IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of the Proposed Waikato Regional Plan Change 1: Waikato and Waipā River Catchments

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STATEMENT OF EVIDENCE OF JONATHAN (JON) MAURICE PALMER

For the Waikato Regional Council

DATED 3 May 2019

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Introduction

1. My name is Jonathan (Jon) Maurice Palmer. I am a Senior Technical Advisor (Healthy Rivers) for Waikato Regional Council. I have been in this role since July 2018. I have worked for WRC for 16 years.

2. I have a Bachelor of Parks Recreation and Tourism (Lincoln) majoring in Natural Resource Management.

3. I also have a Bachelor of Applied Science (Hons) (1st Class) (Massey) majoring in Agricultural Nutrient Management. I am a Certified Nutrient Management Advisor, having completed the Massey University Sustainable Nutrient Management and Advanced Sustainable Nutrient Management courses.

4. I was responsible for the on-the-ground implementation of Waikato Regional Plan rules to protect Lake Taupō, from their inception in 2007 until 2015. This cap and trade regulation was the first of its type in the world, and involved the extensive use of Overseer. I continue to provide oversight to this project, and will be involved in the review of the Lake Taupō rules in the near future.

5. I am an experienced agricultural nutrient advisor and soil conservator. I regularly provide advice regarding the use of Overseer for farm nutrient analysis and for regulation to WRC and other regional councils, farmers and farm consultants.

6. I recently authored the Waikato Regional Council Nitrogen Reference Point (NRP) Development Guidelines (in collaboration with WRC staff and Overseer experts outside of WRC) to assist Overseer users in the preparation of NRPs.

7. I have been a regular advisor and contributor to Overseer, being a member of the former Overseer User Group and Technical Advisory Groups. The Technical Advisory Group was formed to prepare the Overseer Best Practice Data Input Standards. Both groups have recently been disestablished.

8. I am a regular speaker at the Massey University Advanced Sustainable Nutrient Management Course.

9. I am a member of the Nutrient Management Advisor Certification Programmes' Standards Setting Group for the Certified Nutrient Management Advisor programme.

10. I confirm that I am familiar with the Code of Conduct for Expert Witnesses as set out in the Environment Court Practice Note 2014. I have read and agree to comply with the Code. Except where I state that I am relying upon the specified evidence or advice of another person, my evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope of Evidence

11. The purpose of this evidence is to explain the causes of uncertainty in Overseer-predicted nitrogen leaching losses, and the measures and the use methodologies in place to reduce Overseer uncertainty.

12. This evidence will also describe the relationship between stocking rate and predicted nitrogen leaching using Overseer, identified in the appended short report.

13. My evidence does not describe in any detail matters covered in the Parliamentary Commissioner for the Environment report *Overseer and regulatory oversight: Models, uncertainty and cleaning up our waterways*, or the Enfocus Ltd report *Using Overseer in Water Management Planning*, and aims not to repeat content of the Council's s42A report.

14. Finally, this evidence will justify the proposed wording changes to Schedule B to align with recent changes to Overseer.

15. Although I am familiar with the content of the Parliamentary Commissioner for the Environment report *Overseer and regulatory oversight: Models, uncertainty and cleaning up our waterways*, and the Enfocus Ltd report *Using Overseer in Water Management Planning*, the opinions expressed are my own, drawn from 12 years' experience implementing regulation using Overseer.

Statement of support of the content of Waikato Regional Plan Change 1 section 42A report

16. I have read the content regarding Overseer within Councils' s42A report pertaining to the proposed plan change 1. I agree with and support the content pertaining to the use of Overseer. From my experience with Overseer development and application, the following comments explain and provide further background to that support.

Overseer Terminology

17. Overseer, Overseer Ltd, and OverseerFM have different meanings. It is appropriate to clarify those here.

    a. Overseer is the term referring to the model and the company in general.

    b. Overseer Ltd is the name of the not-for-profit company that was established in April 2016 by the Overseer owners to ensure the long-term viability of Overseer and meet growing user needs. The company is jointly owned in equal ordinary shares by the New Zealand Phosphate Company and AgResearch Limited. The Ministry for Primary Industries has equal voting rights alongside the shareholders. There are two independent directors who also hold voting rights.

    c. OverseerFM is the name of the model used for farm modelling (FM) that is used as a nutrient management decision making tool by farmers and their consultants, and is the variant used for regulation. It differs from other variations of Overseer such as Overseer Science and Overseer Education.

What is Overseer?

18. Overseer is a modelling tool that describes the flow of the major nutrients (nitrogen, phosphorus, potassium, sulphur, calcium, magnesium and sodium) through farm systems. Overseer predicts from programmed farm system inputs the likely flow and fate of those nutrients.

19. Overseer analyses the nutrients that are present or introduced to the farm, models how they are used by plants and animals present on the farm, and then estimates how they leave the farm and in what form.

20. Nutrient inputs into the Overseer modelled farm system include:

    a. From water including rain, snow and irrigation.

    b. From imported nutrient sources including fertiliser, supplementary feed, and atmospheric inputs (primarily nitrogen fixation by legumes such as clover).

21. Nutrient use and cycling within the Overseer modelled farm system includes:

    a. Transfers by animals (consuming feed and either the use of those nutrients to support growth and production, or waste via the deposition urine and dung).

    b. Collection, storage and application of effluent produced by the animals present in the farm, onto the farm.

    c. The growing, and either grazing of pasture, crops or supplementary feeds, or harvest and redistribution of grown feeds within the farm.

22. Nutrient outputs and losses from a modelled farm system include:

    a. Nutrients lost to the atmosphere (CO_2, CH_4, N_2O).

    b. Nutrients leaving the farm as products of the farm system including meat, wool, milk, fruit or vegetables, grains, or supplementary animal feeds.

    c. Nutrients lost to water from runoff and leaching.

Overseer model data inputs effect on accuracy

23. The inputs to Overseer (spatial, biophysical, and farm system related) all influence predicted nutrient flows within the model, including nitrogen leaching.

24. Some Overseer inputs have a greater influence on predicted nitrogen leaching than others, particularly stock types and quantities, farm production, cropping, soil type and climate.

25. In my experience it is not uncommon to see a significant level of variability in the way data is entered into Overseer between individual users. This is due to how users interpret data and what assumptions are made regarding partially incomplete data. This is influenced also by the experience of the user and their understanding of farm systems. Variability of data entry into Overseer does influence predicted nitrogen leaching.

26. User selection of the input parameters can have a major effect on the estimates of nutrient cycling for the described farm systems and hence the resultant nutrient budgets.

