

**IN THE ENVIRONMENT COURT
WELLINGTON REGISTRY**

**I TE KŌTI TAIAO O AOTEAROA
TE WHANGANUI-A-TARA ROHE**

UNDER	the Resource Management Act 1991
IN THE MATTER	of appeals under sch 1, cl 14(1) against the decision of Manawatū-Whanganui Regional Council on Plan Change 2 to the One Plan
BETWEEN	TE RUNANGA O RAUKAWA ENV-2021-WLG-20 NGĀTI TURANGA ENV-2021-WLG-21 ANDREW DAY ENV-2021-WLG-22 WELLINGTON FISH AND GAME COUNCIL ENV-2021-WLG-23 Appellants
AND	MANAWATŪ-WHANGANUI REGIONAL COUNCIL Respondent

**STATEMENT OF REPLY EVIDENCE OF DR PAUL FREDERICK LE MIERE ON BEHALF OF
MANAWATŪ-WHANGANUI REGIONAL COUNCIL**

PASTORAL FARM SYSTEMS

Dated: 13 November 2023



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REPLY EVIDENCE OF DR PAUL FREDERICK LE MIERE**A. INTRODUCTION**

- [1] My full name is Paul Frederick le Miere.
- [2] I prepared a statement of evidence dated 12 October 2023 (**Evidence**) on behalf of the Manawatū-Whanganui Regional Council (**Horizons**) for Proposed Plan Change 2 to the One Plan (**PC2**). My Evidence explains my participation in the pastoral farm systems expert conferencing and my analysis of Professor Horne's nitrogen risk assessment tool.
- [3] My experience and qualifications are set out in my Evidence.
- [4] I repeat the confirmation given in my Evidence that I have read and will comply with the Code of Conduct for Expert Witnesses in the Environment Court Practice Note 2023, and that my evidence has been prepared in compliance with that Code.

B. SCOPE

- [5] My reply evidence responds to points made in evidence by:
- (a) Dr Elizabeth Parlato on behalf of Ngāti Turanga and Wellington Fish and Game Council (**Fish & Game**) on the topic of the risk assessment tool for pastoral farm systems.
 - (b) Dr Alison Dewes on behalf of Fish & Game on the topic of farm systems.
 - (c) Mr Michael Scott on behalf of Andrew Day, to the extent that he provides a summary of the limitations Dr Dewes identifies with the nitrogen risk tool.
 - (d) Dr Alec Mackay on behalf of Fish & Game on the topic of good and best management practices (in respect of N loss and Table 14.2).

C. RESPONSE TO DR ELIZABETH PARLATO

- [6] At paragraph 6.23 of her evidence, Dr Parlato expresses concern that Professor Horne's estimated nitrogen leaching reductions under the nitrogen risk assessment tool (as proposed in the amended DV-PC2 provisions) may not accurately reflect the actual nitrogen loss reductions that are able to be achieved when the risk assessment tool is implemented. To illustrate her point, Dr Parlato compares Professor Horne's estimated average percentage decrease in N leaching flux from farms of 13% for Upper Manawatū (Table 1 of Professor Horne's primary evidence) with my estimated percentage reduction in risk score for the 75th percentile farm in the Upper Manawatū of 6% (Figure 3 of my Evidence).
- [7] The first point I wish to make is that I consider that Professor Horne's estimated nitrogen leaching reductions are a reasonable indication of the likely magnitude of reduction in nitrogen loss under the two different tools (i.e. the 20%/75th percentile reduction using Overseer as required by the DV-PC2 and the nitrogen risk matrix in the amended DV-PC2). In my opinion, these are the best estimates that can be made on the basis of currently available information and tools.
- [8] My second point is one of clarification. I am not sure if Dr Parlato is meaning to draw comparisons between the two numbers but Professor Horne's estimate of 13% is not directly comparable with my estimate of 6%. This is for several reasons:
- (a) Professor Horne and I used different datasets for our assessment of the likely reductions existing farms would need to make to achieve the proposed nitrogen risk levels. At the time of my assessment, I had access to a dataset of nitrogen risk scores for 285 Fonterra farmers (194 of them were unconsented) for the 2021/22 season. Professor Horne had access to a dataset of nitrogen risk scores for Fonterra farms for the 2022/23 season. As I explain at paragraphs 66 to 69 of my Evidence, there was a difference between Professor Horne's and my estimated risk score reductions for farms in the Upper Manawatū (19% vs 6%) which could be due to us using

different datasets (i.e. risk scores for different seasons) and some farms doing something different in the 2021/22 season e.g. they might have applied less N fertiliser because there were good grass growing conditions that season.

- (b) Reductions in risk score are not directly comparable to reductions in nitrogen leaching score. This means that Professor Horne's estimated 13% reduction in nitrogen leaching flux for farms in the Upper Manawatū is not directly comparable with my estimated 6% reduction in risk score (for farms at the 75th percentile).
- (c) In his Table 1, Professor Horne was assessing average percentage nitrogen loss reductions whereas in my Figure 3 I was assessing the reduction a farm at the 75th percentile in my dataset would need to make to achieve a weighted average risk score (a concept I explain at paragraphs 56 to 60 of my Evidence).
- (d) My assessment considered reductions that farms would make from their 2021/22 risk score.
- (e) In my opinion, it is very likely that if the reduction farms would need to make was assessed against a baseline of risk scores for 2012, the actual reduction in risk score (and accordingly modelled nitrogen loss) would be much larger than the 6% reduction in risk scores for farms in the Upper Manawatū shown in my Evidence. I am confident that dairy farms in the target WMZs have reduced their nitrogen loss through initiatives such as Fonterra's Tiaki Farm Plan and the DairyNZ Tararua Plantain Project, and also through the ongoing improvements that farmers are voluntarily making (as explained, for example, in the evidence of Murray Holdaway and Aaron Passey for Federated Farmers).

- [9] At paragraph 6.24 of her evidence, Dr Parlato notes that the farms used to assess nitrogen loss reductions under the risk assessment tool were synthetic farms. I acknowledge Dr Parlato's concern that the actual nitrogen loss reductions that will be achieved through implementation of the nitrogen risk assessment tool will depend on how representative the synthetic farms

(that Professor Horne and I used in our respective assessments) are of the unconsented dairy farms in the target WMZs. In my opinion, they are likely to be a reasonable representation on the basis that Professor Horne and I used different synthetic farms and different methodologies to independently arrive at very similar conclusions.

- [10] I also consider that the reliance on the synthetic farms that Professor Horne and I respectively considered is no less uncertain or unrepresentative than the modelling that has been done for Table 14.2 (which relied on 18 farms in Mangatainoka that were assessed in 2008, when the availability of mitigations was very different¹) and the DV-PC2 (where I understand Professor Horne also utilised synthetic farms). We are all relying on the best information available at the time and the knowledge we have of farm systems in the target WMZs.

D. RESPONSE TO DR ALISON DEWES

- [11] At paragraph 22.8 of her evidence, Dr Dewes raises concerns about my assessment of the likely reduction in profitability (under Professor Horne's original nitrogen risk assessment tool) on the basis that I have not done a *"full system assessment on the farm and management skills, economic situation, nor biological modelling."* In footnote 33 of her evidence, Dr Dewes says I have assumed *"profit and production are linearly related"*.
- [12] I agree that the relationship between profits and production is not necessarily linear, and that individual farm systems may be able to reduce nitrogen loss and retain economic viability. However, for all farm systems there is a tipping point at which reductions in inputs and/or intensity result in reductions in profits.

