

**BEFORE THE ENVIRONMENT COURT
AT WELLINGTON**

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

IN THE MATTER of the Resource Management Act 1991

**AND
IN THE MATTER** of appeals under Clause 14 of Schedule 1 of the
Resource Management Act 1991 against the
decision of the Manawatū-Whanganui Regional
Council on Proposed Plan Change 2 to the One
Plan ("PC 2")

BETWEEN **TE RŪNANGA O RAUKAWA**
(ENV-2021-WLG-00020)

NGĀTI TURANGA
(ENV-2021-WLG-00021)

ANDREW DAY
(ENV-2021-WLG-00022)

WELLINGTON FISH AND GAME COUNCIL
(ENV-2021-WLG-00023)

Appellants

AND **MANAWATŪ-WHANGANUI REGIONAL
COUNCIL**

Respondent

**SUPPLEMENTARY STATEMENT OF EVIDENCE OF ALISON MARY
DEWES FOR THE WELLINGTON FISH AND GAME COUNCIL
(Farm Systems)**

Dated: 29 January 2024

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SUPPLEMENTARY STATEMENT OF ALISON MARY DEWES**1. INTRODUCTION**

- 1.1 My full name is Alison Mary Dewes.
- 1.2 I prepared a statement of evidence dated 6 November 2023 on behalf of the Wellington Fish and Game Council (Fish & Game) in relation to Proposed Plan Change 2 to the One Plan (PC2). I have the qualifications and experience as set out in that primary evidence.
- 1.3 I repeat the confirmation given in my primary 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.

2. SCOPE

- 2.1 This statement provides comment on the evidence of Peter William John Clough dated 17 January 2024.

3. SUMMARY

- 3.1 There are significant limitations to the assumptions that produced the 10% reduction in milk solids output metric relied on for Dr Clough's macro-economic modelling of the effect of recalibrated Table 14-2. These limitations appear to be recognised in the NZIER Reports attached to Dr Clough's evidence. The associated 'Parminter Reports' (referred to in this evidence), also identify limitations. While a series of farm clusters were used by Dr Parminter to provide the basis for profitability and productivity reductions for the recalibrated Table 14-2 scenario relied upon by Dr Clough, I question the basis upon which this assessment was made. Although the Parminter Reports acknowledge limitations with the original farm system modelling, I question the profitability and productivity analyses for cluster farms 4 and 5 in particular.

- 3.2 I have referred in my primary evidence to studies that show lower N leaching system farms can remain profitable and productive.¹

4. EVIDENCE

- 4.1 Dr Clough's evidence discusses the macro-economic effects of Plan Change 2.
- 4.2 While not an economist, it is within my expertise to comment on the ability of farms to reduce their nitrogen and other contaminant footprints and retain economic viability. In this statement I comment on the assumptions upon which NZIER and Dr Clough's macroeconomic assessments are based, being the calculated costs for applications for intensive land use activities (IFLU) to meet Table 14-2 of the One Plan (operative and 'recalibrated' versions).
- 4.3 I have reviewed the Reports attached to Dr Clough's evidence, being:
- 4.3.1 NZIER *The macroeconomic impacts of the One Plan's intensive land use provisions: Final Report to Horizons Regional Council* (July 2018) (Clough Appendix A).
 - 4.3.2 NZIER *Economic impact assessment of Plan Change 2 of the One Plan: A CGE modelling analysis* (September 2020) (Clough Appendix B).
 - 4.3.3 Section 42A Technical Report of Peter Clough – Macroeconomic Impacts (4 September 2020).
- 4.4 The three reports attached to Dr Clough's evidence state that assumptions for dairy are made including based on Parminter, Terry (2018), *Regional macroeconomic report, memo from KapAg Ltd for Horizons Regional Council*. (Dr Parminter has some background to the One Plan as he gave evidence for Fonterra Co-operative Group Limited at the original One Plan hearings in 2012.)
- 4.5 On enquiry I also was referred to the following reports by Horizons, and asked to put any further questions in writing to Dr Parminter:²

¹ Dewes EIC at [22.10] – [22.11] and Appendix 5.

² Email from T Parminter to A Dewes 22 January 2024 and Email from S Johnston to S Ongley 24 January 2024.

- 4.5.1 Terry Parminter, January 2018. *An Impact Assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatū Wanganui Region*. Client Report for Manawatū-Whanganui Regional Council (**Parminter First Report**).
 - 4.5.2 Terry Parminter, March 2018. *Selecting Representative Dairy Farms for the Upper Manawatu River Catchment*. Client Report for Manawatū-Whanganui Regional Council (**Parminter Second Report**).
 - 4.5.3 Terry Parminter, May 2018. *A Comparison of Changes to Nitrogen Loss Allowances on Dairying in the Upper Manawatu River Catchment*. Client Report for Manawatū-Whanganui Regional Council (**Parminter Third Report** also referred to as Parminter (2018b)).
 - 4.5.4 Terry Parminter, Scott Ridsdale, Stefan Bryant, February 2019. *The possible impact of having regional nitrogen caps on the milk production and financial viability of dairy farms in the Upper Manawatu River catchment of the Tararua District*, Massey University Fertiliser and Lime Conference (**Publication**).
 - 4.5.5 Section 42A Report of T Parminter on behalf of Manawatū-Whanganui Regional Council – Costs of Changes in Nitrogen Leaching Maxima (Table 14.2) 4 September 2020.
 - 4.5.6 Supplementary s42A Report of T Parminter on behalf of Manawatū-Whanganui Regional Council – costs of meeting Cumulative Nitrogen Leaching Maximums 22 October 2020.
(together the '**Parminter Reports**').
- 4.6 I have also been referred to WSP (2020), a report attached to the evidence of Kerry Mayes entitled "*Proposed Plan Change 2 Farm Scale Financial Impact Model*" (Report prepared for Horizons Regional Council 4 September 2020). This used the previous reports by Dr Parminter for source information on costs and benefits.³

³ EB 202.0849

4.7 I attach to this evidence:

4.7.1 Parminter, Terry (2018), *Regional macroeconomic report, memo from KapAg Ltd for Horizons Regional Council* (Appendix 1).

4.7.2 Section 42A Report of T Parminter on behalf of Manawatū-Whanganui Regional Council – Costs of Changes in Nitrogen Leaching Maxima (Table 14.2) 4 September 2020, which attaches a preliminary version of his First Report and his Second and Third Reports (Appendix 2).

4.8 I do not comment on Commercial Vegetable Production (CVP) assumptions.

5. COMMENT ON ASSUMPTIONS USED FOR MACRO-ECONOMIC MODELLING

5.1 To address the question ‘what would be the macro-economic impacts of adopting the recalibrated Table 14.2?’ Dr Clough (and his former colleague) applied the NZIER Computable General Equilibrium model (CGE) to estimate the potential compliance costs with the original and recalibrated Table 14-2, based on Dr Parminter’s survey of farmer options in the Upper Manawatū catchment in the Tararua District.⁴

5.2 My understanding is that Fish & Game does not oppose the recalibration of Table 14-2 (set out in Dr Hanley’s evidence) and does not oppose in principle the ‘discretionary pathway’. However I have been asked to comment on Dr Clough’s assumptions, to the extent his conclusions may be relied on by the Court.

5.3 Dr Clough states that the dairy industry productivity decrease used was a weighted average of the productivity reduction by farm type/cluster obtained from Parminter, Terry (2018), *Regional macroeconomic report, Memo from KapAg Ltd for Horizons Regional Council* (my Appendix 1).⁵

⁴ Clough EIC 24 January 2024 at [11].

⁵ Clough EIC 24 January 2024 at [14].

5.4 Dr Clough's Appendix A (NZIER *The macroeconomic impacts of the One Plan's intensive land use provisions: Final Report to Horizons Regional Council* (July 2018)) states, under Table 1 "*Summary of modelling scenarios*":⁶

- Dairy production falls by 28% in Tararua and by 22% in Rangitikei under the original Table 14.2 limits.
- Dairy output falls by 10% in the two regions under the revised Table 14.2.

5.5 The footnote to this Table 1 "*Summary of modelling scenarios*" states "*Shocks on productivity have been pro-rated using the share of milk production (in kg mild solid) between Upper-Manawatū catchment and Tararua district. We followed the same procedure to pro-rate the shock in Rangitikei. To estimate these ratio [sic], we used data provided by Parminter (2018) and New Zealand Dairy Statistics (2016/2017).*"

5.6 The 2018 NZIER Report sets out "*Assumptions, caveats and information gaps*" (pages 16-17) including:

...the model itself cannot determine (say) how much time dairy farmers and vegetable growers will need to spend on implementing good or best management practices and how costly these practices will be. These parameters need to be determined outside of the model, and then translated into CGE modelling scenarios that proxy their effects.

And

"In both Scenario 0 (Original Table 14.2) and Scenario 1 (No consent pathway), there was no data available for dairy in the Manawatū and Horowhenua in Parminter's report (2018). After discussions with Horizons and WSP, we assumed all farms across the districts faced similar production conditions and took an average from the dairy cluster farms in Tararua and applied it to the other districts, namely Manawatū and Horowhenua. This method was agreed to be an acceptable way to represent the change even if it doesn't capture effects of the different soil types and climate zones.

⁶ Under the heading "Key Points" on page 3.

If more information and data become available on the on-farm costs associated with meeting the recalibrated Table 14.2 of Plan Change 2 of the One Plan, we will be able to carry out further economic modelling as required.

(Emphasis)

- 5.7 This 2018 Report also states (at B.5.3 “Economic impact modelling of additional costs to farmers and commercial vegetable growers”):

Regarding dairy farms in the Coastal Rangitikei Catchment of the Rangitikei (part) and Manawatū districts (part), some data were not available. We used the figures in the report to design our scenario, but it will need to be refined when we get more information.

(Emphasis)

- 5.8 The further economic modelling in the 2020 NZIER Report, carried the same assumptions as cited above, including the same approach to lack of data available for dairy in the Manawatū and Horowhenua districts.⁷
- 5.9 Dr Clough explains that in 2020, the 2018 CGE scenarios were re-modelled and an additional scenario added of ‘partial compliance’ with PC 2 recalibrated Table 14-2. This remodelling drew on analysis by Ford, S 2017. *Farm scale economic impact analysis of One Plan intensive land use provisions* (The Agribusiness Group) which related to CVP⁸ and WSP (2020). WSP (2020) explains that WSP took the Parminter reports and used the data within the reports to cost the impact of good management practices (**GMP**) adoption.⁹ Therefore, the real farms data for modelling for dairy, remains limited.

6. PARMINTER ANALYSIS

- 6.1 Dr Parminter’s Second Report explains that the cluster analysis can be used *“when there are a limited number of actual farms to be used to represent the catchment in the further analyses for policy*

⁷ NZIER *Economic impact assessment of Plan Change 2 of the One Plan: A CGE modelling analysis* (September 2020) at page 17.

⁸ As referred to in Clough EIC 24 January 2024 at [14]. The Executive Summary of Ford S (2017) states the purpose as *“To calculate the economic impact of mitigations to reduce nitrogen leaching as a result of recommended changes to the consenting process, including the costs associated with consent applications for intensive horticultural land use activities following the Environment Court declaration.”*

⁹ At page 14, EB 202.0865.

development".¹⁰ The system types for the cluster farms used are described as:¹¹

Cluster 1 – represents 27 *self contained* farms

Cluster 2 – represents 10 *Low intensity* farms

Cluster 3 – represents 18 *moderate intensity* farms

Cluster 4 represents 16 *moderate intensity* farms

Cluster 5 represents 55 *Self contained and low intensity* farms.

- 6.2 In the Publication ("*The impact of possible changes to nitrogen loss regulations on the financial viability of dairy farms in the Upper Manawatu-River catchment*", February 2019), Dr Parminter and his co-authors state:

The data used in this analysis were obtained from base-line files in Overseer for 126 farms in the Upper Manawātū River catchment. The identity of the farm owners remained anonymous throughout the analyses. The base-line files included farm system information and nutrient budgets that had been calculated using Overseer. The project was restricted to examining the impact of possible policy changes on different farming systems and business structures rather than including farmer capability or environmental foot prints.

- 6.3 The Publication explains the cluster analysis that Dr Parminter used, for the 126 Upper Manawātū farms, where each farm was related to other farms within each cluster and 5 clusters were selected based on 12 farm system attributes. This produced 5 representative (model) farms, using median figures. The financial viability of these farms were analysed using original Table 14-2 maxima (20 year) and recalibrated maxima (using Overseer 6.2.3) by three farm consultants with each consultant working separately and independently. The Publication states:

When the process with the representative farms was repeated again, using the updated nitrogen leaching maxima in Table 2, the results improve the viability of dairy farms in the catchment (shown in Table 6). Stocking rates needed to be reduced less with the revised nitrogen

¹⁰ Parminter **Second Report** page 2 (March 2018. *Selecting Representative Dairy Farms for the Upper Manawatu River Catchment*. Client Report for Manawātū-Whanganui Regional Council).

¹¹ As referred to in Table 8, page 30, Second Report.

leaching maxima. Only Farms 1 & 2 had some surplus pasture to sell. The other farms also reduced their stocking rates but were able to use the increased availability of pasture to increase milk production per cow up to a maximum of 425 kg MS/cow. As a result of the greater efficiency with which pasture was used for dairy production, the profitability of the representative farms under the revised nitrogen leaching maxima was high enough for them to generally remain viable. However, the most heavily indebted quarter of the 55 farms represented by Farm 5 may still not be financially viable if these changes were to be introduced. The change in nitrogen losses between the representative farms in the baseline condition and year 20 is a reduction of over 37% (Parminter et al. 2019).

- 6.4 For the recalibrated Table 14-2, two of the five farm clusters can either be similarly profitable with a 30-40% drop in N leached. These are cluster farms 1-2 as follows:¹²

Cluster farm 1¹³

	MS production kg MS/Ha	Pasture Harvested/Ha	Profit/Ha	N Leach
Year 1	942	12,540	\$1921	41
Year 20	810	9488	\$1838	24
%	↓14%	↓24%	↓4%	↓40%

Cluster farm 2¹⁴

	MS production kg MS/Ha	Pasture Harvested/Ha	Profit/Ha	N Leach
Year 1	1107	11866	\$2387	42
Year 20	987	10168	\$2379	28
%	↓11%	↓14.3	↓0.3%	↓33%

¹² Refer Parminter Second and Third Reports.

¹³ Cluster 1 represent self-contained farms (were modelled to achieve the reductions in Table 14-2 (R) (denoting recalibrated Table 14-2) between base year 2012/2013 and year 20 – assuming that there would be adoption of GMP, and improved farming practices over 2 decades. This group which represents 21% of the farms in Upper Manawatu, under assumptions, demonstrate a small drop (4%) in profitability while a 40% reduction in Nitrogen Leaching occurs. This marginal drop in profit, means that the farm still performs reasonably well, and with a low impact system, is able to reduce Nitrogen leaching by 40% and still be more profitable than a significant number of farms in Cluster 5.

¹⁴ Cluster 2 represents low intensity farms, demonstrating a 33% reduction in Nitrogen Leaching, and little impact on profitability (0.3%), meaning there is still net profit able to be spent in the wider region.

- 6.5 I note that in cluster 3, there is a 35% improvement in profit at year 20 under the recalibrated Table 14-2, demonstrating that regulation does not impair that system (these farm types are already well positioned and can focus on optimising their systems for both more profit and productivity accompanied by more low footprint milk production).

Cluster farm 3¹⁵

	MS production kg MS/Ha	Pasture Harvested/Ha	Profit/Ha	N Leach
Year 1	880	9158	1,293	28
Year 20	1008	9098	1,737	28
%	↑14.5%	↓0.6%	↑35%	No need to change

- 6.6 However the cluster 4 and 5 farms appear to have had questionable rudimentary assumptions applied to them (the outputs from these have also been relied on by Dr Clough's macroeconomic modelling).
- 6.7 Cluster farm 4 represents 13% of farms of moderate intensity. The farm modelled to demonstrate this cluster was an irrigated farm (65 ha of 131 Ha – 50% of the farm) that initially had a high pasture harvest (11,794 T DM/ha/yr) and was also bringing in 474 T DM to feed cows (3.6 T DM/Ha). The modelling assumptions show the pasture harvested and associated profitability drops over 20 years by 27% to meet Table 14-2 (R)¹⁶, while costs have remained similar.
- 6.8 While cow numbers have reduced by 7%, the farm in year 20 is still importing 327 T DM of feed, (3 Tonne/ha), has not increased the effluent area beyond 13% of the farm area, is still using bought nitrogen, is replacing home grown feed with imported feed, increasing costs, diminishing profit, and still grazing half the herd off for 3 months. This appears to contribute to a high cost, un-productive system.

¹⁵ This Cluster - representing 14% of farms in the catchment, who are categorised as moderate intensity, and already compliant, with the ability to be more profitable than the moderate intensity farms (Clusters 4 & 5) demonstrate a profit that is 35% better, and no need to reduce leaching, and can improve milk solids production by 15%.

¹⁶ Defined as "a revision of the original Table 14.2 to account for changes in Overseer over time, but still to address the same catchment objectives and policies".

Cluster farm 4

	Cows	MS production kg MS/Ha	Pasture Harvested/Ha	Profit/Ha	N Leach
Year 1	385	1137	11794	\$2407	46
Year 20	355	1081	8565	\$1748	22
%	↓7%	↓4.9%	↓27%	↓27%	↓52%

6.9 Cluster farm 5 (108 ha) had significant influence on overall assumptions, as representing 55 farms in the sample group, is assumed to be representing 45%¹⁷ of the farms in the Upper Manawatu catchment. In the modelling, despite claiming to represent low intensity and a self-contained system, this farm was still importing 75 Tonne of feed in year 20, appears to be poorly utilising pasture (pasture eaten is 30% down) thus heavily impacting profitability, elevating costs and retarding milksolids output.

Cluster farm 5

	MS production kg MS/Ha	Pasture Harvested/ T/DM/ha	Profit/Ha \$/ Ha	N Leach Kg N/Ha
Year 1	840	11007	1533	39
Year 20	793	7710	1119	24
%	↓5.5%	↓30%	↓27%	↓38%

6.10 The assumptions of how the farm management adapts over time to regulation in this cluster 5, in my view lacks logic.¹⁸ As noted in my primary evidence, there are numerous studies across NZ that show how lower N leaching systems can be profitable and productive, with less stress on the environment, with time to adapt.¹⁹ As I also refer in my primary evidence, often farmers need to be advised by a cross disciplinary team of specialists to run pastoral farm models, whereby

¹⁷ Parminter Third Report page 6.

