figure 88. Summed moisture from cereal area