¹ These farms are referred to at paragraph 5.10 of Dr Mackay's evidence for Fish & Game and at paragraph 24 of Appendix 6 to Dr Mackay's evidence. At the time these farms were assessed, the availability of DCD (a nitrate inhibitor) was a key mitigation that was assumed to reduce nitrogen by as much as 5kgN/ha/yr, as explained in Mr Peter Taylor's section 42A report for the One Plan hearings in 2009: https://www.horizons.govt.nz/HRC/media/Media/One%20Plan%20Documents/Mr-Peter-Harold-Taylor_1.pdf?ext=.pdf.

- [13] At the first instance hearing, Adam Duker and I each presented farm systems evidence as part of the joint Federated Farmers/DairyNZ case. As part of this, Mr Duker and I worked very closely in the preparation of our evidence and we presented our evidence jointly (given the significant overlap and interrelationship between our evidence). I have continued to consult with Mr Duker as I have undertaken my analysis of the nitrogen risk assessment tool in this proceeding.
- [14] Mr Duker has been employed by DairyNZ for almost 10 years as an Environmental Change Specialist covering the lower North Island. Prior to that, he was employed by Horizons as an Environmental Protection Officer for five years. During this time Mr Duker has worked closely with consented and unconsented dairy farms in the target WMZs.
- [15] As part of his evidence for the first instance hearing, Mr Duker undertook a case study assessment of two dairy farms in the Tararua to assess the on farm financial impacts of the Horizons One Plan. A copy of that case study is attached to my evidence as **Annexure PLMR1**.
- [16] Mr Duker modelled the marginal cost abatement curves for the two dairy farms. I have reproduced that as Figure 1 in Section G.
- [17] The abatement curves within Figure 1 show a roughly exponential relationship between reductions in nitrogen leaching and farm operating profits. For example, reductions of nitrogen leaching by up to 10% had little impact on farm profits for the two case study farms. However, above this level, further reductions in nitrogen meant farm profitability started to drop off sharply. For example, for one farm, a 30% reduction in nitrogen leaching resulted in a 35% reduction in profits, and a 43% reduction in nitrogen leaching resulted in more than a 50% reduction in farm profitability.
- [18] This is consistent with similar abatement curves I have seen for case studies in other regions.
- [19] The two farms in Mr Duker's case study were already operating at or close to good management practice. This is consistent with farms I have reviewed in other regions and, in my opinion, is reflective of the collective efforts of

the dairy industry over the past 10 years or so to improve farm practices through changes to conditions in milk company supply agreements, incentives schemes (whereby milk companies reward suppliers who are early adopters of good management practices with higher milk prices), increased information availability and field days, and voluntary initiatives (like the Clean Streams Accord and Fonterra's Tiaki farm plans).

- [20] My experience is that farms that are operating at or close to good management practice have limited ability to make further reductions in nitrogen without impacting on farm profitability. Some farms will be able to continue to operate at lower profits but there will come a point at which the farm is no longer economically viable. This point will vary between farms, and in my opinion will depend on factors such as debt levels and financing costs, milk payout forecasts etc.

E. RESPONSE TO MR MICHAEL SCOTT

- [21] At paragraph 8.40 of his evidence, Mr Scott sets out a list of five matters that he says Dr Dewes has identified as "*critical limitations of the risk assessment tool*". My response to each of those matters is (following the same sub-paragraph numbering as at paragraph 8.40 of Mr Scott's evidence):

- (a) It [the nitrogen risk scorecard] does not represent the best science, having only had one peer-review and no ground-truthing:
 - (i) I assume that the peer review that Dr Dewes is referring to is the AbacusBio report that was prepared for Gavin Marshall and Matthew Randal at Fonterra, dated 1 November 2019.²
 - (ii) Mr Marshall was heavily involved in the development of the Fonterra nitrogen risk scorecard. Mr Marshall participated in the PC2 farm systems expert conferences on 28 June

² This is attached to the Statement of Evidence of Richard Grant Allen on behalf of Fonterra dated 22 June 2023 in the Environment Court hearing for Waikato Regional Council's Plan Change 1, **PC1** (I participated in expert conferencing in PC1 and provided farm systems evidence for Federated Farmers). This is attached to Dr Dewes evidence as Appendix 1.

2022, 25 August 2022 and 7 October 2022 (after this time he left Fonterra to take up a role in an unrelated field).

- (iii) Mr Randal is still employed by Fonterra, is still involved in the implementation of the nitrogen risk scorecard and I have liaised closely with him in both PC2 and Waikato Regional Council's Plan Change 1 (**PC1**) in my interrogation of the scorecard and analysis of risk scores for individual farms and the Fonterra dataset.
- (iv) In addition to the AbacusBio report, I am aware that Lee Matheson, the Managing Director and Principal Consultant at Perrin Ag Consultants Limited, was engaged by Fonterra to undertake an independent peer review of the nitrogen risk scorecard in 2018 and 2019. Mr Matheson provided farm systems evidence on behalf of Federated Farmers in the PC1 Environment Court hearing, which included analysis of the nitrogen risk scorecard.
- (v) I am not aware if there have been other peer reviews of the nitrogen risk scorecard but I am aware (from my participation in the Environment Court hearing and expert conferencing in PC1) that it has had some interrogation by the Court and experts as part of the PC1 process.
- (vi) In terms of ground truthing, the nitrogen risk scorecard has been the primary assessment tool used by Fonterra (for its 11,000 supplier farms across New Zealand) over the last five years. At the end of each dairy season (30 May), Fonterra farms are required to provide farm data to enable the nitrogen risk score to be calculated. Fonterra contracts an external company to carry an on farm audit of the data provided. Fonterra does this because its marketing/reputation and farmer incentive payments rely on information generated by the nitrogen risk scorecard

(including the aggregate risk score, nitrogen efficiency indicators and purchased nitrogen surplus).

- (vii) From my participation in PC1 expert conferencing, I am aware that DairyNZ has been carrying out research on the relationship between measured farm N loss and the aggregate risk score; and with purchased nitrogen surplus. The graphs in Figure 2 (in Section G of this evidence) were produced during PC1 expert conferencing and relate to nine research farms in the Waikato region.
- (b) It [the nitrogen risk scorecard] relies on self-reporting from farmers, and so the data will not be as robust or reliable.
 - (i) In my opinion, there are several ways that concerns about the reliability of data entered into the nitrogen risk scorecard can be addressed. First, farmers could be required to keep records of the input data and provide them to Horizons on request (to confirm accuracy of input data). Second, Horizons could carry out random audits of input data (and I understand that this has been offered through an independent panel as part of the implementation proposal). Third, the online portal (that the input data is entered into) could be built to have “auto-rules” that flag any inputs that are outside normal ranges.
 - (ii) From my discussions with Mr Randal and others at Fonterra, I understand that Fonterra has developed a process to ensure that the data entered into the nitrogen risk scorecard is as robust as possible. This includes having some fields in Fonterra’s online portal pre-populated with data that is already held for the farm or that is typically constant across multiple seasons, such as the milking platform area. This means that farmers only update or edit data if it has changed between seasons. Fonterra also has built in validation formulas for data entry fields to ensure accuracy

e.g. to ensure that the total area entered in management blocks equals the total effective area of the farm. These checks and balances could easily be transferred to a Horizons portal.

