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TECHNOLOGIES FOR IMPROVING NUTRIENT AND WATER USE EFFICIENCY

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New Zealand agriculture and the technology we use within it to make farming easier, more accurate and more profitable is evolving at a fast pace, both in the technology itself and also how we adapt and use it on farm. Of high importance currently are tools that help improve nutrient and water use efficiency. Some of these tools are:

- Electro-magnetic (EM) surveying
- Variable Rate Irrigation
- Soil moisture probes

These tools and Precision Agriculture (PA) management techniques can be inter-linked to provide a very strong on-farm understanding of the current state of nutrient and water use. They can then be used as a platform to implement further fine tuning to boost nutrient and water use efficiency.

Nutrient waste costs the farmer at many stages; Production or purchase of the nutrients, application, direct waste (runoff or application in non-productive areas) and consequences such as fines when dairy effluent is not applied correctly. Therefore, it is only logical that to improve profitability, the clued up farmer would want to ensure that they are doing all they can to get the best bang for their buck. This means getting the maximum production from anything they apply, and seeing as little go to waste as possible. In other words, it's a win-win for the bank balance and the environment.

EM Surveying provides a method to map and measure the conductivity of the soil, which in NZ strongly correlates to texture and water-holding capacity. When the survey is completed accurately it can be then used to create a water-holding capacity map which can then be used for scheduling irrigation, in particular with variable rate irrigation.

An EM survey is primarily completed (in NZ) using a device known as a DualEM. It provides a range of measured attributes from each survey which can then be post–processed into a wide range of different maps including soil variability, elevation, slope, and watershed modelling using GIS software.

Using a combination of these tools, it is quite simple and quick to spatially quantify soils under an irrigator with different characteristics, ground truth using a neutron probe and calculate AWC. Using this map as a template, different management zones can be created so that varying depths of irrigation can be applied using VRI. The key is knowing how much water to apply in each zone and when. This is achieved using soil moisture probes calibrated to the soil type they are in so that you can track in almost real-time when different soils are reaching refill point, then after a rain or irrigation event, how much Plant Available Water (PAW) is in the soil and whether more irrigation is needed, whether the soil moisture is sitting well, or if a drainage even has occurred.

EXAMPLE: EM MAPPING FOR IRRIGATION MANAGEMENT ON GREENVALE FARM, METHVEN

	Full Point (mm)	**Stress Point (mm)**	**2012 Wheat Yield (t/ha)**	**EM 0.75m (ms/m)**	**EM 1.5m (ms/m)**	**Zone Area (ha)**
Site 1	187	139.5	17.56	4.84	10.95	0.6
Site 2	233	178	12.31	9.28	16.30	3.0
Site 3	228	178	13.26	8.18	15.02	5.4
Site 4	232	178	15.58	7.85	14.71	7.2
Site 5	181	134	16.48	5.18	12.52	3.6
Site 6	106	70	10.00	3.80	10.32	0.6

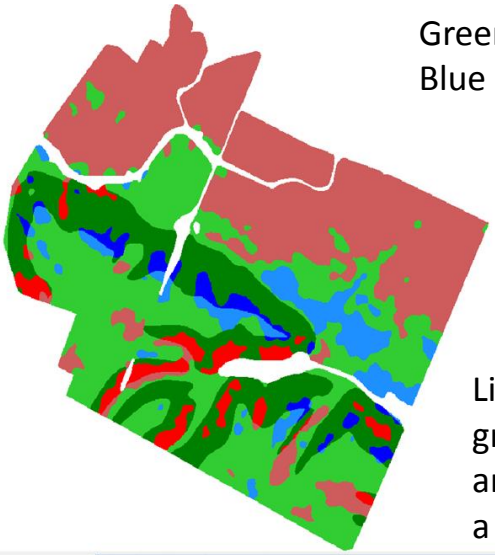
- Sites 1, 4 and 5 had highest yields in 2012
- Anticipated that sites 2 and 3 would have highest yield due to heaviest soils
- Over-watering occurred causing a yield penalty
- Loss of yield 3.71t/ha or **$593/ha** when averaged across the whole field
- VARIABLE RATE Irrigation was applied in 2012 after this trial!!
- Following season saved **12 litre/sec** average by VRI using the **EM map**, eliminating overwatering reduced yield variability.

