IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the hearing of submissions on Proposed Land and Water Regional Plan
BY	**Ravensdown Fertiliser Co-Operative Ltd.**
	<u>Submitter</u>
TO	**Environment Canterbury**
	<u>Local authority</u>

BRIEF OF EVIDENCE OF ANTONY HUGH COLEBY ROBERTS ON BEHALF OF RAVENSDOWN FERTILISER CO-OPERATIVE LTD.

Dated: 12 October 2012

INTRODUCTION

Qualfications and experience

1. My name is Dr Antony Hugh Coleby Roberts. I am the Chief Scientific Officer for Ravensdown Fertiliser Co-Operative Ltd. I have a Bachelor of Agricultural Science degree (1st Class Honours) and a Doctor of Philosophy degree in Soil Science, both from Massey University. I obtained a Certificate of Completion for the Massey University Sustainable Nutrient Management in New Zealand Agriculture course in 2004 and one for Advanced Sustainable Nutrient Management in 2006. I am a Fellow of the New Zealand Soil Science Society and a member of the New Zealand Institute of Primary Industry Management.

2. Prior to joining Ravensdown in 2002, I was a practicing agricultural scientist for 22 years working for the Ministry of Agriculture and Fisheries Agricultural Research Division as a District Agricultural Scientist based in Taranaki from 1980 to 1988, and as the Soils and Organics Group Leader in MAFTech at Palmerston North and Flock House in Manawatu/Rangitikei (1988 to 1990). I eventually transferred to the Waikato (1990 to 2002) where I held the position of Group Leader of the Soils and Fertiliser Group and latterly as a Senior Scientist in the Land Management Group of the Pastoral Agricultural Research Institute of New Zealand, which trades under the name of AgResearch.

3. In the early 1990s, I was one of a group of scientists who initiated work to produce a nutrient budgeting tool, now known as OVERSEER®, as a contract to the Ministry of Agriculture and Fisheries.

4. My research and consultancy interests included soil fertility (particularly in dairying), agronomy, heavy metal accumulation in agriculture, environmental performance indicator monitoring and interpretation, and waste utilisation or disposal to grazed pasture. I have also worked in Tasmania, mainland Australia, Japan and South Africa in the area of soil fertility management on pastoral farms. I am either the senior author or a contributing author of 54 refereed Scientific Journal or Conference papers, a further 53 scientific or extension conference papers, 4 book chapters and 4 extension booklets.

5. Over the past 25 years I have not only conducted many soil fertility experiments but have also had an active consultancy role, particularly with pastoral farmers throughout the country, on soil fertility management to maximise economic return, and more latterly to couple that with minimising off-farm impacts on the environment.

In my current role, I am responsible for managing the agronomic research and development for Ravensdown, for training the 70 Field Officers as well as other staff in soils, fertilisers and pastoral agriculture and working directly with many of our Corporate and other farming shareholders.

Code of Conduct

6. Notwithstanding that this is a Regional Council hearing, I have read the Environment Court Code of Conduct for expert witnesses and agree to comply with it. I confirm that I have not omitted to consider materials or facts known to me that might alter or detract from the opinions I have expressed.

SCOPE OF EVIDENCE

7. My evidence will cover the following matters:

1. OVERSEER 6
   - (a) What is OVERSEER 6?
   - (b) What does OVERSEER 6 do?
   - (c) What an N loss estimate from OVERSEER 6 actually means
   - (d) Limitations of OVERSEER 6
   - (e) Consequences of new OVERSEER versions
2. Methodology for setting nitrogen discharge limits as applies to using OVERSEER to monitor this
3. Mitigating N loss from pastoral farms
4. Conclusions

WHAT IS OVERSEER 6?

8. OVERSEER® is a Decision Support System farm model which allows nutrient budgets to be constructed for many enterprises including dairy, sheep, beef, deer, dairy goats, fruit, vegetables and arable crops.

9. OVERSEER® nutrient budgets allow farms to comprise one or more management blocks (defined as an area of the farm that has common physical and management attributes). Nine separate types of management block are available: pastoral, fodder

crop, cut and carry, fruit, vegetable/arable cropping, trees and scrub, riparian, wetland and house. AgResearch advises that up to 30 different blocks may be specified.

10. It is an annual time step, long term equilibrium model. As such it currently does not reflect year to year or within year variability accurately and should not be used for this purpose.

WHAT DOES OVERSEER 6 DO?

11. The model calculates budgets (inputs and outputs) for each separate management block and a whole farm weighted average for the nutrients N, P, K, S, Ca, Mg, Na and H^+ (acidity - pastoral block only).

12. Additionally, the model estimates animal pasture intake, pasture production, calculates maintenance fertiliser nutrient and lime requirements and estimates losses to the environment i.e., N loss to water (leaching), P run-off risk and greenhouse gas emissions.

