BEFORE THE Canterbury Regional Council

IN THE MATTER OF Variation 2 to the proposed Canterbury Land & Water Regional Plan

STATEMENT OF EVIDENCE OF DR SAMUEL JAMES DENNIS

Prepared for

FEDERATED FARMERS OF NEW ZEALAND

AND

BEEF + LAMB NEW ZEALAND

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Introduction

Qualifications and experience

1. My name is Samuel James Dennis. I hold a B.Agr.Sc (First Class Honours) and a Ph.D. (Soil Science) from Lincoln University. I have completed both the Intermediate and Advanced Sustainable Nutrient Management courses at Massey University. I am currently working as an independent agricultural environmental consultant. I have not yet sought formal certification through the Nutrient Management Adviser Certification Programme. My qualifications are in excess of what is required for certification.

2. I have been contracted by Beef + Lamb New Zealand to model farms in Overseer in the Hinds catchment and prepare a statement of evidence on behalf of Federated Farmers of New Zealand and Beef + Lamb NZ.

3. My Ph.D. thesis was on nitrogen leaching losses from grazed pasture systems.

4. I previously worked as a scientist for AgResearch in the areas of farm systems, farm system modelling, precision agriculture and nutrient leaching loss. Prior to this I worked at Lincoln University as a research technician in the soil science department.

5. While at AgResearch I was a member of an internal expert Overseer user group. Specific areas of scientific research experience include:

    a. Nitrogen leaching losses from grazed pastures.
    b. Use of models to determine nitrogen leaching and greenhouse gas emissions from farm systems.
    c. Experimental design and data analysis.
    d. Systematic experimental design of farm system modelling studies.
    e. Pasture sensors, precision spatial management of grazed pastures.

6. Having grown up and worked on Canterbury farms in a range of industries, I am familiar with the practical realities of agriculture and am able to put scientific principles in context. In this case, my evidence focuses on the on-farm implications of using Overseer to derive and monitor compliance with individual property based nitrogen discharge limits.

7. I am a member of the NZ Society of Soil Science and the International Society of Precision Agriculture.

Disclosure of related work

8. I am currently sub-contracted by another industry body to model farm systems for the Canterbury Regional Council’s Matrix of Good Management.

Scope of evidence

9. My evidence covers the following matters:

    a. Practicality of generating actual baseline nitrogen loss values on real farms using Overseer
    b. Natural year-to-year variability in farm systems and leaching losses
    c. Implications for farmers of the current approach to deriving “baseline” nitrogen leaching loss
    d. The need to provide for flexibility in the plan to account for variation and complexity in farm systems and the difficulty in modelling this.

10. This statement of evidence does not attempt to review Overseer or to critique its general relevance or use as decision support software in aiding and improving on farm nutrient management. My evidence is specifically in respect to Overseer’s use in setting and managing to nitrogen discharge limits in the Hinds catchment.

Selection of case study properties

11. I was contracted by Beef + Lamb to determine the estimated nitrogen leaching losses over the four baseline years (2009/10, 10/11, 11/12 and 12/13) on three farms – a beef breeding property in the Upper Hinds catchment, and two mixed arable / lamb finishing properties in the Lower Hinds.

12. The farms were selected to represent a range of land uses and locations within the catchment. They are not intended to be representative of total catchment land use.

13. The farmers chosen for this process were highly motivated, with a good understanding of nutrient losses, and comparatively good record-keeping.

14. Farm A is a mixed arable property in the Lower Hinds catchment. Key crops include autumn wheat, ryegrass seed, and radish seed (with many others grown less frequently). Lambs are fattened on ryegrass seed crop regrowth, and dairy cattle wintered in one baseline year.

15. Farm B is a mixed arable property very similar to, and located near Farm A. In addition to the crops and animals on Farm A, Farm B has blackcurrants and winters dairy cows on brassica crops.

16. Farm C is a beef breeding & finishing property in the Upper Hinds catchment.

Practicality of generating baseline nitrogen loss using Overseer

17. I found it extremely difficult to model these farms in the baseline years, for several reasons, most critically:
    a. Lack of clear records.
    b. Lack of Overseer support for key crops.
    c. Poor handling of animals grazing arable cropping rotations by Overseer.

Lack of records

18. Farmers were not informed in 2009/10 that they needed to keep the records needed to produce Overseer models of their properties in those years.

19. In practice, modelling relies heavily on memories, which are patchy. Where records have been kept they are disjointed, spread through paper diaries, files and computer software that deal with only small aspects of the farm in isolation and incompletely. It is very difficult and time consuming to find relevant information and collate into a form suitable for Overseer modelling.