- (iii) In my opinion, data that is entered into the nitrogen risk scorecard is no less verifiable or reliable than data entered into Overseer. Data might be required to be entered into Overseer by a Certified Farm Nutrient Advisor (or suitably qualified person, typically a fertiliser representative at Ballance or Ravensdown) but the data that is entered is heavily reliant on what the farmer advises and is difficult to audit/verify e.g. days in which certain stock were a particular paddock or management block. At paragraph 8.3 of her evidence, Dr Dewes refers to the annual Overseer subscription cost being \$690 plus GST. There is also the additional cost of the expert to enter the data and create an Overseer budget (to provide an indication of the cost, Ballance charges \$210 plus GST per hour, with the number of hours required to create an Overseer budget varying depending on the size and complexity of the farm).
- (c) It [the nitrogen risk scorecard] focusses on efficiencies and can be misleading, leading farmers to believe their farm is at low risk of leaching, rather than presenting a more accurate assessment of risk to the receiving environment.
 - (i) The scorecard's primary focus is on the risks of nitrogen loss from management practices and farm set up. The nitrogen risk scorecard does not focus on production efficiencies but on environmental efficiencies e.g. farmers can reduce their score by extending the effluent area, changing winter crop areas, etc.
 - (ii) One of the issues with Overseer is that it relies on models to estimate things like grass growth and dry matter eaten

based on milk production. These estimates can give an illusion of false precision.

- (d) It [the nitrogen risk scorecard] ignores total farm mitigations that would improve water quality, such as the retirement of land for riparian planting or wetlands, and therefore the farmer is not rewarded for putting these beneficial mitigations in place.
 - (i) I agree that farmers should get recognition for mitigations (on other parts of their farm or at edge of field) like retiring land, creating wetlands and riparian planting. However, it is important to also acknowledge the purpose of the nitrogen risk tool in PC2 – being targeted at managing and reducing nitrogen loss risk (primarily by looking at the risk associated with on farm practices).
 - (ii) I also do not agree that there is no recognition of these mitigations in the nitrogen risk scorecard. The experts have agreed some amendments to the scorecard to provide credits (in the form of reductions in risk score) for wetlands.
 - (iii) I also acknowledge that it is not possible to contemplate all possible scenarios within the nitrogen risk scorecard. That is why, in my opinion, it is important that there is a pathway whereby farmers who have adopted mitigations that are not recognised by the scorecard can have their specific situations assessed and judged on their merits. I see this as an important reason for the discretionary activity pathway.
- (e) It [the nitrogen risk scorecard] creates a risk of complacency for the farmers and a resulting shock when it comes to sell property, since a buyer will likely require an Overseer assessment for transparency.
 - (i) I do not understand this point. I am not aware of any requirement for vendors to supply Overseer assessments (as a standard condition of farm sales) and nor am I aware of this information being routinely sought (if it was then I

would expect that the number of Overseer subscribers would be significantly higher than the 5,000 accounts that Dr Dewes says are used each year at paragraph 13.2 of her evidence).

- (ii) Fonterra has not been using Overseer for any of its 11,000 dairy farmers since 2017, so I would be surprised if purchasers of dairy farms who supply Fonterra have required an Overseer assessment as part of the sale.
- (iii) Purchasers of farms will carry out due diligence and I can understand that as part of the due diligence they would want information to verify production levels and regulatory compliance (such as copies of resource consents or compliance with permitted activity standards). Where a farm is required by a rule in a regional plan to have an Overseer budget that would also be required. However, if amended DV-PC2 was adopted, and where a farmer was relying on a controlled activity consent obtained for compliance with the nitrogen risk assessment tool in Table 14.2A, I cannot see why a purchaser would require an Overseer assessment.

F. RESPONSE TO DR ALEC MACKAY

- [22] At paragraph 5.19 of his evidence, Dr Mackay refers to a recent study (by Richard McDowell, Katrina Macintosh and Craig Depree that was published in 2023, **McDowell et al paper**) about the uptake of best management practices on dairy farms and the impacts on water quality over a 20 year period. Dr Mackay relies on the McDowell et al paper to say that “*best practice reduced phosphorus (P), E coli and sediment concentrations but not nitrogen (N) concentrations*”. I do not agree that a definitive conclusion like this can be made based on this paper alone.
- [23] The terms “good management practices” (**GMP**) and “best management practices” (**BMP**) tend to be used interchangeably and to refer to different things, depending on the author or the context. Irrespective of whether a

practice that is targeted at making a nitrogen reduction, such as changing the timing and application of nitrogen fertiliser or increasing the effluent irrigation area, is classified as a GMP or BMP, my opinion is that it will reduce nitrogen losses from a farm.

[24] From my review of the McDowell et al paper, the BMPs they considered appear to be directed at reducing phosphorus, sediment and E coli rather than nitrogen (although the last one, might have had some nitrogen reduction component depending on what “*managing nutrient inputs and outputs*” involved). Those practices (and the timing by which they were to be adopted) were:

- (a) Exclude cattle from 90% of streams wider than 1m and deeper by 30cm by 2019, and significant wetlands by 2007.
- (b) Bridge 90% of stream crossings by 2012.
- (c) Ensure all farms comply with dairy shed effluent consents and have systems in place for managing nutrient inputs and outputs by 2007.

[25] The McDowell et al paper also refers to some catchment specific BMPs, but again they appear to be primarily directed at contaminants other than nitrogen:

- (a) Transitioning from direct discharge to land application of farm dairy effluent.
- (b) Shifting from flood to spray irrigation to minimise surface runoff from excess irrigation.
- (c) Minimising grazing or effluent application on wet and artificially drained soils.

[26] Just as the extent of practice change (and the contaminant the practice change targets) will impact on water quality results, so too will things like in stream response time. Nitrogen is a contaminant that tends to take time to make its way through groundwater and the reason for (or at least part of the

explanation of) observed increases in nitrogen concentrations could be the effects of the load to come.

- [27] In terms of on farm modelling results of the impacts of adopting GMPs and BMPs (as opposed to observed instream water quality responses), the Upper Waikato Sustainable Milk Plan Project provides an indication of the kinds of results the adoption of GMPs and BMPs to reduce nitrogen (and phosphorus) can achieve. That project involved 700 dairy farms in the Upper Waikato Freshwater Management Unit developing and implementing Sustainable Milk Plans (**SMPs**) between 2012-2015.
- [28] Modelling of nutrient loss reductions suggested that nitrogen decreased on average by 8% (range 0-49%) and phosphorus on average by 16% (range 0-64%) as a result of implementing the practices in the SMPs.³
- [29] Actions around wintering strategies and improved feed management had large impacts on reducing nitrogen losses on some farms (some achieved reductions in nitrogen of 30%). The largest phosphorus reductions were achieved with riparian management and improved management of critical source areas, stock exclusion and dairy effluent application.
- [30] I agree with Professor Horne that it is the adoption of practices that will reduce nitrogen losses and drive water quality improvements. I also agree with him that the nitrogen risk scorecard is an effective tool to identify the practices that will reduce nitrogen loss and (just as Overseer) in that sense it is also a means to an end.

13 November 2023

Dr Paul Frederick le Miere

³ Bramley et al 2018, Brocksopp et al 2015, Burger et al 2015.

