

IN THE MATTER

of the Resource Management Act 1991

AND

IN THE MATTER

of appeals lodged against proposed Plan Change 2
to the Manawatu-Whanganui One Plan

JOINT WITNESS STATEMENT OF FARM SYSTEM EXPERTS - PASTORAL

3 February 2023

INTRODUCTION

1. This joint expert witness statement relates to the appeals lodged against proposed Plan Change 2 (**PC2**) of the Manawatu-Whanganui One Plan which focuses on existing intensive farming land use activities within targeted water catchments in the region.
2. At mediation held on 12 December 2022 it was agreed that a risk framework approach should be initially explored further between the experts, with a view to reporting back to parties at a further mediation in early 2023. The matters agreed to, along with agreed next steps, are within a Mediation Agreement dated 12 December 2022.
3. The Mediation Agreement includes a range of questions for experts (farm system advisors and planners) to consider regarding the (then) proposed risk framework. A particular focus is on the range of biophysical characteristics in any risk framework, however the issues for discussion between the experts were also to include the extent of reduction required by any risk framework, and whether Table 14.2 can be amended to reflect risk. The questions posed by the parties are at paras [9] and [10] of the Mediation Agreement, but for ease of reference, are also set out below at paragraph [8] for completeness.
4. It is agreed that the most relevant biophysical characteristics to be considered as part of the risk assessment are soil type/soil vulnerability to N leaching and rainfall/sub-soil drainage.¹
5. Since mediation Professor Dave Horne has circulated an alternative proposal for consideration between the experts. The approach is described in background papers circulated to the parties on 25 January 2023 and 2 February 2023 respectively.² It is an alternative to the risk framework approach which had been discussed at mediation. The experts agree it is necessary to discuss the merits of the alternative proposal before the questions within the Mediation Agreement. This allows them to also address the alternative proposal as they respond to the questions posed to them in the Mediation Agreement. Where questions are not relevant to the alternative proposal (as opposed to the original risk framework proposal, as discussed at mediation) this has been identified.
6. Farm system experts attending the conference were:

¹ Paragraph 8.

² See *"What will the Risk Matrix deliver in terms of nitrate leaching?"* and *"A matrix to help interpret the Fonterra Risk Scorecard and achieve the improvement in farm management sought by Plan Change 2"*.

- (a) Professor David Horne (DH) for Manawatu-Whanganui Regional Council (**Horizons**);
 - (b) Dr Paul Le Miere (PL) for Federated Farmers (via AVL); and
 - (c) Dr Liz Parlato (LP) for Wellington Fish and Game and Ngati Turanga.
7. Dr Anne-Maree Jolly (AJ) for Horizons attended as an observer for Horizons given her role in co-ordinating the development of a risk framework for commercial vegetable growing (CVG) with experts for parties to the proceedings, including in particular, Hort NZ. Expert conferencing for the CVG topic is proposed for next Friday, 10 February 2023.

Agreed Questions

8. The questions set out at paras [9] and [10] of the Mediation Agreement, are set out below. The experts responses are set out in **Annexure A**.

Biophysical factors³

- (a) Should soil type/soil vulnerability to N leaching and rainfall/sub-soil drainage be added to the risk tool?
- (b) What are the graduations for each biophysical factor?
- (c) What factor or multiplier should apply to each biophysical factor?
- (d) Do questions (a)-(c) change which farms are in any particular category (compared with the scorecard without biophysical factors)?

Reduction required⁴

- (e) How much reduction would asking farms to reduce to the 75th percentile deliver?
- (f) Does a 20% reduction in risk equal a 20% reduction in N loss? If not, how can you translate the 20% reduction in N leaching to risk (or actions and mitigations to achieve N loss reductions)?
- (g) Does the answer to questions (e) and (f) change depending on whether you include biophysical factors or not?

³ As set out at paragraph [9] of the Mediation Agreement.

⁴ As set out at paragraph [9] of the Mediation Agreement.

- (h) Is it possible to maintain the 2012/13 baseline? i.e. is there sufficient data for individual farmers to calculate a risk score as at 2012/13?

Revised table 14.2B (which accounts for risk):⁵

- (a) How are the table values calculated?
- (b) How does it ensure that there are no duplications or double counting as between soil types, rainfall, use of Overseer etc?
- (c) How accurate is it?
- (d) How does Table 14.2B account for LUC?
- (e) What is the purpose of Table 14.2B?

CODE OF CONDUCT

- 9. This joint witness statement is prepared in accordance with section 9.5 of the Environment Court Practice Note 2023.
- 10. We confirm that we have read and complied with the Code of Conduct for Expert Witnesses.

PURPOSE AND SCOPE OF CONFERENCING

- 11. Refer paragraphs [2] – [5] above.
- 12. This conferencing session builds on earlier discussions between the experts as part of a suite of workshops, with expert conferencing statements dated 28 June 2022, 25 August 2022, and 7 October 2022 having previously been agreed to by the participating experts.
- 13. The scope of the issues covered at the conference included:
 - (a) Discussion of the alternative proposal of Professor Horne. The relevant background papers to the alternative proposal, as circulated to the experts in advance of expert conferencing are at **Attachment A**.
 - (b) The questions at paras [9] and [10] of the Mediation Agreement.
 - (c) Further work required.

⁵ As set out at paragraph [10] of the Mediation Agreement.
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KEY FACTS AND ASSUMPTIONS

14. Discussions around the alternative proposal were based on background papers circulated by Professor Dave Horne on 25 January 2023 and 2 February 2023 respectively.⁶

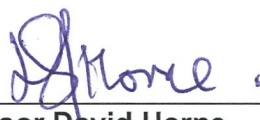
AGREED ISSUES

15. Refer to Annexure A.

DISAGREEMENT AND REASONS

16. Refer to Annexure A.

Date: 3 February 2023



Professor David Horne



Dr Paul Le Miere



Dr Liz Parlato



Dr Anne-Maree Jolly (observer)

⁶ See "What will the Risk Matrix deliver in terms of nitrate leaching?" and "A matrix to help interpret the Fonterra Risk Scorecard and achieve the improvement in farm management sought by Plan Change 2".
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ANNEXURE A

In the matter of Proposed Plan Change 2

Expert conferencing – Intensive Farming Risk Scorecard Continuation (Pastoral Experts – DH, PL, LP)

Issue	Statements	Agreed Position	Disagreements, with reasons
Topic 1 – Alternative Proposal			
Whether biophysical factors should be included in the risk matrix tool.		All agreed that there needs to be the same philosophy behind the pastoral and commercial vege scorecards. DH and LP agree that biophysical factors need to be included in the risk matrix. All agree that there are advantages to both the December 2022 approach and the January 2023 approach. If biophysical factors are to be included, the form of the January 2023 matrix is preferred by the experts over the December 2022 approach (using a multiplier) as a Table 14.2 alternative. However, the experts note that it may have planning implications for the consenting pathways because there will not be a 20% reduction or 75th	PL still disagrees with including biophysical factors in a risk scorecard/matrix, however, sees advantages of these approaches if they are to be included. There has not been sufficient time to consider DH's papers and analyse the impacts of the proposal.