27. Overseer Ltd and the agricultural industry have gone to significant lengths to ensure a greater level of consistency of the entry of data into Overseer. These include:

    a. The preparation of the Overseer Best Practice Data Input Standards by a group of Overseer experts from around the industry, including Overseer Ltd, regional council staff, the fertiliser industry, DairyNZ, and AgResearch. The purpose of providing a 'best practice' standard of data entry is to reduce inconsistencies between different users when operating Overseer to model individual farm systems. The Overseer Best Practice Data Input Standards are currently being incorporated into the Overseer User Guide.

    b. The Nutrient Management Advisor Certification programme has been introduced to ensure that farmers receive high quality nutrient management advice, and also to provide a level of professional accountability to Overseer users. The programme includes training and assessment requirements, as well as continuing professional development requirements. Many of the requirements incorporate the use and interpretation of Overseer. Certified Nutrient Management Advisors (CNMA) are encouraged to consult the Overseer Best Practice Data Input Standards and Overseer User Guide in the preparation of Overseer analyses. CNMA is a requirement to become a Certified Farm Nutrient Advisor for Plan Change 1.

    c. Waikato Regional Council has produced the Nitrogen Reference Point Development Guidelines to assist Overseer users in the preparation of NRPs. These guidelines, based on collective experience of using Overseer for regulation, outline default values to be used in lieu of complete data availability, and describe work-arounds for farm systems not easily or able to be modelled in Overseer. The Nitrogen Reference Point Development Guidelines will ensure consistency of default values and work-arounds used for NRP development and help to ensure a greater level of repeatability and standardisation in the preparation of NRPs. The Nitrogen Reference Point Development Guidelines should be used in conjunction with the OverseerFM User Guide.

Overseer output uncertainties

28. This section describes the uncertainties of Overseers' nitrogen loss predictions.

29. Overseer is a model that describes the nutrient flows across agricultural systems. Overseer analyses the nutrients present or introduced to the farm system and models how they are used by plants and animals on farm and also models the estimated losses of nutrients to air or into the root zone, or if they are immobilised into the soil structure. Overseer accounts for the farms' biophysical characteristics such as climate, topography and soil type when modelling these nutrient flows.

30. Because of the infinite variation in farm biophysical characteristics (that greatly affect predicted N leaching) and also the variability of farm systems and nutrient cycling in stock, Overseer cannot accurately predict *actual* nitrogen leaching for a farm system. Rather Overseer provides an approximation of the likely nutrient flows and losses.

31. Because of the assumption of the OverseerFM model that the farm being modelled is in quasi-equilibrium[1] and the fact that Overseer is a long term model, uncertainty in predicted nitrogen leaching increases when land use and farm systems are changing. Additionally, similar uncertainty may arise when analyses are completed for years where there has been significant climatic variation from the long term average (such as excessive rainfall years or drought years).

32. Uncertainty also increases where nutrient cycling and loss predictions are modelled in farm systems and for some biophysical characteristics where research and ground

[1] Quasi equilibrium means that inputs and farm management practices described are in quasi-equilibrium 'steady-state' with the farm production – i.e. they are not changing.

validation is less robust. This may include modelling farms with particular soil types and cropping-based farm systems.

33. Overseer predictions are refined in an ongoing process involving new research of nutrient cycling within farm systems and field trials to validate nutrient cycling predictions. The model's predictions are refined accordingly based on the results of these field trials.

34. Because of ongoing inclusion of new research and validation trial results into Overseer, and the ongoing refinements to the algorithms within Overseer to ensure more accurate predictions of nutrient cycling and nitrogen leaching, the model is updated regularly. Many of the updates influence (change) the predicted nitrogen leaching for given farm systems

Reducing Overseer prediction uncertainty

35. Overseer predicted nitrogen leaching uncertainty is reduced by using Overseer in a relative (or comparative) sense. Using Overseer comparatively allows for the degree of relative change of predicted nitrogen leaching to be assessed by comparing a baseline Overseer analysis with a predictive Overseer analysis, and allows the user to demonstrate the 'direction of travel' (increase, decrease, no change) between two modelled scenarios. This is an appropriate methodology because the same biophysical parameters for the predictive or scenario analysis are modelled. Users will model comparatively by creating a scenario analysis by changing only the inputs concerning the farm system.

36. To ensure the appropriate comparable use of OverseerFM to account for possible changes to predicted nitrogen leaching due to version change, both the baseline analysis and the predictive scenario analysis must be updated at the time the analyses are being considered. This will ensure that the latest version of OverseerFM, and the latest nitrogen leaching loss predictions, are accounted for.

37. Examples of comparative use include:

   a. Using Overseer as a decision support tool. An Overseer assessment would be completed for a farm to establish a baseline for comparison. The analysis is then copied ensuring that all of the biophysical settings are retained. Then changes to the farm system data inputs can be made to the copy to ascertain the degree of change to predicted nitrogen leaching between the baseline and predictive analyses. Examples of this type of use may be to ascertain the reduction of nitrogen leaching should a dairy farm expand its effluent irrigation area, or ascertain change in nitrogen leaching if a crop were to be grazed for less time per day or grazed during less risky months. Using Overseer comparatively reduces the risks of uncertainty to a point where uncertainty becomes less problematic.

b. Using Overseer to ascertain compliance with a regulation that sets a nitrogen leaching loss number using Overseer to establish a baseline. In this case an overseer analyses would be used to establish a baseline or limit on a per farm basis. The baseline analysis would then be copied (as above) to ensure that the planned farming scenario (a predictive analysis) would likely to be compliant with the baseline limit. The same method could also be used to ascertain compliance. It is currently envisaged that this is how Overseer will be used for the implementation of PC1.

Comparative use of Overseer for Taupō Implementation

38. Comparative use of Overseer has been successfully implemented in the Taupō Catchment to regulate the losses of nitrogen from farm systems. A description of the process used in the Taupō Catchment is included in this evidence to ensure understanding of the comparative use concept and process. Note that the Taupō rules in the Waikato Regional Plan specify the ongoing use of one version of Overseer (v5.4.3) to facilitate nitrogen trading.

a. Farms were analysed for the years 2001 to 2005 to establish the year of highest nitrogen leaching – that became the farm's baseline or benchmark (also known as a nitrogen cap).

b. In order to apply for or obtain a Land Use Consent farmers are required to prepare a Nitrogen Management Plan (NMP). An NMP is prepared by modelling scenarios in Overseer and comparing the results with the baseline nitrogen leaching prediction. If the scenario agreed with the farmer leaches less than the baseline nitrogen leaching loss then that farm system can be approved.

c. The NMP specifies the farm system parameters that were agreed with the farmer when undertaking the scenario analysis. These include stock type, class, age, numbers/month; fertiliser use; supplements grown on farm and used or exported; supplements imported; fodder crops grown and grazed.