¹⁸ These types of farms (lower impact with sound profit) are also represented in part by the farm clusters 1 and 2, all of which have marginal reduction in profit, while reducing N leach by 30-40%.

¹⁹ Dewes EIC [22.10] - [22.11] and Appendix 5.

the most appropriate land uses are adapted to land class (including for example forestry, agroforestry).²⁰

- 6.11 A full range of options for cluster farms 4 and 5 to remain profitable does not appear to have been applied by Dr Parminter (or the other farm consultants). That is, from the information I have been provided, estimating economic impacts on these two cluster farms has not examined for a full range of adaptation techniques. Yet this has been relied on by Dr Clough to assess macro-economic effects. In the time available and the process preferred by Horizons, I have not been able to understand from Dr Parminter the reasons cluster farm 4 and 5 analyses did not appear to consider a wider range of optimisation/adaptation methods over the 20 year timeframe.
- 6.12 For completeness, and also relevant to economic assessment, farmers also change their systems for reasons other than regulation of N-loss, including in response to labour availability, animal welfare, supplier requirements, social and market expectations and consumer perceptions. For example:
- 6.12.1 The removal of the winter crops from clusters 4 and 5 also responds to animal welfare concerns (since the Resource Management (National Environmental Standards for Freshwater) Regulations 2020) there has been a decline in the utilisation of winter cropping due to better understanding of animal welfare as well as environmental impacts.
- 6.12.2 Since 2020, there has been increased use of multi-species pastures (such as the use of plantain), where farmers are adapting to market signals such as the need to reduce scope 3 (GHG) emissions by looking at the footprint of imported feeds.²¹ The benefits of plantain are now able to be modelled and recognised in Overseer.
- 6.12.3 Constrained labour availability forces farms to consider simpler systems with fewer cows, and more technology on

²⁰ Dewes EIC at [22.5].

²¹ Fonterra has committed to Scope 3 reductions which is also linked to reducing nitrogen surplus in the farm system. (Nestle has required Scope 3 emissions reporting from Fonterra suppliers.)

farm (such as Halter²² technology which claims to reduce labour input). In my experience, constrained labour availability is impacting farm system change, extended milking periods, or once a day milking, in some cases fewer cows and fewer inputs.

6.12.4 An improvement in carbon price is incentivising steep land to be retired or restored to a more appropriate and profitable land use.

6.13 The influential landscape for farming is dynamic and has changed since 2018. Farmers are manoeuvring their system in response to other influences apart from just environmental regulation. In order to make conclusions regarding on-farm profitability and productivity on the basis of an analysis such as Dr Parminter's cluster farm analysis, in my opinion farm system change would need to take into account recent innovations, market and other influences.

7. PARMINTER CAVEATS

7.1 In the conclusion of Third Report Dr Parminter acknowledges limitations.²³ Even bearing in mind these limitations, I remain unconvinced of the profitability and productivity reduction conclusions for Cluster Farms 4 and 5, for meeting recalibrated Table 14-2. I understand the limitation may have related to the definition of GMP and BMP (best management practices) developed for the purpose of the various analyses.

²² <https://www.halterhq.com/how-halter-works> This is new technology that enhances efficiency on farm, helps manage cow health and wellbeing.

²³ Parminter 2018b: A comparison of changes to nitrogen loss allowances on dairying in the Upper Manawatu river catchment, stating: "The five farm models were drawn directly from the farm medians in Table 3. It was considered by the author that establishing them first as feasible systems in Farmax® (a step included in the first report), would not be needed in this study. The initial models were drawn from actual farm data, however the models were then changed considerably by introducing potential mitigations and these also were not checked in Farmax® for feasibility."

Each of the Cluster Farms was modelled by a different consultant applying similar principles and assumptions. A similar situation operates across the industry in practice. The main limitation for this study from taking this approach is that the timing and order of the introduced mitigations was not exactly comparable for each Cluster Farm. That means that the intermediate steps for the Cluster Farms between Year 1 and Year 20 in the tables may not be directly comparable. This is particularly visible in Figures 1 – 5."

- 7.2 I would require more information, and the opportunity to discuss the matter with Dr Parminter, to understand why such farms could not further adapt/optimize further, in the two decades allowed for.

Alison Mary Dewes

29 January 2024

ATTACHMENTS

Appendix 1: Parminter, Terry (2018), *Regional macroeconomic report, memo from KapAg Ltd for Horizons Regional Council*.

Appendix 2: Section 42A Report of T Parminter on behalf of Manawātū-Whanganui Regional Council – Costs of Changes in Nitrogen Leaching Maxima (Table 14.2) 4 September 2020



Memo: KapAg Ltd

To	Lynette Baish	Senior Policy Analyst
		Horizons Regional Council
From	Terry Parminter	KapAg
CC		
Date	1 st May 2018	
Reference	Regional Macro-economic Report	

Hi Lynette,

The following is an interim report providing information for the macro-economic analyses being undertaken. These are for all types of dairying, arable cropping and those horticultural activities deemed to be 'commercial vegetable growing' in the One Plan (2014).

1. The purpose:

The economic analyses compare district economic performance in response to three policy situations:

- (i) Before undertaking management changes to achieve One Plan nitrogen-loss requirements
- (ii) After undertaking management changes to achieve One Plan nitrogen-loss requirement in Table 14.2
- (iii) After undertaking management changes to achieve One Plan nitrogen-loss requirement in a proposed revision of Table 14.2(R).

The industries being considered in this report are:

- Dairying in the Upper Manawatū Catchment of the Tararua District
- Dairying in the Coastal Rangitikei Catchment of the Rangitikei (part) and Manawatū Districts (part)
- Horticulture in the Horowhenua District

The information sources are shown in Table 1.

Table 1. The information sources used in this report

	Nitrogen losses	Gross margins	P&L accounts	
Dairy-Upper Manawatū	1	1	1	
Dairy-Rangitikei	1	1	1	
Arable-with livestock	1, 2	1, 2	1, 2	
Market gardens	2,3	2,3	2	
Intensive vegetables	2,3	2,3	2	
Potatoes	1,2	1,2	1,2	
Covered vegetables	3	3	3	

1. Impact of changes to nitrogen loss allowances on dairying in the Upper Manawatū Catchment, Parminter, 2018.
2. Farm scale economic impact analysis of One Plan intensive land use provisions, AgriBusiness Group, 2017.
3. Pers. comm.: Stuart Ford (Agribusiness Ltd), Gillian Mangin (MPI), Annette Carey (MPI)

A comparison between the original Table 14.2 in the One Plan (2014) and a possible revised Table 14.2 is shown in Figure 1.

Figure 1. Nitrogen leaching maximums from “Sensitivity of values in Table 14.2 of the ‘One Plan (2014)’ to a change in the version of OVERSEER. Part B”.

Table 6: Original cumulative N leaching maximums (kg N/ha/yr) by LUC Class from Table 14.2 of Horizons Regional Council’s One Plan.

	LUC I	LUC II	LUC III	LUC IV	LUC V	LUC VI	LUC VII	LUC VIII
Year 1	30	27	24	18	16	15	8	2
Year 5	27	25	21	16	13	10	6	2
Year 10	26	22	19	14	13	10	6	2
Year 20	25	21	18	13	12	10	6	2

Table 7: Revised cumulative N leaching maximums (kg N/ha/yr) by LUC Class, revised using OVERSEER® v6.2.3.

	LUC I	LUC II	LUC III	LUC IV	LUC V	LUC VI	LUC VII	LUC VIII
Year 1	50	44	36	26	23	22	11	3
Year 5	45	41	32	23	19	15	8	3
Year 10	43	36	29	20	19	15	8	3
Year 20	42	34	27	19	17	15	8	3

2. Dairy – Upper Manawatū

There are 133 dairy farms in the Upper Manawatū catchment. In the One Plan (2014) dairy farming is defined as, “...using any area of land greater than 4 ha for the farming of dairy cattle for milk production. This includes land used as a dairy cattle grazing runoff but excludes any dairy grazing arrangement ... with a third party ... for the purpose of temporary grazing.” These farms have been clustered into the following groups:

Cluster Farm #1

The results in Figures 2 and 3 apply to 21% of the dairy farms in the catchment.

Figure 2. A summary of the profit and loss account for Cluster Farm #1 applying the original Table 14.2 from the One Plan (2014)

⌘	Initial·Farm⌘	Year·1⌘	Year·5⌘	Year·10⌘	Year·20⌘
Area·of·Milking·Platform·(ha)⌘	116⌘	⌘	⌘	⌘	⌘
Total·Cows⌘	340⌘	230⌘	180⌘	150⌘	150⌘
Stocking·Rate·(cows/ha)⌘	2.9⌘	2.0⌘	1.6⌘	1.3⌘	1.3⌘
Stocking·Rate·(SU/ha)⌘	24.3⌘	14.6⌘	14.4⌘	12.7⌘	12.0⌘
Farm·Labour·(FTE)⌘	2.5⌘	2.0⌘	1.5⌘	1.5⌘	1.5⌘
Nitrogen·Leaching⌘	41⌘	22⌘	19⌘	17⌘	16⌘
Pasture·Consumption⌘	12540⌘	8056⌘	6386⌘	5417⌘	5313⌘
Production·(kgMS/cow)⌘	321⌘	316⌘	329⌘	349⌘	370⌘
Production·(kgMS/ha)⌘	942⌘	626⌘	511⌘	451⌘	478⌘
Total·Milk·solids·(kgMS/yr)⌘	109,269·⌘	72,616⌘	59,220⌘	52,350⌘	55,500⌘
Milk·as·a·proportion·of·farm·income·(%)⌘	94⌘	87⌘	81⌘	79⌘	79⌘
Gross·Farm·Income⌘	\$758,229·⌘	\$541,804⌘	\$474,070·⌘	\$431,395·⌘	\$459,220⌘
Farm·Working·Expenses⌘	\$523,876·⌘	\$431,746·⌘	\$376,351·⌘	\$342,975·⌘	\$353,342·⌘
Operational·profit⌘	\$234,352·⌘	\$110,058·⌘	\$97,719·⌘	\$88,420·⌘	\$105,878·⌘
Capital·Adjustments⌘	·-⌘	\$20,676·⌘	\$29,095·⌘	\$33,796·⌘	\$31,971·⌘
*Surplus·/·Deficit⌘	\$234,352·⌘	\$130,734·⌘	\$126,814·⌘	\$122,216·⌘	\$137,848·⌘
Profit·per·unit·area·(\$/ha)⌘	\$1,934⌘	\$902⌘	\$765·⌘	\$724⌘	\$868·⌘

*No·drawings,·depreciation,·tax·or·principal·payments·included¶

For the regional analysis the figures for use are an initial farm Earnings Before Interest and Tax (EBIT) of \$241,017 and a final EBIT of \$117,909 in year twenty. In Figure 3 the final EBIT is \$221,161

Figure 3. A summary of the profit and loss account for Cluster Farm #1 applying the revised Table 14.2 from the One Plan (2014)

¤	Initial-Farm¤	Year-1¤	Year-5¤	Year-10¤	Year-20¤
Area-of-Milking-Platform- (ha)¤	116¤	¤	¤	¤	¤
Total-Cows¤	340¤	325¤	270¤	250¤	235¤
Stocking-Rate-(cows/ha)¤	2.9¤	2.8¤	2.3¤	2.2¤	2.0¤
Stocking-Rate-(SU/ha)¤	24.3¤	¤	¤	¤	¤
Farm-Labour-(FTE)¤	2.5¤	2.5¤	2.0¤	2.0¤	2.0¤
Nitrogen-Leaching¤	41¤	32¤	28¤	25¤	24¤
Pasture-Consumption¤	12540¤	11926¤	10392¤	9605¤	9488¤
Production-(kgMS/cow)¤	321¤	325¤	340¤	360¤	400¤
Production-(kgMS/ha)¤	942¤	911¤	791¤	776¤	810¤
Total-Milksolids-(kgMS/yr)¤	109,269·¤	105,625¤	91,800¤	90,000¤	94,000¤
Milk-as-a-proportion-of- farm-income-(%)¤	94¤	94¤	92¤	90¤	91¤
Gross-Farm-Income¤	\$758,229·¤	\$732,863¤	\$650,010¤	\$648,220¤	\$671,920¤
Farm-Working-Expenses¤	\$523,876·¤	\$500,325¤	\$454,341¤	\$455,754¤	\$447,684¤
Operational-profit¤	\$234,352·¤	\$232,537¤	\$195,669¤	\$192,466¤	\$224,236¤
Capital-Adjustments¤	·-¤	\$2,413¤	\$11,401¤	\$13,701¤	\$13,821¤
*Surplus·/-Deficit¤	\$234,352·¤	\$234,950¤	\$206,167¤	\$206,167¤	\$238,057¤
Profit-per-unit-area·(\$/ha)¤	\$1,921¤	\$1,906¤	\$1,604¤	\$1,578¤	\$1,838¤

*No-drawings, ·depreciation, ·tax-or-principal-payments-included¶

Cluster Farm #2

The results in Figures 4 and 5 apply to 8% of the farms in the catchment.

Figure 4. A summary of the profit and loss account for Cluster Farm #2 applying Table 14.2 from the One Plan (2014)

☒	Initial·Farm☒	Year·1☒	Year·5☒	Year·10☒	Year·20☒
Area·of·Milking·Platform·(ha)☒	112☒	☒	☒	☒	☒
Total·Cows☒	336☒	230☒	210☒	170☒	150☒
Stocking·Rate·(cows/ha)☒	3.0☒	2.1☒	1.9☒	1.5☒	1.3☒
Stocking·Rate·(SU/ha)☒	22.7☒	15.9☒	14.4☒	11.8☒	10.9☒
Farm·Labour·(FTE)☒	2.5☒	2.0☒	2.0☒	1.5☒	1.5☒
Nitrogen·Leaching☒	42☒	24☒	22☒	19☒	18☒
Pasture·Consumption☒	12,429☒	8,872☒	8,017☒	6,597☒	6,067☒
Production·(kgMS/cow)☒	369☒	390☒	380☒	390☒	425☒
Production·(kgMS/ha)☒	1107☒	801☒	713☒	592☒	569☒
Total·Milk·solids·(kgMS/yr)☒	123,984☒	89,700☒	79,800☒	66,300☒	63,750☒
Milk·as·a·proportion·of·farm·income·(%)☒	94☒	94☒	82☒	79☒	79☒
Gross·Farm·Income☒	\$853,136☒	\$680,750☒	\$634,040☒	\$543,450☒	\$523,795☒
Farm·Working·Expenses☒	\$476,014☒	\$399,335☒	\$389,911☒	\$320,232☒	\$312,253☒
Operational·profit☒	\$377,122☒	\$281,415☒	\$244,129☒	\$223,218☒	\$211,542☒
Capital·Adjustments☒	·-☒	\$16,726☒	\$21,456☒	\$31,913☒	\$34,438☒
*Surplus·/·Deficit☒	\$375,372☒	\$298,141·☒	\$244,129·☒	\$223,218·☒	\$211,542·☒
Profit·per·unit·area·(\$/ha)☒	\$2,387☒	\$1,839☒	\$1,596☒	\$1,459☒	\$1,383☒

*No·drawings,·depreciation,·tax·or·principal·payments·included¶

For Cluster Farm #2 the initial year has an EBIT of \$402,972 and in the final year of the original Table 14.2 it is \$211,542. In the final year of the revised table it is \$376,806.

Figure 5. A summary of the profit and loss account for Cluster Farm #2 applying Table 14.2 from the One Plan (2014)

⌘	Initial·Farm⌘	Year·1⌘	Year·5⌘	Year·10⌘	Year·20⌘	⌘
Area·of·Milking·Platform·(ha)⌘	112⌘	⌘	⌘	⌘	⌘	⌘
Total·Cows⌘	336⌘	336⌘	326⌘	310⌘	260⌘	⌘
Stocking·Rate·(cows/ha)⌘	3.0⌘	3.0⌘	2.9⌘	2.8⌘	2.3⌘	⌘
Stocking·Rate·(SU/ha)⌘	22.7⌘	⌘	⌘	⌘	⌘	⌘
Farm·Labour·(FTE)⌘	2.5⌘	2.5⌘	2.5⌘	2.5⌘	2.0⌘	⌘
Nitrogen·Leaching⌘	42⌘	37⌘	34⌘	30⌘	28⌘	⌘
Pasture·Consumption⌘	12,429⌘	12,078⌘	11,343⌘	10,999⌘	10,168⌘	⌘
Production·(kgMS/cow)⌘	369⌘	357⌘	366⌘	362⌘	425⌘	⌘
Production·(kgMS/ha)⌘	1107⌘	1071⌘	1066⌘	1002⌘	987⌘	⌘
Total·Milk·solids·(kgMS/yr)⌘	123,984⌘	119,949⌘	119,349⌘	112,240⌘	110,500⌘	⌘
Milk·as·a·proportion·of·farm·income·(%)⌘	94⌘	94⌘	94⌘	94⌘	93⌘	⌘
Gross·Farm·Income⌘	\$853,136⌘	\$826,909⌘	\$822,109⌘	\$773,560⌘	\$771,950⌘	⌘
Farm·Working·Expenses⌘	\$476,014⌘	\$499,045⌘	\$488,559⌘	\$430,573⌘	\$396,144⌘	⌘
Operational·profit⌘	\$377,122⌘	\$327,864⌘	\$333,550⌘	\$342,987⌘	\$375,806⌘	⌘
Capital·Adjustments⌘	·-⌘	-\$1,677⌘	-\$617⌘	-\$600⌘	\$7,846⌘	⌘
*Surplus·/-·Deficit⌘	\$377,122⌘	\$326,187⌘	\$332,933⌘	\$342,387⌘	\$383,652⌘	⌘
Profit·per·unit·area·(\$/ha)⌘	\$2,387⌘	\$2,075⌘	\$2,111⌘	\$2,171⌘	\$2,379⌘	⌘

*No·drawings,·depreciation,·tax·or·principal·payments·included¶

Cluster Farm #3

The results in Figure 6 apply to 14% of the farms in the catchment. In the initial year the EDIT is \$186,149. After applying the original Table 14.2 in the One Plan (2014) this drops and then increases in Year 20 to \$209,676. Applying the revised Table 14.2 does not affect this farm as in the initial year it is already below the required maximums for leaching nitrogen.