Issue	Statements	Agreed Position	Disagreements, with reasons
		percentile calculated due to not having a numerical score that incorporates biophysical factors. LP considers that the December 2022 approach provides a potential method that would allow for these alternative consenting pathways as it amalgamates management risk and biophysical risk into a single score.	
Discussed the form of the matrix and how it should be populated – whether categories should be used or numerical scores.	DH explained that the changes required at this stage are based on categories (Very High, High, Medium, Low, Very Low). There are scores behind the risk categories but they are only used to inform the categories and are not calculated for the farmers. However, these scores could be used if this was the preferred approach. LP sees the benefit in categories making the scorecard more user-friendly, however, she prefers a score because it will make it easier to amalgamate scores for mixed operations or farms with mixed soil types/rainfall. LP raised that if only categories are used, it would be difficult to show a 20% reduction. There may be more flexibility in having a score.	All agreed to put both alternatives to the planners, both a numerical score-based matrix and a categories-based matrix. All experts unanimously agreed that there are both advantages and disadvantages of each approach to the matrix. An idea for a hybrid was also proposed (giving a score but also saying you cannot have any “Very High” practices OR giving a score and saying you cannot have any practices above 60).	

Calibration of the matrix values	PL expressed that he has not had enough time to do his own modelling or sensitivity testing of DH's alternative proposal. From PL's analysis so far, 31% have at least 1 high practise and 27% have at least 1 very high practise. Initial analysis of moving from high/very high to low is quite onerous. Most farm's biophysical characteristics do not put them in the bracket of the matrix which allows them a medium category.	All agreed to use profile available water and rainfall. However, the management risk requirements in the January 2023 matrix at this stage may be too stringent and are to be further analysed by further modelling from PL (with the Fonterra database). The Fonterra database and the 7 base farms used to develop Table 14.2 will now be used to establish more practicable/ achievable criteria.	
Further work		DH to translate matrix into numbers and send to PL by 10 February 2023. PL to calibrate those numbers against the Fonterra farms data. He will endeavour to complete this before the planners conference at the end of February.	

Topic 2 – Biophysical Factors			
(a) Should soil type/soil vulnerability to N leaching and rainfall/sub-soil drainage be added to the risk tool?		DH and LP agree that they should be included in the risk tool.	PL is unconvinced that they need to be in the risk tool and currently believes they should be included elsewhere in the consenting process.
(b) What are the graduations for each biophysical factor?		Agreement on those proposed by DH paper circulated on 2 February 2023.	
(c) What factor or multiplier should apply to each biophysical factor?	For the January 2023 approach, a multiplier is not applicable. As above, calibration of the matrix needs to be further investigated. Further analysis would be needed to agree on a multiplier if the December 2022 approach was preferred.		
(d) Do questions (a)-(c) change which farms are in any particular category (compared with the scorecard without biophysical factors)?		Experts agree that yes, the farms in each category would change. However, the number of farms that would change is unknown until further calibration of the matrix is undertaken.	

Topic 3 – Reduction Required			
(e) How much reduction would asking farms to reduce to the 75th percentile deliver?	PL can show a 75th percentile without biophysical factors but would not be able to calculate a 75th percentile using the matrix because it does not amalgamate a score. From PL's initial analysis of the farms above the 75th percentile, they average a 27% reduction of their risk score, and this ranges from 21 – 33% depending on the 5 priority catchments. The December 2022 approach would allow a 75th percentile with biophysical factors to be calculated but this has not been calculated at this stage.		
(f) Does a 20% reduction in risk equal a 20% reduction in N loss? If not, how can you translate the 20% reduction in N leaching to risk (or actions and mitigations to achieve N loss reductions)?		All agree that no, a 20% reduction in risk categories might not accurately equal a 20% reduction in N loss. However, DH's research shows that reductions in risk may have comparable reductions in estimated N loss (from Overseer) for the farms DH analysed. This would only be relevant to the December 2022 approach, if this approach is preferred, further work will be required here to demonstrate the strength of this relationship.	
(g) Does the answer to questions (e) and (f) change depending on whether you include biophysical factors or not?		All experts agree that yes, they will change.	
(h) Is it possible to maintain the 2012/13 baseline? i.e. is there sufficient data for individual farmers to calculate a risk score as at 2012/13?	It has been confirmed that Dairy NZ has a database that could be used to generate a risk score for farms as of 2012/13.	All agree that this is an advantage of the January 2023 matrix, it overcomes this issue.	

Topic 4 – Revised table 14.2B (which accounts for risk)			
	DH's Table 14.2B, discussed at mediation, is irrelevant if the January 2023 approach is preferred. The proposed January 2023 matrix addresses the concerns raised by these questions – this is another advantage of the January 2023 approach. Refer to discussion above regarding calculations in January 2023 approach and DH's background papers circulated.		
(a) How are the table values calculated?			
(b) How does it ensure that there are no duplications or double counting as between soil types, rainfall, use of Overseer etc?			
(c) How accurate is it?			
(d) How does Table 14.2B account for LUC?			
(d) What is the purpose of Table 14.2B?			

Topic 5 – Any other matters			
Further work	DH to translate matrix into numbers and send to PL by 10 February 2023. PL to calibrate those numbers against the Fonterra farms data. PL will also need to go back and look at the categories once this calibration is made. He will endeavour to complete this before the planners conference at the end of February. DH to rerun the 7 base farms Overseer-risk comparison based on LP's concern that farmers will most likely want to make the minimal change to drop into a lower category.		

Attachment A

A matrix to help interpret the Fonterra Risk Scorecard and achieve the improvement in farm management sought by Plan Change 2

This paper has been prepared for the purposes of without prejudice discussions between the parties to the appeals against Plan Change 2 to the One Plan. It is to be used for those purposes only.

Introduction

The original intent of the One Plan was to require intensive farming land uses in the 'priority catchments' to reduce the risk of nitrogen (N) leaching from their properties. This was to be achieved by adopting Good Management Practices. It has always been acknowledged that some farms posed a greater risk than other farms due to what is often called geophysical or environmental factors i.e. soil type and the quantity of drainage (or rainfall).

Originally, Overseer was the means (i.e. tool) by which farmers were to identify the level of risk of N leaching which would indicate the scope of Good Management practices needed to reduce N leaching risk. When the decision was made to find an alternative to Overseer, a group of experts identified the Fonterra Risk Scorecard as a suitable tool to help dairy (and irrigated pastoral) farmers assess the risk that their management practices posed to N losses in drainage. A group of experts developed an analogous Risk Scorecard for intensive vegetable production.

All experts agreed that in addition to the risks associated with farm management, key geophysical factors should also be accounted for somewhere in the consenting process. However, there was a difference of opinion as to where these factors should be addressed in a risk management approach. Two options have been considered.

In the first approach, adjustment factors which reflected the influence soil type and rainfall on the quantity of N likely to leach, were used to directly modify the management risk scores. This procedure is outlined in **Appendix 1**. This method was discussed at mediation on the 12 December 2022 where a number of concerns were expressed about the basis for the adjustment factors (or weightings).

A second way to incorporate the effect of geophysical factors is to let them provide the context for the interpretation of the risks associated with farm management as assessed by the risk scorecards. As will become apparent below, this approach has several advantages. Firstly, it maintains the integrity of the two Risk scorecards (i.e. they are not modified by adjustment factors). Secondly, it is more in keeping with the 'scorecard' mode (i.e. it is more straightforward). Thirdly it creates a more direct 'line of sight' to the management of risk. Fourthly, it provides a simpler and more transparent matrix.