13. There are a considerable number of misconceptions around the OVERSEER nutrient budget model, how it operates, how it should operate and what it can and cannot do.

14. In terms of the pastoral agricultural model (dairy, sheep, beef, deer etc.) the centerpiece model is not based on a pasture growth or soil fertility driven model but is actually an animal intake model. The model calculates the energy requirements of the block/farm based on the livestock information (milk production, stock numbers and classes, management etc.) provided by the user. With this information plus an energy calculation from any supplementary feed used the model then estimates the amount of pasture dry matter (taking into account pasture quality) that must have been consumed.

15. Once the pasture intake has been calculated the model can estimate pasture grown (by using assumed or entered pasture utilization). Further to this, because pastoral farms are complex in nature many of the other data input requirements are required to understand nutrient transfers around the farm, mainly but not exclusively by the animals depositing dung and urine but also effluent applications and so on. The information generated around how much nutrient is deposited when and where is then also used elsewhere, such as in the N leaching and P run off sub models.

16. The vegetable/arable/fruit crop models operate on the principle of mass balance by accounting for nutrient inputs (e.g., from fertiliser, soil etc.) and removals (e.g., harvested product) while also taking into account the recycling processes (e.g., residue breakdown) and transformations (immobilisation and mineralisation). For

example, in terms of modelling the N component of an arable/vegetable land use, OVERSEER 6 uses the following equation as a monthly iteration:

> Nm+ 1 = Nm + Nrain + Nfixation + Nfert + Nslowfert + Nstover + Nroot + Nirrig + Nmin -N uptake - Ndenit - Nimmob – Nleach, where the terms Nslowfert, Nstover and Nroot relate to the release from material added to the soil (e.g. roots and residues after harvest) and have a slow release component to them.

17. The relevant sub models around drainage are also included.

18. While commentators have criticised the arable/vegetable/horticultural models within OVERSEER as being inadequate to model complex rotations and the vast array of crops and management practices employed, those models have been developed in association with Crop and Food, HortResearch and now Plant and Food scientists based on available research and understanding. Currently, the Foundation of Arable Research (FAR) is undertaking a thorough review of OVERSEER with a potential outcome of providing the necessary information to improve model outcomes for these land uses.

WHAT AN N LOSS ESTIMATE FROM OVERSEER ACTUALLY MEANS

19. A nutrient budget (using OVERSEER 6) for a potato block on a silt loam soil over a stony matrix in the South Canterbury area is shown below by way of example (Figure 1):

Nutrient budget

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na
Nutrients added							
Fertiliser, lime & other	207	113	304	92	116	7	6
Rain/clover N fixation	8	0	11	21	9	22	133
Irrigation	10	0	7	10	39	9	40
Nutrients removed							
As product	248	42	305	13	28	14	13
As supplements and crop residues	164	21	158	11	31	9	6
To atmosphere	23	0	0	0	0	0	0
To water	58	1.4	31	128	85	29	137
Change in block pools							
Standing plant material	-124	-26	-104	-22	-16	-11	-3
Root and stover residuals	-146	-10	-35	-5	-13	-2	-1
Organic pool	-80	5	0	-2	0	0	0
Inorganic mineral	0	-3	-10	0	-2	-3	-4
Inorganic plant available	82	83	-24	0	51	4	30

Figure 1: Nutrient budget for a potato crop on a shallow sedimentary soil

20. In the Nitrogen (N) column the model has estimated that 23 kg N/ha have been lost to the atmosphere as gaseous forms of N and 58 kg N/ha is lost ‘To water’. This is

primarily the estimate of primarily **how much N moves below the root zone in drainage water,** particularly on flat land**.** It is not, nor should be interpreted as, the amount of N which necessarily enters receiving water (confined, unconfined aquifers or surface water).

21. However, the loss to water can be made up of other components too. These components may be found by opening up the 'To water' line on the nutrient budget report (Figure 1a).

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na
Nutrients added							
Fertiliser, lime & other	132	35	28	43	103	0	1
Rain/clover N fixation	107	0	2	5	3	6	32
Irrigation	0	0	0	0	0	0	0
Supplements	27	4	21	3	5	2	1
Nutrients removed							
As products	88	15	20	5	21	2	6
Exported effluent	0	0	0	0	0	0	0
As supplements and crop residues	0	0	0	0	0	0	0
To atmosphere	57	0	0	0	0	0	0
To water	**26**	**1.2**	**17**	**40**	**63**	**8**	**19**
Leaching - urine patches	20	0.0	7	0	16	0	0
Leaching - other	5	0.4	9	40	47	7	19
Runoff	0	0.9	1	0	0	0	0
Direct (animals, drains)	0	0.0	0	0	0	0	0
Direct pond discharge	0	0.0	0	0	0	0	0
Border dyke outwash	0	0.0	0	0	0	0	0
Septic tank outflow	0	0.0	0	0	0	0	0
Change in farm pools							
Standing plant material	0	0	0	0	0	0	0
Organic pool	94	12	3	5	1	0	0
Inorganic mineral	0	3	-21	0	-2	-3	-3
Inorganic soil pool	0	7	34	0	28	2	12

Figure 1a: Expanded nutrient budget report for a flat South Island dairy farm

22. At present this expanded report cannot be printed but it does show the relative proportions of the amount of nutrient lost by leaching from urine patches and other sources (e.g., N fertiliser, non-urine patch soil) runoff, direct losses to water, outwash and so on.

