VIABLE AGRICULTURE LTD
ENVIRONMENTALLY SUSTAINABLE GROWTH

MEASUREMENT OF SOIL NUTRIENTS UNDER GREEN FEED CROPS IN AN INTENSIVE DAIRY SUPPORT OPERATION

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SENTEK Soil Moisture Probes

Sentek probes use a type of capacitance technology – “Frequency Domain Reflectometry”.

All probes read soil moisture, soil temperature and Volumetric Ion Content (VIC).

Advantages

- Minimal soil disturbance – no holes or trenches need to be dug.
- Slim and tapered design allows for a very tight fit – only minimal slurry required in stony soils to seal.
- Can measure whole depth of the profile – every sensor reads a 10cm slice and sensors are placed every 10cm.
- Available in various lengths to suit crop and situation.
- Web software to view and analysis data is the best on the market.
- VIC measurement allows tracking of changes in the concentration of nutrient salts in the soil solution down the soil profile.

Background

- Preliminary investigations of hand dug pits down to 600 mm were completed in the spring of cropping season 2013-14.
- A series of deep soil inspection pits was excavated with a hydraulic digger to enable accurate appraisal of rooting depth of a fodder beet crop at Stonehaven near Mayfield in Mid Canterbury.

This information was required to inform irrigation and nutrient management decisions.

Fodder beet rooting depth

In the following season the fodder beet site was sown to green feed kale

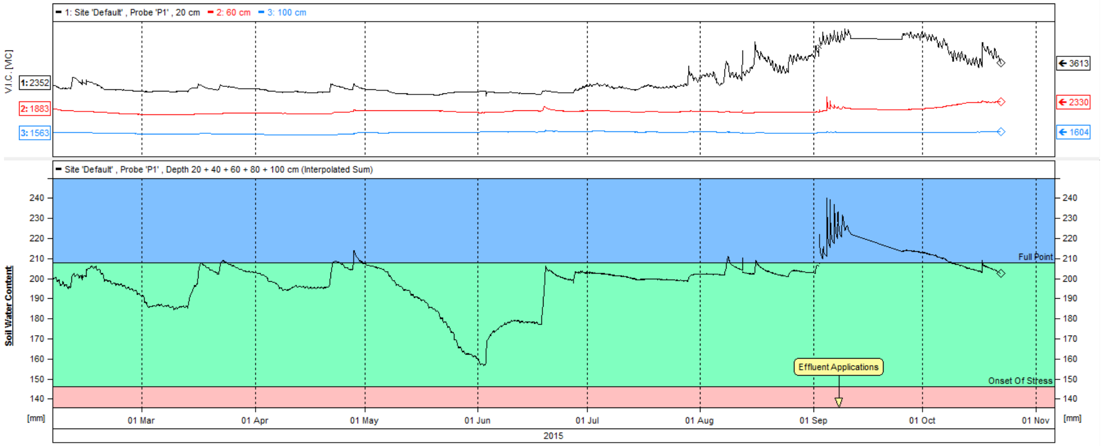
Effluent Analysis Report

1. At the completion of the grazing of the kale, in the spring of 2015, an earth bund of approximately $1m^2$ in area was constructed to encompass the Sentek probe.
2. Barn liquor was then loaded in to the bunded area around the Sentek probe at a rate of 60 litres/day for 8 days.
3. Nitrogen applied as effluent was calculated to be equivalent to 2544 kg/ha.