A matrix to assist the interpretation of the risks associated with farm management.

As noted in Appendix 1, and agreed by experts, soil type and climate determine the amount of surplus N that leaches from farms. Therefore, these characteristics should be accounted for in any assessment of N leaching and, more importantly, the identification of good management practices for adoption.

Figure 1. set out below presents the general form of a matrix to help interpret, or provide context for, the management risk scorecards.

Figure 1. The generalised form of a matrix to help interpret the risk that the surplus N in soils, as assessed by the management risk scorecards, will leach from farms. The matrix suggests how geophysical characteristics can be used to interpret the management risk.

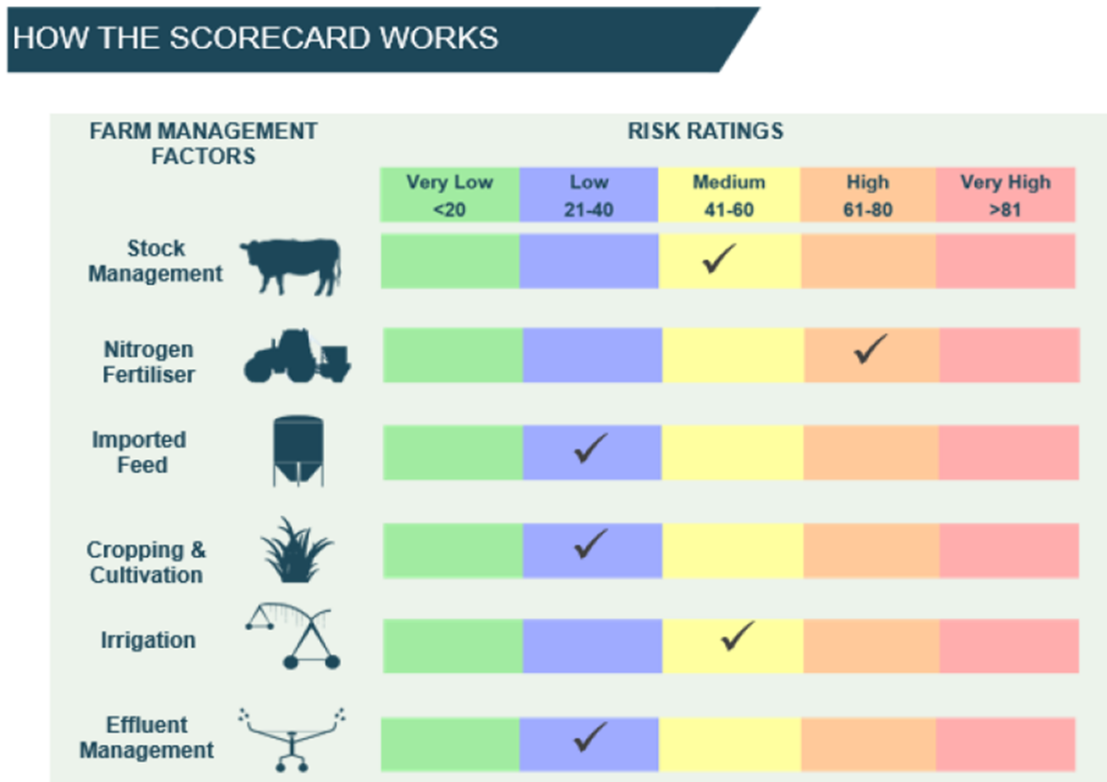
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Drainage 1	Small geophysical risk allows for greater management risk																																																										
Drainage 2	<table><thead><tr><th colspan="2">FARM MANAGEMENT FACTORS</th><th colspan="5">RISK RATINGS</th></tr><tr><th></th><th></th><th>Very Low Risk</th><th>Low Risk</th><th>Medium Risk</th><th>High Risk</th><th>Very High Risk</th></tr></thead><tbody><tr><td>Stock Management</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Nutrient Fertiliser</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Imported Feed</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Cropping & Cultivation</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Irrigation</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Effluent Management</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></tbody></table>			FARM MANAGEMENT FACTORS		RISK RATINGS							Very Low Risk	Low Risk	Medium Risk	High Risk	Very High Risk	Stock Management							Nutrient Fertiliser							Imported Feed							Cropping & Cultivation							Irrigation							Effluent Management						
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The management risk scorecards (assessing the farm management factors) can then be placed within this larger matrix. In this manner, the matrix can help to identify how farmers determine their overall risk status and the good management practices that they need to adopt to mitigate this risk. For example, the risk that the surplus N generated on farms in low rainfall/fine textured landscapes will leach beyond the root zone is relatively small, requiring less management interventions. Conversely, where the soil type and climate are likely to result in much of the surplus N leaching from the root zone, more stringent management interventions are required to reduce the net risk.

Populating the matrix

For the Fonterra Risk scorecard (relevant to dairy and irrigated sheep and beef), it is proposed that, to qualify for the controlled activity pathway, a farm should achieve at most no more than a net or overall 'Low' risk to N leaching (as determined by the above matrix). The farm management factors assessed in the Fonterra risk scorecard are shown in Figure 2. Put simply, farmers will need to, essentially, target a 'low' score across all of the management categories. However, because of the nature of their geophysical characteristics, some farmers will have a little more flexibility and will be able to have some scores in the 'medium' category- these are the Low-risk sectors of the matrix depicted in Figure 1. In contrast, as the risk posed by environmental factors on some farms are greater, they will need to score in the 'very low' category for some management practices.

Figure 2. The Fonterra risk scorecard showing the risk categories for each of the farm management factors



The proposed matrix for dairy and irrigated pasture is presented in Fig. 3. This figure illustrates how the Fonterra risk score can be interpreted within the geophysical risks associated with soil type and the quantity of drainage. As suggested above this provides direct or transparent evidence that the risks associated with farm management are being managed appropriately i.e. (overall) 'Low' risk.

For simplicity, it is suggested that soil type be distinguished by texture (although alternatives might include soil drainage class or Profile Available Water) and that rainfall can be used as a proxy for the quantity of drainage.

A dairy farm (non-irrigated) with 'Medium' texture and rainfall of 1100 mm '(i.e. in the middle of section of the matrix above), would require that the 'Stock Management', Nitrogen Fertiliser', 'Imported feed', 'Cropping and Cultivation' and 'Effluent Management' factors could at most tick or score the 'low' rating i.e. (at most) 5 'low' scores. A farm on a 'Fine' textured soil under 900 mm can score, at most 2 'medium' and 3 'low' rates which, due to these geophysical features, will equate to an overall 'Low' risk in the matrix. In contrast, a farm with a coarse textured soil and 1700 mm rainfall will need to constrain management risk in three categories to 'very low' and 'low' for the other two factors to generate a total 'Low' risk rating. Table 3 illustrates how the Fonterra risk score can be interpreted within the geophysical risks associated with soil type and the quantity of drainage. As suggested above this provides direct evidence that the risks associated with farm management are being managed appropriately i.e. overall 'Low risk' (as assessed by the matrix).

Figure 3. The proposed matrix to help interpret the Fonterra risk score and identify the required good management practices.

