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	**Fertiliser Association of New Zealand**
	Submitter
TO	**Environment Canterbury**
	Local authority

BRIEF OF EVIDENCE OF ANTONY HUGH COLEBY ROBERTS ON BEHALF OF THE FERTILISER ASSOCIATION OF NEW ZEALAND

Dated: 28th March 2013

INTRODUCTION

Qualfications and experience

1. My name is Dr Antony Hugh Coleby Roberts. 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 and the New Zealand Grassland Association. I am the Chief Scientific Officer for Ravensdown Fertiliser Co-Operative Ltd.

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 five 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. Introduction

2. OVERSEER 6

   (a) What is OVERSEER 6?

   (b) What does OVERSEER 6 do?

   (c) What a long term average N loss estimate from OVERSEER 6 actually means

   (d) Limitations of OVERSEER 6

   (e) Consequences of new OVERSEER® versions

3. Mitigating N loss from pastoral farms

4. High nutrient risk farming activity

5. Conclusions

INTRODUCTION

8. OVERSEER® is owned jointly by the Ministry for Primary Industries, the Fertiliser Association of New Zealand and AgResearch (who are also the lead science provider).

9. 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.

10. For example, a quote from a recent article in the December 2012 issue of NZ Grower magazine (Volume 67, No.11, page 23) highlights this:

> "The theory was that Overseer 6 (an IT soil/nutrient calibration model) would be used as the measuring tool to determine whether nutrient, nitrogen and water levels were within the allowable tolerance bands but this tool is only usable for arable grasslands in parts of Canterbury. It is of no use as a measurement tool for other crops such as fresh vegetable crops (where there are over 60 crop variations) or in other regions outside Canterbury where crop, soil and climate variables are significantly different."

11. The excerpt about OVERSEER® is incorrect on a number of counts, in particular the description of what OVERSEER 6 is (in parenthesis), what it does i.e., "determine whether nutrient, nitrogen and water levels were within tolerance bands…" and that it is only usable for arable grasslands (itself somewhat contradictory) in parts of Canterbury. I will elaborate further on these points throughout my evidence.

12. On page 65 of the Section 32 Report on the Proposed Canterbury Land and Water Regional Plan the following statement is made:

> "Nutrient losses from farming activities are based on land use controls (section 9 RMA), in Rules 5.39-5.49. The Overseer™ nutrient model would be used to record nitrogen losses for the previous year."

13. The OVERSEER® tool does have as an output N loss estimates but users of the tool need to fully understand how to operate the model properly, its limitations across the range of farming activities and what the outputs actually mean. This evidence will set out what outputs can be generated by OVERSEER®, the limitations around those outputs and how they should be used.

WHAT IS OVERSEER 6?

14. OVERSEER® is a world class 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. There are some farming enterprises which OVERSEER® specifically cannot model such as outdoor pig production systems, nor are the multitude of specialty plant production systems represented either e.g., meadowfoam or saffron crops.

15. 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, the lead science provider for the model, advises that up to 30 different blocks may be specified.

16. OVERSEER® differs from other farm models in that it aims to be a practical tool relying on input data that are readily obtained, and aims to model most major farm systems across all regions of New Zealand. This broad scope is both a strength and a weakness of the model.

17. OVERSEER® 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?

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

19. Additionally, the model estimates animal pasture intake, pasture production, calculates maintenance fertiliser nutrient and lime requirements and estimates losses to the environment from the boundary of the farm system e.g., N loss to water (leaching), P run-off risk and greenhouse gas emissions. The OVERSEER® boundary is defined as the actual farm boundary, the bottom of the root zone, and the edge of second order waterways.

20. The model does not include losses due to poor management practices (good management practice or best management practice is assumed), direct discharges into waterways (e.g., runoff from raceways, bridges, roads or stock crossings), or losses due to catastrophic events (e.g., earthquakes, storms or volcanic eruptions).

21. In terms of the pastoral agricultural model (dairy, sheep, beef, deer etc.) the centrepiece 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 i.e., its energy content) that must have been consumed.

22. 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.

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

24. Significant concern and comment has been made around the suitability of OVERSEER 6 to model arable and vegetable systems. Specifically, concerns have been expressed that OVERSEER® is inadequate to model complex crop rotations as well as the vast array of crops and management practices employed. As explained in paragraph 14, OVERSEER® is designed to model most major farm systems throughout New Zealand with the exception of outdoor pig production and some specialty plant production systems. Twenty–two crops within grains, greens, leguminous vegetables, and root crops are able to be modelled with this programme.