23. The example Figure 1a demonstrates that **most** N is lost by leaching from urine patches on flat dairy farms and is true for other pastoral farming systems. While the above Figure 1a shows N loss to water as a load (i.e., kg N/ha) the programme also reports N loss as a concentration. OVERSEER 6.0 estimates drainage water concentration from the load of N which is able to be leached and the amount of drainage calculated using the NIWA drainage model. However, OVERSEER only calculates N concentration in drainage water for farms on flat land.

24. N lost to water is more correctly an estimate of the N which enters the area of soil and parent material beneath the root zone but above the water table – sometimes referred to as the vadose zone.

25. Given that the N loss estimate is what is leaving the root zone, it is inappropriate to use OVERSEER loss estimates to solely determine N loss limits. This is because between the end of the root zone and the receiving water there are mixing, assimilation and attenuation processes which may increase or decrease the concentration of N in those receiving waters.

26. In my opinion, in an effects based framework such as being proposed, the allocation of N loss limits needs to be determined by understanding the load the receiving water can assimilate without breaching the water quality standards desired for that receiving water and the degree of assimilation/attenuation occurring to N being lost from the root zone and using these data to back calculate acceptable N loss per hectare on a catchment and land use basis.

27. Mr Norton has expressed the same view in paragraph 64 a of his Section 42A Report of September 2012.

28. Once that is achieved and a farmer knows what N loss limit must be achieved for his/her property, OVERSEER can be used to **monitor** how the farm is performing relative to the N loss limit and also to demonstrate the impact of changing management, inputs or mitigations on N loss from a farm or block.

LIMITATIONS OF OVERSEER 6

29. OVERSEER is a model. It is a mathematical expression of complex biological systems and therefore may not always accurately reflect what is actually occurring with respect to nutrient cycling in the real world.

30. However, many of the useful outputs of the model are the best available estimates that are possible because the model is constructed with the best available scientific information at the time the current version is produced. There is and has been a series of regular updates of the model to keep pace with evolving farm systems, user requirements and new science.

31. With respect to N loss estimates, it is neither practical nor cost effective for individual farmers to **measure** N loss, either as total load (i.e., kg N/ha) or concentration (e.g. mg N/L) from their properties nor in the short term is it useful given the biological variability associated with N loss processes in the real world (see point 33 below). This is a core reason for having models.

32. As discussed in previous sections the model is limited to estimating the longer term equilibrium N losses for a system which does not undergo major changes in management. It was not designed, and therefore does not reflect, extreme differences from long term average data (e.g., extreme weather events) used in some of the sub models. When interest is in the long term quality of receiving waters this would seem to be an appropriate outcome.

Variability (error) associated with N loss estimates

33. Overseer 5 and earlier versions clearly stated on the Block N report that the error associated with the estimate of N in drainage water was ± 30%. It is unclear at present whether or not this applies to Overseer 6 estimates. Nevertheless, the estimate of error reflects what actually happens when attempting to measure N loss in the field.

34. An example of the variability in actual N leaving the root zone is shown in the graph below (Figure 2), which is a study at the Lincoln University Dairy Farm (LUDF) in Canterbury whereby *in situ* field lysimeters were used to capture N loss under dairy cow grazing for 8 successive dairying years.

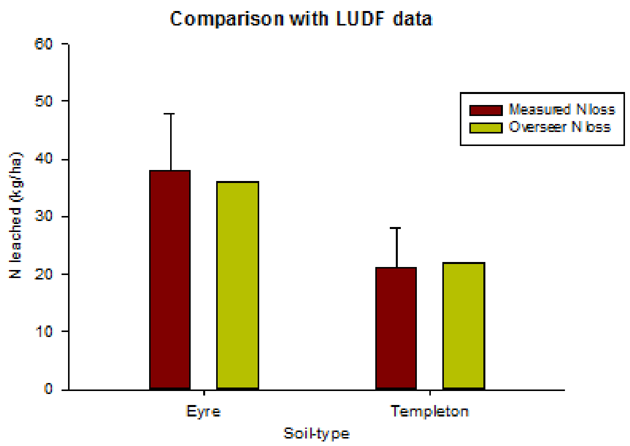


Figure 2: Comparison of measured versus modelled N loss at LUDF

Average N loss **measured** for the Eyre soil was 38 kg N/ha but this varied over the 8 years of measurement between 28 and 48 kg N/ha i.e., a variation (or 'error') of ± 26%. Similarly, for the Templeton soil average N loss was 21 kg N/ha and varied between 14 and 28 kg N/ha or ± 33%. These differences in the actual measured N losses are driven by differences in drainage from year to year principally because of rainfall variation and possibly irrigation practice.