Sample Type: Aqueous						
Sample Name:		Keeley 02-Sep-2015 5:00 pm				
Lab Number:		1471230.1				
Farm Effluent Samples						
Total Nitrogen*	kg/m³	0.53	-	-	-	-
Total Phosphorus*	kg/m³	0.065	-	-	-	-
Total Potassium*	kg/m³	0.26	-	-	-	-
Total Calcium*	kg/m³	0.154	-	-	-	-
Total Magnesium*	kg/m³	0.041	-	-	-	-
Total Sodium*	kg/m³	0.040	-	-	-	-
Total Sulphur*	kg/m³	< 0.3	-	-	-	-
NPK applied for a 10 mm application depth						
Nitrogen applied*	kg/ha	53	-	-	-	-
Phosphorus applied*	kg/ha	6.5	-	-	-	-
Potassium applied*	kg/ha	26	-	-	-	-
NPK applied for a 20 mm application depth						
Nitrogen applied*	kg/ha	105	-	-	-	-
Phosphorus applied*	kg/ha	13.1	-	-	-	-
Potassium applied*	kg/ha	52	-	-	-	-

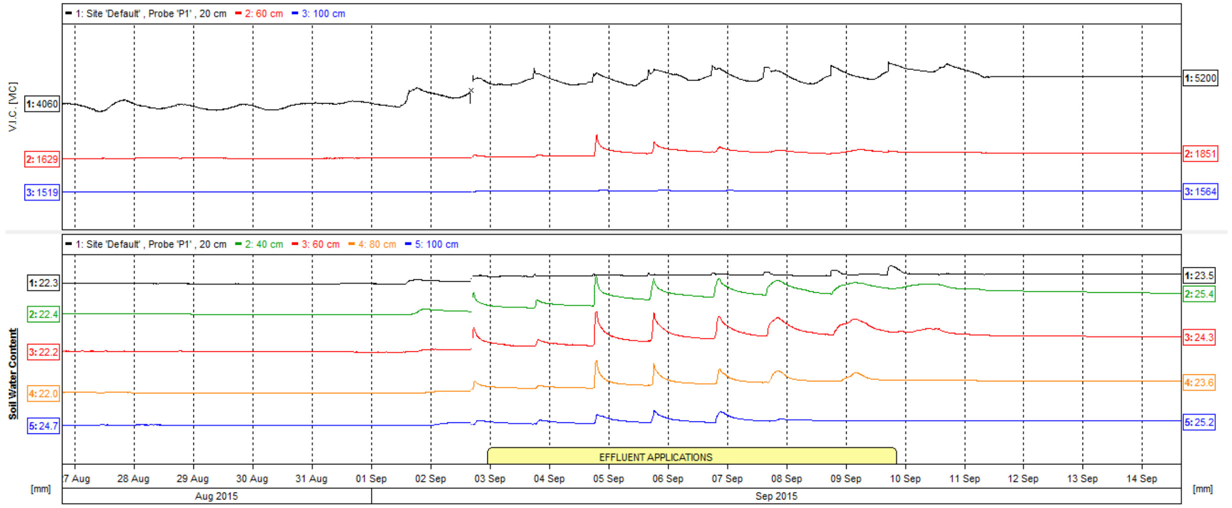
Results

- The Sentek probe showed that VIC did not fluctuate significantly below 600 mm depth and remained static at 1000 mm depth.
- However, during infrequent/significant rainfall events, soil moisture was on one occasion seen to be draining through the profile beyond the 1000 mm depth of the probe in the third week of June.
- The following graphs from the probe show the changes in VIC and soil moisture at different depths down the profile.