Lack of Overseer support for key crops

20. Overseer does not specifically provide for modelling nutrient losses in crops that are grown on the case study farms and many others in this region, including small seeds and blackcurrants:
    a. Small seeds, particularly radish, are grown on large areas of both of the mixed farms that I modelled. The only comparable crops available in Overseer are ryegrass (a very different plant), white clover (which would fix nitrogen so is inappropriate), cereals and peas (which are much higher yielding so have not been calibrated to the low yields of small seeds).

    b. In order to model a small seed crop, the Overseer user must pretend it is a different, similar crop. For example in preparing Overseer nutrient budgets for the modelled properties:
        i. If I modelled radish as “ryegrass”, N loss was in the order of 30 kgN/ha. If I modelled radish as “barley” or “peas (dried)”, N loss was in the order of 90 kgN/ha.

        ii. The Overseer best practice data input standards do not give any guidance on how to correctly model such crops.

    c. Blackcurrants are not supported in Overseer. I have modelled them as “grapes”, by pretending they are a vineyard with the same fertiliser and quantities of fruit harvest that a blackcurrant crop would have. I am not confident that grapes adequately represent blackcurrants, which are a completely different crop with markedly different management practices.
        i. According to Overseer, a blackcurrant crop that is in the ground for 15 years with no cultivation, and low fertiliser inputs, has higher leaching losses than an arable cropping rotation with higher fertiliser inputs and frequent cultivation. In my professional opinion, this is highly improbable.

Poor handling of animals grazing arable cropping rotations

21. Overseer was originally designed for use on farms that are primarily in long term pasture, with a few crops. On pasture, Overseer is feed demand driven, allowing the user to specify the animals on the property and then calculating the amount of pasture grown to supply those animals. But on crops, Overseer is supply driven, with each crop having a yield that is set, usually by the user, and then fed to livestock. The user must ensure that the correct quantity of crop is fed to supply the demand of

the animals.

22. On lamb finishing farms in the lower Hinds catchment, lambs are often grazing ryegrass seed crops. These are an unusual case, as the user can only specify the yield of seed, the yield of grass for grazing is set by Overseer and cannot be controlled, or even viewed, by the user.

23. The model will not give any results until feed supply and demand are balanced. This means that in practice, when ryegrass seed crops are the primary source of feed, the Overseer user must alter animal numbers up and down until Overseer is satisfied that the farm is feasible, before any results can be viewed. This can take an Overseer user a very long time for a single scenario, and result in modelled outputs that are based on completely different animal numbers to what are or were actually on the farm in reality – so it is not actually an estimate of the nitrogen loss from the real farm.

24. The scenarios I have produced are a best estimate of leaching losses given the information I was able to obtain. The estimates used in preparation of this evidence do not necessarily represent the final estimated values that the farmers will use for their own baselines required in the plan, as:

    a. all input data may be subject to revision;

    b. the animal numbers do not always represent what actually occurred in reality, but have been altered to enable the generation of an Overseer nutrient budget;

    c. specific crops grown on these properties are not yet supported in Overseer.

25. The lack of features is not a criticism of Overseer in general, rather a practical assessment of the usability of Overseer at present for the purposes it is proposed to be used for in this proposed plan. Overseer's feature set is and always will be limited to those features for which there has been funding to both research in the field and then build into the model, so it can never be expected to cover every eventuality. However the specific limitations identified here are potentially very important in this particular catchment, especially if they are used to understand compliance with regulation, rather than to support nutrient management decisions on the farm.

Modelled case study farms

26. To model the farms, I:
    a. Informed each farmer of the data needed for Overseer modelling of the four baseline years, for them to prepare.
    b. Visited each farmer in person, interviewing them for several hours to obtain the information needed.
    c. Personally viewed each property.
    d. Obtained soil descriptions from S-map (Landcare Research) and aligned with actual soils on the property based on farmer descriptions of soil types.
    e. Translated the available information into a form suitable for entry into Overseer.
    f. Entered the information into Overseer 6.2.0 in accordance with the latest version of the Overseer Best Practice Data Input Standards. For one farm I was provided with an existing Overseer model, which I reviewed then adapted. Where data was unknown Overseer default values were used.
    g. Circulated a summary of my key data inputs to each farmer for their feedback, and made changes as needed.