35. In terms of Overseer estimates, setting the drainage in the model to that measured in the lysimeters shows in Figure 2 above that the Overseer estimate is only 1 to 2 kg N/ha different from the average N loss measured by the lysimeters.

36. Validation of the drainage model and hence the N loss estimates using Overseer 6 has been studied by AgResearch and is shown in the graph below (Figure 3):

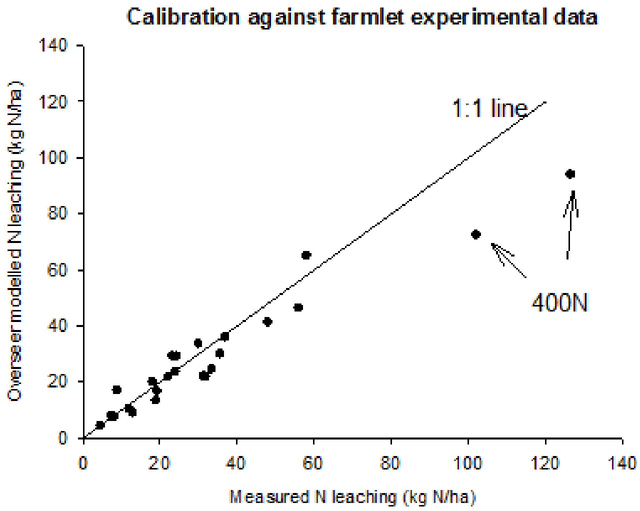


Figure 3: Calibration data for farmlet measured and modelled N loss estimates

The validation data above has been derived from measured N loss data from farmlet studies in the Waikato, Manawatu and Southland where rainfall has been less than 1400mm annually. Certainly, at the lower end of the N loss range (i.e., less than 80 kg N/ha) the correlation with measured and Overseer N losses is very good.

37. The discussion of the errors, both in real life measurements and in modelled estimates, needs to be kept in mind when considering and applying Rule 10.2 Change in Land Use.

38. In Ms White's Section 42A evidence (September 2012) the proposed changed wording (Paragraph 531) with respect to "an increase greater than 10% in the long term release…" assists by way of the fact that OVERSEER, as stated previously, estimates the long term average losses of N and P.

39. The above notwithstanding, a 10% change in N loss from a dryland grazing property which may be currently losing 15 kg N/ha relates to only a 1.5 kg N/ha increase. This

level of increase is well within the ± 30% error commonly associated with OVERSEER estimates of N loss.

40. In my opinion, the use of the OVERSEER programme to **estimate** the long term equilibrium N losses, rather than within and between year N loss fluctuations, from pastoral and other farm types is valid. An N loss estimate from OVERSEER may be used to assist farmers to determine how their farm is performing relative to any imposed N loss limit and may be used to test the effectiveness of management practices and technologies which will assist in achieving N loss reductions over time.

41. Fertiliser Co-Operative staff routinely use this model on dairy farms and larger sheep and beef properties as part of the matrix of tools and techniques to assist their land manager shareholders to manage nutrient flows into and out of their properties for both productivity and environmental outcomes.

42. The OVERSEER model is based on sound science and is regularly updated to reflect both advances in scientific understanding and also the requirements of describing complex and evolving farm systems.

OVERSEER treatment of irrigation

43. It has been suggested that OVERSEER does not handle irrigation nor account for the interaction between shallow stony soils and drainage well. OVERSEER 6 has a completely reworked drainage sub model provided by NIWA scientists which has assisted in giving much better estimates of the impact of water movement through soils, whether by rain or irrigation and accounts for important soil properties which bear on this.

44. OVERSEER requires an annual rainfall number (generally the long term average).The model then uses a set of 'typical' average regional distributions of that rainfall to calculate daily rainfall in a typical year. Thus, it doesn't deal with years where the rainfall pattern is different to the long-term average (Figure 4) and this is why the model is considered a long-term average model.

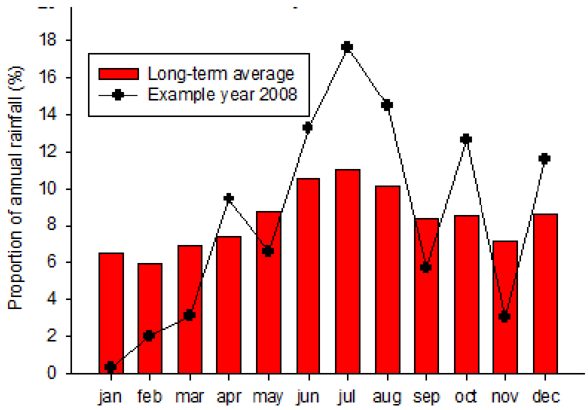


Figure 4: Difference between the distribution of long term average rainfall and individual years.