d. When WRC consent monitoring is required, the farmers are asked to provide verifiable evidence of their farm system for the past year, and those parameters are assessed against the farm system parameters described in the NMP. Consent monitoring of Overseer based regulation is always retrospective.

e. An Overseer analysis (scenario analysis for monitoring) is only prepared should a farmer be non-compliant with the farm system parameters set out in their NMP. This will ensure that the baseline has not been exceeded.

f. If farmers change their farm system in any way they are required to update their NMP.

g. Note that the controlled activity rule for Taupō nitrogen leaching farming activities does not specify that the NMP will be the point of compliance but does require farmers to prepare an NMP. WRC developed the methodology of assessing compliance against farm parameters in the NMP early in the implementation project. In effect compliance with the farm parameters within the NMP equates to compliance with the nitrogen benchmarked cap. Taupō farmers quickly adapted to using the NMP as a point of compliance because farm parameters are more easily understood and meaningful.

h. I also note that the Taupō implementation methodology requires significant staff resource due the hands on WRC approach where staff actively worked with farmers to complete benchmarking and continue to work closely with the farmers in the preparation of nitrogen management plans. Additionally all farms in the Taupō Catchment are regularly monitored.

The relationship between stocking rate and predicted nitrogen leaching from OverseerFM.

39. An analysis of the relationship between stocking rate and Overseer v6 predicted nitrogen leaching from selected dry-stock farms in the Waikato was undertaken by myself and colleagues at the request of the s42A report author. The resulting report is attached to this evidence.

40. This analysis was completed because a strong relationship between stocking rate and predicted nitrogen leaching using Overseer v5.4.3 was observed during the implementation of the Taupō rules.

41. The analysis was also completed to investigate the use of a stock unit proxy for nitrogen leaching for potential use in Plan Change 1.

42. The preliminary analysis showed a marginal relationship between Overseer v6 predicted nitrogen leaching and stocking rate per hectare. It was concluded that this observed variability was due to differences in soil type and climate.

43. The soil types and climate were standardised and the relationship increased markedly.

44. The report concludes that for dry-stock farms that are not grazing dairy stock, farming to a stock-unit per hectare limit is not likely to result in an increase in predicted nitrogen leaching – even if the proportion of stock types present (sheep beef deer) change, or if slight changes to the farm system are implemented. If the stocking rate in a farm increased then it can reasonably be assumed that nitrogen leaching losses will increase.

Proposed changes to Schedule B of the Proposed Waikato Regional Plan Change 1

45. This section of evidence explains the proposed changes to Schedule B as explained in the s42A report.

    a. Change required throughout: *Overseer model* needs to be changed to *OverseerFM*. OverseerFM is the new brand for the specific Overseer model that will be used to implement Plan Change 1, and will avoid confusion with the Overseer science model or the Overseer education model.

b. Change to Schedule B part (b): Clarify the NRP baseline years. The years 2014-2015 and 2015-2016 mean 1 July 2014 to 30 June 2015 and 1 July 2015 to 30 June 2016. These dates correlate with the Overseer "year".

c. Change to Schedule B part (c): Current or most recent version implies that users have a choice of what version could be used. OverseerFM is now a "live" model that may be updated at any time – although large updates will be notified to all OverseerFM users.

d. Change to Schedule B part (d): Overseer files (or electronic output files) are now obsolete. OverseerFM is entirely cloud based. All analyses are saved online rather than being exported and saved on individual computers or servers. OverseerFM has changed the terminology from *File* to *Analysis*.

e. Change to Schedule B part (e): Because Overseer files are now obsolete and because OverseerFM is entirely online, in order for external organisations to be able to view OverseerFM models the farmer or their CFNA must "Publish" the analysis to the Waikato Regional Council Organisation within Overseer. In essence publishing allows an external party to view the farms' OverseerFM analysis.

f. Change to Schedule B part (d): The Overseer Best Practice Data Input Standards are being incorporated into the live and online OverseerFM User Guide. As such the Overseer Best Practice Data Input Standards will soon be obsolete as a standalone document.

g. Change to Schedule B part (g): Annual accounts should be included in records to be retained and provided to Waikato Regional Council on request because they are important in establishing year start and year end stock numbers. Stock numbers have the greatest effect on OverseerFM predicted nitrogen leaching.

h. Change to Schedule B part (g): Invoices pertaining to the purchase of fertiliser are important for confirming fertiliser inputs onto a farm for OverseerFM modelling purposes.

i. Change to Schedule B part (g): Full details of crops grown and consumed are necessary to validate cropping activities. Crop areas on farms generally have the highest rate of nitrogen leaching compared with the rest of the farm due to cultivation, high fertiliser inputs, intensive grazing (especially during winter) and higher drainage due to soil disturbance.

j. Change to Schedule B part (g): The inclusion of farm address in records required is needed as the address is specific to the preparation of the NRP because it is a key input into Overseer governing farm location (for spatial block entry) and some associated climatic settings.

Concluding Statements

46. OverseerFM can be used in a comparative manner for the implementation of OverseerFM based rules for the Proposed Waikato Regional Plan Change 1.

47. OverseerFM should not be used to regulate against a numerical limit. The reasons why this use of OverseerFM is inappropriate is outlined in the s42A report, the Parliamentary Commissioner for the Environment report *Overseer and regulatory oversight: Models, uncertainty and cleaning up our waterways*, and the Enfocus Ltd report *Using Overseer in Water Management Planning*.

48. CFNAs will need to follow the data input guidance provided in the OverseerFM User Guide and the guidance provided in the Waikato Regional Council Nitrogen Reference Point Development Guidelines to minimise uncertainty due to data inputs.

49. Waikato Regional Council implementers will have to determine an appropriate and efficient methodology to ensure equitable comparative (relative) use of OverseerFM to ensure consistent compliance assessments against the original NRP dataset to minimise OverseerFM output uncertainties. A methodology will also be developed to use OverseerFM as a decision making tool to undertake planning analyses for those farms above the 75%ile. All methodologies will account for version change.

50. A strong relationship exists between stocking rate and predicted nitrogen leaching (as modelled in Overseer v6.3.0) for dry-stock farms that do not stock dairy cattle. This relationship may be able to be considered as a proxy instead of using OverseerFM for some aspects of implementation where appropriate.

51. Changes to Schedule B are necessary to align the schedule with recent changes to OverseerFM.

JONATHAN (JON) MAURICE PALMER

3 May 2019

APPENDIX

Attached report *Analysis of the relationship between nitrogen leaching and stocking rate for dry-stock farms*.

Analysis of the relationship between nitrogen leaching and stocking rate for dry-stock farms.