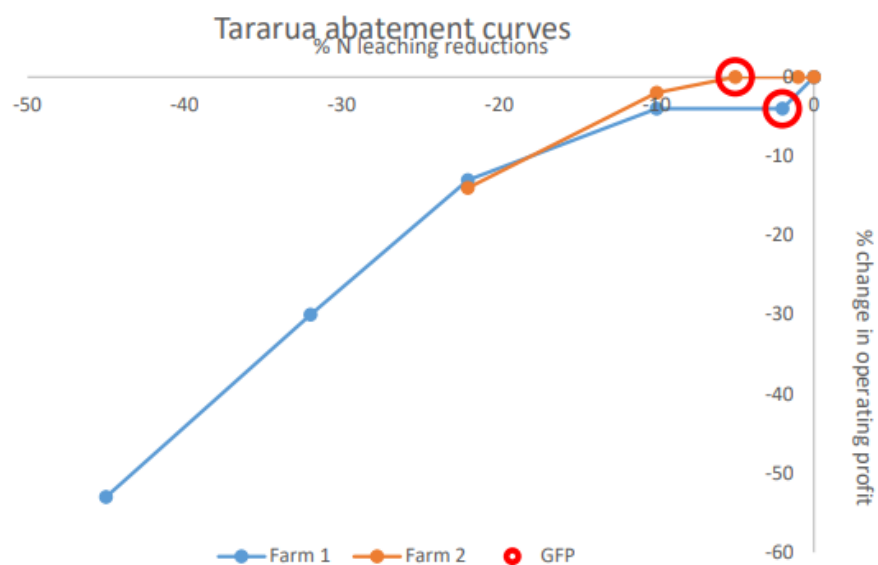
G. FIGURES

Figure 1: Abatement cost curves in Mr Duker's case study assessment

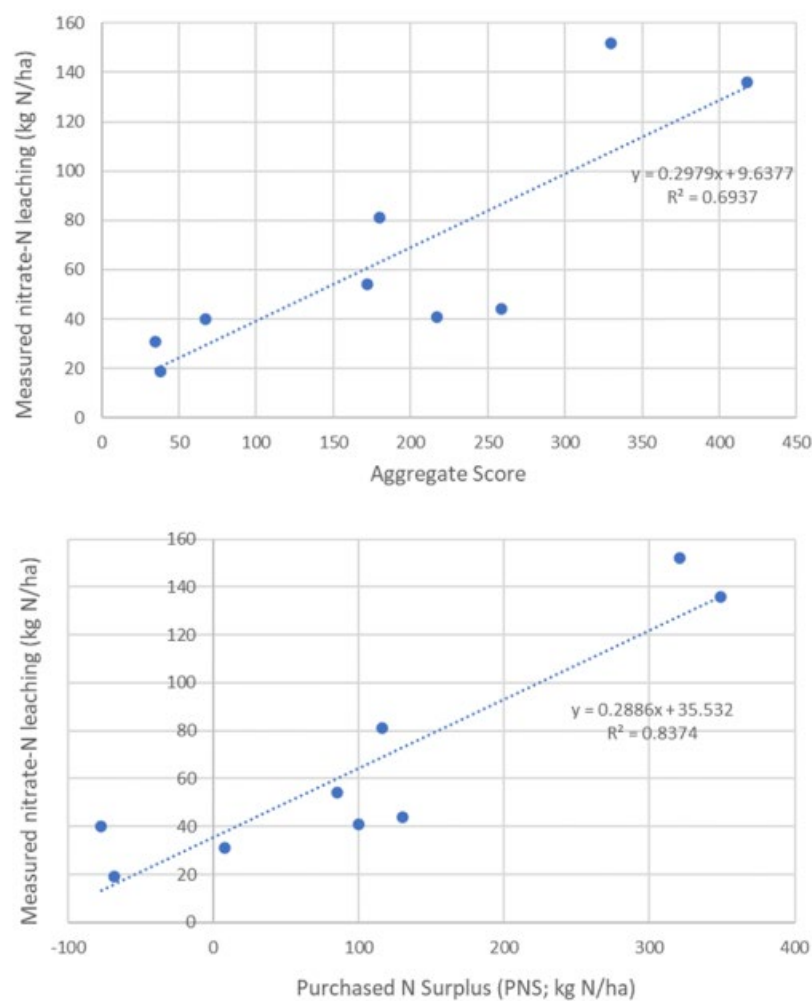


Figure 2: DairyNZ research regarding relationships between Nitrogen Risk Score card metrics (Aggregate N Risk Score and Purchased N Surplus, **PNS**) and rate of measured nitrate leaching for nine research farmlets in the Waikato region (DairyNZ Scott farm and No2 Dairy, Ruakura).

H. REFERENCES

- Bramley, M., Moodie, M., Burger, D., Kalaugher, E. (2018) *Waipā Sustainable Milk Project: Final Report - August 2018*. DairyNZ report for Waikato River Authority.
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- McDowell, R.W., Macintosh, K.A., Depree, C. (2023) *Linking the uptake of best management practices on dairy farms to catchment water quality improvement over a 20-year period*, Science of the Total Environment 895.

I. ANNEXURE – PLMR1



Tararua case study: The on-farm financial impact of the Horizon One Plan Intensive Land Use Cumulative Nitrogen Leaching Maximums.

Authors: Taisekwa Chikazhe, Justine Young and Adam Duker

Version: 4

Date: 24 September 2020

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The mitigations used in this report reflect current practices that can be implemented by dairy farmers and can be modelled in Overseer. DairyNZ acknowledges that there are research programmes underway, that depending on the results and the speed of knowledge transfer, may offer lower cost options to reduce nitrogen loss. DairyNZ also acknowledges that there are some management options currently available that cannot be modelled in Overseer.

For the purposes of this modelling, milksolids production was held constant per cow. DairyNZ acknowledges that increased milksolids production per cow may be achieved for some farms. However, in the absence of data and the variation in factors such as herd genetics and farm management between herds, it could not be agreed with certainty the extent of the increase, if any, for each farm.

This modelling has only considered farm system solutions. Depending on the biophysical context; natural, restored, and constructed wetlands, riparian buffers and other mitigations may also provide effective mitigation options for reducing nitrogen loss.

Purpose

The purpose of this modelling exercise was to assess on farm financial implications of the cumulative nitrogen leaching maximums (CNLM), as set out in the revised Table 14.2 of the Horizons Regional Council Proposed Plan Change 2 (PC2). While some dairy farms currently comply with the CNLMs in the revised Table 14.2, there are also some farms that do not comply.

Methodology

Farm Selection

Two Tararua case study farms were selected to represent a proportion of farms which currently do not meet CNLMs. It is assumed that 2020 is Year 5 (for the purposes of Table 14.2). Farm 1 does not meet the CNLMs in any of the years and Farm 2 meets the CNLMs in Year 1 (which was 2015) but not any of the other years.

The two farms were selected with reference to DairyNZ typologies and dairybase data to ensure a good representation of affected farms. A DairyNZ typology is a cluster of farms that have a unique and similar combination of wetness, slope, drainage, and anion sorption capacity (ASC). Dairybase is a voluntary data analysis service provided by DairyNZ to allow farmers to compare and or benchmark themselves to other dairy farmers in the same milk production region or entire country. The parameters used for the selection included:

- Location
- Soils
- Rainfall
- Effective farm area
- Stocking rate
- Farm system
- Milksolids production
- Profitability

One of the selected farms (Farm 1) is in Eketahuna district, rainfall 1801mm with well drained brown soils, leaching an average of 40kgN/ha and has a N surplus of 106kgN/ha (Table 1). Farm 2 is in Norsewood district, rainfall 1469mm with well

drained brown soils, leaching an average of 35kgN/ha and has got a N surplus of 131kgN/ha (Table 1).