45. As rainfall increases, the estimate of N loss increases because total drainage is higher and there is an increase in the number of months in which drainage occurs (Figure 5).

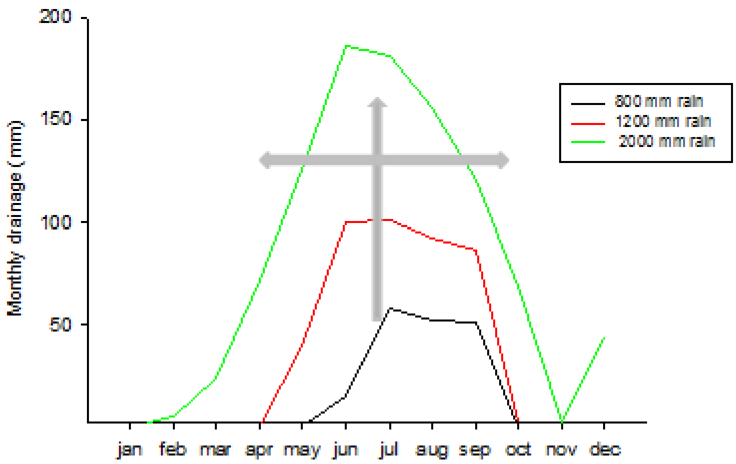


Figure 5: The effect of annual rainfall on monthly drainage

46. Where irrigation is used, this effectively increases the amount of water added to the soil and hence irrigated soils could result in more drainage over more months, especially on the 'shoulders' of the drainage season. This will likely result in higher N loss estimates.

47. An important component of the interaction between rainfall/irrigation and N loss estimates is related to soil properties. In particular, the available water holding capacity (AWC) of the soil. Deep, fine textured soils generally have considerably greater AWCs than shallow, stony soils. The lower the AWC the more water 'washes' through the soil because the soil cannot store or hold the water and hence the proportion of N lost will be correspondingly higher.

48. For example, if we have two soils one with an AWC of 120mm and one with an AWC of 40mm and we have 160mm of drainage, the soil with the higher AWC will only be ‘flushed’ 1.3 times compared to 4 times for the soil with the low AWC (Figure 6). This increase in ‘flushing’ will increase the proportion of total N leached.

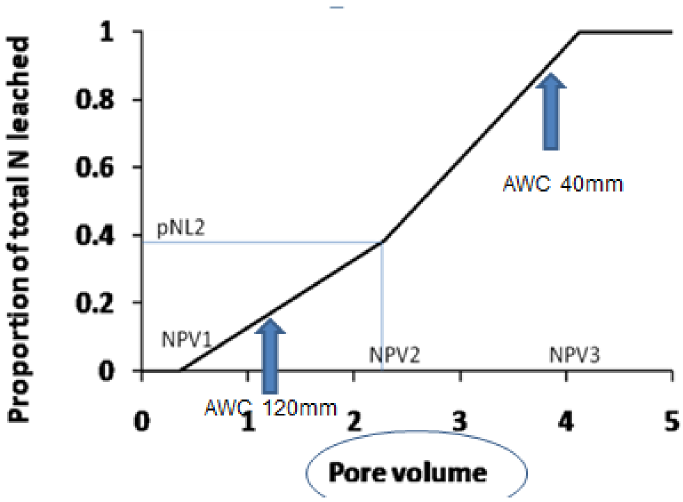


Figure 6: The importance of soil properties on drainage and N loss

49. In terms of irrigation, the model requires the method of irrigation as an input with the choices being pivot, rotorainer or border dyke. The method can make a significant difference to the estimated N loss. For example, an analysis of 58 Canterbury and Otago region nutrient budgets (using the previous Version 5.4.10) prepared over the last 3 years for pastoral farms under border dyke irrigation showed that the estimated average leaching was 70 kg N/ha (range 16-127 kg N/ha) with a standard deviation of 30 kg N/ha. Not all of these farms were dairy farms and the lowest leaching of 16 kg N/ha was for an intensive deer farm.

50. As with the ‘cropping’ models, there has been some criticism of the ability of OVERSEER to properly represent irrigation practices. Currently, Irrigation New Zealand (INZ) have been involved in discussions with the OVERSEER owners and AgResearch scientists with a view to ensuring that irrigation practices are represented in the most scientifically robust way possible.

Use of OVERSEER by trained persons

51. OVERSEER should be used by properly trained and qualified people using long term average data appropriate to the regional or sub-regional area in which the farm lies. University graduates in agriculture will have had an introduction to the theory behind and use of OVERSEER but further training is provided by the Massey University professional development courses including the Intermediate and Advanced

Sustainable Nutrient Management courses. These courses are open to anyone who wishes to gain knowledge and experience with the tool and the wider issues of nutrient cycling on grazed pastoral farms.