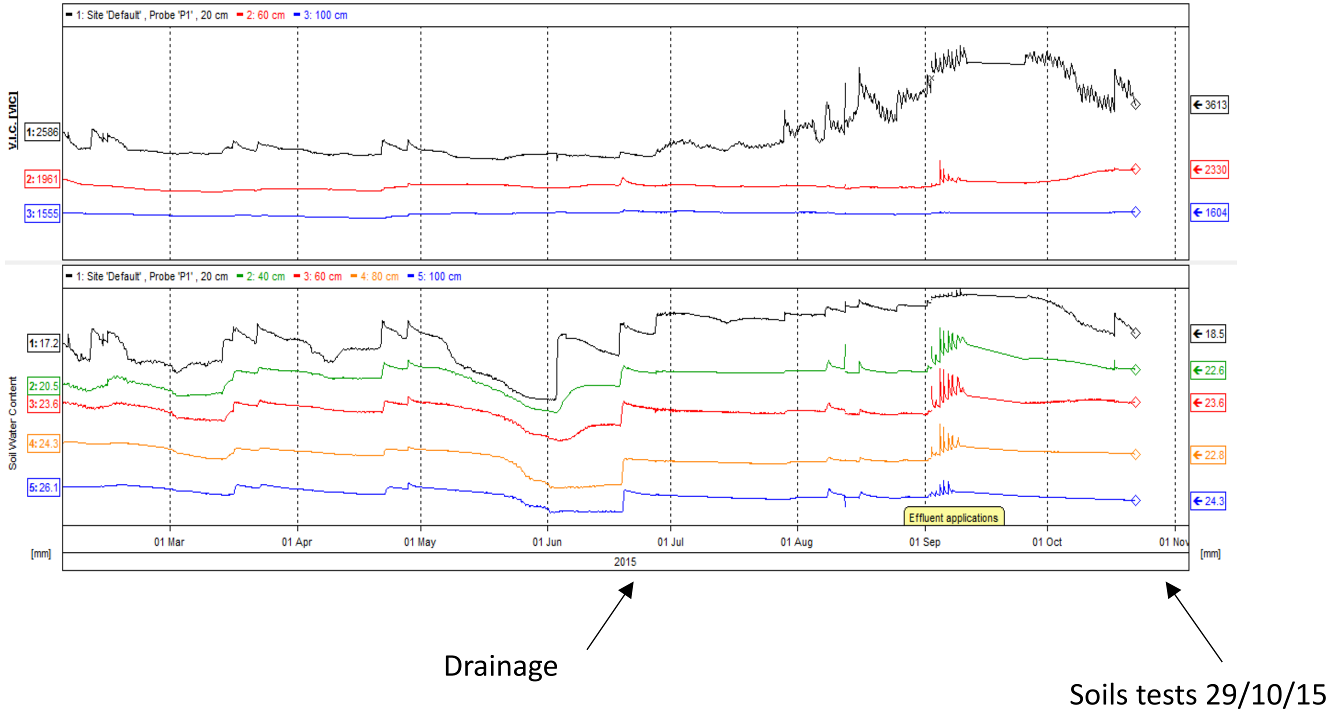


March to November VIC & SMC combined totals with AWC in green band.

VIC at 3 depths & SMC at 5 depths with daily effluent applications.



VIC depths with SMC at 5 depths March to November 2015



Inspection of another deep pit

- The kale crop had roots visible down to 1700 mm depth in February (canopy climax)
- The Sentek probe again recorded very small and infrequent soil moisture drainage events.
- Again, no evidence of nutrient movement below 1000 mm was recorded by the Sentek probe.
- Concurrent analysis of soil samples at the 1500 – 1800 mm depth gave very low levels of all plant nutrients under the actively growing crop prior to winter grazing.

Deep pit soil test results

Sample Name: Pdk #1 G/F Kale **Lab Number:** 1426186.2
Sample Type: SOIL General, Horticulture (S9)