25. In the last quarter of 2012, the Foundation for Arable Research commissioned an expert peer review of OVERSEER® with the following brief:

> *"With respect to estimating nutrient efflux in intensive arable cropping systems including vegetable production and dairy support:*
> 1. *What are the strengths and weaknesses of OVERSEER 6?*
> 2. *What, if any, further developments of* OVERSEER® *would significantly and cost-effectively increase its usefulness and usability?"*

26. While concluding that the current OVERSEER® model "*is the best tool currently available for estimating N leaching losses from the root zone across the diversity and complexity of farming systems in New Zealand",* the review found that there were

areas that needed addressing to improve the utility of OVERSEER® for arable/vegetable system use. For example, the Executive Summary of the Review made the following points:

a) Simplifications used in the arable/vegetable models are consistent with the approach taken in modelling pastoral systems within OVERSEER® but contrast with approaches taken in other crop-soil interaction models. Furthermore, the OVERSEER crop model, in Version 5, has only been tested to a limited extent at one site and required modification to fit into OVERSEER 6 architecture. The modified form was not tested or validated at all. Thus the review strongly advocated more comprehensive validation testing to determine whether these simplifications impair the model's capability for predicting long-term average nitrate leaching in arable systems. Further testing would also help to build confidence amongst users.

b) Compared to the pastoral model, the user interface for crops is also relatively under-developed and is in need of further attention before it will be able to deal effectively with complex crop rotations.

c) In addition to these crop model-specific considerations, application of OVERSEER® in the context of regional council water policy raises new technical and administrative considerations for the development and application of the model. In particular, deployment in a policy context requires greater transparency regarding the scientific basis of the model and in the software development and validation processes. Stakeholder participation in the model's strategic development would also help to build trust.

d) Furthermore, as model predictions are inherently uncertain for a variety of reasons e.g. random error, inaccurate specification of parameters, and biases in process representation, models such as OVERSEER® are generally more robust in predicting relative changes rather than absolute values. Regulatory authorities, and all model users, need to recognise this aspect of model application.

27. It is accepted that the models dealing with arable, vegetable and horticultural uses are not as well developed or as easy to deploy as the pastoral agricultural models. While these models have been developed in association with Crop and Food, HortResearch and now Plant and Food scientists based on available research and understanding, the Review correctly states that there has been very little validation of the cropping models (26a above) and recommends a programme of comparing measured N losses from cropping systems and long term N losses predicted by established research models e.g., APSIM, to predicted N losses from OVERSEER®. Furthermore, as indicated in 26c, to overcome the lack of transparency regarding the scientific basis for the cropping models the Review has recommended that an expert standing reference group be established to provide peer review of model development, not only of the arable component models but pastoral also.

28. The concern regarding the stage of development of the User Interface for arable/vegetable farm systems raised in the Foundation for Arable Research Review (Paragraph 26b) is very valid with respect to attempting to model complex rotations of multiple crops. While it would be difficult and extremely time consuming there would be ways to attempt to develop an overall 'picture' of the long-term N loss from a multi-crop, multi-year rotation. However, the same proviso applies here as with the pastoral model in that any N loss estimate so derived would be the long term average and would not accurately reflect actual year to year variations. No doubt as a result of the Foundation for Arable Research Review, the OVERSEER® owners will look to develop the User Interface for arable/vegetable systems further to enhance usability and simplify the generation of meaningful outputs from the model.

WHAT A LONG TERM AVERAGE N LOSS ESTIMATE FROM OVERSEER® ACTUALLY MEANS

29. By way of example, 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 (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

30. 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 **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).**

31. The loss to water can be made up a number of 'component' losses. By way of further example, a nutrient budget for a South Island dairy farm (Figure 1a) demonstrates these components which 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

32. This expanded report shows 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.

33. The example in Figure 1a is typical of most pastoral systems whereby the greatest proportion of N lost by leaching is derived from urine deposition. 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 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.