Figure 6. A summary of the profit and loss account for Cluster Farm #3 applying Table 14.2 from the One Plan (2014)

☒	Initial·Farm☒	Year·1☒	Year·5☒	Year·10☒	Year·20☒
Area·of·Milking·Platform·(ha)☒	99☒	☒	☒	☒	☒
Total·Cows☒	256☒	256☒	256☒	240☒	175☒
Stocking·Rate·(cows/ha)☒	2.6☒	2.6☒	2.6☒	2.4☒	1.8☒
Stocking·Rate·(SU/ha)☒	18.5☒	17.5☒	17.4☒	15.9☒	13.6☒
Farm·Labour·(FTE)☒	2.0☒	2.0☒	2.0☒	2.0☒	1.5☒
Nitrogen·Leaching☒	28☒	24☒	22☒	19☒	17☒
Pasture·Consumption☒	9158☒	8815☒	8582☒	8310☒	6969☒
Production·(kgMS/cow)☒	340☒	331☒	323☒	323☒	425☒
Production·(kgMS/ha)☒	880☒	855☒	834☒	782☒	752☒
Total·Milk·solids·(kgMS/yr)☒	87,145☒	84,630☒	82,579☒	77,418☒	74,400☒
Milk·as·a·proportion·of·farm·income·(%)☒	94%☒	94%☒	94%☒	94%☒	89%☒
Gross·Farm·Income☒	\$·602,603☒	\$·586,255☒	\$·572,924☒	\$·537,037☒	\$·546,180☒
Farm·Working·Expenses☒	\$·416,454☒	\$·424,637☒	\$·427,288☒	\$·400,239☒	\$·336,504☒
Operational·profit☒	\$·186,149☒	\$·161,618☒	\$·145,636☒	\$·136,798☒	\$·209,676☒
Capital·Adjustments☒	~☒	\$·1,083☒	\$·468☒	\$·2,488☒	\$·9,114☒
*Surplus·/·Deficit☒	\$·186,149☒	\$·160,535☒	\$·145,168☒	\$·139,286☒	\$·218,790☒
Profit·per·unit·area·(\$/ha)☒	\$·1,293☒	\$·1,122☒	\$·1,011☒	\$·950☒	\$·1,456☒

*No·drawings·,depreciation·,tax·or·principal·payments·included¶

¤	Initial·Farm¤	Year·1¤	Year·5¤	Year·10¤	Year·20¤	¤
Area·of·Milking·Platform·(ha)¤	99¤	¤	¤	¤	¤	¤
Total·Cows¤	256¤	253¤	243¤	235¤	235¤	¤
Stocking·Rate·(cows/ha)¤	2.6¤	2.6¤	2.5¤	2.4¤	2.4¤	¤
Stocking·Rate·(SU/ha)¤	18.5¤	18.5¤	18.4¤	18.4¤	18.8¤	¤
Farm·Labour·(FTE)¤	2.0¤	2.0¤	2.0¤	2.0¤	2.0¤	¤
Nitrogen·Leaching¤	28¤	28¤	28¤	28¤	28¤	¤
Pasture·Consumption¤	9,158¤	9,162¤	9,134¤	9,099¤	9,098¤	¤
Production·(kgMS/cow)¤	340¤	349¤	374¤	396¤	425¤	¤
Production·(kgMS/ha)¤	880¤	891¤	919¤	939¤	1,008¤	¤
Total·Milk·solids·(kgMS/yr)¤	87,145¤	88,250¤	91,000¤	93,000¤	99,800¤	¤
Milk·as·a·proportion·of·farm·income·(%)¤	94¤	94¤	95¤	95¤	95¤	¤
Gross·Farm·Income¤	\$·602,603¤	\$609,705¤	626,060\$¤	\$637,580¤	\$681,780¤	¤
Farm·Working·Expenses¤	\$·416,454¤	\$415,896¤	\$414,398¤	\$410,092¤	\$431,636¤	¤
Operational·profit¤	\$·186,149¤	\$193,809¤	\$211,662¤	\$227,488¤	\$250,144¤	¤
Capital·Adjustments¤	--¤	\$782¤	\$1,116¤	-\$1,312¤	-\$4,372¤	¤
*Surplus·/·Deficit¤	\$·186,149¤	\$193,027¤	\$210,546¤	\$226,177¤	\$245,773¤	¤
Profit·per·unit·area·(\$/ha)¤	\$·1,293¤	\$1,346¤	\$1,470¤	\$1,580¤	\$1,737¤	¤

*No·drawings,·depreciation,·tax·or·principal·payments·included¶

Cluster Farm #4

The results in Figures 7 and 8 apply to 13% of the farms in the catchment.

Figure 7. A summary of the profit and loss account for Cluster Farm #4 applying the original Table 14.2 from the One Plan (2014)

¤	Initial·Farm¤	Year·1¤	Year·5¤	Year·10¤	Year·20¤	¤
Area·of·Milking·Platform·(ha)¤	131¤	¤	¤	¤	¤	¤
Total·Cows¤	385¤	380¤	350¤	320¤	300¤	¤
Stocking·Rate·(cows/ha)¤	2.9¤	2.9¤	2.7¤	2.4¤	2.3¤	¤
Stocking·Rate·(SU/ha)¤	25.3¤	20.9¤	19.8¤	18.5¤	17.4¤	¤
Farm·Labour·(FTE)¤	2.5¤	2.5¤	2.5¤	2.5¤	2.5¤	¤
Nitrogen·Leaching¤	46¤	24¤	21¤	19¤	18¤	¤
Pasture·Consumption¤	11794¤	9349¤	8772¤	8030¤	7445¤	¤
Production·(kgMS/cow)¤	387¤	381¤	404¤	425¤	425¤	¤
Production·(kgMS/ha)¤	1137¤	1105¤	1079¤	1038¤	973¤	¤
Total·Milksolids·(kgMS/yr)¤	149,000·¤	144,715¤	141,300¤	136,000¤	127,500¤	¤
Milk·as·a·proportion·of·farm·income·(%)¤	95¤	95¤	95¤	95¤	95¤	¤
Gross·Farm·Income¤	\$1,022,800·¤	\$994,168¤	\$·967,990¤	\$·929,520¤	\$871,190¤	¤
Farm·Working·Expenses¤	\$608,739·¤	\$620,084¤	\$631,711¤	\$621,593¤	\$610,907¤	¤
Operational·profit¤	\$414,061·¤	\$·374,084¤	\$·336,279¤	\$·307,927¤	\$·260,283¤	¤
Capital·Adjustments¤	·-¤	\$·1,574¤	\$·5,198¤	\$·9,428¤	\$·13,738¤	¤
*Surplus·/·Deficit¤	\$414,061·¤	\$·375,657¤	\$·341,477¤	\$·317,356¤	\$·274,021¤	¤
Profit·per·unit·area·(\$/ha)¤	\$2,407¤	\$2,175¤	\$1,955¤	\$1,790¤	\$1,513¤	¤

**No·drawings,·depreciation,·tax·or·principal·payments·included¶*

For Cluster Farm #4 the initial year has an EBIT of \$414,061 and in the final year of the original Table 14.2 it is \$260,283. In the final year of the revised table it is \$274,137.

Figure 8. A summary of the profit and loss account for Cluster Farm #4 applying the revised Table 14.2 from the One Plan (2014)

¤	Initial·Farm¤	Year·1¤	Year·5¤	Year·10¤	Year·20¤	¤
Area·of·Milking·Platform·(ha)¤	131¤	¤	¤	¤	¤	¤
Total·Cows¤	385¤	380¤	380¤	370¤	355¤	¤
Stocking·Rate·(cows/ha)¤	2.9¤	2.9¤	2.9¤	2.8¤	2.7¤	¤
Stocking·Rate·(SU/ha)¤	25.3¤	22.6¤	21.7¤	20.7¤	20.0¤	¤
Farm·Labour·(FTE)¤	2.5¤	2.5¤	2.5¤	2.5¤	2.5¤	¤
Nitrogen·Leaching¤	46¤	30¤	27¤	24¤	22¤	¤
Pasture·Consumption¤	11794¤	10209¤	9764¤	9207¤	8565¤	¤
Production·(kgMS/cow)¤	387¤	390¤	390¤	390¤	399¤	¤
Production·(kgMS/ha)¤	1137¤	1131¤	1131¤	9207¤	1081¤	¤
Total·Milk·solids·(kgMS/yr)¤	149,000·¤	148,222¤	148,222¤	148,115¤	141,553¤	¤
Milk·as·a·proportion·of·farm·income·(%)¤	95¤	95¤	95¤	95¤	95¤	¤
Gross·Farm·Income¤	\$1,022,800·¤	\$1,013,928¤	\$1,016,963¤	\$1,015,368¤	\$970,375¤	¤
Farm·Working·Expenses¤	\$608,739·¤	\$632,607¤	\$654,773¤	\$647,681¤	\$674,383¤	¤
Operational·profit¤	\$414,061·¤	\$381,320¤	\$362,190¤	\$367,686¤	\$295,992¤	¤
Capital·Adjustments¤	·-¤	\$662¤	\$482¤	\$1,394¤	\$4,682¤	¤
*Surplus·/·Deficit¤	\$414,061·¤	\$381,942¤	\$362,672¤	\$369,080¤	\$300,674¤	¤
Profit·per·unit·area·(\$/ha)¤	\$2,407¤	\$2,221¤	\$2,109¤	\$2,146¤	\$1,748¤	¤

*No·drawings,·depreciation,·tax·or·principal·payments·included¶

Cluster Farm #5

The Cluster #5 farm results are shown in figures 9 and 10. They apply to 44% of the farms in the catchment.

Figure 9. A summary of the profit and loss account for Cluster Farm #5 applying the original Table 14.2 from the One Plan (2014)

¤	Initial-Farm¤	Year-1¤	Year-5¤	Year-10¤	Year-20¤	¤
Area-of-Milking-Platform·(ha)¤	108¤	¤	¤	¤	¤	¤
Total-Cows¤	270¤	185¤	155¤	120¤	100¤	¤
Stocking-Rate·(cows/ha)¤	2.5¤	1.7¤	1.4¤	1.1¤	0.9¤	¤
Stocking-Rate·(SU/ha)¤	21.5¤	14.9¤	12.6¤	10.4¤	9.4¤	¤
Farm·Labour·(FTE)¤	2.5¤	2.5¤	1.5¤	1.5¤	1.5¤	¤
Nitrogen·Leaching¤	39¤	22¤	19¤	17¤	16¤	¤
Pasture·Consumption¤	11007¤	7150¤	5957¤	4779¤	4237¤	¤
Production·(kgMS/cow)¤	336¤	340¤	358¤	380¤	425¤	¤
Production·(kgMS/ha)¤	840¤	582¤	514¤	422¤	394¤	¤
Total·Milk·solids·(kgMS/yr)¤	90,720¤	62,900¤	55,490¤	45,600¤	42,500¤	¤
Milk-as-a-proportion-of-farm-income·(%)¤	90¤	91¤	87¤	82¤	81¤	¤
Gross-Farm-Income¤	\$628,140¤	\$447,580¤	\$414,820·¤	\$363,440·¤	\$340,210¤	¤
Farm·Working·Expenses¤	\$453,423¤	\$398,252·¤	\$345,388·¤	\$324,969·¤	\$326,074·¤	¤
Operational·profit¤	\$174,717¤	\$49,328·¤	\$69,432·¤	\$38,471·¤	\$14,136·¤	¤
Capital·Adjustments¤	·-¤	\$15,642¤	\$20,505¤	\$26,552¤	\$29,242¤	¤
*Surplus·/-·Deficit¤	\$174,717¤	\$64,971¤	\$89,937¤	\$65,023¤	\$¤	¤
Profit·per·unit·area·(\$/ha)¤	\$1,533¤	\$433¤	\$609¤	\$337¤	\$124¤	¤

*No-drawings,·depreciation,·tax-or-principal-payments-included¶

For Cluster Farm #5 the initial year has an EBIT of \$174,717 and in the final year of the original Table 14.2 it is \$14,136. In the final year of the revised table it is \$117,302.

Figure 10. A summary of the profit and loss account for Cluster Farm #5 applying the revised Table 14.2 from the One Plan (2014)

¤	Initial·Farm¤	Year·1¤	Year·5¤	Year·10¤	Year·20¤	¤
Area·of·Milking·Platform·(ha)¤	108¤	¤	¤	¤	¤	¤
Total·Cows¤	270¤	261¤	230¤	230¤	230¤	¤
Stocking·Rate·(cows/ha)¤	2.5¤	2.5¤	2.5¤	2.5¤	2.5¤	¤
Stocking·Rate·(SU/ha)¤	¤	20.4¤	18.7¤	18.5¤	18.5¤	¤
Farm·Labour·(FTE)¤	2.5¤	2.5¤	2.5¤	2.5¤	2.5¤	¤
Nitrogen·Leaching¤	39¤	32¤	28¤	25¤	24¤	¤
Pasture·Consumption¤	11007¤	10423¤	9163¤	9036¤	8775¤	¤
Production·(kgMS/cow)¤	336¤	335¤	358¤	372¤	372¤	¤
Production·(kgMS/ha)¤	840¤	809¤	762¤	793¤	793¤	¤
Total·Milk·solids·(kgMS/yr)¤	90,720¤	87,420¤	82,340¤	85,620¤	85,620¤	¤
Milk·as·a·proportion·of·farm·income·(%)¤	90¤	94¤	94¤	95¤	95¤	¤
Gross·Farm·Income¤	\$628,140¤	\$605,170¤	\$567,510¤	\$588,830¤	\$588,830¤	¤
Farm·Working·Expenses¤	\$453,423¤	\$447,694¤	\$435,777¤	\$443,789¤	\$456,394¤	¤
Operational·profit¤	\$174,717¤	\$157,476¤	\$131,733¤	\$145,041¤	\$132,436¤	¤
Capital·Adjustments¤	·-¤	\$1,606¤	\$5,850¤	\$4,866¤	\$4,866¤	¤
*Surplus·/·Deficit¤	\$174,717¤	\$159,082¤	\$137,583¤	\$149,907¤	\$137,302¤	¤
Profit·per·unit·area·(\$/ha)¤	\$1,533¤	\$1,367¤	\$1,104¤	\$1,230¤	\$1,119¤	¤

*No·drawings,·depreciation,·tax·or·principal·payments·included¶

3. Dairy – Upper Manawatū Summary

For the dairy farms in the Upper Manawatū catchment the average milk solids production is 927 kg milk solids per hectare per year (kgMS/ha/yr). Applying the original Table 14.2 that drops to 566 kgMS/ha/yr. Applying the revised Table 14.2 it drops to 848 kgMS/ha/yr.

4. Dairy - Rangitikei

The Manawātū Wanganui Regional Council estimates that there are 111 dairy farm consents required to be issued in the Coastal Rangitikei sub-catchment. Seventy six consent applications have already been approved. On average these farms are estimated to be leaching 24 kgN/ha in their base year.

Controlled consents can be issued by the Regional Council when the One Plan (2014) requirements, including the nitrogen caps in Table 14.2 are fully met or exceeded. Applying the original Table 14.2 nitrogen caps, 68% of the dairy farmers in the Rangitikei River catchment could have applied for a controlled consent. Applying the revised Table 14.2(R), 90% could apply for a controlled consent. In regard to their low level of nitrogen leaching, these farms appear to be similar to Cluster Farm 3 from the Upper Manawātū and they could be included in those results.

5. Dairy – Rangitikei Summary

Including the 111 Rangitikei catchment dairy farms with the 126 dairy farmers from the Upper Manawātū catchment changes the initial over-all production average to 905 kgMS/ha/yr. Applying the original Table 14.2 reduces this to 653 kgMS/ha/yr. Using the revised Table the reduction would be down to 863 kgMS/ha/yr.

6. Dairy – Industry Adaptation Over 20 years

Over the next twenty years the dairy industry can be expected to adapt to the environmental and policy pressures identified in the previous figures. It is unlikely that the projected reductions in production and profitability will occur to the full extent of the numbers shown. Over the next twenty years three trends in particular are expected to emerge:

- Increasing production per cow to maintain farm production and increase productivity. This has been included in the figures.
- Increasing the size of low-input farms to achieve greater economies of scale. For example it is expected that the farms in Cluster #5 will increase from a typical milking platform of 108ha to about 160ha or more. Herd sizes (cows per farm) may stay the same but production per cow continue to increase from 336 kgMS/cow/yr to 410 kgMS/cow/yr or more. These changes will enable dairy farms to maintain a similar level of profitability (EBIT) and keep their nitrogen leaching below 25 kgN/ha/yr.
- Farms like Cluster Farm #4 and examples in the other clusters are similar to the System Four farm in the previous report. In that report, by introducing part-time housing for the cows, for most of the year, cows were still able to be grazed outside for most of the year in an intensive dairy system. These farms are expected to be able to maintain the existing farms operational profit (EBIT) and reduce their nitrogen leaching to below 20 kgN/ha/yr.

7. Horticulture-Introduction

Not all horticultural crops are required to meet the nitrogen caps in the One Plan (2014) and that are shown in Figure 1. In the One Plan “commercial vegetable growing” is defined as “...using an area of land greater than 4ha for producing vegetable crops for human consumption. It includes the whole rotation cycle, being the period of time that is required for the full sequence of crops, including any pasture phase in the rotation. Fruit crops, vegetables that are perennial, dry field peas or beans are not included. [Table 14.2] only applies to all arable crops and commercial vegetable production.

In the 2012 census the following horticultural enterprises were operating in the Horowhenua, shown in Table 2.

Table 2. Horticultural production in the Horowhenua (2012)

Crop	Area (ha)	Typical Annual Applications of Nitrogen
Outdoor vegetables		
Potatoes	452	Main crop: 150-250 kgN/ha Process: 300-400 kgN/ha
Broccoli	444	150-250 kgN/ha
Lettuce	273	150-250 kgN/ha
Onions	203	100-150 kgN/ha
Cabbage	140	150-250 kgN/ha
Cauliflower	124	150-250 kgN/ha
Pumpkin	85	30-150 kgN/ha
Squash	50	30-150 kgN/ha
Carrots	7	25-45 kgN/ha
Sweetcorn	5	70-150 kgN/ha
Tomatoes (outdoor)	1	50-130 kgN/ha
Other field vegetables	40	
Indoor vegetables and herbs	0.4	1000-3700 kgN/ha
Fruit		
Apples	24	25-75 kgN/ha
Olives	17	0
Strawberries	15	10-30 kgN/ha
Pears	13	25-75 kgN/ha
Kiwifruit	7	100-200 kgN/ha
Feijoas	5	0
Hazel nuts	4	0
Plums	3	0-100 kgN/ha
Other fruit		

Since these figures were obtained the areas of asparagus (90 kgN/ha) and blue berries (100-250 kgN/ha) have increased in the Horowhenua.