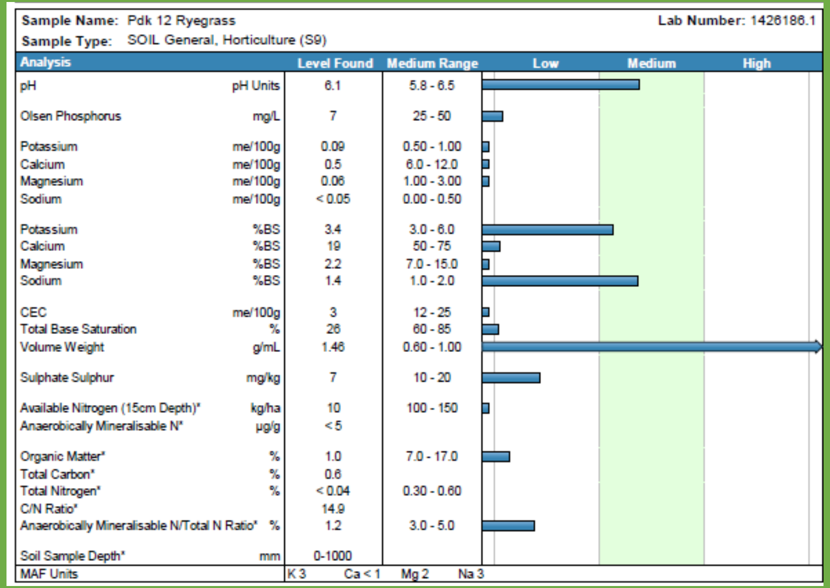
Analysis		Level Found	Medium Range	Low	Medium	High
pH	pH Units	6.0	5.8 - 6.5			
Olsen Phosphorus	mg/L	7	25 - 50			
Potassium	me/100g	0.05	0.50 - 1.00			
Calcium	me/100g	0.6	6.0 - 12.0			
Magnesium	me/100g	0.07	1.00 - 3.00			
Sodium	me/100g	< 0.05	0.00 - 0.50			
Potassium	%BS	1.7	3.0 - 6.0			
Calcium	%BS	19	50 - 75			
Magnesium	%BS	2.2	7.0 - 15.0			
Sodium	%BS	1.0	1.0 - 2.0			
CEC	me/100g	3	12 - 25			
Total Base Saturation	%	24	60 - 85			
Volume Weight	g/mL	1.47	0.60 - 1.00			
Sulphate Sulphur	mg/kg	3	10 - 20			
Available Nitrogen (15cm Depth)*	kg/ha	< 10	100 - 150			
Anaerobically Mineralisable N*	µg/g	< 5				
Organic Matter*	%	0.9	7.0 - 17.0			
Total Carbon*	%	0.5				
Total Nitrogen*	%	0.05	0.30 - 0.60			
C/N Ratio*		10.4				
Anaerobically Mineralisable N/Total N Ratio*	%	< 0.5	3.0 - 5.0			
Soil Sample Depth*	mm	0-1000				
MAF Units		K 2 Ca 1	Mg 2 Na 2			

An additional series of deep inspection pits were also excavated

throughout the wider Mid Canterbury area in February 2015.

This was completed so comparisons were able to be made across a range of soil types and sites under various crops.

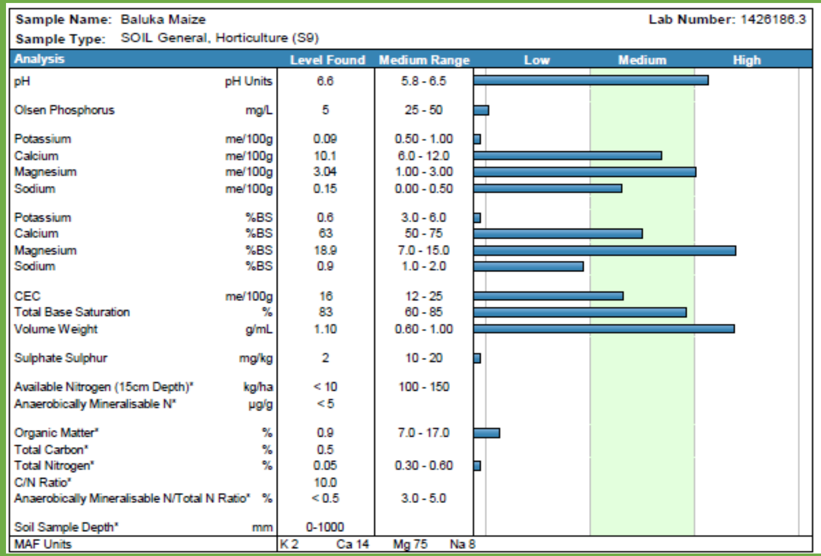
This included process potatoes, process carrots, forage maize, grazed ryegrass aftermath at Stonehaven, and also the green feed kale discussed earlier on.