	Soil type A (Fine texture)	Soil type B (Medium texture)	Soil type C (Coarse texture)
Rainfall 1 <1000 (mm)	Medium - 2	Medium - 2	Low - 4
	Low - 3	Low - 3	Very low - 1
Rainfall 2 (1000 – 1200 mm)	Medium - 2	Low - 5	Low - 3
	Low - 3		Very low - 2
Rainfall 3 (1200 – 1400 mm)	Low - 5	Low - 4	Low - 2
		Very low - 1	Very low - 3
Rainfall 4 >1400	Low - 5	Low - 3	Low - 2
		Very low - 2	Very low - 3

Reductions in N leaching

A comparison between the use of the proposed matrix to categorise overall risk and Overseer estimates of N leaching is not straightforward. In some ways, a more important comparison is the extent to which these tools drive similar changes in farmer behavior and the adoption of good management practices. It was the opinion of experts that the Fonterra Risk scorecard is a widely used method for identifying and encouraging the adoption of good practices to reduce the risks posed by pastoral farm management. In assisting with the interpretation of the management risk, the matrix proposed here brings the overall assessment of risk more 'in line' with Overseer estimates.

The above concerns notwithstanding, a simple attempt was made to compare the likely outcome of employing the proposed matrix on N leaching as assessed by Overseer. This involved typical farm systems being run through Overseer. The most direct comparison is where all five management factors must score 'low'. Overseer files were set up that used inputs suggested by possible scenarios captured in this sector of the matrix (e.g. rainfall 1100 mm, medium soil texture, and management factors that gave a 'low' score as described in the manual for the Fonterra Risk Scorecard). As noted, it is not straightforward when comparing categories (the matrix and the Risk scorecard) with specific values (Overseer). Nevertheless, the result of this exercise suggests that if this farm used the matrix to identify the management practices that it needed to adopt, then it would leach very approximately 35 to 45 kg N/ha/yr. This compares very favorably with Cumulative Nitrogen Leaching Maximum of 30

to 40 kg N/ha/yr as described in Table 14.2 for this type of farm. Further analysis of farming systems in Overseer is proposed to confirm the early indications that setting targets at overall 'Low' risk in the matrix would require significant management practices, and therefore significant N leaching reductions consistent with PC2.

Summary

The matrix proposal presented within this paper provides a means of incorporating the geophysical factors in the assessment of the risk of N leaching from farms. It does so in a manner that maintains the integrity of the Risk Scorecard. It helps the scorecard to identify the good management practices required on farms by accounting for the influence of soil type and drainage on the quantity of 'at risk' N that leaches. Importantly, it also addresses the two key geophysical risk factors (soil and rainfall) in a more transparent way and will constrain the overall risk of N leaching from farms to a 'Low' level. Preliminary analysis of the proposal suggests it would result in reductions in N consistent with PC2. Further work is being done to test the approach, and these early, indicative results.

APPENDIX 1

Without Prejudice

**A proposal to modify the Fonterra Risk Matrix to identify the Overall Risk Matrix for N leaching
from pastoral farms to help achieve the PC2 outcomes for improved water quality:
a discussion document**

1. Some simple theory

Nitrogen (N) leaching might be thought of as two interconnected processes. Firstly, there is the quantity of N that accumulates in the soil which is at risk to leaching. This is determined by, amongst other factors, the type and intensity of the farm system. For example, given a similar climate and soils, N leaching under a highly stocked dairy farm will generally be greater than N loss to water under a moderately stocked sheep farm. The point system embedded in the Fonterra Risk Matrix seeks to describe the effects of farm inputs and management practices on the relative magnitude, and hence risk, of the N that is likely to accumulate in soils on dairy farms.

However, not all this 'at risk' N will necessarily leach. So, in estimating the quantity of N likely to leach from a farm, it is equally important to be able to identify the proportion of the mobile N in the soil that will be lost in drainage. The fraction of the 'at risk' N that will leach will be very sensitive to environmental factors i.e. climate and soil type. Climate and soil type will determine the quantity of drainage, and just as importantly, the nature of the pores that this drainage will flow through. These two concepts are combined when the quantity of drainage is expressed as 'pore volume' equivalents. Put simply, this is the number of pore volumes that will be replaced by drainage and might be thought of as a measure of the number of times a soil profile is flushed. If the pore volume is flushed many times (e.g. 8) then there will be more opportunity for mobile water to collect N and leach it beyond the soil profile. If on the other hand, the pore volume is only flushed a few times (e.g. 3) then more of the N is likely to remain in the soil.

Overseer uses pore volumes drained in its predictions of N leaching. Currently, there is no comprehensive database for 'pore volume' as it is understood in this context. Therefore, for simplicity and, following the protocol used by Overseer, the Profile Available Water (PAW) will be used as an indicator of pore volume.

In summary, focusing on 'pore volume' equivalents drained has the advantage of essentially merging the two environmental factors of climate and soil type into one parameter, making the incorporation of environmental factors (climate and soil type) into the Fonterra Risk Matrix more straightforward.

2. The effect of Environmental factors (climate and soil type) on N leaching

Overseer files for a series of farms in the priority catchments were used to investigate the importance of the so-called environmental factors, captured here as pore volume equivalents drained (which, as noted, is determined by climate and soil type) on the estimate of N leaching. For each farm, all inputs other than soil type were kept constant: this in effect changed the number of pore volumes draining. On some farms, this was a natural occurrence i.e. they had contrasting soil types.

It is clear that climate and soil type (or pore volume equivalents drained) have a determinative effect on the quantity of N leaching from farms. The quantity of N leaching under the same farm inputs and management (i.e. the same Fonterra Risk score) might vary 3 or 4 fold depending on soil type and climate combinations. There does not appear to be any reasonable case that can be made to ignore environmental factors in predictions of the relative risk of N leaching from pastoral farms.