Author:

Jon Palmer, Senior Technical Advisor, Waikato Regional Council.

Contributions and edits by:

Don Harford, Sustainable Agriculture Advisor, Waikato Regional Council.

Joseph Edlin, Senior Resource Officer, Waikato Regional Council.

1. Introduction

This analysis was developed at the request of Matthew McCallum-Clark and Urlwyn Trebilco in order to investigate the relationship between stocking rate and nitrogen leaching on typical dry-stock farms in the Waikato Region.

It was requested that this analysis investigate the validity of using a stocking rate proxy instead of annual Overseer analysis to confirm compliance with section 5 of Schedule 1, and with rule 3.11.5.2 of the Waikato Regional Council Proposed Plan Change 1.

Although it is currently envisaged that all farms over 20 hectares in size will complete an initial Nitrogen Reference Point, ongoing annual monitoring requiring the use of Overseer® could possibly be avoided by using a stocking rate proxy in its place.

2. Preliminary analysis to test the relationship between stocking rate and predicted nitrogen leaching from randomly selected farms.

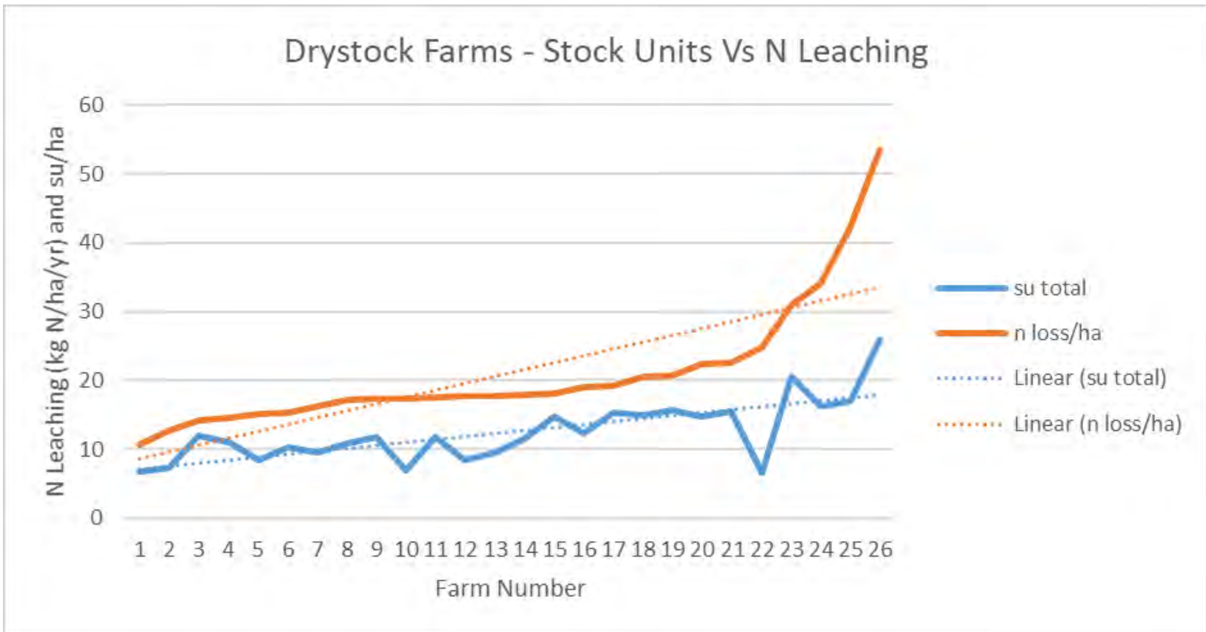
Twenty six Overseer v6.3 farm analyses used during the study *improving water quality in Waikato Waipa Catchment: Options for dry stock and dairy support farms*[2], along with selected Taupo Catchment NDA analyses[3] were used as representative farm cases for this study.

From these Overseer analyses total stocking rate (su/ha) and nitrogen leaching (kg N/ha/yr) were extracted and their relationship analysed. The sorted data set can be viewed in Table 1.

This preliminary analysis shows only a marginal correlation between stocking rate and nitrogen leaching, with an R^2 value of 0.635 (see figure 2). In general, increasing stocking rate demonstrated a disproportional increase in predicted nitrogen leaching. However, due to the observed variability in stocking rate compared with predicted nitrogen leaching, a clear relationship between stocking rate and N loss was not evident.

It was thought likely that the observed variation is due to variations in soil, climate, and fertiliser use between analyses. Such variability is well known to be present across the Waikato Region. Variability in biophysical parameters may also be having influencing stocking rate on individual farms due to higher producing soils, rainfall variability, and inconsistent use of nitrogenous fertiliser. In addition, individual farm efficiency in terms of nitrogen use and productive capacity will also vary. This may be influencing the observed fluctuations of the stocking rate/nitrogen leaching relationship.

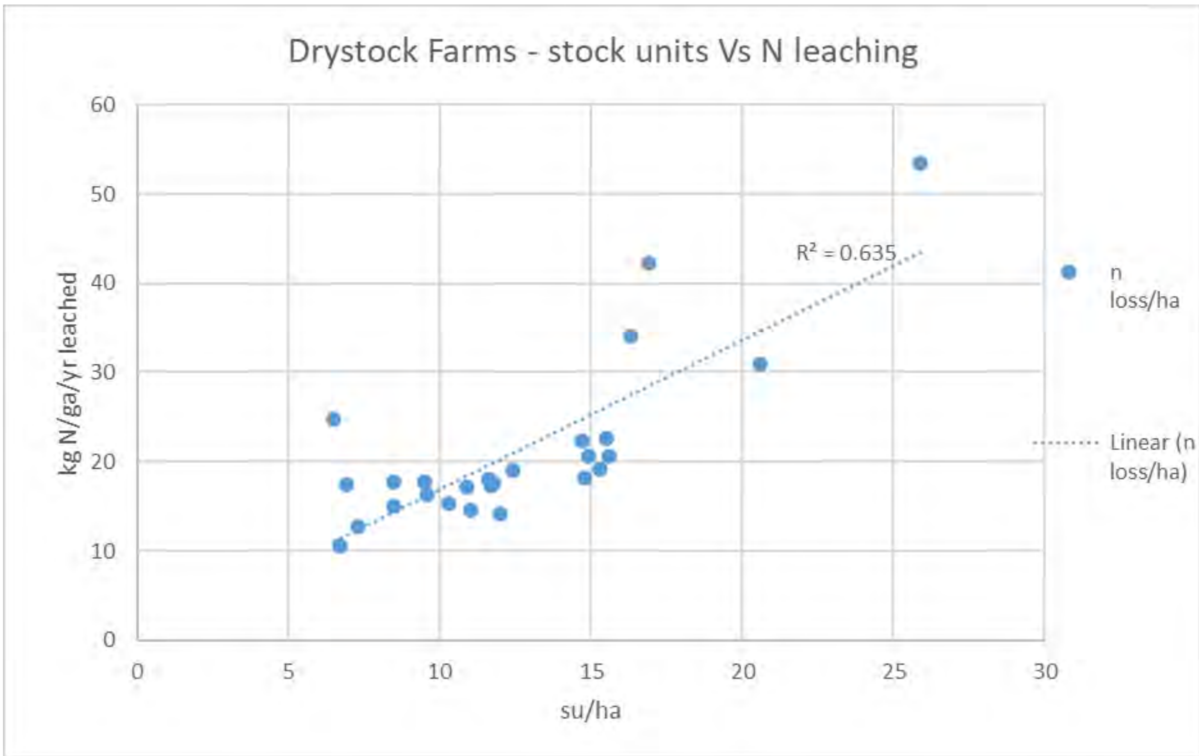
Figure 1: Preliminary analysis - Stocking Rate Vs Nitrogen Leaching