Sample Name: Pdk 12 Ryegrass — Lab Number: 1426186.1
Sample Type: SOIL General, Horticulture (S9)

Analysis	Units	Level Found	Medium Range
pH	pH Units	6.1	5.8 - 6.5
Olsen Phosphorus	mg/L	7	25 - 50
Potassium	me/100g	0.09	0.50 - 1.00
Calcium	me/100g	0.5	6.0 - 12.0
Magnesium	me/100g	0.06	1.00 - 3.00
Sodium	me/100g	< 0.05	0.00 - 0.50
Potassium	%BS	3.4	3.0 - 6.0
Calcium	%BS	19	50 - 75
Magnesium	%BS	2.2	7.0 - 15.0
Sodium	%BS	1.4	1.0 - 2.0
CEC	me/100g	3	12 - 25
Total Base Saturation	%	26	60 - 85
Volume Weight	g/mL	1.46	0.60 - 1.00
Sulphate Sulphur	mg/kg	7	10 - 20
Available Nitrogen (15cm Depth)*	kg/ha	10	100 - 150
Anaerobically Mineralisable N*	µg/g	< 5	
Organic Matter*	%	1.0	7.0 - 17.0
Total Carbon*	%	0.6	
Total Nitrogen*	%	< 0.04	0.30 - 0.60
C/N Ratio*		14.9	
Anaerobically Mineralisable N/Total N Ratio*	%	1.2	3.0 - 5.0
Soil Sample Depth*	mm	0-1000	
MAF Units		K 3 Ca < 1 Mg 2 Na 3	

Deep pit soil tests results from a rye grass paddock (opposite the kale paddock)



Sample Name: Baluka Maize — Lab Number: 1426186.3
Sample Type: SOIL General, Horticulture (S9)

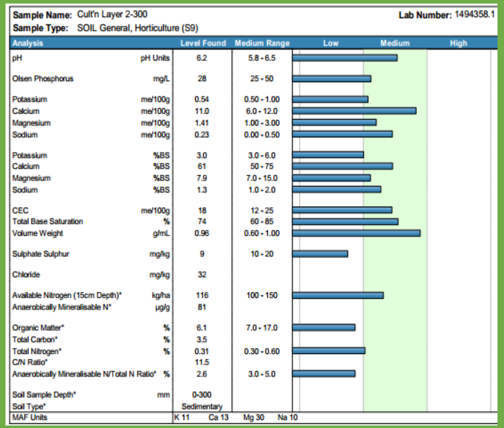
Analysis	Units	Level Found	Medium Range
pH	pH Units	6.6	5.8 - 6.5
Olsen Phosphorus	mg/L	5	25 - 50
Potassium	me/100g	0.09	0.50 - 1.00
Calcium	me/100g	10.1	6.0 - 12.0
Magnesium	me/100g	3.04	1.00 - 3.00
Sodium	me/100g	0.15	0.00 - 0.50
Potassium	%BS	0.6	3.0 - 6.0
Calcium	%BS	63	50 - 75
Magnesium	%BS	18.9	7.0 - 15.0
Sodium	%BS	0.9	1.0 - 2.0
CEC	me/100g	16	12 - 25
Total Base Saturation	%	83	60 - 85
Volume Weight	g/mL	1.10	0.60 - 1.00
Sulphate Sulphur	mg/kg	2	10 - 20
Available Nitrogen (15cm Depth)*	kg/ha	< 10	100 - 150
Anaerobically Mineralisable N*	µg/g	< 5	
Organic Matter*	%	0.9	7.0 - 17.0
Total Carbon*	%	0.5	
Total Nitrogen*	%	0.05	0.30 - 0.60
C/N Ratio*		10.0	
Anaerobically Mineralisable N/Total N Ratio*	%	< 0.5	3.0 - 5.0
Soil Sample Depth*	mm	0-1000	
MAF Units		K 2 Ca 14 Mg 75 Na 8	