8. Arable with Livestock

There are two sources of information on the response of arable farming to the introduction of nitrogen loss limits in Table 14.2 of the One Plan (2014). In the One Plan “cropping” is defined as, “... using an area of land in excess of 20 ha to grow crops [including] cereal, coarse grains, oilseed, peanuts, lupins, dry field peas or dry field beans. This definition does not include crops fed to animals or grazed on by animals on the same property”.

In Agribusiness (2017) a 210ha property was modelled in a three year rotation: grain (10ha), pasture (180ha), potatoes (10ha). The results are shown in Table 2. The good practice mitigations include constraining the timing of nitrogen applications to reduce losses. Also reducing the amount of nitrogen applied to 70% of conventional practice resulting in reduced crop yields. The changes due to livestock removal were added to those from implementing good practices.

Table 2. Financial results from modifying arable farming practices based on Agribusiness (2017)

	Initial Year	Good practice mitigations	Livestock removed
Gross farm revenue	523,860	405,735	275,055
Farm operating expenses	203,268	189,918	178,805
Cash operating surplus	320,592	215,817	96,250
Net cash position	156,716	68,896	64,864
Nitrogen loss to water (estimated using Overseer®; kgN/ha/yr)	23	20	19

Not that the information in the last column has been calculated from the supplied information.

In Parminter (2017) two arable enterprises were modelled. One of these models of a property of 100ha effective included livestock. The results are shown in Table 3.

Table 3. Financial results from modifying arable farming practices based on Parminter (2017)

	Initial Year	Good practice mitigations	Livestock removed
Gross farm revenue	553,971	N/A	397,380
Farm operating expenses	371,066		300,810
Cash operating surplus	182,905		96,570
Net cash position	-	-	-
Nitrogen loss to water (estimated using Overseer®; kgN/ha/yr)	45		20

The nitrogen reductions in both models are sufficient to meet the nitrogen reductions required in Table 14.2 on classes I and II land. In the original table these required reaching a maximum after twenty years of 21 kgN/ha/yr. In the revised table the maximum was 34 kgN/ha/yr.

9. Market Gardens

Market gardens were modelled in the Agribusiness report (2017). The results for a 20ha property are shown in Table 3. It is not known how many growers fit this definition but possibly about thirty (HortNZ pers. comm. 2018).

Table 3. Financial results from modifying market garden practices based on Agribusiness (2017)

	Initial Year	Good practice mitigations	Cut'n carry offset
Gross farm revenue	960,980	579,492	1,004,540
Farm operating expenses	580,568	430,698	619,749
Cash operating surplus	380,412	148,794	384,791
Net cash position	196,572	-9627	113,333
Nitrogen loss to water (estimated using Overseer®; kgN/ha/yr)	61	49	30

The use of the “cut'n carry offset” was not included the good practice mitigations in the third column.

The good practice mitigations include constraining the timing of nitrogen applications to reduce losses. Also reducing the amount of nitrogen applied to 70% of conventional practice resulting in reduced crop yields. A Cut'n carry offset is required to bring nitrogen loss levels below the maximum required for class I and II land in the revised Table 14.2 in the One Plan (2014). However, the amount offset land used here (35ha) is insufficient to realise the nitrogen loss limits in the original Table 14.2.

10. Intensive Vegetables

Intensive Vegetables were modelled in the Agribusiness report (2017) for a 105ha property. The results are shown in Table 4. It is not known how many growers fit this definition but possibly about fifteen (HortNZ pers. comm. 2018).

Table 4. Financial results from modifying intensive vegetable practices based on Agribusiness (2017)

	Initial Year	Good practice mitigations	Cut'n carry offset
Gross farm revenue	2,557,680	1,639,440	2,804,520
Farm operating expenses	1,927,017	1,479,939	1,908,337
Cash operating surplus	630,663	159,501	896,183
Net cash position	404,773	30,473	357,189
Nitrogen loss to water (estimated using Overseer®; kgN/ha/yr)	69	60	30

The use of the “cut'n carry offset” was not included the good practice mitigations in the third column.

The good practice mitigations include constraining the timing of nitrogen applications to reduce losses. Also reducing the amount of nitrogen applied to 70% of conventional practice resulting in reduced crop yields. A Cut'n carry offset is required to bring nitrogen loss levels below the maximum required for class I and II land in the revised Table 14.2 in the One Plan (2014). However, the amount offset land used here (170ha) is insufficient to realise the nitrogen loss limits in the original Table 14.2. That would require either more off-set land purchased or the addition of the good practice mitigations.

11. Potatoes

This section draws on Parminter (2017). Potatoes were included in the Agribusiness report (2017) as part of the arable example used earlier in this report. There are about five growers in Horowhenua affected by these policies.

The results for a 200ha effective area farm are shown in Table 5. In this example, there are no livestock being farmed on the property, instead forage crops are conserved in mid spring and sold as baleage.

Table 5. Financial results from modifying potato growing practices based on Parminter (2017)

	Initial Year	Good practice mitigations	
Gross farm revenue	2,151,972	1,010,788	
Farm operating expenses	1,513,550	779,362	
Cash operating surplus	638,422	231,426	
Net cash position	-	-	
Nitrogen loss to water (estimated using Overseer®; kgN/ha/yr)	50	19	

The good practice mitigations include reducing the area sown in potatoes from 100ha to 10ha and including additional grain crops in the rotation to take up surplus available nitrogen. In both the situations modelled there have been forage crops included in the rotations but the area for this has been reduced in the good practice model.

The final result is below 20 kgN/ha/yr loss and that is sufficient for class I and II land in the original Table 14.2 and the revised Table 14.2.

12. Covered Vegetables

No work was carried out for covered vegetables.

13. Horticulture Summary

The horticultural section of this report also includes arable with livestock.

The average arable property has an EBIT of \$251,750 or \$1,228/ha in their initial management. To meet the original specifications in Table 14.2 EBIT would drop to \$96,410 or \$470/ha. There is expected to be no change to their EBIT if they are required to meet the revised table.

For commercial vegetable growers (potatoes, intensive vegetables and market gardens) the average EBIT is \$481,288. After twenty years the average EBIT is expected to drop to \$160,269 following the introduction of all the good practices being applied. In general, these are still not sufficient to meet the nitrogen loss requirements of the original Table 14.2.

It is suggested that the only way for horticultural growers to meet the requirements of the original Table 14.2 is for them to use off-set parcels of land for alternative uses as part of their enterprises. These include berries, asparagus, and cut'n-carry forage cropping and/or including more grain crops in their rotations.

At present three growers are producing vegetables under cover. In comparison to field production these strategies would have an average EBIT of \$555,255. Using hydroponics, soilless media, or grow-bags under cover can provide an alternative, but more expensive, way of producing vegetables with a minimum nitrogen loss on the actual growing site.

BEFORE THE HEARINGS PANEL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of proposed Plan Change 2 to the One Plan

AND

IN THE MATTER of the submissions and further submissions
set out in the s 42A Officer Report

SECTION 42A TECHNICAL REPORT OF DR TERRY GRAHAM PARMINTER

ON BEHALF OF MANAWATŪ-WHANGANUI REGIONAL COUNCIL

COSTS OF CHANGES IN NITROGEN LEACHING MAXIMA (TABLE 14.2)

4 SEPTEMBER 2020

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A. INTRODUCTION

1. My full name is Terry Graham Parminter. I am currently self-employed as a private agricultural consultant with KapAg Ltd. I have been in that position since 2009. Prior to 2009 I was employed as a senior scientist with AgResearch.
2. I provide advice about farm management, farm systems, and the design of interventions for achieving human & social behaviour change.
3. I work with individual dairy farmers in the Manawatū Whanganui Region to plan for increasing their productivity whilst reducing their environmental 'footprint', including the improvement of water quality in nearby waterways. Since 2014 I have been assisting farmers with their consent applications under the One Plan. My reports for Manawatū-Whanganui Regional Council, included inputs from two other farm consultants working in other companies. The three of us have assisted almost 100 dairy farmers with their Intensive Landuse Consents.
4. I am working with NZ Beef and Lamb and DairyNZ on social research and agricultural extension projects to improve the efficiency of uptake of farm practices and innovations.
5. I am also working with MPI and MfE on projects about farm economics and the design of policy interventions for achieving water quality and reductions in greenhouse gases on farm.
6. I hold a doctoral degree in Management Systems from The University of Waikato. I am a member of the NZ Institute of Primary Industry Management, the NZ Agricultural and Resource Economics Association, the NZ Institute of Agriculture and Horticultural Science, and the NZ Association of Resource management.
7. I am certified in Advanced Sustainable Nutrient Management (Massey University); Farm Dairy Effluent: System Design and Management (Massey University); and Land Management Planning (NZARM).
8. I have been asked by Manawatū-Whanganui Regional Council ("**Horizons**") to provide a section 42A technical report summarising earlier (2018) reports that I prepared regarding replacement of the Cumulative Nitrogen Leaching Maxima currently in the

One Plan, Table 14.2 (“**Current CNLMs**”), with recalibrated Cumulative Nitrogen Leaching Maxima (“**Recalibrated CNLMs**”) that are based on a more recent version of Overseer®.¹

B. CODE OF CONDUCT

9. I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014. I confirm that I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express, and that this evidence is within my area of expertise.

C. SCOPE

10. I have previously completed a number of reports for Horizons about the impacts on farming systems and businesses of compliance with the Current CNLMs and One Plan policies. I was asked to prepare these reports following on from the Environment Court Declaration Proceedings March 2017 in respect of the Horizons consenting processes and, generally, to advise on the economic impacts of requiring farms to meet the Current CNLMs and comparing those outcomes against recalibrated CNLMs. My reports focussed on the economic profitability, sustainability, and viability of dairy farms.
11. My contribution to PC2 has been to evaluate the impacts on farmers of requiring all intensive farming land use activities to meet the Current CNLMs or Recalibrated CNLMs (i.e. on the basis that farmers and growers were all required to comply). My analysis informed the Section 32 Assessment Report for PC2 as notified.
12. My evidence addresses, by reference to previous reports I have published:
- (a) Evaluating the on-farm economic impacts on a range of farming systems of employing industry good management practices (GMP) to meet the Current CNLMs;

¹The Current CNLM’s are based on Overseer® v5.2.6, and the Recalibrated CNLMs are based on Overseer® v6.2.3.

- (b) Developing farm system models representative of farms in the Upper Manawatū River catchment and using these to further evaluate the on-farm effects of applying GMP to meet the Current CNLMs;
 - (c) Evaluating for the representative farms (in b) the effects of applying GMP to achieve the results from recalibration of Table 14.2 Recalibrated CNLMs; and
 - (d) Likely outcomes for a range of farming systems to meet the Current and Recalibrated CNLMs, in terms of economic profitability, sustainability and viability.
13. Much of the information contained in the reports has also been published in peer-reviewed journal articles. My evidence provides a summary discussion of these reports, and includes the reports in full as Appendices. I also note that my evidence and reports rely on the evidence of James Hanly, Senior Lecturer in Soil Science, School of Agriculture and Environment at Massey University, and other reference material as set out at Section F of this evidence.
14. There were no issues arising from submissions requiring my technical input.

D. BACKGROUND

15. Following the Environment Court's Declaration in March 2017, I understand that Horizons gave further consideration to the existing planning framework. In December 2017 it was estimated by Horizons staff that out of 384 dairy farms in the Horizons region that required an intensive land use consent under the One Plan, only 217 consents for these farms had been granted. A further 167 consents were unconsented ("**the Unconsented Farms**"). The rural advisory staff at Manawatū-Whanganui Regional Council indicated that they were concerned that most of these remaining farming businesses could not meet the Current CNLM's and remain financially viable.
16. At this time, I was approached by Horizons to research the following:
- (a) For the Unconsented Farms, I was asked to calculate the on-farm costs associated with meeting the Current CNLMs and applying for resource consents under the existing policies and rules in the One Plan. This study is addressed by my publication, *"An impact assessment of One Plan policies and rules on*

farming systems in the Tararua District and the Manawatū-Whanganui Region – August 2017". I refer to this as my '**first report**', attached to this 42A technical report as **Attachment A** (I note that my first report was subsequently re-published in January 2018 with the addition of various appendices, and this re-published version can be accessed on the Horizons website,² with all of my reports).

- (b) Using individual farm data from the Upper Manawatū River catchment, I was asked to identify representative dairy farms within the catchment, and calculate the financial viability of their farming businesses if they were to operate within the Current CNLMs. This study is addressed by my publication, "*Selecting Representative dairy Farms for the Upper Manawatū River catchment – March 2018*". I refer to this as my '**second report**', attached to this 42A technical report as **Attachment B**.
- (c) Building on the report by Hanly et.al. (2018) as provided to Horizons, I was asked to compare the economic impact between dairy farms in the Upper Manawatū River catchment operating within the Current CNLMs, and operating within a possible revision of the CNLMs. This study is addressed by my publication, "*A comparison of changes to nitrogen loss allowances on dairying in the Upper Manawatū River catchment – May 2018*". I refer to this as my '**third report**', attached to this 42A technical report as **Attachment C**.

17. It is important to bear in mind that in my modelling I was assuming that all farmers had to meet the nitrogen maximums in year 20 of the Current Table 14.2, and the Recalibrated Table 14.2, which involved introducing new management practices, with their related costs, system interactions, and farmer capability.

18. The following sections of my evidence summarise the conclusions.

E. SUMMARY OF REPORTS

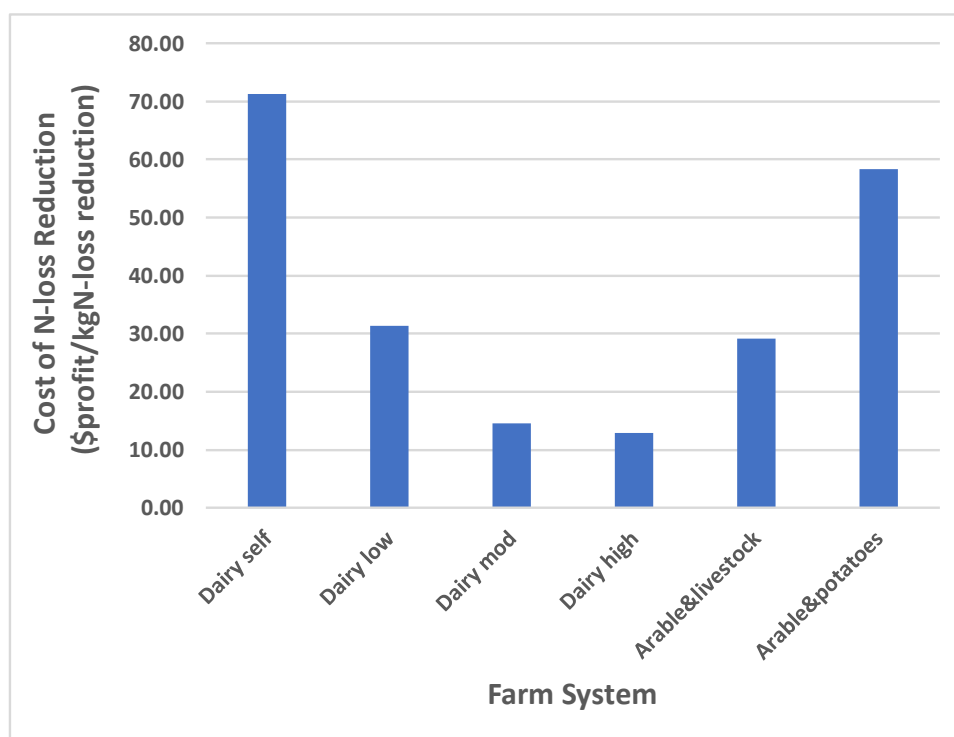
19. My first report showed that meeting the Current CNLMs would result in reductions in profitability for the four dairying and two arable farming systems modelled and reduced

² <https://www.horizons.govt.nz/publications-feedback/one-plan-reviews-changes/nutrient-management>.

rates of return on capital invested (ROA). The size of the economic impact was different for each of the farming systems as well as between the two types of landuse. The moderate and high-intensity dairy farm systems required access to additional capital for animal housing in order to meet the Current CNLMs and remain financially viable. The final level of profitability for all other farming systems modelled was generally insufficient to meet typical farm debt levels and the reductions in ROA could potentially reduce their property values.

20. Figure 1 shows the estimated reduction in profitability (\$/ha) for each unit of reduction in nitrogen leaching. The costs were calculated to be greatest for low input dairy systems where stock numbers had to be reduced over winter (instead of keeping animals off paddocks), and for arable farmers also growing potatoes and leafy greens.

Figure 1. The reductions in farm profitability (\$/ha) expected after meeting the nitrogen cumulative leaching maximums in Table 14.2 for a range of dairy and arable production systems.



Second and Third Reports: representative dairy farms and CNLM comparison

21. In my second report, representative dairy farms for the Upper Manawatū River catchment were identified from the available farm data and these were used to describe the range and quantity of farms affected by the two different forms of Table

- 14.2. The Tararua District was a focus because it contained almost half of the dairy farms in the Horizons and the Upper Manawatū River catchment had about 80% of the dairy farms yet to be consented at the time of the study (Horizons Regional Council, December 2017). The approach used meant that every farm influenced the farm system represented by their cluster and no farm was missed out in the analysis.
22. In my third report, I applied the new clustering approach to the Upper Manawatū River catchment. Five cluster farms were used to represent the diversity and similarity between all the farms in the catchment. After the baseline situation had been established (for Year 2012/13), each farm system was modified by introducing a series of industry recognised Good Management Practices (GMP), until all the farms were able to achieve the CNLMS required for a controlled activity consent under original and recalibrated scenarios.
23. In my experience, every dairy farm obtaining a consent seems to need a different mix of GMP depending on the farmer's goals and capabilities, the farm system and its physical characteristics (Parminter 2015). In this study, the GMP selected were those commonly applied on dairy farms around the Region, they were all able to be modelled in Overseer and include both operational and farm system changes (Box 1).
24. In general, when the initial farm systems are compared with the farms after it was assumed that they complied with the Current CNLMs, the results show a decline in farm profitability. However, on three of the five cluster farms, profitability was largely able to be maintained after compliance with the Recalibrated CNLMs.