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

35. Given that the N loss estimate is what is leaving the root zone, it is inappropriate to use OVERSEER® loss estimates to determine N loss limits that are designed to protect ground or surface water quality. This is because between the end of the root zone and the receiving water there are mixing, assimilation and attenuation processes that may increase or decrease the concentration of N in those receiving waters. In the Waikato Regional Council's Variation 5 dealing with the Western Taupo catchment

and in the Horizons One Plan, an attenuation factor of 0.5 was used although there is no way of knowing how accurate this might be. Using the OVERSEER N loss estimate together with an attenuation factor could allow OVERSEER to assist determining N loss limits.

36. A strength of OVERSEER® is that it is able to demonstrate the impact of changing management, inputs or mitigations on N loss from a farm or block. However, the user of OVERSEER® must be conversant with its operating principles to ensure that the consequences of any changes made are consistent with all the other input parameters used to set up the original nutrient budget. Scenario testing provides the farmer with valuable information to assess what management changes he/she could make and to reduce N loss if that is required. Further analysis of the costs associated with changes to management and indeed the practical feasibility of changes also need to be completed outside of the OVERSEER® analysis.

37. Again the outputs, such as the N loss figure, of the scenario testing referred to in paragraph 36 is the long term N loss from the system at equilibrium and should be generated using expected long term average input data for production, fertiliser and feed use. Annually these inputs can and will vary on farm as farmers respond to within year climatic and financial challenges but the model was not designed to model short term (i.e., annual) changes.

LIMITATIONS OF OVERSEER 6

38. 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.

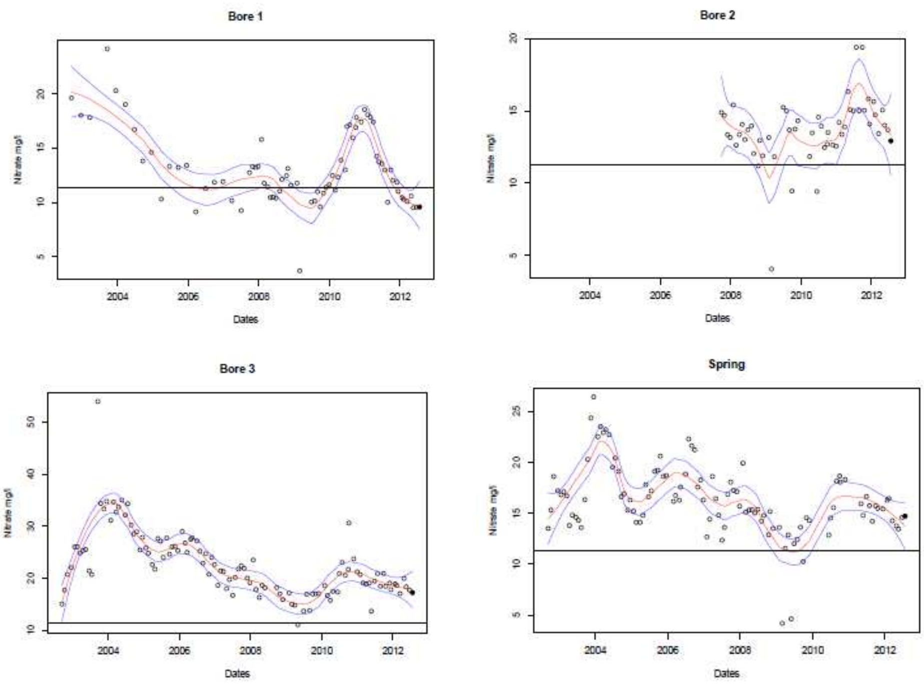
39. However, many of the useful outputs of the model are the best available estimates that are possible because the model is constructed with the best available scientific information at the time the current version is produced. There is and has been a series of regular updates of the model to keep pace with evolving farm systems, user requirements and new science. Notwithstanding this, concern has been expressed by experts not involved in model development that the lack of transparency means that they have no way of assessing the veracity of the preceding sentences. Clearly, on-going and transparent peer review will be required for general acceptance within the wider scientific community and public.

40. 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 paragraphs 41-43, 48-49 below). This is one of the reasons for having long term equilibrium models such as OVERSEER®.

41. An example of the variability of groundwater N concentrations with time (Figure 2) 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 2: Variation in measured groundwater nitrate nitrogen concentrations



42. 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.

43. 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.

44. 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.