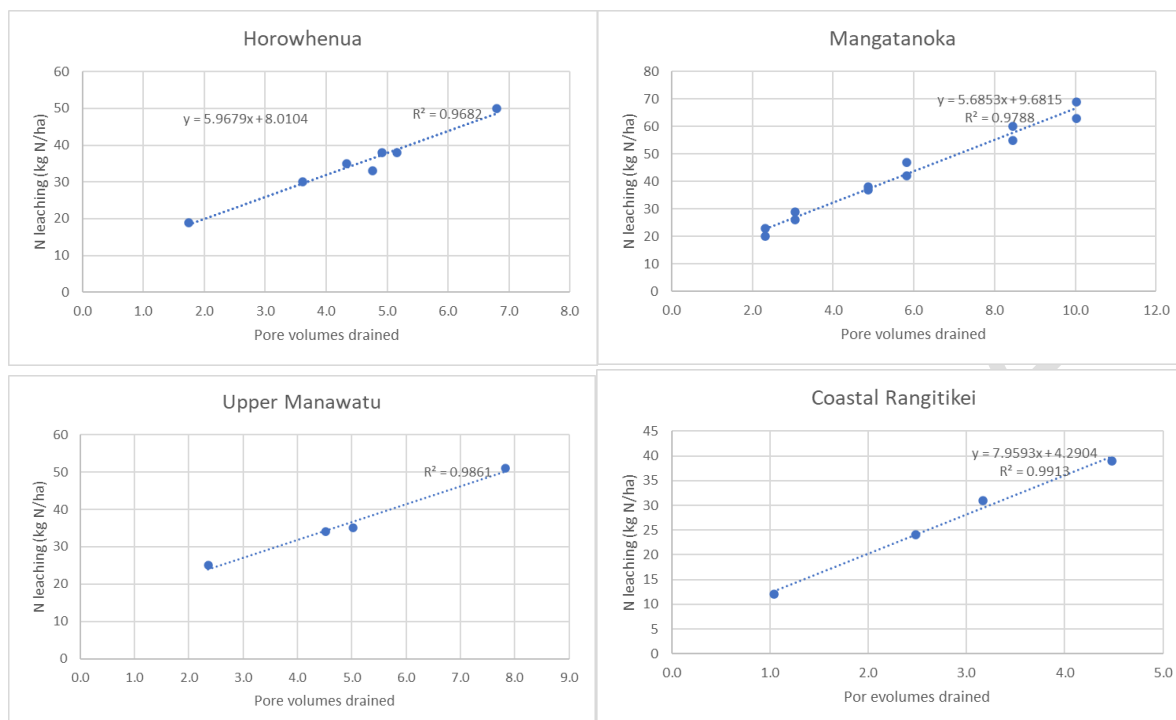


Figure 1. The relationship between drainage, expressed as pore volume equivalents, and N leaching for some case study dairy farms in the priority catchments.

3. Modifying the Fonterra Risk Matrix

The importance of climate and soil type on estimates of N leaching from pastoral farms has not been disputed in expert conferencing. All experts agreed that incorporating environmental factors into the Fonterra Risk Matrix would be a challenge. I am suggesting that the use of pore volumes provides a possible solution to this problem.

It is important to note a key, if obvious, difference between Overseer and the risk matrices. Overseer estimates the quantity of N that will leach from a farm and expresses this as a flux i.e. a meaningful value (e.g. 40 kg N/ha). In comparison, a risk score is not a physical phenomena in the same way: it has no sensible units and a risk score cannot be thought of as actual leaching. Therefore, risk scores can only be used to rank or sort. In order to think about the likely impact of a risk score on water quality the risk score needs to be compared to a known farm's risk score and its leaching rate. In this section, I use an average farm for the Horizons region i.e a farm with average inputs and farm management practices and 400 mm of drainage through an intermediate textured soil. Approximately 35 kg N/ha is leached from this farm. (The way that I will use these values means that the exact nature of this farm is not that important i.e. remember that this is a comparative or relativising exercise).

If the values in the analyses reported in Fig 1 are normalized to an average (inputs and performance) farm with average drainage (400 mm) on an average soil type (intermediate textured silt loam) then Fig 2 is produced. This yields the relationship between pore volumes drained and the relative quantity of N leaching. Figure 2 suggests that if the quantity of at 'risk N' is known -using the Fonterra Risk Matrix - the relationship developed here can be used to modify this risk and identify the Overall Risk

of N leaching. In other words, the Fonterra Risk score can be multiplied by a factor reflecting the number of pore volume equivalents that are drained (the influence of environmental factors).

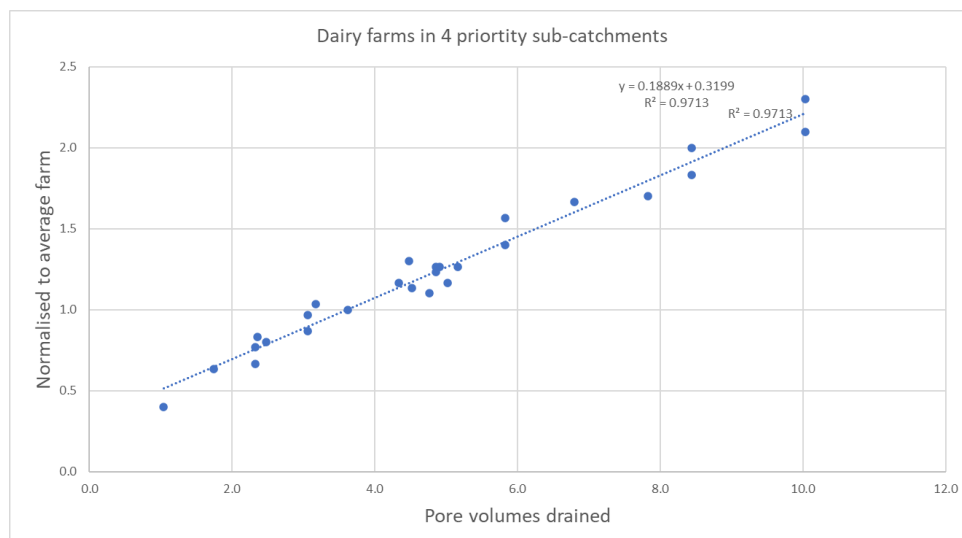


Figure 2. Normalization of the data presented in Fig 1 to an 'average' farm in the Horizons region (in terms of farm management and inputs i.e. risk score and environmental factors)

This raises the question as to how to determine the pore volume equivalents that are drained. These can be easily calculated from Overseer outputs in a manner which would allow direct insertion into the expression given in Fig.2. However, many farmers have let their subscription to Overseer lapse. Furthermore, it is suggested that rather than using the mathematical expression given in Fig. 2, a more general categorisation might be simpler, easier to use and a better fit with the 'category' approach of the Fonterra Risk Matrix i.e. the rigour implied in the maths here does not match the more approximate nature of the Risk framework.

Accordingly, Tables 1, 2 and 3 were developed. These Tables show how the Fonterra Risk score can be modified by a factor that accounts for environmental features. These Tables are presented here for consideration and discussion, which it to say, that more or fewer bands/categories for rainfall and drainage in Tables 2 and 3 could be employed. Average rainfall for a farm is well known, so obtaining a reliable value for precipitation presents few problems. Furthermore, three soil categories may appear to be too few or insufficiently nuanced. However, given the nature of the approximations and broad categories in the Fonterra Risk matrix and the assumptions in the argument outlined above, three soil classes may be sufficient. Fewer soil categories will be easier to work with as it is not obvious how more categories could be described in a way that was useful to end users of the matrix.

Table 1. The relationship between the pore volumes drained (as it reflects environmental factors) and the relative risk of N leaching (to an average farm inputs/risk score and rainfall/soil type). These values have been smoothed or generalized to better fit with the more approximate nature or category approach of the Fonterra Risk matrix.

Pore volumes drained	Fraction of Risk Matrix score that is leached	Smoothed fraction
1	0.5	0.5
2	0.7	0.75

3	0.9	0.75
4	1.1	1
5	1.3	1.25
6	1.5	1.5
7	1.6	1.5
8	1.8	1.75
9	2.0	1.75
10	2.2	2

Table 2. Identifying the pore volumes drained for the environmental categories (rainfall/drainage and soil type) that are common in the priority catchments.

Pore volume equivalents drained				
Rainfall (mm)	Drainage (mm)	Soil type (Texture and PAW)		
		Fine 160 (mm)	Medium 110 (mm)	Coarse 60 (mm)
<1000	300	2	3	5
1000 -1200	400	3	4	7
1200 -1400	500	3	5	8
>1400	650	4	6	11

Table 3. Combining Tables 1 and 2 to identify the values for the modifying factor that can be used to adjust the Fonterra Risk Matrix to account for environmental attributes and arrive at an Overall Risk Matrix.