Nitrogen surplus is the balance between N inputs and N outputs, i.e., how much N was lost in the N cycle of the production of milk, meat, wool, crops, etc. It varies widely between farms.

Overseer N surplus calculation = N in inputs (fertiliser, purchased supplementary feed, biological fixation (e.g. by clover), irrigation, atmospheric deposition (via rainfall) – N in outputs (milk, meat, crops sold) (kg N/ha).

While N surplus is an important indicator for the amount of N that could be leached, other aspects of the farm's environment and farm management drive the actual loss due to drainage of water with dissolved N to below the root zone and out of the reach of plants. These include soil type and climate, and irrigation system and management (if applicable). Soil type and climate cannot be changed by farmers, but N surplus is a useful indicator of the scope for improving management to reduce the N surplus and N leaching.

Table 1, Description of selected farms.

	Farm 1	Farm 2
Milking platform area(ha)	168.5	262.5
Support block area(ha)	130	76.2
Stocking rate (effective milking platform)	2.3	3
Farm system	3	3
N fertilizer	83	76
N surplus	106	131
Milk production (kgMs/ha effective milking platform)	765	1149
Operating profit (\$/ha effective milking platform)	763	1900
% cows wintered on	100	43
% young stock grazed on	100	50
Rainfall(mm)	1801	1469
Soil type	Brown	Brown
Drainage	well	well
N leaching (KgN/ha)	40	35

Modelling Approach

The modelling followed DairyNZ protocol which takes a staged approach to applying farm mitigations, starting with good farming practice (GFP) mitigations that are consistent with the principles agreed by agricultural industry bodies¹, through to more complex and costly farm systems changes (additional mitigations to achieve a particular N leaching rate). The GFP practices focused on management changes that can generally be implemented with only small losses in production and profit (and in some cases may improve these).

The following farm system changes were applied for small losses in production and profit:

1. If a stand-off structure already exists, increase its utilisation particularly in times where there is greater risk of N leaching i.e. winter and autumn.
2. Substitute high protein feed e.g. soy meal with low protein feed e.g. barley grain/maize silage (provided there is infrastructure to accommodate the new feed).
3. Nitrogen fertiliser management
 - No nitrogen fertilizer applications during the drainage periods May-August.
 - Fertilizer application rates do not exceed 40 kg N/ha per application.
4. Effluent management
 - Effluent application is based on soil moisture levels and ensure nitrogen applied through effluent does not exceed 150 kg N/ha/year by having adequate effluent area.
 - If increasing effluent area size, ensure it is only onto suitable soils and topography.
5. Tillage practice - Where appropriate practice minimum tillage.

After these farm system changes, additional mitigations were applied with the specific purpose of achieving a specific N loss number by reducing farm inputs and

¹ Good farming practice: Action Plan for water quality 2018.

forage cropping, and then adjusting stock numbers to match feed supply to demand.

This stage was done after consideration of GFPs as it is a complex mitigation that involves farm system change. These farm system changes might increase, maintain, or quite often reduce farm profitability:

1. Consider culling early, 90 percent of the known culls gone by April then reduce autumn nitrogen fertiliser application.
2. Reduce cropping area by:
 - Importing feed to compensate for reduced crop area
 - Reducing stocking rate to match feed supply to demand.
 - Planting high yielding crops and achieve same dry matter requirements from a smaller area.
3. Reduce nitrogen fertiliser
 - reduce nitrogen fertiliser applications. The first applications which were removed were in the autumn and winter period when leaching rates were likely to be higher and pasture response from the application were likely to be lower (compared with other times periods through the year). If this did not deliver enough of a reduction in N loss, then other applications were adjusted.
 - then compensate the reduction in pasture growth (due to reduced nitrogen fertiliser) by reducing feed demand*.
4. Reduce farm system inputs further and make associated changes to feed demand.

*Feed demand can be adjusted through an overall reduction in stocking rate or through culling.

Models Used

Overseer (Science version 6.3) - Model used to predict the environmental outcome of each mitigation.

Farmax (version 7.1.2.41) - Model used to predict the financial impact of the mitigations and to ensure mitigation scenarios are biologically feasible.

Fixed Costs for Mitigations

Costs that remained fixed during mitigations include the following:

1. Labour - Small changes in cow numbers as a mitigation will not reduce labour requirements, farmers will still incur the same labour cost. Labour is a 'sticky' cost and only varies when cow numbers are reduced significantly. For example, a decrease of 150 cows will reduce labour by one Full Time Equivalent (FTE) as this is approximately the average number of cows per FTE. When a labour unit is reduced, ACC costs will also need to be adjusted.
2. Management wage - includes unpaid management and family labour and this will remain a fixed cost through the mitigation scenarios.
3. Repairs and Maintenance (R&M) - small changes in stock numbers are unlikely to alter R&M costs, however large changes in the number of cows will require R&M for plant and machinery to be adjusted accordingly. R&M for land and buildings might not change. When new equipment and infrastructure is bought or built, for example feed pad or improved effluent system, R&M for land and buildings and R&M for machinery and equipment should reflect the additional equipment and infrastructure. This should also reflect increased depreciation costs.
4. Administration, Insurance, Weed and Pest Control and Council Rates - remained fixed throughout the mitigation scenarios.
5. Depreciation - reducing stocking rate or changing the enterprise does not affect depreciation, however the addition of new equipment or infrastructure in mitigation scenarios required depreciation costs to be adjusted to reflect the additional infrastructure and equipment.

Results

Each farm reported N leaching reduction because of the mitigations with corresponding financial implications. The co-benefits of N leaching mitigations such as GHG and phosphorous loss reductions were also reported. Refer to the Appendix for descriptions and detailed results of the mitigations applied to each of the case study farms.

The targeted N leaching reduction for each farm was derived from PC2 Table 14.2. Tables 2 and 3 show the relative proportion of each LUC class on the farm according to the available LUC map (Farm 1 had LUC mapping completed by a soil pedologist at 1:6,000 scale (paddock scale), and for Farm 2 LUC was assessed using the LUC maps sourced from Horizons Regional Council at 1:50,000 (regional scale)). The reference in the tables to “platform” is to part of the farm where lactating cows are grazed, and “run-off” is the part of the farm where non-lactating animals are grazed. The right-hand side of the table is taken directly from PC2 Table 14.2 and shows the CNLMs for each LUC class. The ‘farm leaching target’ row in each table is the N leaching limit the farmer must comply with under PC2 at Years 1, 5, 10 and 20. Note that it is assumed that 2020 is Year 5.