45. Following on from the above, in my opinion, OVERSEER® should not be used to report annual nutrient losses using annual input parameters e.g., animal production, supplements used, fertiliser used which change because of short term climatic factors and minor management changes. Putting in changing annual figures will change the nutrient loss outputs but as OVERSEER® is a long term equilibrium model this is an inappropriate use of the model. Demonstration of change in nutrient loss over time is desirable and appropriate use of the model but given the long term equilibrium nature of the model, it would be more appropriate to use 'rolling 3 or 5 yearly average data' rather than a single year's data.

46. Following on from paragraph 45 if there are major farm system changes made e.g., significant changes in stock numbers, productivity, feed inputs, farm infrastructure , land area and management then a 'new' OVERSEER® analysis for that farm would be required using expected long term average values for the changed inputs.

Errors associated with N loss estimates

47. Questions have been raised over the accuracy of the OVERSEER® estimates. The following explanations of the bold terms are drawn from information provided by AgResearch, the lead science provider for OVERSEER®. **Accuracy** of a measurement is the closeness of this to the quantity's actual (true) value. This concept has limited applicability to the estimate of whole farm nutrient loss where it is not practical to measure this directly e.g., the whole farm annual N loss to water.

48. The **precision** (or repeatability) of the measurement is the degree to which repeated measurements under unchanged conditions show the same results. With respect to OVERSEER®, as a model repeatability between measurements and operators will be excellent provided exactly the same input parameters are used. The creation of industry agreed user protocols for choice of assignable default parameters in particular will assist in this.

49. **Errors** are the level of disagreement between a measured value i.e., in this case an OVERSEER® estimated value and the true (or accepted) value. The concept of error clearly has limited application where actual measurement is not practicable e.g., whole farm nutrient losses. **Uncertainty** in the context of a model like OVERSEER® can be defined as a potential limitation in some part of the modelling process that is a

result of incomplete knowledge. This concept is most applicable to the use of OVERSEER® given the number of assumptions and errors in the model produces a level of uncertainty about the estimate of nutrient losses.

50. OVERSEER 5 and earlier versions clearly stated on the Block N report that the error (or uncertainty) 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.

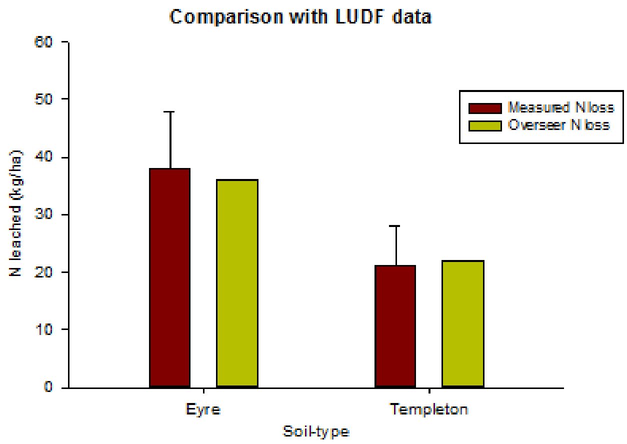


Figure 3: Comparison of measured versus modelled N loss at Lincoln University Dairy Farm

51. An example of the variability in actual measured N leaving the root zone is shown in the graph below (Figure 3), which is a study at the Lincoln University Dairy Farm in Canterbury whereby *in situ* field lysimeters were used to capture N loss under dairy cow grazing for 8 successive dairying years.

52. 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.

53. In terms of OVERSEER® estimates, setting the drainage in the model to that measured in the lysimeters shows that the OVERSEER® estimate is only 1 to 2 kg N/ha different from the average N loss measured by the lysimeters (Figure 3).

54. 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.**

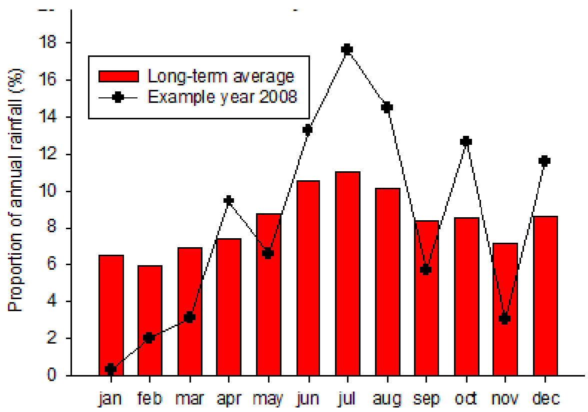


Figure 4: Difference between the distribution of long term average rainfall and individual years.