Box 1. Industry GMP applied to fully achieve the CNLM contained in Table 14.2

1. All farms were required to make the following operational changes:
 - Remove all nitrogen fertiliser applications from the effluent application area.
 - Remove winter applications of nitrogen fertiliser (April to July inclusive).
 - Reduce annual nitrogen fertiliser applications to 70kgN/ha per year or less. This was figure was based on the catchment median.
 - Aggressively cull non-pregnant and poor performing cows by moving their cull-date one month earlier from April into March (17% of herd).
 - Replace high-protein imported feeds with low-protein. In particular replacing grass supplements with maize silage.
 - Remove all nitrogen applications except for one application in Spring, if required. Reduce herd numbers to balance.
2. Following operational changes, system changes were introduced. The scale of these changes varied with each farm and version of Table 14.2.
 - The effluent treatment field was increased to reduce effluent applications to the equivalent of 100 kgN/ha/yr. This required a capital investment.
 - Irrigation applications (on Cluster Farm #4) were optimised to reduce drainage.
 - Graze off-farm (and out of catchment) rising 2yr heifers and weaned calves. Graze off-farm dry cows although if it was possible, retain at least 0.5 cows/ha for winter grazing on the milking platform. Increase pasture conserved to maintain pasture production and reduce imported feed.
 - Shorten lactation length first to 10th May and reduce herd numbers. Increase pasture conserved to maintain pasture production and reduce imported feed.
 - Shorten lactation length to 30th April and reduce herd numbers. Increase pasture conserved to maintain pasture production and reduce imported feed.

25. My study indicated that if all the dairy farms within the Upper Manawātū River catchment were made to comply with the Current CNLMs then, based on the results from the five cluster farms, nitrogen losses from dairy farms will drop by over 300 tonnes annually (60%) over 20 years. If they were made to comply with the Recalibrated

CNLMS, the reduction would be over 200 tonnes annually (40%). Over the same 20 year period, I expected milk production to decrease by 5,000 tonnes annually (40%) for the Current CNLMS and 700 tonnes annually (5%) for the Recalibrated CNLMS.

26. In the Upper Manawatū River catchment, introducing the Recalibrated CNLMS would enable most (but not all) dairy farms to introduce industry recognised Good Management Practices (GMP) and remain financially viable. Under the Recalibrated CNLMS, a proportion of farms would still be constrained from fully implementing GMP and reaching the minimum nitrogen loss levels in Table 14.2 by their need to maintain minimum pasture utilisation to hold pasture composition. In the same situation, another group of farms had debt levels that are too high to make the amount of investment required to comply with the Recalibrated CNLMS.
27. On the basis of my analyses I estimated the number of dairy farmers in the catchment that could not meet the Current CNLMS. This varied from 15% with the Current CNLMS, to 82% under the Recalibrated CNLMS. This comparison is shown in Table 2 below. The second column in Table 2 has the number of farms across all the clusters in the Upper Manawatū River catchment that could meet the requirements of Table 14.2 in its current and recalibrated forms. The third column in Table 2 includes all the farms that could not maintain their current farming systems if they were to meet the requirements of the two versions of Table 14.2 (although it was still technically possible for them to conform to the CNLM), while the last column in Table 2 shows all the farms expected not to be able at all to meet the conditions required in Table 14.2 for them to apply for a controlled consent.³

Table 2. Detailed comparison of dairy farm results for Table 14.2 comparing the Current Table 14.2 with the Recalibrated Table 14.2.

	Dairy system fit with Table 14.2	Dairy system near Table 14.2	Dairy system distant from Table 14.2
Current Table	20 (15%)	84 (66%)	23 (18%)
Recalibrated Table	103 (82%)	14 (11%)	9 (7%)

³ These are the farms that are not expected to be remain profitable due to above average levels of farm debt.

28. In summary, my third report found that in the Upper Manawatū River catchment, introducing the Recalibrated CNLMs would enable most (but not all) dairy farms to introduce industry recognised Good Management Practices (GMP) and remain financially viable. In a situation where the Recalibrated CNLMs was applied, a proportion of farms would be constrained from fully implementing GMP and reaching the minimum nitrogen loss levels in the table by their need to maintain minimum pasture utilisation to hold pasture composition. In the same situation, another group of farms have debt levels that are too high to make the amount of investment required to comply with the nitrogen loss limits in the table.
29. Therefore without an alternative consenting pathway, it was estimated that about 84% of dairy farmers in the catchment required significant systemic changes or a loss of financial viability if they were to meet Current CNLMs. This reduces to about 18% of dairy farmers in the same position to meet the Recalibrated CNLMs after change to Table 14.2.

Dr Terry Graham Parminter

4 September 2020

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G. ATTACHMENTS

- **Attachment A** - An impact assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatū-Whanganui Region – August 2017.
- **Attachment B** – Selecting Representative Dairy Farms for the Upper Manawatu River Catchment.
- **Attachment C** – A Comparison of Changes to Nitrogen Loss Allowances on Dairying in the Upper Manawatu River Catchment.

ATTACHMENT A



An Impact Assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Wanganui Region

1st August 2017

Terry Parminter

Title: An Impact Assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Wanganui Region

Date: 1st August 2017

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1. Acknowledgements

This report was prepared by Terry Parminter of KapAg Ltd. Most of the farming systems analyses were carried out by Stefan Bryant of BakerAg and Scott Ridsdale of RD Consulting. The report would not have been possible without their hard work.

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Lynette Baish, Helene Lowe and Ian McNabb at Horizons provided client support and feedback for the report. They made it very much a team effort.

Katie Bicknell, lecturer in applied econometrics at Lincoln University, has checked the report to ensure that the appropriate methods for this analysis have been applied.

Despite my very heart-felt appreciation for the above people, they are in no way responsible for the opinions expressed in this report. I take full responsibility for its contents.

2. A Guide for Readers

This report has been prepared for the Councillors of the Manawatu-Wanganui Regional Council and for the staff working with them in policy development for the One Plan. The report may also help to inform discussions between the Council and industry and environmental groups. It will have done its job if this report helps makes Council's decisions easier and not harder.

In this report I have focussed on the financial implications to farmers of changes in the consenting process. For that reason the report describes its results at the farm scale. They have not yet been multiplied up to the whole of the catchment or the region, although that is possible at some stage in the future. I have not addressed the cultural outcomes, environmental outcomes and the needs of other social groups that might be described in other work.

After the summary and introduction, the next section of the report describes its purpose and how I went about responding to that. You may prefer to go straight to the results section and that should be able to be read without referring to any of the other chapters. The farm data is difficult to present clearly. I expect that if you have a lot of farming experience, that I have not provided enough information and if you have no farming knowledge, there may not be quite enough.

After the results section there is a discussion and conclusions section. Like the results section this is intended for you to be able to jump straight in and read from here. There are no recommendations in the discussion. Like this report, it is intended to be informative rather than directive. I have included a graph in here summarising the results to save people having to flick back to the results section. The last chapter is about the assumptions and limitations and ways in which this report could be improved still further.

3. Executive Summary

This report has been prepared for the Councillors of the Manawatu-Wanganui Regional Council and for the staff working with them on policy implementation and a review of the One Plan. In this report I have focussed on the financial implications to farmers of meeting the requirements of the intensive farming land use provisions in the One Plan following the Regional Council's response to a recent declaration by the Environment Court specifying opportunities for improvement. For that reason the report describes its results at the farm scale. They have not yet been multiplied up to the whole of the catchment or the region, although that will be possible at some stage in the future.

The purpose of this report is to "calculate the costs associated with applications for intensive land use activities and the economic impact of mitigations to reduce nitrogen leaching likely to be incurred as a result of the recommended improvements in the consenting process." It is a small-scale study of on-farm economic impacts associated with Council's intensive land use consenting and policy framework. It is intended to provide information to Council staff implementing and reviewing the existing rules and policies in the One Plan. For the latter, further work at a catchment and regional scale will be needed.

The author responded to the project brief by focussing on four dairy farms in the Tararua District and two arable farm systems in the Rangitikei District. These farming systems have been described and mitigations applied to achieve the standards in Table 14.2 and Table E2 of the One Plan. Appendix A of this report includes a copy of Table 14.2. The costs of applying for the modified landuse consents have also been calculated. Taken together these form the basis of the discussion and conclusions towards the end of the report.

To determine the costs to individual farmers of obtaining and implementing their landuse consents, a farm management approach was taken in this report. This approach involved considering the operation of specific farming systems and attaching costs and returns to each of those operations. These costs and returns are then accumulated into an operational profit. The operational profit of farms before and after they have obtained a landuse consent is the main method used to show its economic impact. Some of the mitigations involve significant capital investments. These changes are evaluated in this report by calculating the return on capital on the farms before and after the mitigations have been introduced. The farms each have a calculated capital value and some commentary is provided on how that might be affected on farms that have been modified like these.

The process that was used involved selecting suitable farm systems, determining the changes needed in those systems for them to apply to the Council for a consent, and then evaluating the costs of introducing those changes. The farms were not existing farms. Instead each model farm was created around a particular farm system. The models were synthesised from many different farms known to exist in the region and adjusted to represent dairy farming systems that can be found in the Tararua District and arable farms in the Rangitikei District. These districts were selected because that is where most of the unconsented farms can be found.

The farm management changes between the base farms and the adjusted farms will require many farmers to grow their capability in managing pasture cover and pasture quality. The costs of a change in capability has not been included in this analysis.

The analytical results that were used were:

Farm Model: Self-contained dairy farm

This farm model has all the heifers grazed off the farm for 12 months from 9 months of age. It assumes that there has already been some adjustment to reducing its environmental footprint by grazing half the dairy cows off the farm over winter. Regular soil tests are taken and maintenance phosphate fertiliser is applied. A summer forage crop of turnips is grown to manage a possible risk of a dry summer. On average 30kg N/ha is applied in early spring and autumn to extend pasture production in those seasons.

To meet Table 14.2 in the One Plan, the farm has to reduce the number of dairy cows from 270 to 140 animals. It can no longer apply nitrogen fertiliser and must stop all cropping. The farm is expected to no longer bring in feed supplements for the cows. Instead it harvests 288 tonnes of pasture DM and sells most of this off the farm. The sale of surplus feed is a very important part of pasture management on this farm because animal consumption has dropped to almost 6,000 kgDM/ha/yr. Without harvesting surplus feed, the quality of the pasture would fall and in a few years pasture composition would suffer.

The farm started with leaching 32 kgN/ha and was modified to be leaching only 18 kgN/ha, a reduction of 44%. These changes reduced the expected farm profit from \$1,627/ha to \$629/ha, a drop of over 60%. The return on assets dropped from 5.3% to 2.0%.

The self-contained farm model has had to reduce its labour but it has surplus pasture available for alternative landuses, and therefore its adaptability might increase overall. Nitrogen conversion efficiency has increased to 66% and so it can be expected to be more sustainable in its use of natural resources. However, its profitability is not enough to support the level of debt found on many farms in this region. The return on assets is insufficient to attract off-farm investment, should that be required for future improvements. Unless farms like this have less than half the amount of debt as the model farm, they will not survive the changes required to address Table 14.2 .

Farm Model: Low-intensity dairy farm

The low-intensity dairy farm is very common in the Tararua District and in the region generally. In this model there are more cows and they have greater production than the self-contained farm. On this farm there is more supplementary feed (260 tonnes DM) brought onto the farm and greater use is made of cropping in both winter and summer. Over the whole farm more than 100 kgN/ha is applied, mainly to lengthen the grass growing season in spring and autumn.

To meet Table 14.2 in the One Plan, the farm has to reduce the number of cows from 400 to 250 animals. They will also need to reduce nitrogen fertiliser applications to an average of 5 kgN/ha/yr and stop importing supplementary feed and growing a winter crop. The summer crop remains, and 443 tonnes of DM are conserved. Three quarters of the conserved feed is sold off the farm to maintain pasture quality.

The farm started with leaching 42 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of 60%. These changes reduced the expected farm profit from \$1,848/ha to \$1,064/ha, a drop of over 40%. The return on assets dropped from 6.4% to 3.7%.

The low intensity farm model has not reduced its labour and it has surplus pasture available for alternative landuses. It's adaptability might increase overall. Nitrogen conversion efficiency has

increased to 56% and so it can be expected to be more sustainable in its use of natural resources. However, its profitability is not enough to pay tax and support the level of debt found on many farms in this region. The return on assets is insufficient to attract off-farm investment, should that be required for future improvements. Unless farms like this can reduce the amount of debt below that of the model farm they will not survive the changes required to address Table 14.2 .

Farm Model: Moderate-intensity dairy farm

This farm has 600 cows and achieves high production. The farm imports 757 tonnes DM, grows winter and summer crops and applies an annual application of over 150 kgN/ha.

To achieve Table 14.2 in the One Plan this farm has a covered barn installed for all the cows so that they can be housed all year. Although inside for much of the time, the cows are grazed outside for fixed periods throughout the year – 8 hours per day while lactating and 2 hours per day over winter. The farm imports the same amount of supplementary feed as it did previously and harvests another 38 tonne of supplements to maintain production. Dairy effluent is applied across the whole of the milking platform and nitrogen fertiliser applications reduced to 50 kgN/ha.

The farm started with leaching 54 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of almost 70%. These changes reduced the expected farm profit from \$2,283 /ha to \$1,745/ha, a drop of almost 25%. The return on assets dropped from 7.0% to 5.0%.

The moderate intensity farm model has not reduced its labour but it has had to increase its overall pasture utilisation. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency only increases slightly to 27% and so there is not much improvement expected in the sustainable use of natural resources. However, the profitability of this farm is sufficient to support its expected level of debt and it has sufficient return on assets to provide financial security for its owners.

Farm Model: Irrigated high-intensity farm

The irrigated high intensity dairy farm in the base model has 640 cows and has a centre pivot irrigator and a feed pad. The farm imports 757 tones DM per year as a supplement or 1,180 kgDM/cow. It uses 187 kgN/ha of nitrogen a year.

To meet the requirements of Table 14.2 in the One Plan this farm has built housing for the cows so that they can be kept inside all year. The farm already had a feed pad and so the effluent system for housing the animals was already in place. While they are lactating, the cows are grazed outside for up to 8 hours per day. The amount of imported supplements on this farm is increased to 1,170 tonnes DM and 22 tonnes of supplements are made on the farm.

The farm started with leaching 64 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of over 70%. These changes reduced the expected farm profit from \$2,456/ha to \$1,850/ha, a drop of 25%. The return on assets dropped from 6.8% to 4.8%.

The irrigated high intensity farm model has not reduced its labour but it has had to increase its overall pasture utilisation. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency only increases slightly to 28% and so there is not much improvement expected in the sustainable use of natural resources. However, the profitability of this farm is sufficient to support its expected level of debt and it has sufficient return on assets to provide financial security for its owners.

Farm Model: Arable farm with livestock

Both the arable farms are larger than the typical farms to be found in the Manawatu. Making them larger makes it easier to compare these farms with the dairy farms that have a similar size. This farm specialises in grain production over summer. It has been able to do that without irrigation. Half of the farm is used for growing barley and in winter it has been growing ryegrass for finishing livestock. The farm finishes lambs and heavy cattle over a 12 month period. Over the year 150 kgN/ha is applied to the cropping area or an average of 60 kgN/ha across the whole farm.

The changes required to meet Table 14.2 in the One Plan are to dispose of all the livestock and harvest as silage and hay the permanent pasture and ryegrass green crop. The area in barley had to be reduced from 100ha to 70 ha. Over a whole year 1,399 tonnes of pasture dry matter was made and exported from the farm.

The farm started with leaching 39 kgN/ha and was modified to be leaching only 24 kgN/ha, a drop of almost 40%. These changes decreased the expected farm profit from \$915/ha to \$477/ha, a decrease of 47%. The return on assets dropped from 2.6% to 1.3%.

The arable with livestock farm model has not reduced its labour but it has become dependent on the supplementary feed market. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency has increased to 89% and so natural resource sustainability has also increased. The profitability of this arable farm is insufficient to support its expected level of debt and it has insufficient return on assets to provide much financial security for its owners.

Farm Model: Arable farm with potatoes

This model farm was again large for a cropping farm. This time there were no livestock and instead two different rotations were modelled. The second rotation of potatoes and brussels sprouts required a total application of 428 kgN/ha over a year. The other rotation of maize silage and winter oats for forage only needed 110 kgN/ha. Irrigation was used over summer on the potato crop and 500mm/yr was used.

The changes required for meeting Table 14.2 in the One Plan included reducing the amount of nitrogen fertiliser going on to the potato rotation (332 kgN/ha) and better timing fertiliser applications to align with crop requirements. A new rotation growing barley for grain was introduced to replace some of the area originally in a high nitrogen feeding crop (potatoes). To reduce drainage from excess irrigation a moisture probe was installed and a water budget put in place. This reduced the amount of water needed to 380mm/yr.

The farm started with leaching 60 kgN/ha and was modified to be leaching only 25 kgN/ha, a drop of almost 60%. These changes reduced the expected farm profit from \$3,192/ha to \$1,152/ha, a drop of over 64%. The return on assets dropped from 8.2% to 3.0%.

The arable with potato farm model has some reduction in casual labour and it has had to increase the range of crops being grown. Its adaptability might therefore increase overall. Nitrogen conversion efficiency has increased to 94%, a big improvement in the sustainable use of its natural resources. However, the profitability of this farm is insufficient to support its expected level of debt and it has insufficient return on assets to provide financial security for its owners.