Deep pit soil test results from a maize paddock (different location from the kale and ryegrass)

- The Sentek probe was excavated and removed from the site in late October prior to spring cultivation operations.
- This was 4 weeks after the effluent drainage had ceased to register on the Sentek probe.
- At this time another set of soil samples were taken from three separate horizons down the profile within the column of soil visible to the probe.

Sampling site below the probe showing sandy soil texture

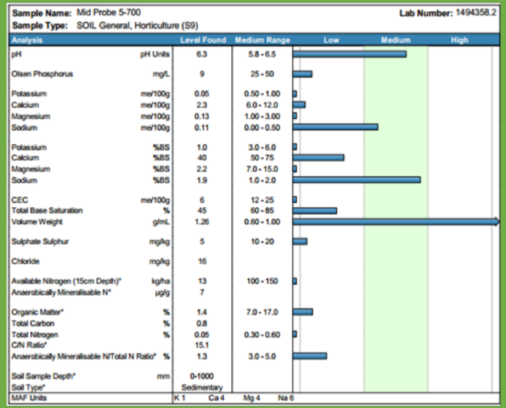
Sampling site



Sample Name: Cult'n Layer 2-300 **Lab Number:** 1494358.1
Sample Type: SOIL General, Horticulture (S9)

Analysis		Level Found	Medium Range
pH	pH Units	6.2	5.8 - 6.5
Olsen Phosphorus	mg/L	28	25 - 50
Potassium	me/100g	0.54	0.50 - 1.00
Calcium	me/100g	11.0	6.0 - 12.0
Magnesium	me/100g	1.41	1.00 - 3.00
Sodium	me/100g	0.23	0.00 - 0.50
Potassium	%BS	3.0	3.0 - 6.0
Calcium	%BS	61	50 - 75
Magnesium	%BS	7.9	7.0 - 15.0
Sodium	%BS	1.3	1.0 - 2.0
CEC	me/100g	18	12 - 25
Total Base Saturation	%	74	60 - 85
Volume Weight	g/mL	0.96	0.60 - 1.00
Sulphate Sulphur	mg/kg	9	10 - 20
Chloride	mg/kg	32	
Available Nitrogen (15cm Depth)*	kg/ha	116	100 - 150
Anaerobically Mineralisable N*	µg/g	81	
Organic Matter*	%	6.1	7.0 - 17.0
Total Carbon*	%	3.5	
Total Nitrogen*	%	0.31	0.30 - 0.60
C/N Ratio*		11.5	
Anaerobically Mineralisable N/Total N Ratio*	%	2.6	3.0 - 5.0
Soil Sample Depth*	mm	0-300	
Soil Type*		Sedimentary	
MAF Units		K 11 Ca 13 Mg 30 Na 10	

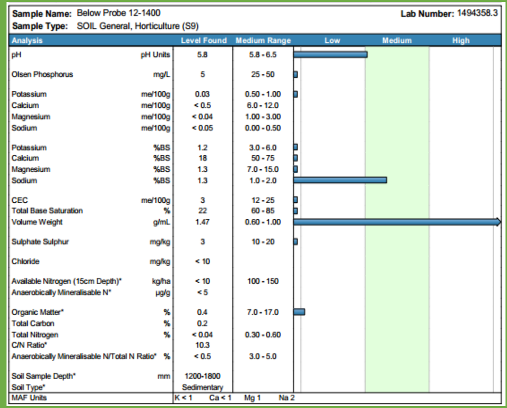
Soil test results cultivated layer within bund under effluent after cessation of drainage.