55. Validation/calibration of the drainage model and hence the N loss estimates, at least for dairy farm systems, using OVERSEER 6 has been studied by AgResearch and is shown in the graph below (Figure 5).

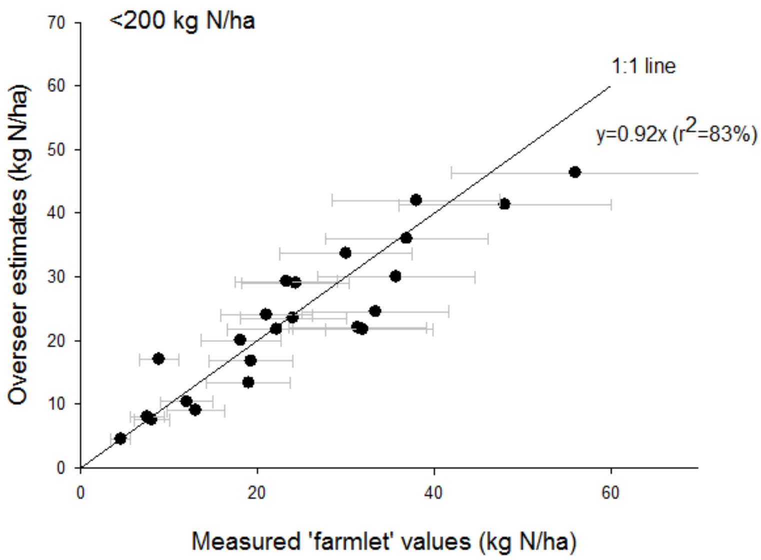


Figure 5: Calibration data for farmlet measured and modelled N loss estimates

56. The validation data above has been derived from measured N loss data from dairy farmlet studies in the Waikato, Manawatu and Southland where rainfall has been less than 1400mm annually and less than 200 kg N/ha as fertiliser has been applied annually. Certainly, at the lower end of the N loss range (i.e., less than 60 kg N/ha)

the correlation (r^2=0.83) with measured and OVERSEER® N losses is considered very good for a biological model.

57. Notwithstanding this good correlation, the errors associated with measuring N loss are depicted by the horizontal bars. However, given the discussion about uncertainty of model estimates in paragraph 49 above, there is also a degree of uncertainty around the OVERSEER® estimates which, if known, could be depicted by vertical error bars on the data displayed in Figure 5.

58. The discussion on errors in paragraph 57 is completely in accord and synonymous with the discussion of Type A and Type B errors in Dr Edmeades evidence (paragraphs 10-25).

59. It must also be remembered that actual N loss (where measured) can vary to a much greater extent than that for the Lincoln University Dairy Farm (Figure 3). In higher rainfall, free draining soils measured N loss may vary by more than 100% from one year to the next.

60. The discussion of the errors, both in real life measurements and in modelled estimates, needs to be kept in mind when tying proposed Regional Plan standards or resource consent conditions to single number N loss limits, however those limits may be derived.

61. In my opinion, the use of the OVERSEER® programme to **estimate** the trend in 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 over the long term 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. These points are in accord with the views expressed by Dr Edmeades in his evidence (paragraphs 29, 30).

62. The MfE report ‘Freshwater Reform 2013 and Beyond’ includes the use described in paragraph 61, as one of 4 uses for OVERSEER® results as well as the three below which, in my opinion, are also appropriate uses of OVERSEER® modelled outputs:

- a trigger for increased support from regional council land management officers or sector advisers to assist farmers to reduce discharge levels
- a threshold for increased regulatory requirements e.g., the farm may be required to submit an audited nutrient management plan or apply for a consent if discharges exceed a particular level

- a way of monitoring compliance with a regulated discharge cap. With careful policy design to account for the model's capabilities and limitations.

63. 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.

64. 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 and soil drainage

65. 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 that 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.

66. 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 6).