27. Table 1: Estimated nitrogen losses of the three farms modelled (kgN/ha):

Farm	2009/10	2010/11	2011/12	2012/13	Mean
A	13.5	14.1	12.8	12.5	13.2
B	45.5	44.6	45.0	45.2	45.1
C	13.2	13.0	13.1	13.1	13.1

Farm A

28. Farm A is a mixed arable property in the Lower Hinds catchment. Key crops include autumn wheat, ryegrass seed, and radish seed (with many others grown less frequently). Lambs are fattened on ryegrass seed crop regrowth, dairy cattle were wintered in one baseline year, and a small herd of beef cattle is present.

    a. Over the baseline years the farming system remained essentially the same. However loss fluctuates due to the cropping rotation – some crops have higher losses than others, and in some years more high loss crops happen to coincide.

    b. This is already a very efficient farm, in terms of practices influencing nitrogen leaching losses. These are low losses for arable cropping, and techniques such as minimum tillage and wetlands are already used. In my opinion, barring drastic changes such as planting the entire farm in trees, there is little potential for further reductions in nitrogen loss as most potential “mitigation” practices are already adopted.

Farm B

29. Farm B is a mixed arable property very similar to, and located near Farm A. However the estimated nutrient losses from this property are higher due to:

    a. Dairy support on a small area of the farm with light soils.

    b. Blackcurrants, which Overseer estimates to have higher nitrogen losses than arable (which is unlikely in my opinion).

    c. Different soils, a slightly different rainfall depth (according to Overseer's climate tool), and slightly different cultivation practices.

    d. The leaching losses are comparatively stable from year to year simply due to lack of data — in the time available the farmer could not provide me with a comprehensive record of the area of each crop in these years so I had to assume the same proportions of most crops in each year. This underestimates variation, the loss will in reality fluctuate like Farm A, and if the farm were managed in future in the same manner as in those baseline years the farm would have higher losses than the baseline about 50% of the time.

    e. This farm is unlikely to actually be leaching 45kgN/ha. In my opinion, this value would reduce if Overseer were to be developed specifically to support and model outputs for blackcurrants.

Farm C

30. Farm C is a beef breeding & finishing property in the Upper Hinds catchment.

    a. Leaching losses are reasonably stable across the baseline years— due to the lack of arable crops, estimated losses from pasture are more consistent.

    b. The farm would still exceed its baseline loss if managed in the exact way it was in the 2009/10 baseline year, so such a cap would prevent management at baseline.

"Baseline" will actually force farmers to reduce loss to comply

31. Estimated leaching losses do vary from year to year, particularly on mixed cropping farms, and in these cases they did vary over the baseline period (noting the limitations on the accuracy of these values as described above). If a farm is run exactly as it was during the baseline period, it will theoretically exceed the baseline nutrient leaching losses every second year.

32. To stay below the baseline, a farmer will have to reduce average leaching losses. Farm A for example leached 12.5 – 14.1 kgN/ha in the four baseline years. Such fluctuations will always occur and cannot be eliminated. So, if required to stay below 13.2 kgN/ha, this farm would have to reduce leaching losses to ensure that years of peak loss do not exceed 13.2.

a. In this case, mitigations would have to be implemented to reduce leaching by approximately 1 kgN/ha, to achieve leaching of 12.5, 13.1, 11.8 and 11.5 if growing the same crops as in the four baseline years.
b. This would result in a mean leaching loss of 12.2 kgN/ha.
c. This is a 9% reduction in leaching loss.
d. On this particular farm, that is already very efficient, such reductions may be impossible without drastically changing the farming system.

33. A four-year rolling average does not in itself provide for this variation in the plan. To illustrate using farm A:

    a. If farm A were given a baseline N leaching value of 13.2, and could not exceed that in any individual year, it would have exceeded that loss in 2013/14 if run as in 2009/10 or 2010/11. On a long-term basis it would exceed the baseline about every second year.

    b. If the baseline estimated N loss value is to be calculated as a rolling average, in 2013/14 the farm would have had an effective limit of 13.5 kg N/ha. If run as it was in 2010/11 the farm would still have breached its baseline.

    c. Irrespective of how well this farmer applies good management practice this farm will exceed the baseline in some years, unless the farm system is drastically changed.

Demonstration using simulated farms

34. To illustrate the difficulty of managing and modelling at a determined baseline I also simulated theoretical farms that are maintained at the same farming practices as in the baseline years, but with year-to-year variation in N loss. I generated random N leaching values between 12 and 15 kgN/ha for 2000 modelled farms over 100 years, calculated the baseline (being the average of the first four years), and the rolling averages for all subsequent years. This simulation was run in the statistical software R, using normally distributed randomised N leaching values.

    a. In any individual year, the leaching loss exceeded the baseline 49 – 51% of the time.

    b. In any set of four years, the average leaching loss also exceeded the baseline 49 – 51% of the time.

    c. The only difference was that the individual year differed from the baseline by 0.8 kg N/ha on average, while the rolling average differed by 0.5 kg N/ha on average.

    d. The rolling average reduces the amount the baseline is exceeded by, but doesn't change the fundamental problem that the farm will still breach their baseline leaching losses 50% of the time, even without intensifying the system at all.

e. However if the maximum year in the first four years was taken as the baseline, rather than the mean, the farms only exceeded this 19% of the time on an individual year basis, or 9% as a rolling four year average.