Sample Name: Mid Probe 5-700 **Lab Number:** 1494358.2
Sample Type: SOIL General, Horticulture (S9)

Analysis		Level Found	Medium Range
pH	pH Units	6.3	5.8 - 6.5
Olsen Phosphorus	mg/L	9	25 - 50
Potassium	me/100g	0.05	0.50 - 1.00
Calcium	me/100g	2.3	6.0 - 12.0
Magnesium	me/100g	0.13	1.00 - 3.00
Sodium	me/100g	0.11	0.00 - 0.50
Potassium	%BS	1.0	3.0 - 6.0
Calcium	%BS	40	50 - 75
Magnesium	%BS	2.2	7.0 - 15.0
Sodium	%BS	1.9	1.0 - 2.0
CEC	me/100g	6	12 - 25
Total Base Saturation	%	45	60 - 85
Volume Weight	g/mL	1.26	0.60 - 1.00
Sulphate Sulphur	mg/kg	5	10 - 20
Chloride	mg/kg	16	
Available Nitrogen (15cm Depth)*	kg/ha	13	100 - 150
Anaerobically Mineralisable N*	µg/g	7	
Organic Matter*	%	1.4	7.0 - 17.0
Total Carbon	%	0.8	
Total Nitrogen	%	0.05	0.30 - 0.60
C/N Ratio*		15.1	
Anaerobically Mineralisable N/Total N Ratio*	%	1.3	3.0 - 5.0
Soil Sample Depth*	mm	0-1000	
Soil Type*		Sedimentary	
MAF Units		K 1 Ca 4 Mg 4 Na 6	

Soil test results mid probe after effluent drainage.



Sample Name: Below Probe 12-1400 **Lab Number:** 1494358.3
Sample Type: SOIL General, Horticulture (S9)

Analysis		Level Found	Medium Range
pH	pH Units	5.8	5.8 - 6.5
Olsen Phosphorus	mg/L	5	25 - 50
Potassium	me/100g	0.03	0.50 - 1.00
Calcium	me/100g	< 0.5	6.0 - 12.0
Magnesium	me/100g	< 0.04	1.00 - 3.00
Sodium	me/100g	< 0.05	0.00 - 0.50
Potassium	%BS	1.2	3.0 - 6.0
Calcium	%BS	18	50 - 75
Magnesium	%BS	1.3	7.0 - 15.0
Sodium	%BS	1.3	1.0 - 2.0
CEC	me/100g	3	12 - 25
Total Base Saturation	%	22	60 - 85
Volume Weight	g/mL	1.47	0.60 - 1.00
Sulphate Sulphur	mg/kg	3	10 - 20
Chloride	mg/kg	< 10	
Available Nitrogen (15cm Depth)*	kg/ha	< 10	100 - 150
Anaerobically Mineralisable N*	µg/g	< 5	
Organic Matter*	%	0.4	7.0 - 17.0
Total Carbon	%	0.2	
Total Nitrogen	%	< 0.04	0.30 - 0.60
C/N Ratio*		10.3	
Anaerobically Mineralisable N/Total N Ratio*	%	< 0.5	3.0 - 5.0
Soil Sample Depth*	mm	1200-1800	
Soil Type*		Sedimentary	
MAF Units		K < 1 Ca < 1 Mg 1 Na 2	

Soil test results below probe after cessation of effluent drainage.