Costs of Consents

There are expected to be four consent application pathways for farmers:

- An existing farm may already be able to meet the conditions and standards of a controlled activity in the One Plan. That means that it can show that it will be able to meet the cumulative nitrogen leaching maximum in Table 14.2 of the One Plan and has appropriate mitigation of waterway contamination from phosphorus, sediment, and E.coli. The application will need to provide enough evidence from Overseer® to support the Council approving a controlled consent. The main costs will be for an agricultural consultant to describe the existing farm system and carry out a standard AEE. This should show that the farming business can operate within the effects anticipated by the One Plan. The total cost for a consent application is likely to be about \$8,200.
- Some existing farms may be able to meet the leaching caps in Table 14.2 of the One Plan and mitigate any potential waterway contamination from phosphorus, sediment, and E.coli but their mitigations cannot be calculated using Overseer. These will require extra preparation work to quantify the benefits of these mitigations. Such farms will need to apply for a restricted discretionary consent that shows calculations of the effectiveness of their mitigations. Generally the size of the benefits from these mitigations will be quite site specific and so information about the site as well as the mitigation will need to be provided. For example, the use of high carbon ditches to intercept nitrogen leaching will depend on the hydrology of the site. An agricultural consultant working with a farmer can provide the Council with this information with the support of industry scientists. The total cost for a consent application is likely to be about \$12,500.
- Farms that can meet the nitrogen leaching caps in Table 14.2 within four years will need to address through their AEE the effects of the four year delay in meeting the Table. The additional costs for these farmers are generated from needing the advice of a professional ecologist and obtaining information about the cumulative effects for the catchment. The total cost for a consent application is likely to be about \$22,000.
- The farms that are not anticipated to meet the nitrogen caps in Table 14.2 will need to apply for a restricted discretionary consent and prepare a very robust AEE. They will need to employ technical expertise to show that their effects on the environment are less than minor. The total cost for a consent application is likely to be about \$25,500. It is probable that these applications could be publically notified and an additional deposit for this will need to be made to Horizons. The deposit may be around \$20-30,000 in addition to these costs.

These costs could easily vary by 20% either up or down depending upon the complexity of the work involved.

Adaptability, Sustainability and Viability

The model farm systems are changed significantly in order to meet the criteria for consents in the One Plan. The self-contained dairy farm, the low intensity dairy farm and the arable farm with potatoes might become more adaptable as a result of these changes. All of the model farms improved their efficiency of nitrogen use for production. They might therefore be considered to have become more sustainable production systems.

However, all of the model farms became less profitable as a result of introducing the mitigations necessary to comply with the conditions in the One Plan. The self-contained dairy farm and the low intensity dairy farm do not have sufficient profit to remain viable at typical industry levels of debt. All the model farms returned less than 5% on assets except for the moderate intensity dairy farm (ROA=5%). Therefore, all their owners now lack future financial security from their investment in these farming businesses. The reduced profitability is likely to result in a downward pressure on the future property values for these farms.

4. Introduction

This report and the work described, was produced at the request of the Manawatu Wanganui Regional Council (Horizons). A summary of the brief for this work is provided in Appendix B.

The One Plan for managing all the natural resources in the Manawatu Wanganui Region became fully operational in 2012. It was called the One Plan because it combined the previous regional policy statement (RPS) and the regional plan (RP) in one document. There are two chapters relating to the management of freshwater in the region. Chapter five has the objectives and policies for water quality to achieve the values and standards in Schedule B, Table 1 and Schedule E, Table 2. It could be considered the RPS part of the plan. Chapter 14 has the policies and rules relating to discharges to land and water. It is the RP part of the plan. The One Plan sets out a framework for managing water quality in fresh water and seeks to control the effects of both point source and non-point source discharges to maintain good water quality and enhance poor water quality. Through the One Plan, intensive farming land users require resource consents in the targeted water management sub-zones identified in the Plan.

Landuse consents for dairy and arable farms consider four main risk areas from non-point sources affecting waterways. These are: nitrogen losses, phosphorus losses, sediment and pathogens (e.g. E.coli). The latter three are managed through the adoption of good management practices. and nitrogen losses are managed through the cumulative nitrogen leaching maximums set out in Table 14.2. Applicants for land use consents use the Overseer software package and farm system inputs to model on-farm nitrogen leaching loads and determine their activity status for the consenting process.

Dairy and arable farmers have been applying to Horizons for landuse consents to continue their existing or establish new farming activities in the region. Horizon's consenting process was challenged in the Environment Court earlier this year and their decision identified some opportunities for improving Horizon's processes. Changes to the consenting processes are likely to have economic implications for applicants and Horizon's intends to quantify these as much as possible.

This report was commissioned in June 2017 to "calculate the costs associated with applications for intensive land use activities and the economic impact of mitigations to reduce nitrogen leaching likely to be incurred as a result of the recommended improvements in the consenting process."

The author responded to the project brief by focussing on four dairy and two arable farm systems. These farming systems have been described and mitigations applied to achieve the standards in Table 14.2 and Table E2. The costs of applying for the modified landuse consents have also been calculated. Taken together these form the basis of the discussion and conclusions towards the end of the report.

In order to progress this report in the time available some assumptions have had to be made and these are described in the penultimate chapter. There are some limitations to the report, particularly if its results are being applied outside the original brief. Finally, in the last chapter there is some further reading to assist those readers that want to examine further the principles behind this study.

5. Purpose

Natural resource management in the Manawatu Wanganui Region requires both voluntary efforts by land owners and their compliance with the policies and rules contained in the One Plan. The policies and rules in the One Plan are intended to achieve natural resource improvements benefiting the values of all people in the region. Achieving these improvements now and in the future requires time, effort and resources. Farmers will face new and additional costs in order to mitigate the impact on waterways of their farming activities.

The purpose of this report is to “calculate the costs associated with applications for intensive land use activities and the economic impact of mitigations to reduce nitrogen leaching likely to be incurred as a result of the recommended improvements in the consenting process.” It is a small-scale study of on-farm economic impacts associated with Council’s intensive land use consenting and policy framework and it is intended to provide information to Council staff considering implementation of the existing rules and policies; and preparing for future One Plan development. For the latter, further work at a catchment and regional scale will be needed. A summary of the project brief is included in Appendix B.

6. Problem Solving Approach

To determine the costs to individual farmers of obtaining and implementing their landuse consents, a farm management approach was taken in this report. This approach involved considering the operation of specific farming systems and attaching costs and returns to each of those operations. These costs and returns are then accumulated into an operational profit. The operational profit of farms before and after they have obtained a landuse consent is the main method used in this report to show its economic impact. Some of the mitigations involve significant capital investments. These changes are evaluated by calculating the return on capital on the farms before and after the mitigations have been introduced. The farms each have a calculated capital value and some commentary is provided on how that might be affected on farms that have been modified like these to achieve Table 14.2 in the One Plan.

The problem solving approach used here involved selecting suitable farm systems, determining the changes needed in those systems for them to apply to the Council for a consent, and then evaluating the costs of introducing those changes. The farms were not existing farms. Instead each model farm was created around a particular farm system. The models were synthesised from many different farms known to exist in the region and adjusted to represent farming systems that can be found in the Tararua and Rangitikei Districts. These districts were selected because that is where most of the remaining unconsented farms can be found for dairying and cropping respectively.

Four dairy farm systems were selected to reflect the different farm systems to be found in the Tararua District. The dairy farms were standardised for land area, rainfall and soil types. Each farm was then adjusted to reflect the differences in farm system and matched to the expected nitrogen loss rate.

The analysis followed the following steps for each dairy farm:

- (i). The base farm was established in Overseer®, compared to the initial specifications and modified if necessary to better fit these.
- (ii). The farm was entered into Farmax® and the stock reconciliation checked and the supplementary feed inventory checked.
- (iii). Any changes in Overseer as a result of the Farmax exercise were made.
- (iv). The farm's operational profit and loss account was finalised to provide the base farm information summarised in the results section.
- (v). The farm in Overseer was modified until it could achieve the nitrogen loss profile in year 20 of Table 14.2
- (vi). The modified farm was again checked in Farmax.
- (vii). Any consequential changes in Overseer were made.
- (viii). The farm's new operational account was finalised and compared to the base farm account
- (ix). Return on capital was calculated.

The two cropping farm systems were processed in a similar way to the four dairy farms.

The analyses have included considerable changes in the way that farming – both dairy and arable will need to be done in the future. The adjustments require growing farming capability and building new expertise amongst the professionals advising them. The structures and costs of human development have not been addressed in these analyses.

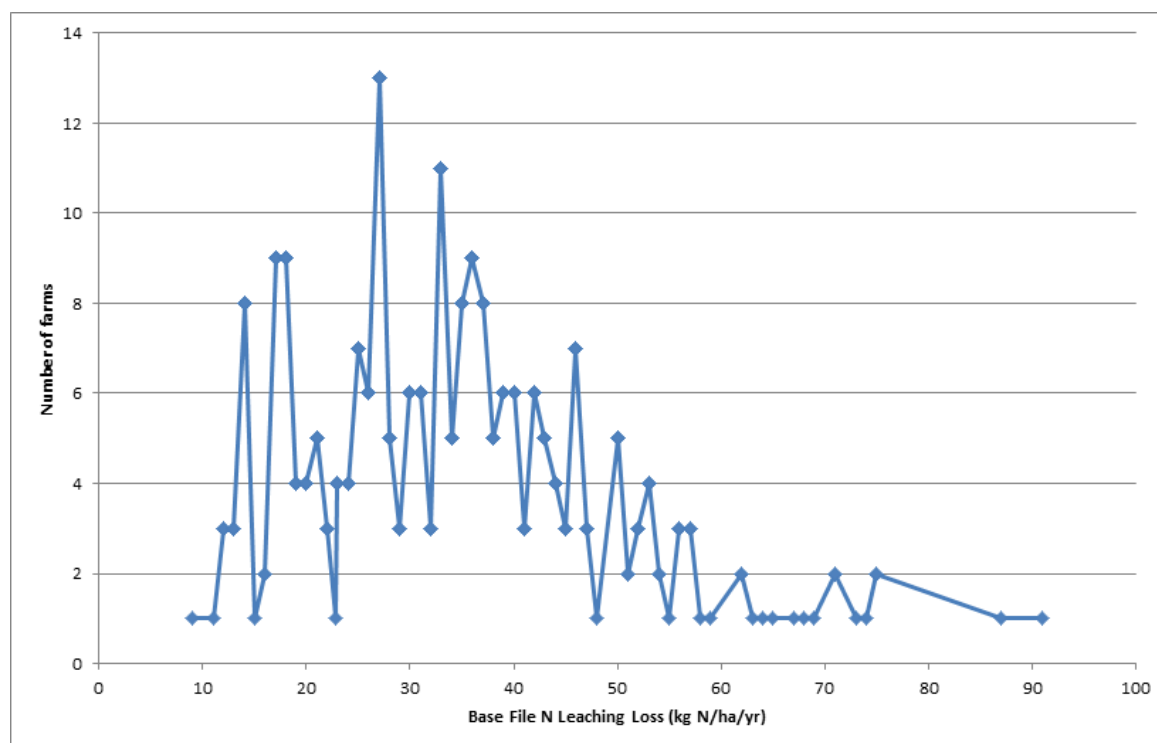
In this report the initial state of each of the farming businesses has been compared with those same farming businesses in year 20 of Table 14.2. At the end of year 20 each of the farms would be fully compliant with the intensive land use rules in the One Plan. Between year 1 and year 20 in Table 14.2 the model farms would need to step down their nitrogen leaching by almost 25%. However, due to the length of time involved, on many farms, the completion of this transition process is likely to occur after there have also been changes in farm ownership. The uncertainty of the transition is increased by a possible plan review of the One Plan during that time and structural adjustments in the market to accommodate the adaptations required in farming systems.

7. Results

7.1 Farming Systems

There were no figures from industry available to guide the development of representative dairy farms in the region. However, Horizons were able to provide a chart of base file nitrogen losses found in the region and this was used to guide the development of the model farms (Figure 1).

Figure 1. Base file nitrogen leaching of resource consents currently granted in the Horizons region.



The data below 20 kgN/ha in Figure 1 are likely to be from specialist dairy farms or discrete parcels of land on part-farm's that required consenting rather than whole-farms. The figures above 60 kgN/ha are likely to be from high-input farms in high rainfall areas and on soils with a propensity for high nitrate leaching.

Farm consultant's in the region work with a range of farm systems, from low intensity to high intensity systems. For this study, different dairy farm systems were matched with the likely nitrogen loss rates to be found in Tararua District (Table 1). The table highlights that only four combinations of farm systems and nitrogen losses were selected in this study. However they are spread out across the table. Although other combinations of farm systems and nitrogen loss rates might be possible in the region it was hoped that their results could be approximated using the results of this study.

The two arable farms were modelled as farms similar in size to the dairy farms (200 ha). One arable farm included livestock as a significant source of its nitrogen losses, the other arable farm had no livestock but did have potatoes and brussels sprouts as the most significant sources of its nitrogen losses.

Table 1. Selected dairy farm systems and their associated nitrogen loss rates

Expected Annual Nitrogen Loss (kgN/ha)	Dairy System			
	Type 1-2 System	Type 2-3 System	Type 3-4 System	Type 3-4 System
30 kgN/ha	Self-contained			
40 kgN/ha		Low intensity		
50 kgN/ha			Moderate intensity	
70 kgN/ha				Irrigated

The non-irrigated Tararua dairy farms shared the same soil types and had an annual average rainfall of 1200-1300mm. The irrigated dairy farm was modelled in a slightly drier area in the Tararua District. It had an average annual rainfall 100mm lower than the other dairy farms, and used irrigation to add an additional 600mm. The three most intensive farm models included runoffs for grazing replacement animals and wintering non-lactating (dry) cows. The runoffs were also sometimes used for cropping and making surplus grass into supplementary feed. The self-contained farm had no runoff. In Table 14.2 the dairy farms all had the same mix of land classes. The milking platforms were: LUC II (20%), LUC III (65%) and LUC IV (15%). The runoffs were: LUC III (40%) and LUC IV (60%). The dairy farms had to operate inside a leaching cap by year 20 of 18 kgN/ha per year.

The Rangitikei arable farms were both on the same soil type in an area receiving about 900mm annual rainfall. The arable farm with irrigation added a further 500mm/ha. In Table 14.2 the cropping farms each operated on LUC II with a leaching cap in year 20 of 21 kgN/ha.

There were no farms modelled that in their initial state could reach Table 14.2 in the One Plan without making some changes to their farming practices. The expected trajectory in nitrogen leaching loss of the farms modelled is shown in Figure 2. In the Figure all the dairy farm models have to be leaching below 24 kgN/ha by year 1, and the arable farms below 27 kgN/ha. By year 20 the dairy farms have to be below 18 kgN/ha and the arable farms below 21 kgN/ha. The modelled dairy farms in Tararua District had to reduce their nitrogen leaching to between 60-25% of their current leaching. The modelled arable farms in the Rangitikei District had to reduce their nitrogen leaching to 50-35% of their current leaching.

In the next section a one page summary of each of the farms is provided before their farm systems have been modified to achieve the expected results in Table 14.2. The summary of each farm is divided into four sections. At the top is a description of the farm infrastructure and soils. This includes the amount of maintenance fertiliser required annually that has been calculated by Overseer.

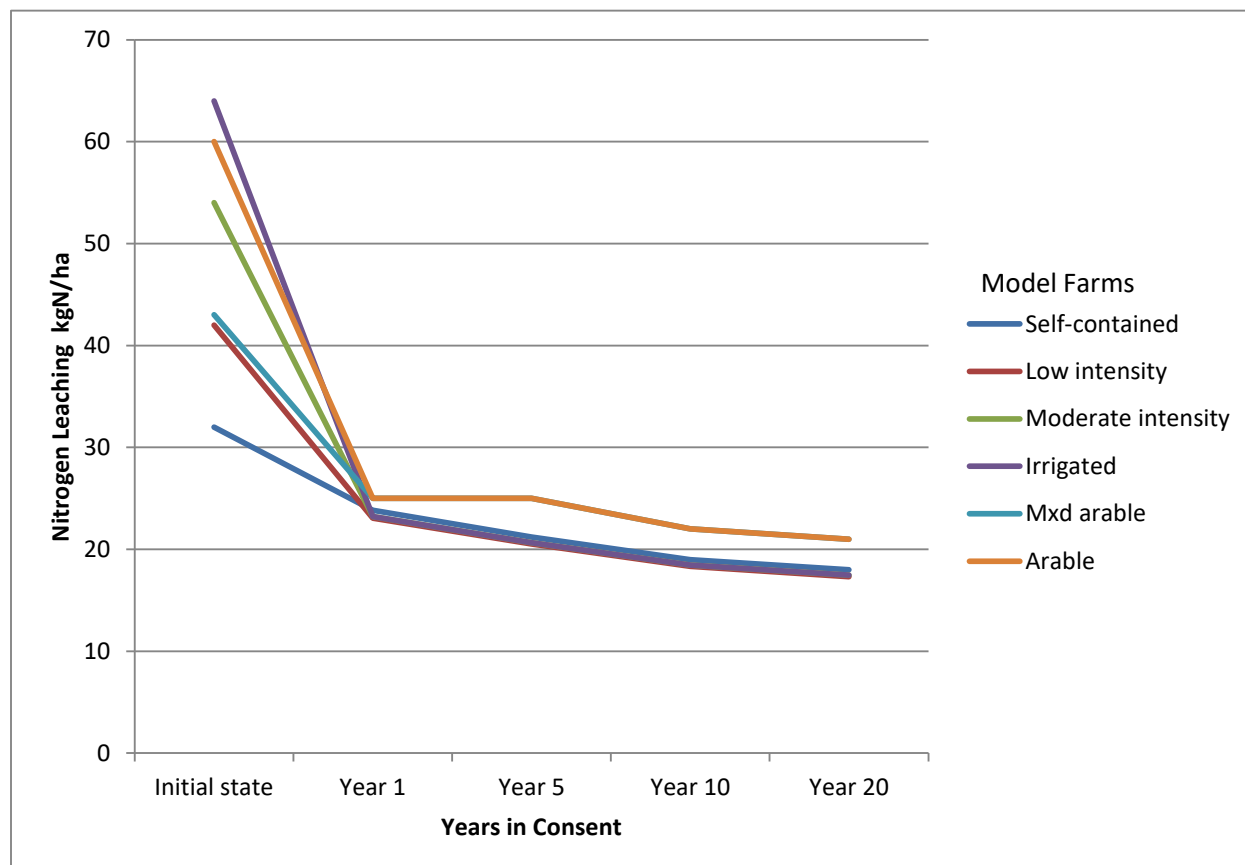
The next sections are labelled “herd” and “pasture and feed”. For each farm the balance between feed supply and animal requirements has been checked in Farmax to ensure that it is a feasible farming system and that it is in a stable equilibrium.

The “nutrients” section of each farm summary provides results from the nutrient budget in Overseer. This includes both nitrogen losses to water (mainly as leaching) and phosphorus losses to water (mainly as runoff).

The final section in the summary addresses the operational profit for each of the farms. See Appendix E for some of the financial assumptions applied in this analysis. Each dairy farm has milk and livestock income. They have fixed farm overheads such as repairs and maintenance, land costs such as weed spraying, and livestock costs such as animal health.