As seen in the example above, Prior to adopting Variable Rate Irrigation, an EM survey was conducted on this farm and it was found that due to overwatering certain areas, yield loss alone due to over-watering certain soil zones amounted to an average penalty of $593/ha when averaged across the whole field. This doesn't even account for the nutrients lost due to leaching or runoff in the over-watered areas.

The following season, water savings were made, yield variability decreased, and it stands to reason that less nutrient was wasted.

EM AND SLOPES

A concept that is currently being trialled in New Zealand is the use of elevation data to calculate slope, intersected with EM data. On farmland where runoff is significant, the resulting map can be used to further refine VRI application to match infiltration rates to slopes to avoid excess runoff as well as not over-water the areas at the bottom of slopes where any runoff ends up.



Red= low EM
Green = Medium
Blue = High EM

Light red, green & blue are zones with a gentle slope.

	Zone			Zone Name	Area (ha)	
123	1	1 (19.93)	1 (3.65)	L EM / L Slope	37.8	
123	2	1 (19.93)	2 (20.90)	L EM / H Slope	4.2	
123	3	2 (28.90)	1 (3.65)	M EM / L Slope	33.2	
123	4	2 (28.90)	2 (20.90)	M EM / H Slope	17.7	
123	5	3 (40.19)	1 (3.65)	H EM / L Slope	6.5	
123	6	3 (40.19)	2 (20.90)	H EM / H Slope	2.4	

METHVEN DAIRY FARM IN OVERSEER

Blocks entered in Overseer per management group			Estimated N Leached / Ha			
	AREA	% OF AREA	VV	FV	VF	FF
Block 1 -Paddocks 1-4	39	18%	39	43	58	142
Block 2 -Paddocks 5-8	38	17%	39	43	58	141
Block 3 -Liquid Effluent Paddocks	85	39%	48	53	68	154
Block 4 -Non-Liquid Effluent Corners	57	26%	39	43	58	141
Total	219	100%	42	47	62	146

Blocks entered in Overseer & managed per EM soil Map			Estimated N Leached / Ha			
	AREA	% OF AREA	EM, $V_{return}V_{depth}$	EM, $F_{return}V_{depth}$	EM, $V_{return}F_{depth}$	EM, $F_{return}F_{depth}$
Block 1(a) Paddocks 1-4 (Eyre)	29	13%	39	43	58	142
Block 1(b) Paddocks 1-4 (Mayfield)	10	5%	24	24	26	67
Block 2(a) Paddocks 5-8 (Eyre)	24	11%	39	43	58	141
Block 2(b) Paddocks 5-8 (Mayfield)	14	6%	23	22	24	65
Block 3(a) Liquid Effluent Paddocks (Eyre)	49	22%	48	53	68	154
Block 3(b) Liquid Effluent Paddocks (Mayfield)	36	16%	32	31	33	76
Block 4(a) Non-Liquid Effluent Corners (Eyre)	37	17%	39	43	58	141
Block 4(b) Non-Liquid Effluent Corners (Mayfield)	20	9%	24	24	26	67
Total	219	100%	37	39	50	118

This table created IN 2015 from Will Meads' findings in a study on EM and Overseer gives us a high level view of how Overseer's outputs can change if you refine the information that you feed into it with farm management based on the findings of a ground-truthed EM Map.

The top table shows the output of Overseer's estimated N leaching per Ha under the four defined irrigation types available.

If we EM map the soil and then ground truth the findings of the EM survey using a neutron probe, we can classify the soils with greater resolution and manage accordingly. If we then split these into different management blocks and feed the inputs into Overseer, the N leached under the different soil types becomes quite a different story. For example, using an FV irrigation system (Fixed Return, Variable Depth), Estimated N leached drops from 47kg/Ha to 39 kg/Ha.

Currently trials on this farm and others using lysimeters are backing up the hypothesis that using these Precision Ag techniques, leaching is being reduced, money on fertiliser and irrigation is being saved and yields are improving.

In NZ we are only scratching the surface with the adoption and use of these tools. Precision Agriculture techniques and technologies are providing an effective way to map, measure and manage more precisely the way in which we farm to ensure that the use of water and nutrients is maximised to increase farm efficiency and help maximise productivity from current input levels while reducing environmental risks. Precision Ag can easily be incorporated into Farm Environment Plans and Overseer modelling by using the information gathered to break the farm into different management areas and inputs varied accordingly to help improve farm management. Ultimately this helps to provide incentive to increase water and nutrient use efficiency for all of NZ agriculture.