35. I then determined how much these farmers would have had to reduce their leaching loss in order to comply with their baseline leaching caps.

    a. If the baseline is the mean of the four baseline years, they would have to reduce average loss by 1.5 kgN/ha, or 10%, to not exceed it in any one year. If assessed on a 4 year rolling average basis they would have to reduce mean loss by 1.0 kgN/ha, or 7%.

    b. If instead the baseline is the maximum of the four baseline years, they would have to reduce average loss by 0.6 kgN/ha, or 4%, to not exceed it in any one year. If assessed on a 4 year rolling average basis they would have to reduce mean loss by 0.1 kgN/ha, or 0.5%.

36. Capping the baseline at the mean of the 4 baseline years would in practice require all farmers to reduce average leaching losses by possibly up to 10%, depending on how this is assessed and the level of year-to-year variability in their particular farming system.

37. Only capping losses at the maximum year in the baseline period and assessing this on a rolling average basis would allow farmers to continue with current management, with negligible requirement to reduce losses.

Further unintended consequences

38. In this analysis, Farm A, which has relatively low leaching losses— partly due to the farmer voluntarily adopting minimum tillage techniques and establishing extensive wetlands— would receive a very low baseline nutrient leaching value. However the very similar Farm B, which has not implemented such practices, will be rewarded with a high baseline nutrient leaching value— even if some sort of reductions are required, the farmer may still be better off than Farm A.

Providing for operating flexibility to account for model estimates and farm management

39. It is not realistic to expect all farms to reduce leaching losses. Low leaching loss farms may already be doing all reasonable practices that minimise loss, and may have little ability to reduce loss further. It is essential that year-to-year variability in loss is allowed for to ensure low loss farms can at least continue to operate within current management practice.

40. In addition, the modelled leaching loss for a farm is likely to change with the release of new versions of Overseer as it has with past updates, and the plan needs to allow for this. Updates to Overseer do not change the actual loss from the farming system, just improve our understanding of this loss.

41. As described above, the baseline could be calculated as the maximum rather than the mean of the four baseline years.

42. It is important to note that changing the baseline to the maximum rather than the mean would not increase losses, so does not affect current modelling of catchment loads. This change in calculation method would simply allow farmers to maintain current farming practices, to allow farmers to operate at baseline leaching losses.
    a. The mean of the baseline years is a valuable figure to calculate catchment loads. However if used as a regulatory tool it could have the unintended consequence of requiring all farmers to reduce N loss irrespective of their current practice or their practical ability to do so.

    b. The maximum of the baseline years is more appropriate to use on an individual farm basis to define nitrogen loss limits.

    c. Both values are complementary; they just need to be used in the correct context.

43. In my opinion using the maximum number to calculate the baseline on a rolling four year average is the minimum flexibility the plan should provide for in terms of the changes in modelled outputs by Overseer. However this will still result in challenges in managing to limits for those farmers with relatively lower estimated N losses.

44. This will also only work for farms where enough data is available to model the baseline years in enough detail to get an accurate assessment of year-to-year variation. Where the baseline years are modelled in a more generalised fashion (e.g. Farm B) some variation may not be captured, and the maximum loss from that modelling exercise may not give sufficient flexibility for long-term management. Even the results for Farm A presented here may not capture all the year-to-year variation actually present and that would appear if managed in the same fashion in the future.

45. Providing for flexibility up to a limit would overcome some of the current limitations in managing to baseline numbers:

    a. For some farms, the baseline years are not representative of long-term financially viable management.

    b. For farms of particularly low N loss, it is debatable whether the high cost of compliance with the regulation would deliver meaningful results for the catchment.

Conclusions

46. It is extremely difficult and expensive in practice to model Hinds catchment farms during the four baseline years. This has implications for the actual ability of farmers to comply, and the council to assess compliance. Furthermore Overseer does not currently support key aspects of the farming systems in the Hinds catchment well enough to be used for this purpose.

47. Actual N loss from many farms naturally varies from year to year, in ways that are not entirely in the farmer's control. Requiring farms to stay below the mean loss in the baseline years will, in effect, require nutrient loss to be reduced even on low N loss properties. Simply assessing loss on a four-year rolling average basis does not correct this.

48. In my opinion such reductions will not be realistically achievable on many low N loss farms, without drastic and expensive changes to the farm system.

49. In my view, the plan needs to provide flexibility for year-to-year variation in N loss, simply in order for farmers who already have relatively low N loss risk to maintain current farming practices.