Modifying factor for Risk Matrix score				
Rainfall (mm)	Drainage (mm)	Soil type (Texture and PAW)		
		Fine 160 (mm)	Medium 110 (mm)	Coarse 60 (mm)
<1000	300	0.75	0.75	1.25
1000 -1200	400	0.75	1	1.5
1200 -1400	500	1	1.25	1.75
>1400	650	1	1.5	1.75

A couple of general points might be made in defense of Table 3 i.e. criteria for a 'sense' test. Firstly, it is simple and coarse in scale i.e. it is not 'overcooked'. Many of the risk frameworks currently being developed around the country are populated with values based on expert opinion. I suggest that if presented with an empty Table 3, a group of experts familiar with leaching rates from dairy farms in the priority catchments might well have come up with values similar to the ones derived here from what is a more theoretical and quantitative process.

4. Identifying the Overall Risk Matrix for Nitrogen leaching from a pastoral farm

It might be argued that in its current form, the Fonterra Risk Matrix identifies only part of the risk that farming poses to the aquatic environment i.e., the risk posed by the addition of N to the soil. It is

suggested that an Overall Risk Matrix for pastoral farms can be developed by incorporating a modifying factor that accounts for the role of environmental factors (climate and soil type) on the risk of N leaching to waterways. Essentially this will involve multiplying the current Fonterra Risk score (which identifies the risk of N in the soil profile) by the environmental factor (which identifies the fraction of this at-risk N that is actually at risk to leaching). As noted above, this conforms to the architecture of most models that simulate N leaching from agricultural soils. This conventional approach to predicting N leaching and the particular version proposed here to identify the relative risk on N leaching are depicted in Fig. 3

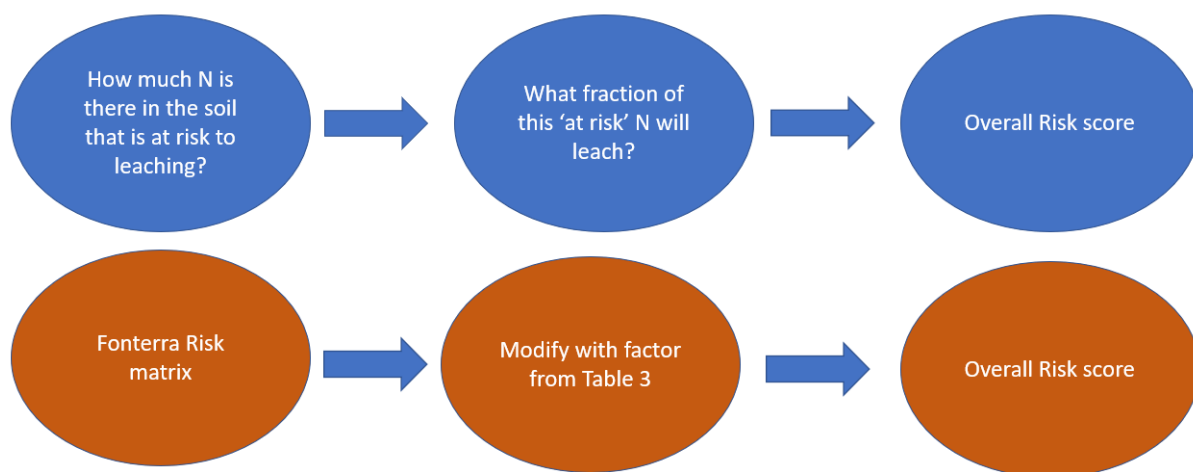


Figure 3. The components of a simulation of N leaching from pastoral farms and the specific tools proposed to identify an analogous Overall risk score of N leaching

$$\text{Overall Risk score} = F(\text{cl, st}) \times \text{Fonterra risk score}$$

Where F is a modifying fraction which is a function of climate (cl) and soil type (st)

5. Re-worked Table 14.2 – the Overall Risk Matrix version and pathways to consent

In keeping with PC2, Table 14.2 has been re-worked to produce an Overall Risk Matrix score for each Landuse Class. This Table will act as a guide for farmers: it suggests the target (or aspirational) risk profile required to help minimize the impact of dairy farming on water quality. It will also identify those farmers who have already reduced the Overall Risk score below these target values.

Table 4 Re-worked Table 14.2 to show the cumulative Overall Risk score maximum for each Landuse class.

LUC	I	II	III	IV	V	VI	VII
Year 1	273	243	215	165	135	120	60
Year 5	246	225	188	147	110	80	45
Year 10	237	198	170	128	110	80	45

In general terms there are a number of pathways available to a dairy/pastoral farmer to secure a consent to farm when relying on a risk framework. These can be expressed as -

- 1) There Overall Risk score is equal to or less than their cumulative Nitrogen Risk score CNRS described in a risk version of Table 14.2
- 2) They adopt sufficient GMPs to reduce their Overall Risk score to match their CNLM
- 3) They can reduce their Overall Risk score by the greater of a reduction to the 75th percentile value or a percentage decrease in Overall Risk score of some value (assuming some sort of one to one 'correspondence' between the Fonterra Risk Matrix and Overseer values, the PC2 value of 20% is assumed here).

6. The importance of incorporating environmental factors, and considering all dairy farmers

The intention of PC2 was that farmers who exceeded their CNLM would improve their management via the introduction of GMPs to reduce N leaching and their impact on water quality. Farmers with leaching rates greater than their CNLM but less than the 75th percentile leaching rate were required to reduce their leaching rate by 20%. In the present context, this would translate to the adoption of sufficient GMPs to reduce their Overall Risk score (a reduction of 20% is currently being explored).

The implications of using the Overall Risk score can be easily demonstrated by considering three farms, one each in the priority catchments of; coastal Rangitikei, Horowhenua and Upper Manawatu. Each of these farms has a Risk score just under the 75th percentile value for the sub-catchment (according to the data provided by Fonterra). If the Fonterra Risk Matrix is applied (Table 5), all three farms will have to make very similar improvements to management and reduce the risk by 26 to 32 (risk) points. This can be contrasted with the reduction required if a 20% decrease in Overall Risk score is required: now the spread is much greater (24 to 43 points).

Unfortunately, due to the environment they operate in, some farms leach greater quantities of N from their soils. PC2 requires farms with coarser and intermediate textured soils with greater rainfall to make larger reductions in the risk that they pose to rivers in the region.

Table 5. A comparison of the difference between the Fonterra Risk score and the Overall Risk score and the magnitude of a 20% reduction for three farms in the priority catchments

Catchment	Rainfall	Soil type	Fonterra Risk score	Required reduction in score	Overall Risk score	Required reduction in score
Coastal Rangitikei	850	Medium	160	32	120	24
Horowhenua	1000	Medium	131	26	131	26
Upper Manawatu	1450	Medium	143	29	215	43

The other point that is obvious in Table 2 is that if sufficient N is to be removed from farm drainage, there needs to be some requirement for farms with an Overall Risk score between the 75th percentile and the re-worked Table 14.2 value. Without this requirement, the farms in the above Table would not be required to make any management changes to reduce their risk (i.e. the required reduction in both columns would be 0).