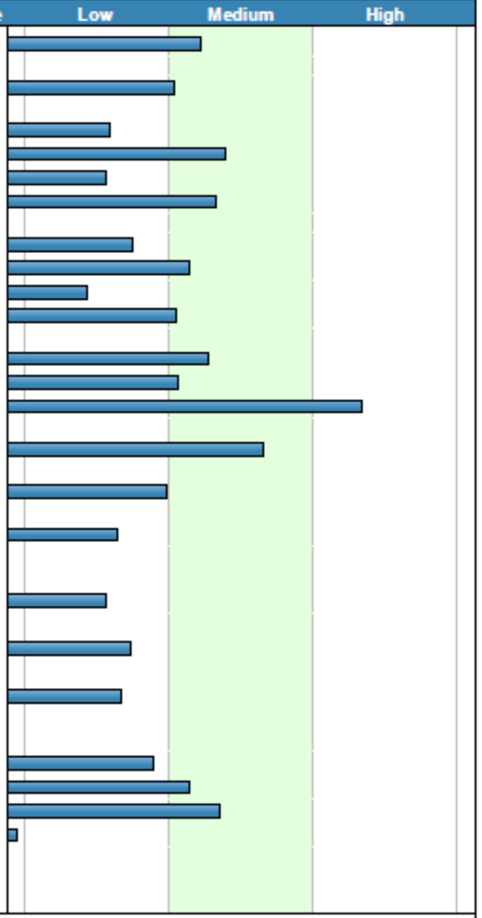
A normal whole paddock test was also taken.

Sample Name: NP#1 G/F Kale

Lab Number: 1496662.1

Sample Type: SOIL General, Horticulture (S9)

Analysis		Level Found	Medium Range
pH	pH Units	6.0	5.8 - 6.5
Olsen Phosphorus	mg/L	26	25 - 50
Potassium	me/100g	0.40	0.50 - 1.00
Calcium	me/100g	8.3	6.0 - 12.0
Magnesium	me/100g	0.69	1.00 - 3.00
Sodium	me/100g	0.16	0.00 - 0.50
Potassium	%BS	2.5	3.0 - 6.0
Calcium	%BS	54	50 - 75
Magnesium	%BS	4.4	7.0 - 15.0
Sodium	%BS	1.1	1.0 - 2.0
CEC	me/100g	16	12 - 25
Total Base Saturation	%	62	60 - 85
Volume Weight	g/mL	1.08	0.60 - 1.00
Sulphate Sulphur	mg/kg	17	10 - 20
Boron	mg/kg	1.0	1.0 - 2.0
Available Nitrogen (15cm Depth)*	kg/ha	82	100 - 150
Anaerobically Mineralisable N*	µg/g	51	
Organic Matter*	%	3.9	7.0 - 17.0
Total Carbon*	%	2.3	
Total Nitrogen*	%	0.25	0.30 - 0.60
C/N Ratio*		9.2	
Anaerobically Mineralisable N/Total N Ratio*	%	2.0	3.0 - 5.0
Iron	mg/kg	226	
Manganese	mg/kg	44	50 - 400
Zinc	mg/kg	3.1	2.0 - 10.0
Copper	mg/kg	2.4	1.0 - 5.0
Cobalt	mg/kg	0.6	2.0 - 4.0
Soil Sample Depth*	mm	0-300	
Soil Type*		Sedimentary	
MAF Units		K 9 Ca 11	Mg 17 Na 8



Outcomes

- This investigation has been able to obtain hard data on what is actually visible under the crops and soils in question.
- This provides verification of the information generated by the Sentek probe using strategic soil testing at depth down the profile in close proximity to the probe within the soil column of the profile that is being measured.

Conclusion

Laboratory analyses of soil samples from this site have clearly demonstrated that the nutrients remaining in the grazed aftermath of the second consecutive green feed crop (kale following beet); as well as the additional barn effluent applied; was contained well within the root zone of the crop after drainage. Such nutrient is thus potentially available to be utilised by current and subsequent crops. Furthermore, additional deployment of objective actual measurement by Sentek probe and accurate soil testing is highly likely to affirm that appropriate nutrient management strategies can thus be employed to mitigate any actual, or perceived, risk of nutrient losses to ground water in such locally typical scenarios. This approach also has the added advantage of giving growers the confidence to work to increase the yield potential of the crops they grow, knowing that robust technology is available to them to demonstrate that they can measure the NUE and WUE of the cropping systems they choose to employ, and hence provide objective proof of good practice and environmental stewardship.