52. Completion of the two courses above alone does not mean that a user of OVERSEER would be necessarily completely competent. The ability to actually use the model is a pre-requisite before completing these courses. Knowledge of farm systems and the implications of how to collect and interpret the appropriate data about the farm system and the relevant default parameters to use all take considerable time to learn and understand.

53. The development of input parameter protocols is one way of standardising the creation of nutrient budgets and the Dairy Industry has produced one under their Primary Growth Partnership (PGP) funding. Fonterra has been the first dairy company to invoke a requirement for all of their suppliers to provide N loss, nitrogen conversion efficiency (NCE) and P loss data at end of season by having nutrient budgets produced using the protocol.

54. An independently run nutrient management accreditation scheme is currently being developed by DairyNZ, the Fertiliser Industry and other stakeholders to give assurance of the credibility of ‘nutrient management advisors’ who prepare OVERSEER analyses of farm businesses. It is expected that attendance at and qualification in the two Sustainable Nutrient Management courses will form part of the necessary requirements for accreditation as a ‘nutrient management advisor’. This scheme will hopefully be in place in the next 12 months, if not sooner.

55. Mr Brown in his Section 42A evidence (September 2012) has tabulated (Table 1) mention of the above accreditation scheme as a proposed control strategy to assist in lowering the risk of non-compliance. Given that the accreditation scheme and suitable auditing procedures (paragraph 57) are soon to be put in place this might help reduce Mr Brown’s ascribed level of risk from moderate to low.

Auditing OVERSEER nutrient budgets

56. Furthermore, as a further assurance of credibility and transparency an OVERSEER analysis is auditable by third parties provided an Input Parameter Report is supplied with the output reports. The Parameter Report would then allow a qualified third party to recreate the OVERSEER analysis to check compliance with proper use of the OVERSEER programme.

57. The overall objective of using OVERSEER should be to establish a benchmark N loss figure for a property and over time with management and technology changes, demonstrate a long term minimisation or reduction in N loss, without causing the existing business to become economically untenable.

58. Whether or not our understanding of the attenuation and assimilation processes which occur between the end of the root zone and the receiving water is complete, long term practically achievable reductions in N loss from below the root zone will logically and ultimately result in better receiving water quality.

CONSEQUENCES OF NEW OVERSEER VERSIONS

59. It is important to deal with the issue of OVERSEER version control where the model estimates are being used to monitor farm performance against a nutrient loss allocation in a Plan.

60. A mechanism whereby the most current Version is used needs to be built into the Plan. As an example, the Waikato Regional Council (WRC) for Variation 5 to their current Plan determined N loss limits by ‘grandparenting’ farms on the western side of Lake Taupo based on OVERSEER calculated N discharges between the years 2001 and 2005. The idea was to use an average of these 4 years but after an Environment Court appeal process the farmers were able to choose the year of highest discharge.

61. Aware that OVERSEER versions changed, the WRC specified that Version 5.3.4 would be used. Just this month I read the following statement from the WRC Manager of On Farm Consents responsible for this: “*Overseer Version 6 is due for release on 1 August which has implications for landowners and Council, given that Version 5.4.3 is the version specified for the Taupo Catchment. Discussions and several strands of work are underway about adapting to Version 6 and future upgrades. Several factors need to be considered when narrowing the options including maintaining the integrity of the policy, as well as cost and administration impacts for landowners and Council. As soon as some options have been scoped WRC will be talking with landowners.”*

62. The recently released Environment Court interim decision on the Horizons Regional Council One Plan has meant that the originally proposed N loss limit table will be applied to all existing land uses within priority water catchment areas. The N loss limits in this table were developed based on the qualitative potential carrying capacity estimates (made in the 1970s) for each of the 8 land use classes. These carrying capacities were used as inputs to an unspecified earlier version of OVERSEER to derive N loss limits by LUC, after applying an attenuation factor of 0.5.

63. Given the changes in N loss estimates by moving to OVERSEER 6, it is my contention that the N loss limit table based on LUC needs to be reworked using OVERSEER 6, for the reasons discussed in the following points.

64. The change from Version 5.4.10 to Version 6.0 has seen significant increases in the estimates of N loss, particularly in areas of high rainfall and for shallow, stony soils as discussed in sections 44 to 49 above.

65. To illustrate the point about the importance of considering OVERSEER versions in any Plan, below is the N loss report (Figure 7) generated for a typical (and real) dairy farm in the Waitaki area of South Canterbury using OVERSEER Version 5.4.10.