In summary, the Overall Risk Matrix is required to identify the pastoral farms that need to make the largest reduction in risk score, and it is needed to identify the magnitude of reduction for these farms.

7. Some thoughts on the percent reduction required in the Overall Risk score

As noted above, a risk matrix does not translate directly to a value of N leaching, however, if such matrices are to be useful, they cannot be entirely disconnected from N loss in drainage from farms. In keeping with the intention of One Plan changes, the focus is on using the Overall Risk Matrix to inform changes in farmer behaviour and encourage the adoption of GMPs.

There is agreement that farmers with a risk score greater than the 75th percentile value should reduce this score to the 75th percentile value.

My argument here is that there is a population of farmers with risk scores between the 75th percentile Overall Risk score and the re-worked Table 14.2 values who also need to make changes to their management practices (greater use of GMPs) in order to reduce their impact on the region's rivers and achieve the PC2 outcomes. The best way to drive this change in farm management practices needs to be identified. Based on the claimed effectiveness of the Fonterra Risk Matrix and the synergies with Overseer, I am of the view that a 20% reduction in the Overall Risk score is not an unreasonable 'starting point'. It is not my intention to argue that a 20% reduction in any risk score equates in an unambiguous manner to a 20% decrease in N leaching. However, one does need to be confident that use of the Risk Matrix will result in the adoption of the GMPs that will decrease N leaching and improve water quality. Further modelling to support this approach is well progressed.

8. Conclusions

The Fonterra Risk Matrix identifies that amount of N which accumulates in the soil profile and hence the quantity of N that is 'at risk' to leaching but not the risk of leaching. The magnitude of N in the soil is a result of landuse and management practices. However, just as importantly, climate and soil type will determine the fraction of this 'at risk' N that will leach in drainage

Therefore, these environmental factors cannot be ignored in any meaningful estimate of the risk of N leaching from farms or the magnitude of the reduction required in a farm's risk score.

Fortunately, the combined influence of climate and soil type can be captured in the concept of drainage expressed in pore volume equivalents.

The quantity of drainage expressed as pore volume equivalents can be easily incorporated into the Fonterra Risk Matrix in a generalized manner that is in keeping with the approximate nature of the Fonterra Risk matrix.

Table 14.2 can be re-worked so that it reflects a cumulative overall risk score.

With the re-worked Table 14.2 and the ability to predict the likely Overall Risk posed by any individual farm - which includes both the impacts of farm management and the effects of the environment - an analogue of the original pathways to consent as specified in PC 2 can be used.

The approach outlined here with environmental factors (climate and soil type) incorporated in the Overall risk Matrix aligns with or reflects the original approach and intentions of the One Plan, including use of Table 14.2. This approach adheres to the original Intention of the One Plan which seeks to help each farmer – with her unique mix of climate and soil type(s) - identify the (scale of) GMPs that she is required to implement to reduce N leaching and improve water quality in the region.

If the reduction in N leaching targeted in PC2 is to be achieved, then it will be important to reduce the risk profile of all farms who cannot meet their cumulative risk score (the risk version of Table 14.2).

Concentrating on only those farmers who exceed the 75th percentile will not drive the management changes (sufficient adoption of GMPs) which PC2 seeks.

A mechanism is required to help farmers with risk scores between the re-worked Table 14.2 value and the 75th percentile to identify the GMPs that they need to adopt if the intentions of PC2 are to be achieved. It was suggested that a reduction of 20% (or some similar value) in the Overall Risk score might help in the identification of these GMPs.

D. J. Horne

Without Prejudice

What will the Risk Matrix deliver in terms of nitrate leaching?

As I have stated on a number of occasions, it is very difficult to compare an indicator of risk, where banded 'scores' are assigned to a selected range of management practices, with the output of Overseer which seeks to predict the effect of a range of processes on the specific quantity of nitrogen (N) leaching. In this sense a risk matrix does not translate directly to value of N leaching.

Nevertheless, I have attempted to investigate the likelihood that the proposed Matrix will deliver similar outcomes in terms of N leaching as the use of Table 14.2, Overseer and associated pathways. In other words, whether the proposed Matrix can result in the adoption of the good management practices that Plan Change 2 seeks. In my view, this can be achieved by the proposed Matrix driving the same improvement in farmer behaviour as the use of Table 14.2/Overseer would have.

Comparing Table 14.2 with the Risk Matrix

In Plan Change 2, farmers were strongly encouraged to match their cumulative nitrogen leaching maximum (CNLM) as defined by re-calibrated Table 14.2. The original Table 14.2 was based on a series of baseline or model farms and these farms were used to re-calibrate Table 14.2 for Plan Change 2.

The risk posed by the management of these farms was assessed using the Fonterra Nitrogen Risk Scorecard. These scores are given in the first part of Table 1. All these farms, which by definition achieve their CNLM) have a number of 'medium' risk practices including those farms on Class III to V.

The proposed Matrix was then used to identify the scores (i.e. management practices) that would likely to be required on these baseline farms (i.e. under the current proposal). While this exercise is approximate (not least of all because the most likely location of these farms is assumed), it suggests that the proposed Matrix will require a similar, if not greater, adoption of good management or mitigation practices as Table 14.2 and Overseer. The use of 'medium' practices are confined to soils where the risk of nitrate leaching is smaller. There is also a requirement for those farms where the risk of nitrate leaching is greater to employ more 'very low' risk practices.

As all farms will be required to meet the Matrix scores and the practices required by the Matrix seem to be in-keeping with those embedded in Table 14.2, it might be argued that the proposed Matrix will have a similar impact on the adoption of good management practices and therefore the quantity of N leaching.

Table 1. The Nitrogen Risk score for the baseline farms used to generate all versions of Table 14.2, along with the scores that would be required on farm by the use of the proposed Matrix.

LUC	I	II	III	IV	V
Table 14.2 CNLM (Overseer)	52	46	41	30	26
Fonterra Nitrogen Risk score for 'baseline farms' (which achieve CNLM)					
Number of 'medium' scores	4	4	3	2	2
Number of 'low' scores	1	1	2	2	0
Number of 'very low' scores				1	3
Required Matrix scores for baseline farms					
Number of 'medium' scores	2	2			

Number of 'low' scores	3	3	5	3	2
Number of 'very low' scores				2	3

Can the proposed Matrix be easily applied?

To demonstrate how the proposed Matrix can be applied in the priority catchments, a number of databases have been used to segment these catchments according to rainfall and soil type (as identified according to Profile Available water (PAW) – see below for an explanation). An example of the output of this exercise for one of the larger priority areas is shown in Table 2. While the final values for demarcating PAW and rainfall are to be discussed by experts, this exercise demonstrates that a Matrix to help provide context for interpreting the NRS can be quickly developed and applied to farms in the Horizons' region.

Table 2. The percentage area of dairy farms in the Tamaki-Hopelands catchment that fall within rainfall and Profile Available Water (PAW) zones.

Tamaki - Hopelands Catchment (area = 338 km ² ; Dairy=113 km ²)				
Mean Annual Rainfall Zone		PAW		
		High	Moderate	Low
	<1000	0%	0%	0%
	1000-1300	2%	49%	0%
	1300-1600	0.3%	33%	0%
	>1600	0%	16%	0%

Comparison of the Matrix score with Overseer values

A large number of farms in the priority catchments fall within what could be termed medium rainfall and medium texture (or PAW) soils i.e. 1000 to 1400 mm rainfall and 'Medium texture' soil as defined in the proposed Matrix (see Table 2 for an example)).