[2] Olubode-Awosola, F.; Palmer, J.; Webby, R.; Jamieson, I. (2014). Improving water quality in Waikato-Waipa Catchment: Options for dry stock and dairy support farms. Paper presented at the New Zealand Agricultural & Resource Economics Society.

[3] Overseer analyses derived from the pool of benchmarked properties from the Protect Lake Taupo project. Farm names are omitted.

Figure 2: Preliminary analysis - Stocking Rate Vs Nitrogen Leaching. R^2 value = 0.635



3. **Testing the relationship between stocking rate and predicted nitrogen leaching with standardised soil climate and fertiliser settings.**

In order to further investigate the extent to which biophysical factors may be influencing the observed correlation between su/ha and nitrogen loss, the preliminary analysis Overseer files used for were standardised by changing all block soil, climate, and fertiliser settings to standard settings[4]. All fertiliser inputs were deleted from the analyses to reduce any influence that form and type of fertiliser may have on the resultant correlation.

This analysis demonstrated a stronger relationship than the preliminary analysis between predicted nitrogen leaching and stocking rate on sheep and beef farms. The R^2 value of 0.8128 indicates a strong relationship between predicted nitrogen leaching and stocking rate when soil, climate, and fertiliser is standardised. See Figures 3 and 4. It is acknowledged that there is a noticeable outlier present in the data set. This is removed in figure 5.

Figure 3: su/ha Vs N leaching with soil climate and fertiliser standardised

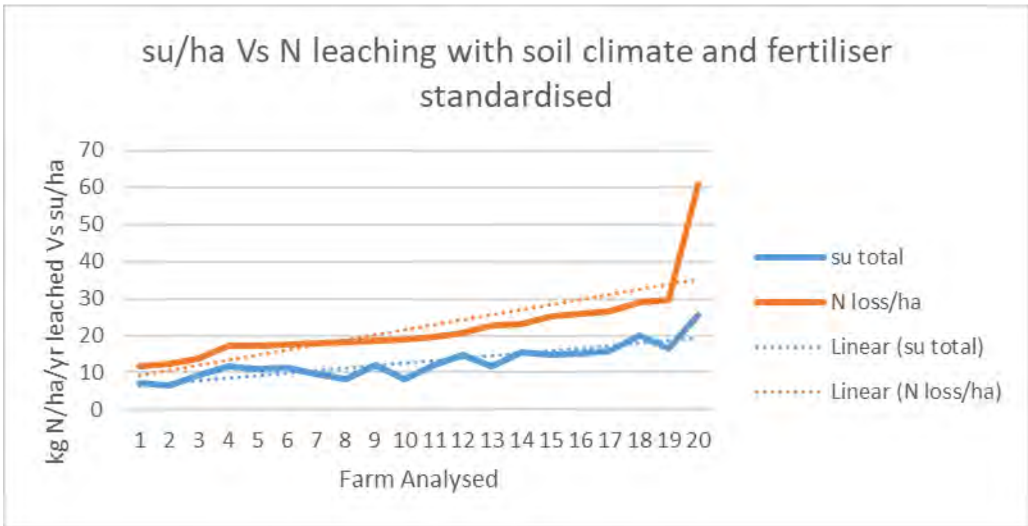
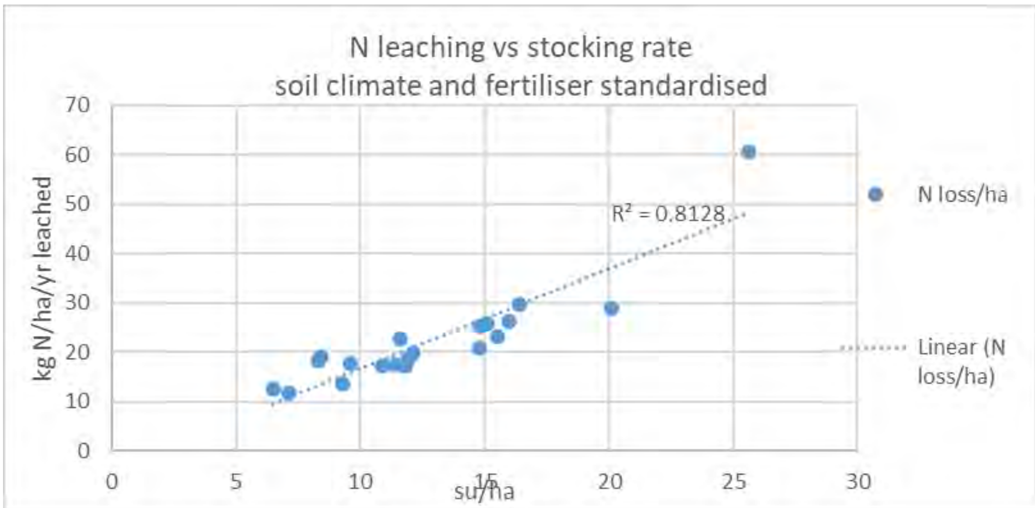
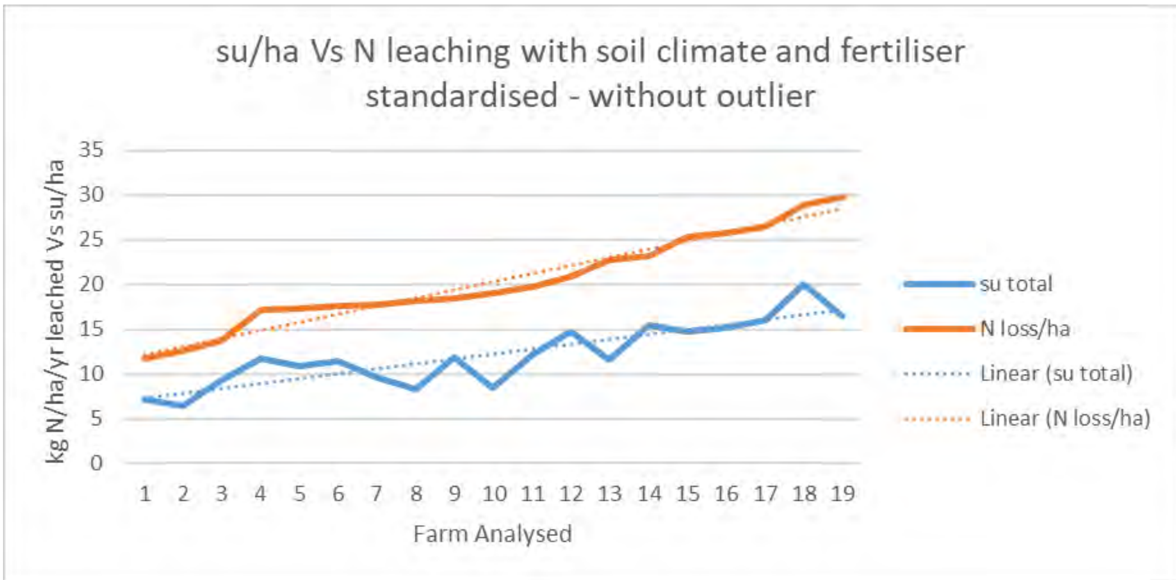