Block nitrogen report

For: Current farm

Block name	N in drainage * (ppm)	N leached	N surplus	Added N **	% reduction in wetland
		(kg N/ha/yr)			
Non Effluent	7.9	31	210	201	0
Effluent Area	7.0	28	235	235	0
Overall farm	7.6	31	174		

Figure 7: N Block Report (Overseer v5.4.10) for South Canterbury dairy farm

66. The whole farm N loss estimate was 31 kg N/ha (or 7.6 ppm nitrate in drainage water). Making no other changes to the input data except to convert to OVERSEER Version 6.0, the leaching estimate more than doubled to 67 kg N/ha (Figure 8).

Block name	Total N lost (kg N/yr)	N lost to water (kg N/ha/yr)	N in drainage * (ppm)	N surplus (kg N/ha/yr)	Added N ** (kg N/ha/yr)
Non Effluent	8899	66	18.9	109	160
Effluent Area	3145	71	20.2	160	160
Other farm sources	152				
Whole farm	12196	67			
Less N removed in wetlands	0				
Farm output	12196	67			

Figure 8: N Block Report (Overseer 6.0) for South Canterbury dairy farm

67. This change has very large ramifications for any decisions on the achievability or otherwise of N loss limits based on loss estimates from previous OVERSEER versions.

METHODOLOGY FOR SETTING NITROGEN DISCHARGE LIMITS AS APPLIES TO USING OVERSEER TO MONITOR THIS

68. A fixed drainage water N concentration was used in a study reported by Lilburne *et al.* 2010 to determine typical n losses for different land uses and intensities of land use for the Canterbury region. The issue I have with this approach is that concentration is

dependent on the amount of drainage water and assuming a fixed relationship between load and concentration is incorrect.

Lilburne, L., Webb, T., Ford, R., Bidwell, V. (2010). Estimating nitrate-nitrogen leaching rates under rural land uses in Canterbury. Environment Canterbury report R10/127.

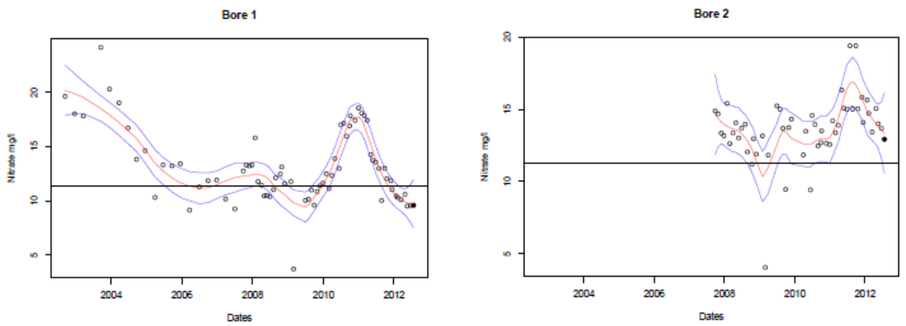
69. The Lilburne report was part of the information used in the LUCI project involving a range of scientists from several CRI's, designed to inform ECAN for its proposed Land and Water Plan. The report used to derive the "look up" tables clearly stated that the N leaching rates in these tables were indicative only and that it would be inappropriate to use these to set water quality or N loss limits.

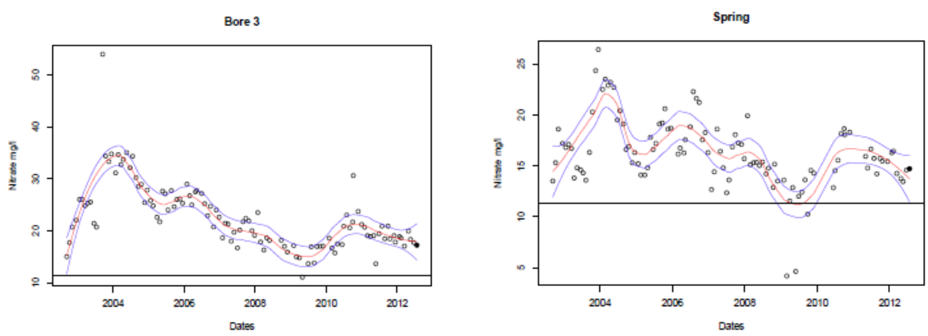
70. This is a reprint of the statement in the Environment Canterbury Report R10/127 entitled "Estimating nitrate-nitrogen leaching rates under rural land uses in Canterbury" which was authored by Lilburne et al. 2010:

> In the meantime, the values in this report are a reasonable starting point to gain an understanding of the regional implications of land use in relation to nitrate-N leaching. An important point that was raised and agreed by participants at the Caucus Workshop was that while these values are suitable for exploration of regional or large catchment scale land use scenarios and for screening the effects of proposed changes in land uses, they are not suitable for use at the farm scale (e.g in a consent process) as these values are simple long term annual estimates that do not take into account the many management practices that can minimise or add to the actual leaching. Also the extrapolation does not take into account the feasibility of some of the soil/climate/land use combinations.