Table 2: N loss limits for Farm 1 based on Table 14.2 of PC2 (compared with current N loss of 40kgN/ha)

Land Use Capability* (LUC)	LUC Areas (ha)			Table 14.2 N Leaching Limits (kgN/ha)			
	Total	Platform	Run-off	Year 1	Year 5	Year 10	Year 20
I	0.0	0.0	0.0	51	46	44	43
II	13.2	13.2	0.0	45	40	37	35
III	87.7	83.2	4.5	40	35	32	30
IV	14.0	9.5	4.5	29	25	23	21
V	0.0	0.0	0.0	25	22	20	19
VI	183.3	62.6	120.7	24	19	17	16
VII	0.0	0.0	0.0	11	8	8	8
VIII	0.0	0.0	0.0	3	3	3	3
Farm Area (ha)	298.2	168.5	129.7				
FARM LEACHING TARGET (kgN/ha)				30	25	23	21
Total Nitrogen (kg)				8,907	7,430	6,733	6,320

***NOTE:** A description of LUC can be found in: Land Use Capability Survey Handbook, 3rd Edition. (Available at http://www.landcareresearch.co.nz/data/assets/pdf_file/0017/50048/luc_handbook.pdf)

Table 3: N loss limits for Farm 2 based on Table 14.2 of PC2 (compared with a current N loss of 35kgN/ha)

Land Use Capability* (LUC)	LUC Areas (ha)			Table 14.2 N Leaching Limits (kgN/ha)			
	Total	Platform	Run-off	Year 1	Year 5	Year 10	Year 20
I	0.0	0.0	0.0	51	46	44	43
II	28.1	0.0	28.1	45	40	37	35
III	185.3	185.3	0.0	40	35	32	30
IV	124.1	77.2	46.9	29	25	23	21
V	0.0	0.0	0.0	25	22	20	19
VI	1.2	0.0	1.2	24	19	17	16
VII	0.0	0.0	0.0	11	8	8	8
VIII	0.0	0.0	0.0	3	3	3	3
Farm Area (ha)	338.7	262.5	76.2				
FARM LEACHING TARGET (kgN/ha)				36	32	29	27
Total Nitrogen (kg)				12,304	10,735	9,844	9,168

***NOTE:** A description of LUC can be found in: Land Use Capability Survey Handbook, 3rd Edition. (Available at http://www.landcareresearch.co.nz/data/assets/pdf_file/0017/50048/luc_handbook.pdf)

Figure 1 shows the percentage change in operating profit as more mitigations are applied to each farm. The mitigation abatement curve (Figure 1) for each farm was different and dependent on current profitability and the amount of N leaching that had to be reduced for the farm to comply with Table 14.2. Mitigations consistent with GFP did not achieve more than a 5% N reduction as both farms are currently operating

close to GFP (Figure 1). Nitrogen leaching reductions of up to 10% for both farms seemed achievable with a small loss in operating profit. However, for N leaching reductions greater than 10% modelling predicts a substantive reduction in operating profit.

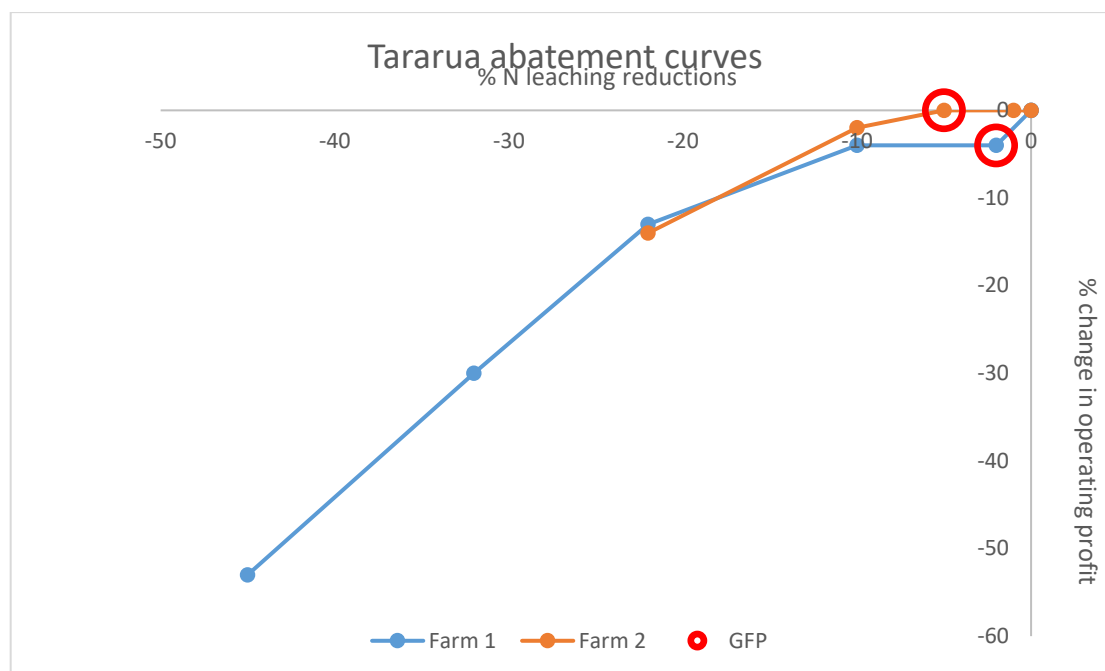


Figure 1: Abatement curve for case study farms from current state to achieve GFP (red circle) and progressive reductions for each mitigation. The starting point for each graph is the farm respective base, found at 0% N leaching reduction and % change in operating profit.

Discussion

Both farms are already operating at close to GFP and therefore mitigations that are based on GFP did not substantively reduce leaching. Farm 1 has a lower N surplus (106kgN/ha) than Farm 2 (131kgN/ha). The size of the N surplus indicates the quantity of N that is at risk of leaving the farm. Increasing the efficiency with which N inputs are converted to outputs will reduce the N surplus and resulting risk of N losses to the environment.

While Farm 2 is currently meeting Year 1 in Table 14.2 of PC2, both farms will have to make reductions to meet the CNLMs for Years 5, 10 and 20 i.e. in 2020, 2025 and 2035.

To achieve Year 10 CNLMs, Farm 1 is required to reduce N leaching by 43% (i.e. reduce from 40kgN/ha to 23kgN/ha) compared with Farm 2 which is required to reduce N leaching by 17% (i.e. reduce from 35kgN/ha to 29kgN/ha). For each farm the Year 10 CNLM target has been selected as a reasonable timeframe for consent, in that it will allow the farm to operate through to 2034 (at which time a further step down to achieve Year 20CNLM would be required)

Both farms have similar soils – well drained brown soils.

The CNLMs in Table 14.2 of PC2 were derived using the livestock carrying capacities in the extended legend of the LUC handbook for each land use capability (LUC) class, converting that number to a pasture production number (assuming a grass based system with no external inputs) and using that to obtain a N leaching number in Overseer. A significant factor in the N leaching of these two farms is rainfall and slope rather than soil type, which is not reflected in the CNLMs for these farms. N leaching in these cases is a poor indicator of farm N use efficiency as it is largely driven by rainfall and slope which are outside the farmer's control.

In contrast, N surplus is a management performance indicator that reflects farmer management practice for which efficiencies and N improvement can be pursued. Reducing N surplus not only benefits the environment, but it can also contribute to farm profitability. N inputs, N outputs, nitrogen surplus alongside N leaching should

be considered together when finding the best overall (environmental and economic) outcome for the farm.

Nitrogen leaching reductions of up to 10% for both farms seemed achievable with a small loss in operating profit. However, for N leaching reductions more than 10% modelling predicts a substantive reduction in operating profit as uneconomic farm system changes will have to be implemented to meet the leaching reduction targets in PC2. When contrasting the two farms modelled, it is evident Farm 1 has a significantly more difficult undertaking to achieve its farm level PC2 CNLM than Farm 2.