Figure 4: su/ha Vs N leaching with soil climate and fertiliser standardised. R^2 value = 0.8128.



The removal of the outlier farm produces a closer relationship – see figure 5, although the R^2 value did not change materially from the data displayed in Figure 4.

Figure 5: su/ha Vs N leaching, standardised leaching, with outlier farm removed.



Although there is still some variability in stocking rate, the observed trends indicate a close alignment between nitrogen leaching and stocking rate.

It was recognised that differences in farming systems and stock type may also be contributing to some of the observed variability. Such factors were thought likely to include differing sheep to beef ratios, percentage of female cattle, and percentage of breeding to finishing stock. Farm system efficiencies may also influence the correlation.

[4] For the standard Overseer 6 settings please see the appendices.

4. Testing the relationship between predicted nitrogen leaching and stocking rate using a fixed farm system with proportional changing stock numbers

In order to further test the correlation between stocking rate and predicted nitrogen leaching, if farms do not make major changes to their systems, analyses were undertaken using a steady state farm and the predicted N loss change in response to incremental stocking unit increase measured.

A sheep and beef farm was selected with a sheep to cattle ratio of 60:40. In this analysis the number of stock entered into the model was simply increased in 10% increments for each stock class and type. The results demonstrated a strong relationship (R^2 0.99) between stocking rate and predicted nitrogen leaching as seen in Figures 6 and 7.

Figure 6: Stocking rate Vs predicted nitrogen leaching with incremental increases to animal numbers

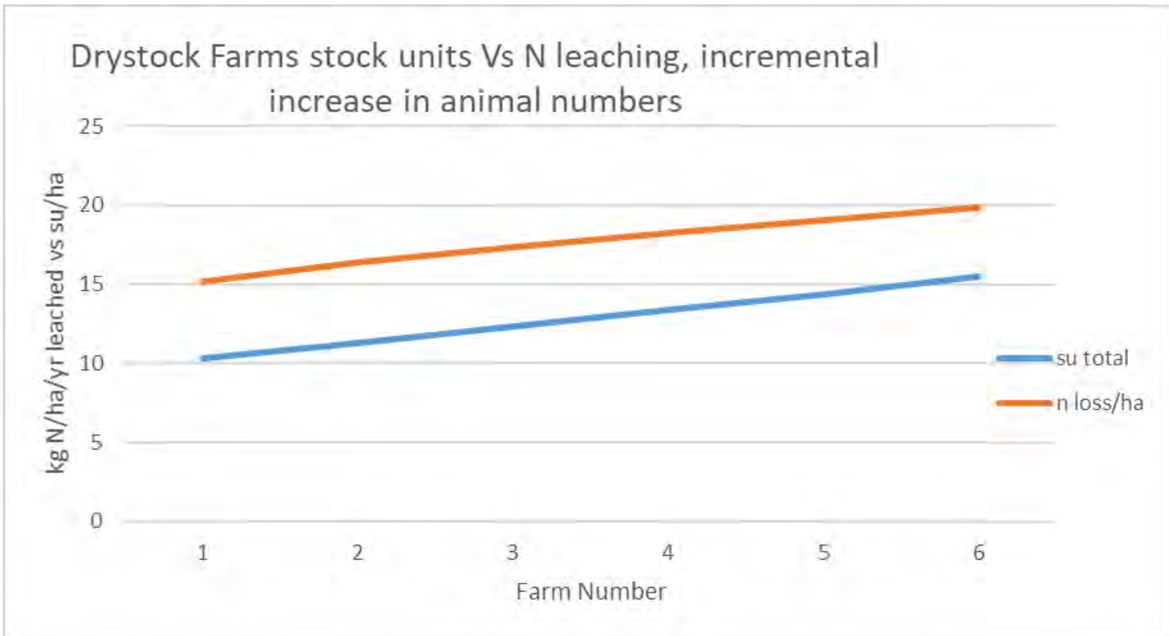
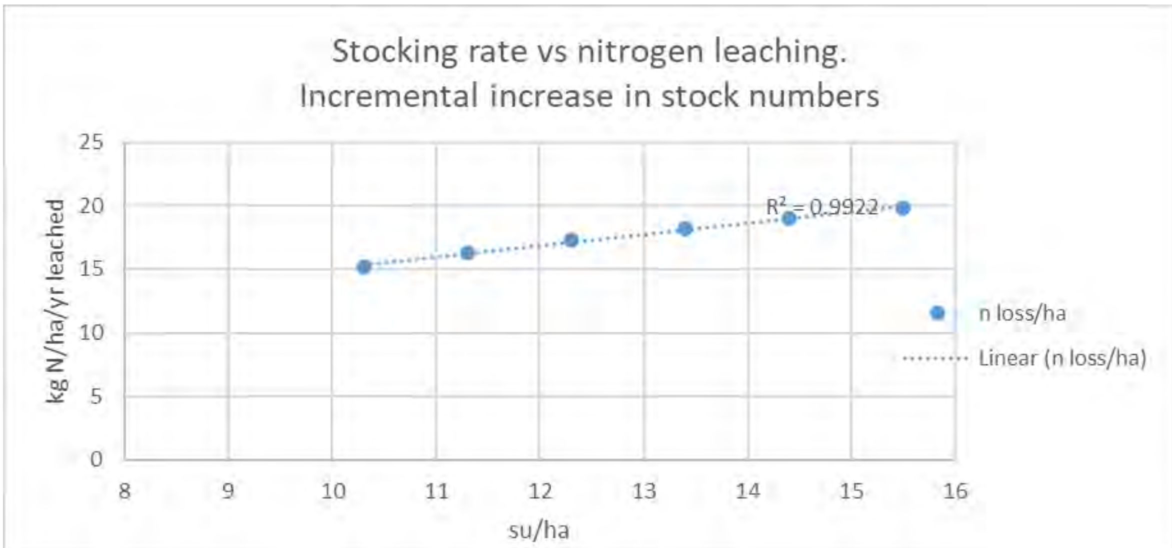