71. An example of the variability of groundwater N concentrations with time (Figure 9) is shown in groundwater piezometer measurements made monthly pertaining to an intensive dairy farm operation (Dairy NZ system 5) on irrigated sedimentary soils overlying gravels. This farm, not in Canterbury, would emulate conditions pertinent to many in this region.

Figure 9: Variation in measured groundwater nitrate nitrogen concentrations





72. Bore 1 is 'upstream' of the dairy farm, Bore 2 is adjacent to the farm dairy effluent block while Bore 3 is in the farm dairy effluent block. The Spring bore is 'downstream' of the dairy farm. A smoothing programme (LOWESS) has been applied to show the trend (red line) and the 95% confidence intervals of the data.

73. There is considerable variation in concentrations between and within bores over time and all are measuring N moving with drainage water from the same soil, with the same water-holding capacity in the same climatic environment. The milk production and management of the farm over the measurement period was relatively constant.

74. Therefore any relationship between the N concentration calculated using OVERSEER and the concentration of N entering receiving water needs to account for the impact of drainage amounts as well as attenuation and assimilation between the end of the root zone and that receiving water.

MITIGATING N LOSS ON PASTORAL FARMS

75. Many people associate N loss from (particularly) dairy farms with nitrogen (N) fertiliser use. This is not wholly true. To illustrate this point, let us take an example of an irrigated dairy farm in the South Island growing 15t dry matter/ha as grass/clover pasture using no N fertiliser. At 4% N in the herbage, this equates to a requirement for N of 600 kg N/ha – none of which comes from N fertiliser but from clover N fixation and recycling of N from dung, urine, and soil organic matter breakdown.

76. It is the fact that grazing animals are consuming this herbage and excreting 80-90% of the nutrients they ingest back onto the soil that is the major cause of N loss to water.

77. Applying N fertiliser will, of course, add to the pool of N cycling through the soil-plant-animal system and consequently will increase the amount of N lost below the root zone but mostly indirectly through the animal and via urine.

78. While nitrification inhibitors (e.g., eco-n) have been successfully developed to help retain some of the N in urine against leaching in the soil for subsequent plant growth, the maximum benefit to date would be in the order of 30-40% reduction in nitrate leaching from grazed pastures, which in many cases will still not be sufficient to allow farmers to meet the proposed limits.

79. The use of eco-n is a mitigation which is simple and effective and need not cause any disturbance to the current management systems in place on farm. This is because designated contractors with the appropriate application gear apply the product, however, it is not without cost.

80. Standard practice is to apply 2 applications in autumn and then late winter and this would cost $210/ha.

81. Recent research from AgResearch and Massey University indicates that urine deposited as early as February, March and April contributes significantly to N leaching in winter drainage water. This has made us re-evaluate application times and frequencies for eco-n application to increase its efficacy.

82. Furthermore, this change of thinking has been incorporated into OVERSEER 6 and is why mitigations such as grazing off over winter now **less** effective at reducing N loss than they were in previous versions of the model.

83. Most other potential mitigations which would have equal or better effectiveness really involve large system changes and considerable expense.

84. Recent examples of current OVERSEER 6 estimates of N loss from 14 either dryland or spray and border dyke irrigated dairy farms in the Otago Region ranged from 23 to 77 kg N/ha.

CONCLUSIONS

85. In my opinion, the use of the OVERSEER programme to **estimate** the long term equilibrium N losses, rather than within and between year N loss fluctuations, from pastoral and other farm types is valid. OVERSEER is also a valuable tool to test the effectiveness of management practices and technologies (i.e., running scenarios) which will assist in achieving N loss reductions over time.

86. The OVERSEER model is based on sound science and is regularly updated to reflect both advances in scientific understanding and also the requirements of describing complex and evolving farm systems.

87. OVERSEER should be used by properly trained and qualified people using long term average data appropriate to the regional or sub-regional area in which the farm lies. Knowledge of farm systems and the implications of how to collect and interpret the appropriate data about the farm system and the relevant default parameters to use all take considerable time to learn and understand.

88. No model is perfect and OVERSEER has limitations. Critics have pointed especially to the arable/vegetable models and the treatment of irrigation. Industry bodies (e.g., FAR and INZ) are working with the OVERSEER owners to identify the weaknesses and provide information to assist in improving model outputs in these areas.

89. The relationship between N loss (as a load i.e., kg N/ha) and concentration (i.e., mg/L or ppm) is not fixed, and this must be factored in to any N loss allocation process.

90. OVERSEER alone should not be used to **determine** N loss limits as the estimates are of N leaving the root zone, not estimates of N entering receiving waters. Attenuation processes between the end of the root zone and the receiving water must also be taken into consideration and factored in to any allocation of N loss (OVERSEER estimate value) back to a particular land use, locality or individual farm.

91. An N loss estimate from OVERSEER may be used to assist farmers to determine how their farm is performing relative to any imposed N loss limit.

Antony Hugh Coleby Roberts

12 October 2012