A series of farms which are representative of these conditions was examined. By constraining the analysis to similar geophysical conditions, it is possible to explore the relationship between the proposed Risk Matrix and Overseer leaching losses. Figure 1 suggest that in many cases there is a relationship between the risk score and Overseer predictions of N leaching. (It should be noted that in order to increase the likelihood of generating a relationship between the risk score and Overseer value, only 'significant' changes were made to farm management e.g. N fertiliser use was decreased by, say, 40 kg N ha⁻¹ yr⁻¹ whereas a change of only, say, 5 kg N ha⁻¹ yr⁻¹ might have been adequate to decrease the N risk score.)

The initial Risk Matrix score and Overseer leaching loss were identified for the study farms. Changes were made to farm management so that the farm complied with its Matrix score. Finally, these modifications to management were inputted to Overseer and the new leaching rates were simulated. This data is presented in Figure 1. The blue points to the right of the graph represent the original farms, where both the risk score and Overseer leaching rates are greater. N losses, as predicted by Overseer, exceeded their Table 14.2 CNLM values by 5 to 10 kg N ha⁻¹ yr⁻¹. The changes to management required by the proposed Matrix and the corresponding Overseer values are given by the red points in Figure 1. Modifications to farm management have resulted in relatively small risk scores and N leaching losses. These farms would now comply with their CNLMs. In other words, the Matrix has affected the

management changes required to reduce N leaching to similar levels to those generated using Table 14.2 and Overseer.

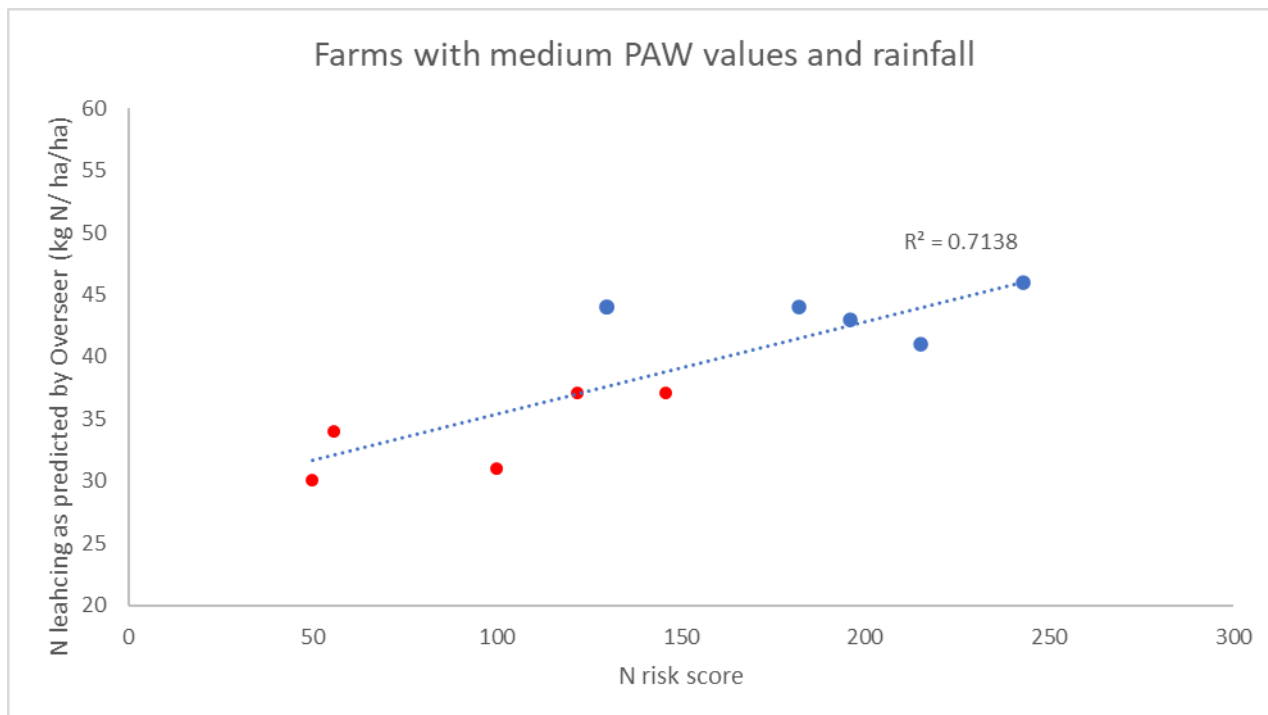


Figure 1. An example of how use of the proposed Matrix can decrease N leaching from farms. The blue points show N leaching from case study farms in a typical situation i.e. medium rainfall and PAW. The red points show these farms after the Matrix has been applied.

Modifying farm management

I have considered the range of farm practice improvements required under the proposed Matrix, as compared with Table 14.2/Overseer. Table 3 is a list of mitigations that were required for a number of farms in the Mangatainoka to secure consent. The noteworthy features of Table 3 is that these practices are all prominent in the risk scorecard. Therefore, in my view, it is highly likely that the proposed Matrix will encourage the adoption of these very same or similar practices or mitigations.

Table 3. A list of improved management practices required for farms in the Mangatainoka catchment to secure consent under Table 14.2, Overseer and associated pathways.

Mitigation	Mitigation	Mitigation	Mitigation
Increase effluent area	Reduce number of cows wintered by 45	Remove April N input	-
Increase land area by 20ha	No fert on effluent block	Increase effluent area to minimum size	Increase effluent area to 30 ha
Shift N app to avoid high risk periods	Increase effluent area by 6ha	Reduce in cow numbers calved	Increase autumn feedpad usage

Shift N app to avoid high risk periods	Remove July N app	-	-
Change N inputs and timing	-	-	-
Increase effluent area from 23.3 to 31 ha	Sow turnips November instead of October and reduce fert used	Remove Urea from effluent block	Remove October Urea application
Extend effluent area from 21 to 55 ha	Cull cows earlier	Reduce N fert from 123 to 102 kg	Apply effluent solids in December instead of April
Eliminate N fert on effluent block	Increase effluent area	Increase feedpad use	Eliminate summer turnip crop
Move June N application to May	Remove crops 2ha of kale and oats	-	-
Increase effluent area by 25 ha	Remove winter kale crop	Half April N app	Construct lined effluent pond
Combining MP and RO	Increase effluent area from 17.2 to 25 ha	halve Urea applied in April	Complete waterway fencing on RO

Profile Available water

In my previous paper (December 2022), I suggested that texture could be used to differentiate between soil types in the Matrix. I have since learnt that there is limited s-map information across much of the priority catchments. However, as I noted, there are alternative, and perhaps better, ways to categorise soil type in the Matrix. Profile available water (PAW) is probably the single best way to describe the differences between soils in the Matrix. Fortunately, the 'Fundamental Soil Layer' gives PAW for soils in the priority catchments. The PAW for soils in the region is shown in Figure 2.

I am proposing that the experts consider using PAW as the basis for the contribution of soil type to the effect of geophysical factors on the risk of N leaching.

David Horne

1 February 2023