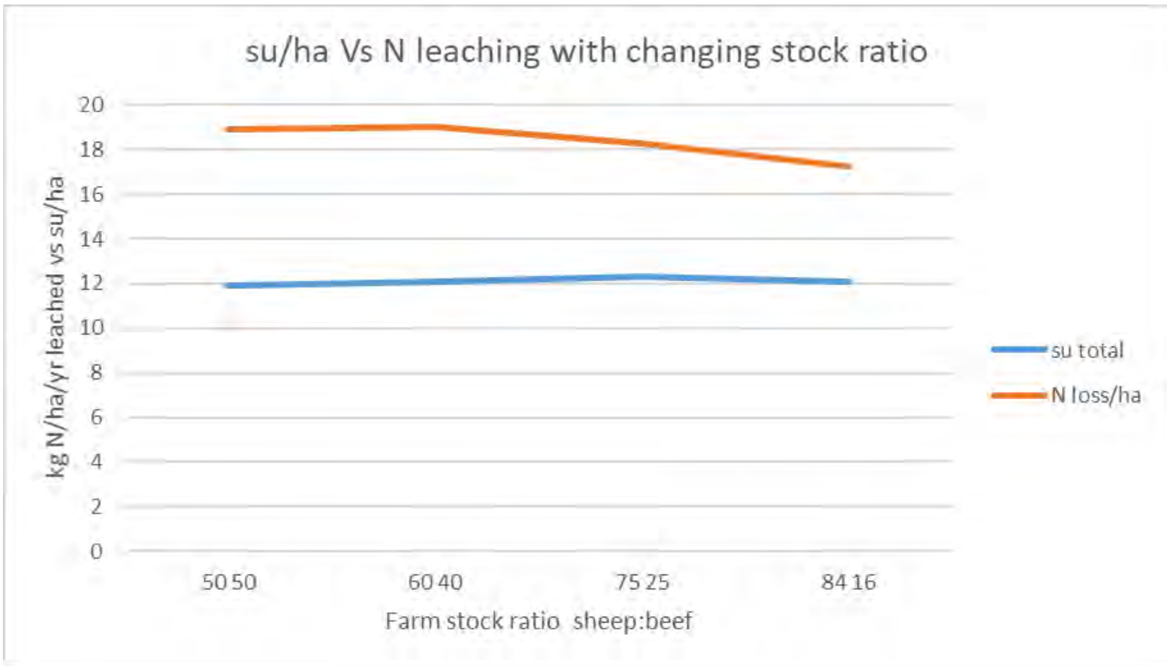
Figure 7: Stocking rate Vs predicted nitrogen leaching with incremental increases to animal numbers. R^2 value = 0.9922



This result is useful for the purpose of this analysis. Generally speaking, dry stock farms will not significantly change their farm system often, rather there will be minor fluctuations in stock numbers due to greater or lesser breeding success, changes to feed ability and climate that will affect the timing of the achievement of target weights for sale (the draft). Changes to the stock schedule may also encourage the farmer to sell early or to wait for more favourable market prices.

5. Predicted nitrogen leaching with changing sheep to beef ratios

There may be some variation in dry stock farm systems nitrogen leaching with varying sheep to beef ratios. In order to test this, four sample farms were set up with consistent biophysical parameters and with defined sheep to beef ratios. Predictably, as the ratio of sheep increased predicted nitrogen leaching decreased.



6. Conclusions

This analysis suggests a very strong relationship between nitrogen leaching and stocking rate for individual farms.

Analysis of farms that do not (or minimally) change their system produced a strong correlation between N leaching and stocking rate. Because most dry-stock farms do not vary significantly year on year, it is thought reasonable that this analysis represent realistic farm scenarios.

This strong relationship between predicted nitrogen leaching and stocking rate could be used as a proxy for compliance with the Waikato Proposed Plan Change 1 rules regarding Nitrogen Reference Point and Permitted Activity Rule 3.11.5.2.

Regulatory guidance for the use of any such proxy should consider the amount of allowable change to the farm system, including:

- Introduction of new stock classes such as deer or dairy cattle grazing to traditional sheep and beef farms.
- Any change from primarily breeding to finishing system
- Any increase in breeding success exceeding 5%
- Any changes to sheep to cattle ratio, where the ratio of beef or dairy grazing increases over sheep or deer.
- Large increases in the amount or area of cropping or supplement production
- Any increase in nitrogen fertiliser
- Any increases in bought-in feed
- Any increase to cropped area
- Any increase in the area irrigated or the amount of water irrigated on a farm

If a farm changed ownership or the farmer simply wanted to change their system, the new system could be modelled using Overseer – and if the proposed new system fit within their NRP (with changed versions of Overseer accounted for), then that system and its stocking rate could be used as the farms' new (updated) proxy.

It is a viable option to consider the use of a stocking rate proxy as an alternative to annual overseer analysis to ensure compliance with NRP as long as there are no significant changes to the farm system.

6.1. Rule 3.11.5.2

This proxy could also be used for proposed rule 3.11.5.2 (Permitted Activity) section 4, b, ii. This rule states that for farms over 20 hectares in area, an NRP is to be produced and that the diffuse discharge of nitrogen is not exceed the lesser of either:

- The NRP value (kg N leached) or
- 15 kg N/ha/yr

For compliance with this rule, the system described above will work. To comply with the 15 kg N/ha/yr limit, a scenario analysis could be created in Overseer that reflects the farm system and does not exceed 15 kg N/ha/yr, and the stocking rate noted – and future compliance with that stocking rate could then demonstrated by the farmer. Compliance with the NRP value may be required as described in the conclusions above.