Summary

This modelling exercise has shown that it is possible to achieve CNLM nitrogen loss reductions, but there will be financial implications for some farms. Nitrogen leaching reductions of up to 10% for both case study farms seems achievable with a small loss in operating profit. However, for these case study farms N leaching reductions greater than 10% result in significant reductions in operating profit. In addition, the CNLMs in Table 14.2 of PC2 are driven by the LUC class (and assumptions about how Overseer was used to generate a N loss number for each class) rather than farmer practice, rainfall, or slope.

This case study modelling reflects two farm systems within Taranaki – with these two farms selected to provide good representation of affected farms (farms currently sitting above the PC2 updated Table 14.2 CNLM numbers). Each farm system and biophysical characteristics are unique to the respective farm and as such these case studies cannot represent every affected farm.

Appendix

A summary of farm information used in the modelling and nitrogen reductions across different mitigation scenarios for the two selected case study farms are included in this Appendix. For each of the case study farms a summary table of the farm's base/current state has been provided as well as a description of the mitigation scenarios and mitigation modelling results.

Farm 1- Base/ Current State

Farm Stock			
Total cows	362	Peak cows milked	350
Breed	FxJ	Liveweight (kg/cow)	454
Stocking rate (per effective milking ha)	2.3		
Farm area			
Total Ha	298.2	Support Effective (ha)	130
Milking Effective (ha)	155	Total Effective (ha)	285
Production			
Production (kg MS)	118,600	System	3
Production (kg MS/effective milking ha)	765	Production (kg MS/cow)	339
Grazing Off			
R1 post weaning (% peak cows)	23	% off modelled farm	0
R2 % peak cows	23	% off modelled farm	0
June (%) - cows wintered off modelled farm	0	July (%) - cows wintered off modelled farm	0
Fertilizer			
N fertilizer (kg N/ha)	83	P Fertilizer (kg P/ha)	27.0
Effluent			
FDE - storage	<i>Holding pond</i>	FDE - application rate	<i>12-24mm</i>
Effluent area	25	Effluent area (% of effective milking ha)	16%
Stand Off Structures			
Structure - type	<i>Feed pad</i>	Structure - management	Only for standing cows off on wet days.
Feed			
Total pasture Eaten (t DM/ha)	8.9	Supplement imported %	15.9
Crop Types	Fodder beet & turnips	Total crop area (ha)	15.0
Nutrient Loss			
Current N loss (kg N/ha)	40	P loss (kg P/ha)	1.2
Farm Profit			
Operating Profit (\$/effective milking ha)	\$763		
Farm working expenses (\$/kg MS)	\$4.75	Farm operating expenses (\$/kg MS)	\$5.36
Soils type and rainfall	Brown well drained soil	Rainfall (mm)	1801

Farm 1- Farm leaching targets (CNLMs) for each year contained in Table 14.2 of PC2

Land Use Capability* (LUC)	LUC Areas (ha)			Table 14.2 N Leaching Limits (kgN/ha)			
	Total	Platform	Run-off	Year 1	Year 5	Year 10	Year 20
I	0.0	0.0	0.0	51	46	44	43
II	13.2	13.2	0.0	45	40	37	35
III	87.7	83.2	4.5	40	35	32	30
IV	14.0	9.5	4.5	29	25	23	21
V	0.0	0.0	0.0	25	22	20	19
VI	183.3	62.6	120.7	24	19	17	16
VII	0.0	0.0	0.0	11	8	8	8
VIII	0.0	0.0	0.0	3	3	3	3
Farm Area (ha)	298.2	168.5	129.7				
FARM LEACHING TARGET (kgN/ha)				30	25	23	21
Total Nitrogen (kg)				8,907	7,430	6,733	6,320

Farm 1 - Mitigation actions progressively increasing to achieve to meet year 10 CNLMs.

Scenario	Scenario Outline
Base	Some of the leased land was not renewed. The total farm area including support block was reduced from previously 383.3ha to 298.2ha.
Increased feed pad utilisation	Increase utilization of the existing stand-off pad (feed pad). Stand-off 100% of the cows for 4 hours/day March-August.
Increase effluent area	Increase effluent area by 34.1 ha, by including Flat Rangitikei and Kopua blocks as effluent blocks. New effluent pump and stirrer \$15k, pipes \$8/m estimate 1km. Total \$23k. Annual costs include: interest @ 7%=\$1610, depreciation assuming 8-year life=\$2875
Remove summer crop	Remove low yielding turnip crop and instead import PKE keeping an eye on FEI. Do a grass to grass regrassing instead.
Cull early & remove autumn N fertiliser	Cull early 90% of the culls sold by April, then remove autumn N fertiliser and import more maize silage to fill the deficit.
Remove all N fertiliser applications & reduce stocking rate by 6 %	Remove all N fertiliser applications and then reduce stocking rate by 6% to match feed supply to demand.
Remove winter crops and import wintering feed	Remove winter cropping and instead winter on pasture and do a grass to grass regrassing, import more maize silage for wintering.

Farm 1 results table

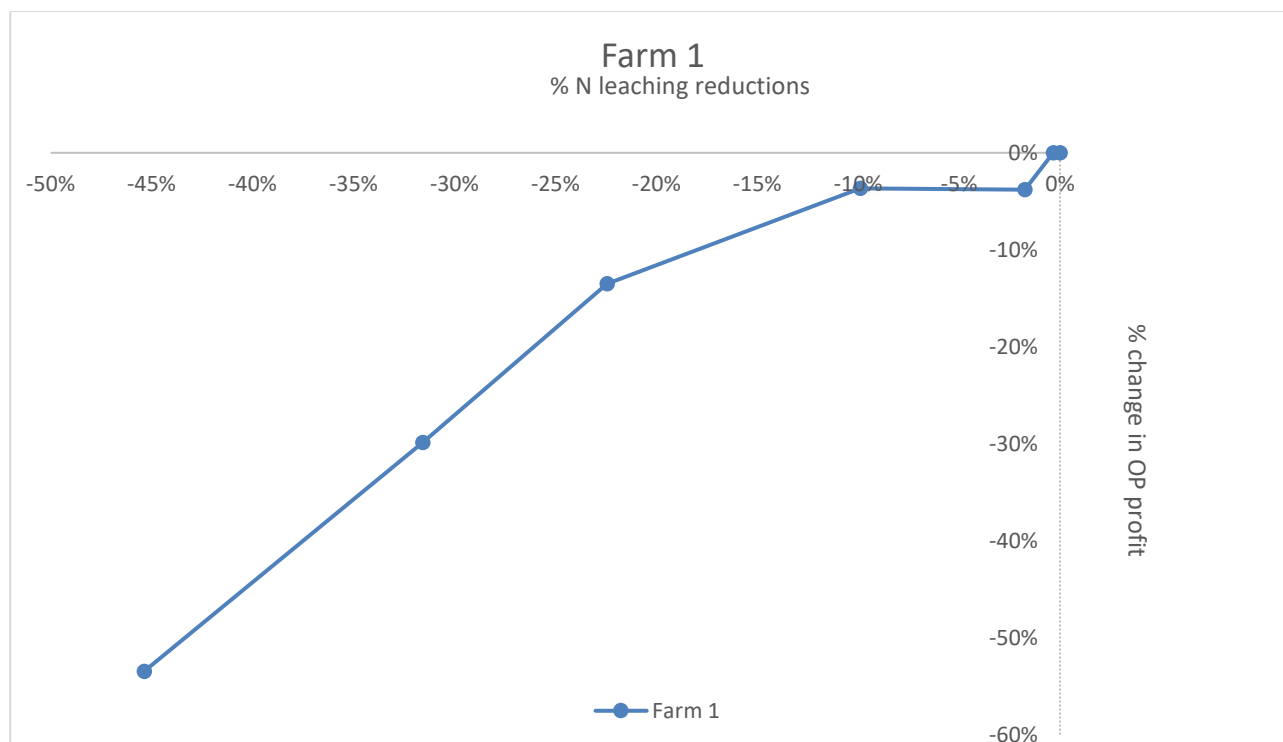
Scenario	Base	Increased SO pad utilization	Increase effluent area	Remove summer crop	Cull early No autumn N fertilizer	Remove all N fertilizer & reduce SR by 6%	No winter crop, import wintering feed
N loss kg/ha	40	40	40	36	31	28	22
Total N loss (KgN)	12,019	11,979	11,810	10,829	9,322	8,224	6,566
P loss (Pkg/ha)	1.2	1.2	1.2	1.2	1.2	1.2	1.1
Total P loss	354	354	354	351	350	348	324
Methane kg/ha	3689	3708	3708	3742	3714	3503	3518
NO2 kg/ha	1095	1071	1069	1078	980	803	772
CO2 kg/ha	957	981	981	1039	1008	759	974
Total GHG kg/ha	5741	5760	5758	5859	5702	5065	5264
N loss % reduction	0%	0%	-2%	-10%	-22%	-32%	-45%
P loss % reductions	0%	0%	0%	-1%	-1%	-2%	-8%
Operating profit	763	763	734	735	660	535	355
Total GHG % reduction	0%	0%	0%	+2%	-1%	-12%	-8%
% Change operating profit relative to Base	0%	0%	-4%	-4%	-13%	-30%	-53%