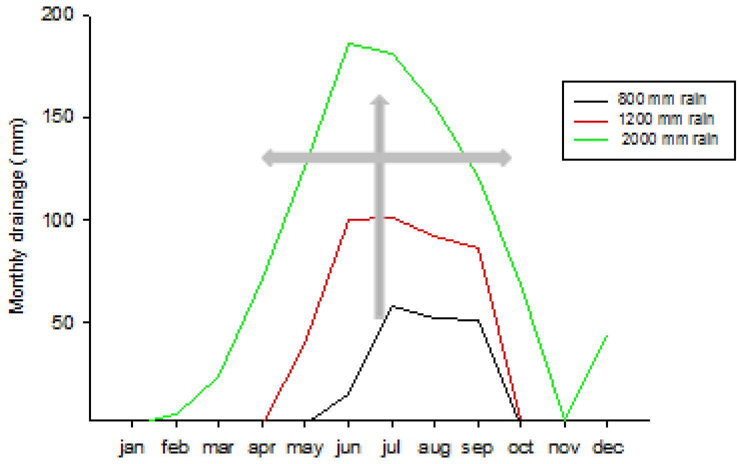


Figure 6: The effect of annual rainfall on monthly drainage

67. 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.

68. 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.

69. 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 7). This increase in 'flushing' will increase the proportion of total N leached.

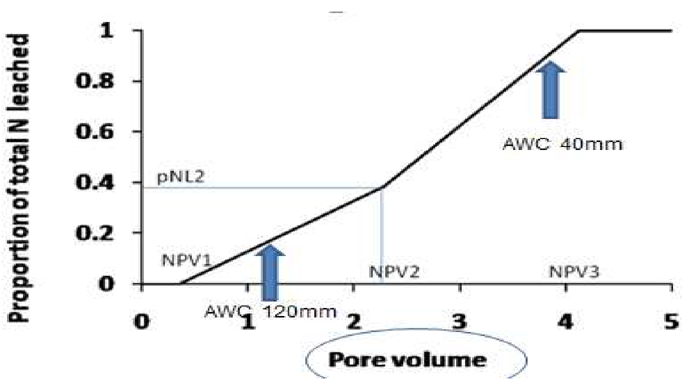


Figure 7: The importance of soil properties on drainage and N loss

70. 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.

71. Not everyone accepts that OVERSEER® adequately models the impacts of irrigation, and there are potentially the same errors (e.g., Type A and B errors discussed in Dr Edmeades evidence, paragraphs 10-25) associated with the way the model calculates the effects of irrigation, as with non-irrigated systems. Irrigation New Zealand have or will be involved in discussions with the OVERSEER® owners and science providers with a view to ensuring that irrigation practices are represented in future OVERSEER® releases in a way that reflects the latest in irrigation technology and management, in the most scientifically robust way possible.

Use of OVERSEER® by trained persons

72. 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.

73. 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.

74. 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 funding. Fonterra has been the first dairy company to invoke a requirement for all of their suppliers to provide N loss, nitrogen conversion efficiency and P loss data at end of season by having nutrient budgets produced using the protocol. There is no suggestion that input parameter protocols or guidelines will remove all input errors, but if followed will provide consistency (between users) of choice of inputs, especially the qualitative ones, and assist in minimizing, or at least explaining, potential conflicts where more than one qualified user has provided nutrient budgets for the same farm business.

75. 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. Attendance at and qualification in the two Sustainable Nutrient Management courses will form part of the necessary requirements, as well as consideration of the advisors past experience and current activities, for accreditation as a 'nutrient management advisor'. This scheme is intended to be ready and open to any person wishing to seek accreditation in the first half of 2013.

Auditing OVERSEER® *nutrient budgets*

76. 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.

77. I note that on page 84 of the Section 42A report (R13/11) on the proposed Plan there is a definition suggested for an Environmental Farm Plan Auditor. This could be amended to include the developments around accreditation discussed in paragraph 73, such that an auditor requires a Certificates of Completion for Advanced Sustainable Nutrient Management and evidence of the requisite professional experience in practice.

78. 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, measure N loss responses to those management and technology changes.

79. 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, in most intensively farmed agricultural catchments logically and ultimately result in lower concentrations of N in receiving waters.

CONSEQUENCES OF NEW OVERSEER® VERSIONS

80. 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.

81. A mechanism whereby the most current Version is used needs to be built into the Plan. As an example, in the Waikato Regional Council's Variation 5 to their current Plan, N loss limits were determined 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.

82. Aware that OVERSEER® versions changed, the Waikato Regional Council specified that Version 5.3.4 would be used. Waikato Regional Council has been informed by the owners that Version 5.3.4 would only be available to them for a further 1 year. Recently, I read the following statement from the Waikato Regional Council Manager of On Farm Consents:

: "*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.*"

I understand that the decision has now been made to transition the farmers affected by the Nitrogen Discharge Allowance provisions in Variation 5 of the Waikato Regional Plan to OVERSEER Version 6.