7. Appendices

7.1. Data from Overseer analyses

Table 1. Data used for the preliminary analysis

	su sheep	su beef	su deer	su total	pasture	eff area	n loss eff incl other	n loss/ha	Rain	Soil Order	Soil Group
Farm 1	0.3	6.4		6.7	4487	173.3	1833	10.57703405	1426	Brown	Volcanic
Farm 2	5.3	2	0	7.3	5498	473.8	6044	12.75643732	1461	Brown	Sedimentary
Farm 3	4.3	7.7		12	8384	172.8	2442	14.13194444	1236	Brown	Sedimentary
Farm 4	0.9	10.1	0	11	6225	64	934	14.59375	1400	Allophanic	Volcanic
Farm 5	0.5	7.9	0.1	8.5	6024	115.7	1743	15.06482282	1241	Allophanic	Volcanic
Farm 6	2.6	7.7	0	10.3	7493	320	4901	15.315625	1300	Allophanic	Volcanic
Farm 7	0	9.6	0	9.6	7320	79.3	1292	16.2925599	1207	Allophanic	Volcanic
Farm 8	7.8	3.1	0	10.9	8495	113.5	1942	17.11013216	1970	Gley	Sedimentary
Farm 9	7.5	4.2		11.7	8497	2338	40413	17.28528657	1220	Pumice	Pumice
Farm 10	4.3	2.6	0	6.9	8470	470	8198	17.44255319	1400	Allophanic	Volcanic
Farm 11	7.9	3.9	0	11.8	8720	96.7	1705	17.63185109	1510	Allophanic	Volcanic
Farm 12		8.5		8.5	5598	234.9	4159	17.70540656	1467	Brown	Sedimentary
Farm 13	6.9	2.6		9.5	7068	258.7	4596	17.76575184	1628	Allophanic	Volcanic
Farm 14	7.9	3.7		11.6	9079	170.5	3062	17.95894428	1566	Allophanic	Volcanic
Farm 15		14.8		14.8	9856	66.1	1197	18.10892587	1185	Allophanic	Volcanic
Farm 16	8.6	3.8		12.4	9810	1514	28705	18.95970938	1352	Pumice	Pumice
Farm 17	9.9	5.4		15.3	11825	290.3	5580	19.22149501	1416	Pumice	Pumice
Farm 18	2.8	12.1	0	14.9	9641	207	4257	20.56521739	1300	Allophanic	Volcanic
Farm 19	8.9	6.7		15.6	11473	1180	24356	20.64067797	1350	Pumice	Pumice
Farm 20	0	17.7	0	14.7	7736	173	3866	22.34682081	1400	Allophanic	Volcanic
Farm 21	8.4	5	2.1	15.5	11758	1631.7	36855	22.58687259	1430	Pumice	Pumice
Farm 22	3.1	3.4	0	6.5	9865	121	2990	24.7107438	1500	Pumice	Volcanic
Farm 23	11.9	5.5	3.2	20.6	16216	2946.2	90997	30.88622633	1468	Pumice	Pumice
Farm 24	9.2	5.5	1.5	16.3	12680	2145	73022	34.04289044	1724	Pumice	Pumice
Farm 25	10.1	5.3	1.4	16.9	13275	1050	44377	42.26380952	2003	Pumice	Pumice
Farm 26		25.9		25.9	14081	55.2	2947	53.38768116	1246	Allophanic	Volcanic

Table 2. Data used for the testing the relationship between stocking rate and predicted nitrogen leaching with standardised soil climate and fertiliser settings (20 of the 26 farms used for the preliminary analysis).

	su total	n loss eff incl other	N loss/ha
Farm 1	7.1	5553	11.72014
Farm 2	6.5	2174	12.54472
Farm 3	9.3	3537	13.67221
Farm 4	11.8	1655	17.11479
Farm 5	10.9	1969	17.34802
Farm 6	11.4	2992	17.54839
Farm 7	9.6	1410	17.78058
Farm 8	8.3	4282	18.22903
Farm 9	11.9	3194	18.4838
Farm 10	8.4	2195	18.97148
Farm 11	12.1	29947	19.78005
Farm 12	14.8	6060	20.87496
Farm 13	11.6	53208	22.75791
Farm 14	15.5	27415	23.23305
Farm 15	14.8	1670	25.26475
Farm 16	15.1	42130	25.8197
Farm 17	16	56661	26.41538
Farm 18	20.1	85297	28.95153
Farm 19	16.4	31218	29.73143
Farm 20	25.6	3352	60.72464

Table 3. Data used for the testing the relationship between predicted nitrogen leaching and stocking rate using a fixed farm system with proportional changing stock numbers

	su sheep	su beef	su deer	su total	pasture	eff area	n loss eff incl other	n loss/ha	Rain
SU Test Base	6.2	4.1		10.3	7998	400	6073	15.1825	1200
SU Test Base + 10%	6.8	4.5		11.3	8803	400	6538	16.345	1200
SU Test Base + 20%	7.4	4.9		12.3	9593	400	6933	17.3325	1200
SU Test Base + 30%	8.1	5.3		13.4	10405	400	7301	18.2525	1200
SU Test Base + 40%	8.7	5.7		14.4	11192	400	7612	19.03	1200
SU Test Base + 50%	9.3	6.2		15.5	12009	400	7934	19.835	1200

Table 4. Data used for testing the relationship between predicted nitrogen leaching and stocking rate with changing sheep to beef ratios

Differing ratios	su total	n loss eff incl other	N loss/ha
50 50	11.9	7567	18.9175
60 40	12.1	7594	18.985
75 25	12.3	7316	18.29
84 16	12.1	6898	17.245

7.2. Overseer Standardised Settings

PARAMETER	SETTING
FARM LEVEL	
Location	Waikato
Animal Distribution on pasture	No difference between blocks
Distribution of animal classes within blocks	Same as ratio of total animal intake
Supplements Imported	None
BLOCK LEVEL	
Cultivated in the last % years	No
Topography	Rolling
Distance From Coast	100 km
Daily rainfall pattern setting	731-1450 moderate
Mean annual rainfall	1400 mm
Mean annual temperature	13°C
Potential evapotranspiration	651-800 mm/yr
PET seasonal variation	Moderate
Soil order	Allophanic
Profile drainage class	Well
Topsoil texture	Unknown and not stony
Lower profile	Left blank – no data entry
Soil Properties	K leaching potential left as default, no other data entered
Soil tests	Used defaults where there was missing data
Hydrophobic condition	Used default
Susceptibility to pugging	Winter
Artificial drainage method	None
Runoff intercepted by grass filter strip	No
Pasture type	Ryegrass/white clover
Other pasture settings	Left blank
Fertiliser	None entered
Irrigation	None entered
Animals, grazing management	Grazing months set to all months for all enterprises
Stock access to streams	None
Production	Non-finishing
DCD applications	Left blank
Supplements made	none