Key:

Light green shade indicates good farming practice mitigations applied

Darker green shade indicates beyond good farming practice mitigations applied to achieve required N-loss reduction

Farm 1 abatement curve



Farm 2 – Base / Current State

Farm Stock			
Total cows	700	Peak cows milked	688
Breed	Jersey Ayrshire mix	Liveweight (kg/cow)	430
Stocking rate (per effective milking ha)	3.0		
Farm area			
Total Ha	338.7	Support Effective (ha)	70
Milking Effective (ha)	226.0	Total Effective (ha)	296
Production			
Production (kg MS)	259,756	System	3
Production (kg MS/effective milking ha)	1,149	Production (kg MS/cow)	378
Grazing Off			
R1 post weaning (% peak cows)	23	% off modelled farm	0
R2 % peak cows	23	% off modelled farm	100
June (%) - cows wintered off modelled farm	57	July (%) - cows wintered off modelled farm	57
Fertiliser			
N fertiliser (kg N/ha)	86	P Fertiliser (kg P/ha)	1.0
Effluent			
FDE - storage	<i>Holding pond</i>	FDE - application rate	12-24mm
Effluent area	58	Effluent area (% of effective milking ha)	26%
Stand Off Structures			
Structure - type	<i>Feed pad</i>	Structure – management- Used in Autumn and spring for maximum of 3 hours.	.
Feed			
Total pasture Eaten (t DM/ha)	8.3	Supplement imported %	4.0
Crop Types	Fodder beet, Chicory (milking platform) & Maize (support block)	Total crop area (ha)	29.0
Current Nutrient Loss			
N loss (kg N/ha)	35	P loss (kg P/ha)	1.0
Farm Profit			
Operating Profit (\$/effective milking ha)	\$1,900		
Farm working expenses (\$/kg MS)	\$4.31	Farm operating expenses (\$/kg MS)	\$4.66
Soils type and rainfall		Brown well drained soils.	
		Rainfall(mm)	1469

Farm 2 - Farm leaching targets (CNLMs) for each year contained in Table 14.2 of PC2

Land Use Capability* (LUC)	LUC Areas (ha)			Table 14.2 N Leaching Limits (kgN/ha)			
	Total	Platform	Run-off	Year 1	Year 5	Year 10	Year 20
I	0.0	0.0	0.0	51	46	44	43
II	28.1	0.0	28.1	45	40	37	35
III	185.3	185.3	0.0	40	35	32	30
IV	124.1	77.2	46.9	29	25	23	21
V	0.0	0.0	0.0	25	22	20	19
VI	1.2	0.0	1.2	24	19	17	16
VII	0.0	0.0	0.0	11	8	8	8
VIII	0.0	0.0	0.0	3	3	3	3
Farm Area (ha)	338.7	262.5	76.2				
FARM LEACHING TARGET (kgN/ha)				36	32	29	27
Total Nitrogen (kg)				12,304	10,735	9,844	9,168

Farm 2 - Mitigation actions progressively increasing to achieve year 10 CNLMs.

Scenario	Scenario Outline
Base	300 cows wintered on the milking platform 234 in calf MA cows and 166 in calf R2 heifers in leased Hawkes bay support block, which is not modelled as in this analysis as it is outside the catchment. 166 R1 heifers grazing at owned Garfield support block. - Pasture silage, hay all coming from Garfield owned support block and fodder beet bought coming from Hawkes bay leased support block. Maize silage grown on both owned Garfield and leased Hawkes bay support blocks.
Direct drill chicory crop	Change chicory crop tillage practice from conventional to direct drilling.
Increase feed pad utilisation	Increase feed pad usage from current 3 hours to 4 hours March to August. Feed pad utilized by 100% of the herd.
Cull early and reduce autumn N fertiliser	Consider culling early 90% of the culls sold by mid-April, then reduce Autumn nitrogen fertilizer application by removing April nitrogen fertilizer on the effluent block. Currently 67% of the culls are sold by mid-May.
Reduce N fertiliser and stocking rate	Reduce Nitrogen fertiliser by 44kgN/ha targeting the shoulders first and then reduce stocking rate by 7% to match feed supply to demand.

Farm 2 results table

Scenario	Base	Direct drill chicory crop	Increase feed pad utilization	Cull early and reduce autumn fertilizer	Reduce N fertilizer and stocking rate
N loss kg/ha	35	35	34	32	28
Total N loss (KgN)	12,016	11,870	11,454	10,769	9,322
P loss (Pkg/ha)	1.1	1.1	1.1	1.1	1.1
Total P loss	386	386	387	384	377
Methane kg/ha	5496	5496	5507	5412	5056
NO ₂ kg/ha	1502	1501	1512	1475	1199
CO ₂ kg/ha	1039	1039	1039	994	737
Total GHG kg/ha	8037	8036	8058	7881	6992
N loss % reduction	0%	-1%	-5%	-10%	-22%
P loss % reductions	0%	0%	0%	-1%	-2%
Operating profit	1900	1900	1900	1866	1643
Total GHG % reduction	0%	0%	0%	-2%	-13%
% Change operating profit relative to GMP	0%	0%	0%	-2%	-14%

Key:

Light green shade indicates good farming practice mitigations applied

Darker green shade indicates beyond good farming practice mitigations applied to achieve required N-loss reduction

Farm 2 abatement curve