The depreciation costs for plant and machinery, and the costs of labour and drawings are all in the fixed farm overheads. The farmers' operational profits are what they use to reinvest in the farm and to repay mortgages and loans.

Figure 2. The nitrogen-loss trajectory of all the models in this study



The farm's return on assets (ROA) indicates how much better (or worse) the farm might be if it is compared with selling the farm and investing the money in an alternative business. Even money in the bank can return around 5% to its investor and most of the farms started out in this study earning their owners above that amount.

The arable farm models have profiles that have similar information to the dairy farms except that the description of the cropping rotations has also been included.

7.2 Base-line Farm Results

PRODUCTION SYSTEM		Self-Contained		
INFRASTRUCTURE				
Farm Area	125 ha	Milking platform	120 ha	
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator	17 ha
		Irrigation system	N/A	
Soils	Dannevirke SL	Flat	Fert (PKS): 32.38.07	102 ha
	Matamau SL	Rolling	Fert (PKS): 29.51.20	18 ha
HERD				
270 cows	59 replacements (grazed off for 12 months from 9 months of age)		Cow wintering	Half the herd for 2 months
86,163 kgMS	718 kgMS/ha MP		319 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)			10,010 kgDM/ha/yr	
Imported feed			23 T DM	
Winter forage crop			N/A	
Summer forage crop			6 ha	Crop - Turnips 10 T/ha yield
Imported feed and grazing off as a percentage of the total feed offered			21%	
NUTRIENTS				
Clover nitrogen	136 kg/ha	Other nitrogen	5 kg/ha	
Imported nitrogen	30 kg/ha	Available nitrogen	171 kg/ha	
Surplus nitrogen	119kg/ha	Nitrogen conversion efficiency	29 %	
Lost nitrogen to water	32 kg/ha	Phosphorus losses	0.6 kg/ha	
OPERATIONAL PROFIT				
Farm fixed overheads	\$151,230	Milk income	\$551,444	
Land operational costs	\$96,605	Livestock income	\$25,822	
Livestock & feed costs	\$135,284	Operational profit	\$195,291	
Farm working expenses	\$4.45/kgMS	Per eff. hectare	\$1,627	
		Per cow	\$723	
Capital Value (total assets)	\$3,685,428	Return on assets	5.3%	

PRODUCTION SYSTEM		Low Intensity		
INFRASTRUCTURE				
Farm Area	210 ha			
Milking platform	150 ha	Irrigation system and area	N/A	
Runoff	50 ha	Effluent system and area	Sump, to pond and travelling irrigator	25 ha
Soils	Dannevirke SL	Flat	Fert (PKS): 27.22.06	127.5 ha
	Kopua SL	Flat	Fert (PKS): 26.31.10	20 ha
	Matamau SL	Rolling	Fert (PKS): 25.33.15	52.5 ha
HERD				
400 cows	91 replacements grazed on runoff from weaning until 23 months		Cow wintering	Half herd on MP, half herd on RO on crop
144,312 kgMS	962 kgMS/ha MP		361 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)			10,644 kgDM/ha/yr	
Pasture conserved			50 T DM	
Imported feed T DM			260 T DM	
Winter forage crop			9 ha	Kale 12 T DM/ha yield
Summer forage crop			9 ha	Turnips 10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered			13.2%	
NUTRIENTS				
Clover nitrogen	93 kg/ha	Other nitrogen	28 kg/ha	
Imported nitrogen	101 kg/ha	Available nitrogen	222 kg/ha	
Surplus nitrogen	171kg/ha	Nitrogen conversion efficiency	23 %	
Lost nitrogen to water	42 kg/ha	Phosphorus losses	0.7 kg/ha	
OPERATIONAL PROFIT				
Farm fixed overheads	\$228,250	Milk income	\$923,595	
Land operational costs	\$184,957	Livestock income	\$40,350	
Livestock costs	\$180,971	Operational profit	\$369,682	
Farm Working Expenses	\$4.12/kgMS	Per eff. hectare	\$1,848	
		Per cow	\$936	
Capital Value (total assets)	\$5,810,922	Return on assets	6.4%	

PRODUCTION SYSTEM		Moderate Intensity		
INFRASTRUCTURE				
Farm Area	262 ha	Milking platform (MP)	200 ha	
		Runoff (RO)	50 ha	
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator	42 ha
		Irrigation system and area	N/A	
Soil Type	Dannevirke SL	Flat	Fert (PKS): 24.05.03	170 ha
	Kopua SL	Flat	Fert (PKS): 24.25.08	20 ha
	Matamau SL	Rolling	Fert (PKS): 25.30.16	60 ha
HERD				
600 cows	136 calves grazing on the runoff from weaning with half grazed off for a further 12 months of age from 11 months old.		Cow wintering	Half herd on MP, half herd on RO on crop
240,677 kgMS	1203 kgMS/ha MP		401 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)		11,753 kgDM/ha/yr		
Pasture conserved		30 T DM		
Imported feed T DM		757 T DM		
Winter forage crop		14 ha	Kale	12 T DM/ha yield
Summer forage crop		14 ha	Turnips	10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered		26%		
NUTRIENTS				
Clover nitrogen		72 kg/ha	Other nitrogen	65 kg/ha
Imported nitrogen		151 kg/ha	Available nitrogen	288 kg/ha
Surplus nitrogen		222 kg/ha	Nitrogen conversion efficiency	23 %
Lost nitrogen to water		54 kg/ha	Phosphorus losses	0.7 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		\$396,050	Milk income	\$1,540,331
Land operational costs		\$243,751	Livestock income	\$64,011
Livestock costs		\$393,708	Operational profit	\$570,834
Farm Working Expenses		\$4.29/kgMS	Per eff. hectare	\$2,283
			Per cow	\$951
Capital Value (total assets)		\$8,183,862	Return on assets	7.0%

PRODUCTION SYSTEM		High Intensity with Irrigation			
INFRASTRUCTURE					
Farm Area	210 ha	Milking platform (MP)	200 ha		
		Runoff (RO)	50 ha		
Feedpad	Yes	Effluent system and area	Sump, to pond and travelling irrigator.	90 ha	
		Irrigation system and area	Centre pivot	80 ha	
Soils	Dannevirke SL	Flat	Fert (PKS): 24.14.00	170 ha	
	Kopua SL	Flat	Fert (PKS): 23.15.07	20 ha	
	Matamau SL	Rolling	Fert (PKS): 28.47.18	60 ha	
HERD					
640 cows	145 calves grazing on the runoff from weaning with half grazed off for a further 12 months of age from 11 months old.		Cows wintered off		Half herd on MP, half herd on RO on crop
281,376 kgMS	1407 kgMS/ha MP		440 kg MS/cow		
PASTURE AND FEED (Milking platform)					
Pasture eaten (Overseer)		13,103 kgDM/ha/yr			
Pasture Conserved		38 T DM			
Imported feed T DM		757 T DM			
Winter forage crop		15 ha	Kale	12 T DM/ha yield	
Summer forage crop		15 ha	Turnips	10 T DM/ha yield	
Imported feed and grazing off as a percentage of the total feed offered		29%			
NUTRIENTS					
Clover nitrogen		63 kg/ha	Other nitrogen		73 kg/ha
Imported nitrogen		187 kg/ha	Available nitrogen		323 kg/ha
Surplus nitrogen		247 kg/ha	Nitrogen conversion efficiency		24 %
Lost nitrogen to water		64 kg/ha	Phosphorus losses		0.8 kg/ha
OPERATIONAL PROFIT					
Farm fixed overheads		\$473,350	Milk income		\$1,800,806
Land operational costs		\$280,322	Livestock income		\$72,250
Livestock costs		\$505,504	Operational profit		\$613,881
Farm Working Expenses		\$4.48/kgMS	Per eff. hectare		\$2,456
			Per cow		\$959
Capital Value (total assets)		\$9,053,006	Return on assets		6.78%

PRODUCTION SYSTEM		Arable with Livestock		
INFRASTRUCTURE				
Farm Area	210 ha	Permanent pasture	100 ha	
Effective farm area	200 ha	Cropping area	100 ha	
		Irrigation	Nil	
Animals				
Cattle sold store	80	Cattle sold prime	220	
Lambs sold store		Lambs sold prime	1,200	
CROPS				
Rotation				
Spring Sown Barley 100ha		8 T/ha/yr		
Autumn Sown Annual Ryegrass 100ha		6 T/ha/yr (grazed)		
NUTRIENTS				
Clover nitrogen		78 kg/ha	Other nitrogen	2 kg/ha
Imported nitrogen		88 kg/ha	Available nitrogen	168 kg/ha
Surplus nitrogen		115 kg/ha	Nitrogen conversion efficiency	31 %
Lost nitrogen to water		45 kg/ha	Phosphorus losses	0.3 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		\$128,250	Cropping income	\$269,730
Land operational costs		\$98,265	Trading sheep & wool income net of purchases	\$44,020
Livestock costs		\$7,841	Trading beef income net of purchases	\$240,221
Cropping costs		\$136,710		
Operational profit		\$182,905		
Per eff. hectare		\$915		
Capital Value (total assets)		\$7,125,000	Return on assets	2.6%

PRODUCTION SYSTEM		Arable with Potatoes		
INFRASTRUCTURE				
Farm Area	210 ha	Permanent pasture	Nil	
Effective farm area	200 ha	Cropping area	100 ha	
		Irrigation	Travelling Irrigator	100 ha
Animals				
Cattle sold store	Nil	Cattle sold prime	Nil	
Lambs sold store	Nil	Lambs sold prime	Nil	
CROPS				
Rotation				
Spring Sown Maize Silage 100ha	17 T/ha/yr			
Autumn Sown Forage Oats 100ha	7 T/ha/yr			
Rotation				
Spring Sown Potatoes 100ha	55 T/ha/yr			
Autumn Sown Brussel Sprouts	12 T/ha/yr			
NUTRIENTS				
Clover nitrogen	2 kg/ha	Other nitrogen	7 kg/ha	
Imported nitrogen	280 kg/ha	Available nitrogen	289 kg/ha	
Surplus nitrogen	31 kg/ha	Nitrogen conversion efficiency	89 %	
Lost nitrogen to water	50 kg/ha	Phosphorus losses	0.8 kg/ha	
OPERATIONAL PROFIT				
Farm fixed overheads	\$175,050	Cash Cropping income	\$1,690,272	
Land operational costs	\$39,500	Forages Sold	\$461,700	
Cropping costs	\$1,299,000			
Operational profit	\$638,422			
Per eff. hectare	\$3,192			
Capital Value (total assets)	\$7,785,000	Return on assets	8.2%	

7.3 Mitigations for Reducing Environmental Effects under the One Plan

The least difficult mitigating practices to introduce on farm are operational changes that don't disrupt existing farming systems. These are generally also the most preferred by farmers. However, to achieve larger reductions in nitrogen losses, farmers may need to make system changes. The dairy farm systems have not been optimised to minimise their costs of production. Instead farm practices have been introduced that suit the existing systems and the assumed managerial capability required to operate them at their current level of efficiency. Opportunities for farmers to increase cow performance are assumed to equally exist both now and in the future and have not been changed in this analysis.

In higher rainfall areas and free-draining soils such as can be found in the Tararua District, capital investments may have to be made to enable the farm system to be adapted further to meet Table 14.2 in the One Plan. The mitigations applied to each dairy farm system in this report are shown in Table 2. Further information on these practices can be found in Appendix C.

The dairy farms were each expected to have one or more wetlands and riparian areas that could be fenced off from livestock. The fenced wetlands and riparian areas could protect native habitat and also trap runoff coming from farms containing sediment and phosphorus. The farms are expected to have to provide extra cutoffs along farm races and around the farm dairy to ensure that stormwater travels across grassy paddocks before entering water channels. The grassy paddocks act as filters. On some farms, drains may be converted to swales to increase nutrient filtering. Some drains may be shortened to stop them discharging directly into streams. Instead they may be able to allow water to run over grassy areas or riparian vegetation. As part of their consent, each model farm is expected to invest \$10,000 towards these mitigations.

The model dairy farms were assumed to be fully fenced from waterways, including their run-offs. This mitigation was considered the main way of reducing E.coli losses into nearby waterways and so no further action was taken.

Table 2. The mitigations applied on the dairy farms in the order in which they were applied

Mitigations	Dairy Farm System			
	Self-contained	Low intensity	High intensity	Irrigation and high intensity
<u>Operational practice changes</u>				
Remove nitrogen fertiliser from the effluent area	✓	✓	✓	✓
Remove winter applications of nitrogen (April to July inclusive)	✓	✓	✓	✓
Reduce nitrogen to a maximum of 60 kgN/ha	✓	✓	✓	✓
Aggressive summer culling of cows	✓	✓	✓	✓
Replace high protein feed with low protein	✓	✓	✓	✓
<u>System practice changes</u>				
Spread effluent to reduce rates to 100kgN/ha	✓	✓		
Remove all nitrogen fertiliser and export surplus feed	✓	✓		
Irrigation applications optimised				✓
Winter cows off the farm	✓	✓		
Reduce cow numbers and bring grazed off heifers home to replace them	✓	✓	✓	✓
Reduce overall stocking rates	✓	✓	✓	✓
Use a stand-off pad in wet winter weather			✓	✓
<u>Structural practice change</u>				
Covered feed pad			✓	✓
Housed cows with duration controlled grazing			✓	✓

The arable farms had simple crop rotations on the two different blocks on each farm. For the mitigations added to the arable farms see Table 3. Further information on these practices can be found in Appendix D. On the mixed livestock arable farm, in order to reduce nitrogen leaching enough for Table 14.2, all the livestock had to be removed from the system and surplus stock feed sold off the farm. The arable farm with potatoes was able to reduce some nitrogen use and reduce its use of irrigation by installing a moisture meter and water budgeting. On this farm the area in the potato crop rotation also needed to be reduced. It was replaced with a grain crop rotation that included a green mulch to incorporate some nitrogen back into the soil organic matter.

Both of the arable farms avoided having extended fallow periods between crops. They provided enough space to add a bund around their intensively cropped areas to reduce runoff containing sediment and nutrients from running into nearby waterways.

Table 3. The mitigations applied on the arable farms in the order in which they were applied

	Arable Farm System		Notes on Overseer
Mitigations	Arable with livestock	Arable with potatoes	
<u>Operational practice changes</u>			
Use minimal tillage and direct drilling between crops in rotation	✓	✓	Able to be modelled in Overseer
Minimise nitrogen applications to industry good practice	✓	✓	Able to be modelled in Overseer
Apply nitrogen fertiliser in side dressings		✓	Not able to be modelled
Spread nitrogen applications of over 45kgN/ha over several weeks.	✓	✓	Difficult to model
Add a bund between the block and waterways to catch runoff	✓	✓	Difficult to model the effect of a bund but reduced crop area can be included.
<u>System practice changes</u>			
Install moisture metering probe and move to active water management	✓	✓	Able to be modelled in Overseer
Replace fallow periods with actively growing crops or ‘green mulch’	✓	✓	Able to be modelled in Overseer
Remove livestock	✓		Able to be modelled in Overseer
Harvest and export surplus green feed as fodder	✓	✓	Able to be modelled in Overseer
Replace heavy nitrogen feeding crops with grain crops		✓	Able to be modelled in Overseer

7.4 Mitigated Farm Results

PRODUCTION SYSTEM		Self-Contained		
INFRASTRUCTURE				
Farm Area	125 ha	Milking platform (MP)	120 ha	
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator	17 ha
		Irrigation system and area	N/A	
Soils	Dannevirke SL	Flat	Fert (PKS): 28 0 06	102 ha
	Matamau SL	Rolling	Fert (PKS): 35 71 21	18 ha
HERD				
140 cows	28 replacements grazed on the farm from weaning to calving, but wintered off as yearlings (May-July)		Cows wintering	Half the herd for 2 months
49,522 kgMS	496 kgMS/ha MP		354 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)		6,028 kgDM/ha/yr		
Imported feed		Nil		
Supplements Made		288 TDM	Supplements Exported	212 TDM
Imported feed and grazing off as a percentage of the total feed offered		11.3%		
NUTRIENTS				
Clover nitrogen		127 kg/ha	Other nitrogen	2 kg/ha
Imported nitrogen		0 kg/ha	Available nitrogen	129 kg/ha
Surplus nitrogen		43 kg/ha	Nitrogen conversion efficiency	66 %
Lost nitrogen to water		18 kg/ha	Phosphorus losses	0.5 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		\$131,230	Milk income	\$316,940
Land operational costs		\$94,973	Livestock income	\$13,718
Livestock & feed costs		\$103,128	Income from Capital Released	\$21,095
Operational profit		\$75,510	Income from Exported Supplements	\$53,100
Per eff. hectare		\$629		
Farm Working Expenses		\$6.65/kgMS		
Capital Value / Employed		\$3,695,428	Return on assets	2.0%

PRODUCTION SYSTEM		Low Intensity		
INFRASTRUCTURE				
Farm Area	210 ha	Milking platform	150 ha	
		Runoff	50 ha	
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator	25 ha
		Irrigation system and area	N/A	
Soils	Dannevirke SL	Flat	Fert (PKS): 32.44.08	127.5 ha
	Kopua SL	Flat	Fert (PKS): 26.31.10	20 ha
	Matamau SL	Rolling	Fert (PKS): 28.38.19	52.5 ha
HERD				
250 cows	55 replacements grazed on runoff from weaning until 21 months, but with all heifers off for the months of May, June and July		Cows wintering	100 % of cows off for 2 months
100,364 kgMS	669 kgMS/ha MP		401 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)		5,835 kgDM/ha/yr	Imported feed T DM	0
Supplements Made		443 TDM	Supplements Exported	293 TDM
Summer forage crop		9 ha	Turnips	10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered		12.5%		
NUTRIENTS				
Clover nitrogen		119 kg/ha	Other nitrogen	4 kg/ha
Imported nitrogen		5 kg/ha	Available nitrogen	128 kg/ha
Surplus nitrogen		56kg/ha	Nitrogen conversion efficiency	56%
Lost nitrogen to water		17 kg/ha	Phosphorus losses	0.6 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		\$210,150	Milk income	\$642,333
Land operational costs		\$160,732	Livestock income	\$25,593
Livestock & feed costs		\$185,842	Income from Capital Released	\$28,424
Operational profit		\$212,813	Income from Exported Supplements	\$73,188
Per eff. hectare		\$1,064		
Farm Working Expenses		\$5.55/kgMS		
Capital Value / Employed		\$5,820,922	Return on assets	3.7%