83. 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 dairy, intensive (irrigated) sheep and beef, cropping, and vegetable production 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 Land Use Class, after applying an attenuation factor of 0.5.

84. Given the changes in N loss estimates by moving to OVERSEER 6, it is my contention that the N loss limit table based on Land Use Class needs to be reworked using OVERSEER 6, for the reasons discussed in the following points. However, discussions with Horizons personnel indicate this is unlikely to occur and that farmers who might have fallen under the Controlled Activity status (by being below their Land Use Class based N loss limits using the earlier version of OVERSEER®) but who now exceed these limits using OVERSEER 6 will now need consent as a Restricted Discretionary Activity.

85. 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 65 to 69 above.

86. To illustrate the point about the importance of considering change in OVERSEER® versions in any Plan, below is the N loss report (Figure 8) 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
Non Effluent	7.9	31
Effluent Area	7.0	28
Overall farm	7.6	31

Figure 8: N Block Report (OVERSEER v5.4.10) for South Canterbury dairy farm

87. 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 9).

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

Figure 9: N Block Report (Overseer 6.0) for South Canterbury dairy farm

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

89. It is my opinion that Regional Plans should only specify that the latest version of OVERSEER® be used and that any N loss limits directly linked to OVERSEER® estimates be recalculated each time a substantive new version is released.

MITIGATING N LOSS ON PASTORAL FARMS

90. 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.

91. 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 on pastoral farms. In arable/vegetable systems it is N fertiliser, soil, cultivation and residue management which are all drivers of N cycling and loss.

92. 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.

93. 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.

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

95. Most potential effective mitigations for N loss from agricultural systems involve large system changes and considerable expense. Dr Edmeades evidence shows worked examples of some of these mitigations, their costs and benefits for a large dairy business in the Selwyn-Waihora catchment. As further science allows quantification of the effectiveness of mitigations these are incorporated, when possible, into the latest version of OVERSEER®. This is another reason why Plans should allow for the most recent version of OVERSEER® to be used.

HIGH NUTRIENT RISK FARMING ACTIVITY

96. I note that on page 87 of the Section 42A report (R13/11) on the proposed Plan that a definition of what is considered to be high nutrient risk farming activity. The Officer's report does qualify that the definition is not fully described and that well managed activities with high risk of nutrient discharges may have lower discharges than a low risk activity poorly managed.

97. I agree that feeding cattle on winter fodder crops (whether irrigated or not), farmed pigs and irrigated dairy may be considered high risk activities (in terms of nutrient discharge).

98. I could envisage that arable farming may also be high risk particularly where catchments are near to over allocated with respect to nutrients, especially if the Officer's definition of arable farming includes commercial vegetable production. However, I cannot see why horticulture (excluding commercial vegetable production) is regarded as high risk and grapes are excluded.

99. Most perennial fruit crops have very little fertiliser nutrients applied (relative to other land uses) and often have pasture between the row crops which is mowed or mulched. Very few animals are ever run through orchards. The exception to this is vineyards,

where often grape growers use sheep to graze the grass between the vines after harvest and through winter.

CONCLUSIONS

100. 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. It is the trend in N loss from the root zone over time which is the most useful indicator of how a farm system is being managed to minimise N loss.

101. 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.

102. OVERSEER® alone should not be used to **determine** N loss limits, in a regulatory sense, 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. There are, however, a number of technical reasons covered in the preceding evidence why OVERSEER® should not be used in this manner.

103. 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.

104. 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.

105. No model is perfect and OVERSEER® has limitations, as discussed earlier in this evidence. Critics have pointed especially to the arable/vegetable models and the treatment of irrigation. Industry bodies (e.g., Foundation for Arable Research and Irrigation New Zealand) are working with the OVERSEER® owners to identify the weaknesses and provide information to assist in improving model outputs in these areas. The OVERSEER® owners are keen to bring the arable and horticultural models and validation of same up to the same level of robustness as the pastoral model, where possible.

106. An N loss estimate from OVERSEER® may be used to assist farmers to determine how their farm is performing over the long term relative to any imposed N loss limit.

Antony Hugh Coleby Roberts

28th March 2013