PRODUCTION SYSTEM		Moderate Intensity		
INFRASTRUCTURE				
Farm Area	262 ha	Milking platform	200 ha	
		Runoff	50 ha	
Barn with Feed Pad	Used Feb – Aug	Effluent system and area	Sump, to pond and travelling irrigator	170 ha
		Irrigation system and area	N/A	
Soils	Dannevirke SL	Flat	Fert (PKS): 31.0.0	170 ha
	Kopua SL	Flat	Fert (PKS): 32.13.20	20 ha
	Matamau SL	Rolling	Fert (PKS): 23.20.06	60 ha
HERD				
550 cows	120 replacements grazed on runoff from weaning with half grazed of at 11 months from May to May		Cows wintering	All cows wintered on – grazing 2 hours/day and then in barn
238,892 kgMS	1194 kgMS/ha MP		434 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)		10,779 kgDM/ha/yr	Imported feed T DM	814 T DM
Supplements Made		38 TDM	Supplements Exported	nil
Summer forage crop		12 ha	Turnips	10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered		25.7%		
NUTRIENTS				
Clover nitrogen		136 kg/ha	Other nitrogen	58 kg/ha
Imported nitrogen		51 kg/ha	Available nitrogen	245 kg/ha
Surplus nitrogen		222 kg/ha	Nitrogen conversion efficiency	27 %
Lost nitrogen to water		17 kg/ha	Phosphorus losses	0.8 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		\$419,900	Milk income	\$1,528,099
Land operational costs		\$267,897	Livestock income	\$57,451
Livestock costs		\$395,261	Other income	\$-
Cost of Additional Capital		\$65,958		
Operational profit including capital cost		\$436,321	Profit per eff. hectare	\$1,745
Farm Working Expenses (incl cost of additional capital)		\$ 4.82/kgMS		
Capital Value / Employed		\$8,784,602	Return on assets	5.0%

PRODUCTION SYSTEM		High Intensity with Irrigation		
INFRASTRUCTURE				
Farm Area	262 ha	Milking platform	200 ha	
		Runoff	50 ha	
Barn with Feed Pad	Used from Feb through to Aug	Effluent system and area	Sump, to pond and travelling irrigator.	170 ha
		Irrigation system and area	80 ha centre pivot	
Soils	Dannevirke SL	Flat	Fert (PKS): 03.02.03	170 ha
	Kopua SL	Flat	Fert (PKS): 23.15.06	20 ha
	Matamau SL	Rolling	Fert (PKS): 31.20.20	60 ha
HERD				
620 cows	136 replacements with half grazed off from 1 May for 12 months		Cows wintered off	Nil (all wintered on in barn)
277,200 kgMS	1386 kgMS/ha MP		470 kg MS/cow	
PASTURE AND FEED (Milking platform)				
Pasture eaten (Overseer)		11,207 kgDM/ha/yr	Imported feed T DM	1,170 T DM
Supplements made T DM		Nil	Supplements Exported	Nil
Summer forage crop		15 ha	Turnips	10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered		32%		
NUTRIENTS				
Clover nitrogen		135 kg/ha	Other nitrogen	83 kg/ha
Imported nitrogen		51 kg/ha	Available nitrogen	269 kg/ha
Surplus nitrogen		194 kg/ha	Nitrogen conversion efficiency	28 %
Lost nitrogen to water		17 kg/ha	Phosphorus losses	0.8 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		\$495,250	Milk income	\$1,790,445
Land operational costs		\$295,839	Livestock income	\$70,839
Livestock costs		\$533,105	Income from Capital	\$
Cost of Additional Capital		\$74,512	Income from Exported Supplements	
Operational profit including capital cost		\$462,578		
Per eff. hectare		\$1,850		
Farm Working Expenses		\$5.00/kgMS		
Capital Value/Employed		\$9,731,656	Return on assets	4.8%

PRODUCTION SYSTEM		Arable with Livestock		
INFRASTRUCTURE				
Farm Area	210 ha	Permanent pasture	150 ha all harvested & exported for pasture silage	
Effective farm area	200 ha	Cropping area	50 ha	
		Irrigation	Nil	
Animals				
Cattle sold store	Nil	Cattle sold prime	Nil	
Lambs sold store	Nil	Lambs sold prime	Nil	
CROPS				
Rotation				
Spring Sown Barley 50ha		8 T/ha/yr		
Autumn Sown Annual Ryegrass 50ha		6 T/ha/yr (harvested and sold as baleage)		
Supplements Made		1,549 TDM		
Supplements Exported		1,549 TDM		
NUTRIENTS				
Clover nitrogen		61 kg/ha	Other nitrogen	2 kg/ha
Imported nitrogen		38 kg/ha	Available nitrogen	101 kg/ha
Surplus nitrogen		11 kg/ha	Nitrogen conversion efficiency	89 %
Lost nitrogen to water		20 kg/ha	Phosphorus losses	0.2 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		\$128,250	Cropping income	\$119,880
Land operational costs		\$76,800	Sale of Surplus Feed	\$277,500
Livestock costs		\$0		
Cropping costs		\$95,760		
Cost of Additional Capital		\$1,098		
Operational profit including capital cost		\$95,472		
Per eff. hectare		\$477		
Capital Value (total assets)		\$7,135,000	Return on assets	1.3%

PRODUCTION SYSTEM		Arable with Potatoes		
INFRASTRUCTURE				
Farm Area	210 ha	Permanent pasture	nil	
Effective farm area	200 ha	Cropping area	200 ha	
		Irrigation	Travelling Irrigator	100 ha
Animals				
Cattle sold store	Nil	Cattle sold prime	Nil	
Lambs sold store	Nil	Lambs sold prime	Nil	
CROPS				
Rotation				
Spring Sown Maize Silage 100ha		17 T/ha/yr		
Autumn Sown Forage Oats 100ha		7 T/ha/yr		
Rotation				
Spring Sown Potatoes 10ha		55 T/ha/yr		
Autumn Sown Brussel Sprouts 10ha		12 T/ha/yr		
Rotation				
Spring Sown Barley 90ha		7 T/ha/yr		
Autumn Sown Annual Rye 90ha		5 T/ha/yr		
NUTRIENTS				
Clover nitrogen		1 kg/ha	Other nitrogen	4 kg/ha
Imported nitrogen		186 kg/ha	Available nitrogen	191 kg/ha
Surplus nitrogen		11 kg/ha	Nitrogen conversion efficiency	94 %
Lost nitrogen to water		19 kg/ha	Phosphorus losses	0.4 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		\$175,050	Cash Cropping income	\$819,538
Land operational costs		\$39,500	Forages Sold	\$191,250
Cropping costs		\$564,812		
Cost of Capital		\$1,098		
Operational profit		\$230,328		
Per eff. hectare		\$1,152		
Capital Value (total assets)		\$7,795,000	Return on assets	3.0%

7.5 Changes in Farm Profitability

All the modelled farms had reduced profitability after making the system changes. In Table 4 the future profitability of the self-contained and low intensity dairy farms and the arable farms are very dependent on being able to sell their surplus feed to other livestock farmers.

Table 4. Summary of profit, capital and labour changes between the base farm models and their profitability after farm system adjustments

Farms	Self-Contained (\$)	Low Intensity (\$)	Moderate Intensity (\$)	High Intensity with Irrigation (\$)	Arable with Livestock (\$)	Arable with Potatoes (\$)
Base Total Income	578,411	963,860	1,604,343	1,873,057	553,971	2,151,972
Base Total Expenses	383,120	594,178	1,033,509	1,259,176	371,066	1,513,550
Base Profit	195,291	369,682	570,834	613,881	182,905	638,422
Base Profit / ha	1,627	1,848	2,283	2,456	915	3,192
Extra Income (from invested capital)	21,095	28,424	N/A	N/A	N/A	N/A
Extra Income (from exported supps)	53,100	73,188	N/A	N/A	277,500	191,250
Additional Capital Costs	N/A	N/A	65,958	74,512	1,098	1,098
Adj Income (From Produce)	330,646	67,925	1,585,337	1,861,284	119,880	819,538
Total Adj Expenses	329,331	556,724	1,083,058	1,324,194	300,810	779,362
Change in Expenses	-53,789	-37,454	49,549	65,018	-70,256	-734,188
Adjusted Future Profit	75,510	212,813	436,321	462,578	95,472	230,328
Adjusted Future Profit / ha	629	1,064	1,745	1,850	477	1,152
Change In Profit	-119,781	-156,869	-134,513	-151,303	-87,433	-408,094
Change In Profit / ha	-998	-784	-538	-605	-437	-2,040
% Change in Profit	-61%	-42%	-24%	-25%	-48%	-64%
Net Capital Investment	10000	10000	600740	678650	10000	10000
Base Capital Value	3,685,428	5,810,922	8,183,862	9,053,006	7,125,000	7,785,000
Base Return on Assets	5.3%	6.4%	7.0%	6.8%	2.6%	8.2%
New Capital Employed	3,695,428	5,820,922	8,784,602	9,731,656	7,135,000	7,795,000
Adjusted Return on Assets	2.0%	3.7%	5.0%	4.8%	1.3%	3.0%
Change in ROA	-61%	-43%	-29%	-30%	-48%	-64%
Base Farm Labour	Owner plus casual	Owner plus 1 FTE	Owner plus 3 FTE	Owner plus 3 FTE	Owner plus casual	Owner plus casual
Adjusted Future Labour	Owner	Owner plus 1 FTE	Owner plus 3 FTE plus casual	Owner plus 3 FTE plus casual	Owner plus casual	Owner plus casual

Two of the dairy farmers have additional income provided from the capital value of the livestock that they sold. The more intensively managed farms with greater supplementary feed inputs are able to consider housing their cows. In these models the cows were able to be housed and effluent systems expanded for less than \$1,200 per cow.

On current valuations, all the initial farms were expected to return over 5% on capital except for the arable farm with livestock. After the farm systems had been adjusted, all the dairy farm models had returns drop to 5% or less than assets. The results suggest that there will be a continued downward pressure on dairy farm valuations to readjust for improved returns on assets.

It is common in the dairy industry for farmers to have about \$21/ kgMS of debt on their farms. Based upon an interest rate of 7% that would mean each of the model farms has the following annual interest payments.

Self-contained: \$126,660

Low intensity: \$212,139

Moderate intensity: \$353,795

Irrigation and high intensity: \$413,623

Arable with livestock: \$157,576

Arable with potatoes: \$530,134

All of the model farms in their base operation would be able to pay this amount of debt from their profit. After the farms have been adjusted to achieve Table 14.2 only the dairy farms at moderate to high intensity could still cover this amount of debt. The low intensity dairy farm might need a slight reduction in debt to survive. The self-contained dairy farm and the two arable farms would need to almost halve their debt.

The reduction in profitability of the modelled farms in order to meet the requirements of Table 14.2 is likely to reduce their market value while they are under these constraints. In the case of farms where their intensive use and profitability is reduced, the market would “consider” what the resulting highest and best use of the farm could be after these changes.

The market for dairy milking platforms that are no longer viable may change to them being viewed as a dairy run off or intensive finishing farms for dry stock. Both of these options would reduce their value on a per hectare basis. While the underlying value of the bare land may only experience a small decrease (say 5%) the value of the specialist dairy improvements (cowshed, effluent system, races) would be virtually nil under an alternative land use scenario.

In the case of farms that have used capital expenditure (e.g. cow housing) to meet Table 14.2, the market would factor in the added value of these new assets to a degree, but probably not enough to reflect the total capital cost of installing the infrastructure.

In the example in Table 5 it has been assumed that 70% of the cost to install the cow housing is reflected in changed capital value. This is reflective of how the market “prices” such infrastructure at present.

Table 5. Hypothetical examples of changes in farm capital value following mitigation

Self-Contained Farm			125ha	Irrigated high Intensity farm			262ha
Status Quo Value			\$3,000,000	Status Quo Value			\$6,200,000
Split as:				Split as:			
-				-			
	Land Value		2,600,000		Land Value		5,000,000
	Cowshed		120000		Cowshed		600000
	Effluent System		50000		Effluent System		120000
	Races		25000		Races		50000
	Other Improvements		\$205,000		Other Improvements		\$430,000
Value After System Change			\$2,680,000	Value After System Change			\$6,550,000
Split as:				Split as:			
-				-			
	Land Value		2,470,000		Land Value		5,000,000
	Cowshed		nil		Cowshed		600000
	Effluent System		nil		Effluent System		120000
	Races		5000		Races		50000
	Other Improvements		\$205,000		Cow housing (70% of cost)		350000
					Other Improvements		\$430,000

8. Costs Associated with the Consenting Process

The One Plan in Chapter Five has objectives and policies regarding the management of water quality in sensitive catchments identified within the Manawatu and Wanganui region. The water quality values for each subzone within the catchments are shown in Table B2 of the One Plan and the water quality targets are shown in Table E2.

Under policies 14.5 and 14.6 of the One Plan the owners of all existing intensive farming operations must apply for a land use consent to continue operating. Rule 14.1 and Table 14.2 describe the conditions under which the Council can issue a controlled consent. If the conditions for a controlled consent cannot be met, the alternative is a restricted discretionary consent. The focus of this chapter in this report is on the costs for applicants of applying for a consent, with particular application to dairy farmers applying for a restricted discretionary consent.

There are expected to be five consent application pathways for existing farmers. These are shown at the top of Table 6, note that pathway 2&3 are combined in the Table. Each pathway to a consent is expected to require the following sources of information, although the level of detail and the amount of background evidence required will need to be matched to the assessment needs for that particular pathway.

- Farm Management and nutrient management information to describe the existing farming activity, and quantifying this activity in relationship to the objectives, policies and rules in the One Plan. Particularly this involves information about nutrient, sediment and pathogen losses, riparian and habitat management, fertiliser inputs, bridging and culverting, animal effluent management and nearby sources of community drinking water. The farm management information includes a description of the steps already being taken to avoid, remedy, and mitigate the effects of the farming activity on the environment and proposed steps to address the objectives, policies, and rules in the One Plan. The intensity and volume of the information being provided to Council is not expected to change across the different consenting pathways, except that in some pathways, as alternative operational and system changes are proposed by the other 'experts' employed, these will have to be evaluated, adjusted and potentially incorporated in any proposal.
- Policy analysis information that assesses the proposed activity against the relevant objectives and policies of the One Plan, the National Policy Statement for Freshwater Management (NPSFM), the 'discharge' sections of the RMA, and the National Environmental Standard for Sources of Human Drinking Water (NESHDW). In this report it is expected that suitably experienced people could provide the information for controlled consents but that policy specialists would be required for restricted discretionary applications.
- Hydrogeological information to describe the pathways for freshwater between farming activities, and wetlands, groundwater, lakes and surface water. This includes information about attenuation and lag-times. In this report it is expected that for controlled consents, experienced people could provide the information required from public records. Restricted discretionary consents would require specialists in hydrogeology using local (farm specific) information. Farm specific information may require placing a number of bores for sampling groundwater in the relevant areas.

- Assessment of environmental effects information to evaluate the impacts of farming activities on surface water management values for the affected catchment/s (Schedule B in the One Plan), and surface water quality targets for the catchment/s (Schedule E in the One Plan). For controlled consents the information could be provided by experienced people to show that the effects are consistent with meeting the standards for controlled consents in the One Plan. For restricted discretionary consents, a specialist may be required to carry out a physical assessment of effects at the farm scale and the catchment scale.

The consenting pathways shown in Table 6 are described as follows:

- Where an existing farm is able to meet the nitrogen leaching caps in Table 14.2 of the One Plan and to mitigate any potential waterway contamination from phosphorus, sediment, and E.coli, their application will need to provide enough evidence from Overseer® to support the Council approving a controlled consent. The main costs will be for an agricultural consultant to describe the existing farm system and carry out a standard policy statement and AEE. This should show that the farming business can operate within the effects anticipated by the One Plan.
- Some existing farms may be able to meet the leaching caps in Table 14.2 of the One Plan and mitigate any potential waterway contamination from phosphorus, sediment, and E.coli but their mitigations cannot be calculated using Overseer. These will require extra preparation work by a farm management specialist to quantify the benefits of these mitigations. Such farms will need to apply for a restricted discretionary consent that shows calculations of the effectiveness of their mitigations. Generally the size of the benefits from these mitigations will be quite site specific and so information about the site as well as the mitigation will need to be provided. For example, the use of high carbon ditches to intercept nitrogen leaching will depend on the hydrology of the site.

In the same category are farms meeting Table 14.2, but failing to meet other standards in Rule 14.1. These require additional material in their application to describe how the effects on the standards will be mitigated.

An agricultural consultant working with a farmer can provide the Council with this information with the support of industry scientists.

- Farms that can meet the nitrogen leaching caps in Table 14.2 within four years will need to address through their AEE the effects of the four year delay in meeting the Table. The additional costs for these farmers are generated from needing the advice of a professional water quality scientist.
- The farms that are not anticipated to meet the nitrogen caps in Table 14.2 will need to apply for a restricted discretionary consent and prepare a very robust AEE. They will need to employ technical expertise to show that their effects on the environment are less than minor. It is probable that these applications could be publically notified and an additional deposit for this will need to be made to Horizons. The deposit may be \$20,000 - \$30,000 in addition to the costs already shown in Table 6.

The costs shown in Table 6 could easily vary by 20% either up or down depending upon the complexity of the work involved.

Table 6. Detailed costing of consent application options

Costs Generated in the Consent Application	Controlled Consent	Restricted Discretionary Consents		
	Existing farm system meets Table 14.2 (\$)	Existing farm system could meet Table 14.2 with customised mitigations (\$)	Delayed farm system change to meet Table 14.2 with mitigations (\$)	Restricted Discretionary consent outside Table 14.2 (\$)
Farm Consultant Site with farm system description	1000	1000	1000	1000
Activity proposal – basic (Overseer)	4000	4000	4000	4000
Activity and proposal (Overseer plus additional options)	-	2500	2500	6000
Initial assessment against One Plan objectives, policies and rules	500	500	500	500
Assessment of environmental effects - local	1500	2500	-	-
Specialists - Planner - Ecologist - Hydrogeologist			4000 4000 4000	4000 4000 4000
<i>Consent application fee</i>	1200	2000	2000	2000 Plus \$20-30,000 if notified
Total	\$8,200	\$12,500	\$22,000	\$25,500 Plus \$20-30,000 if notified

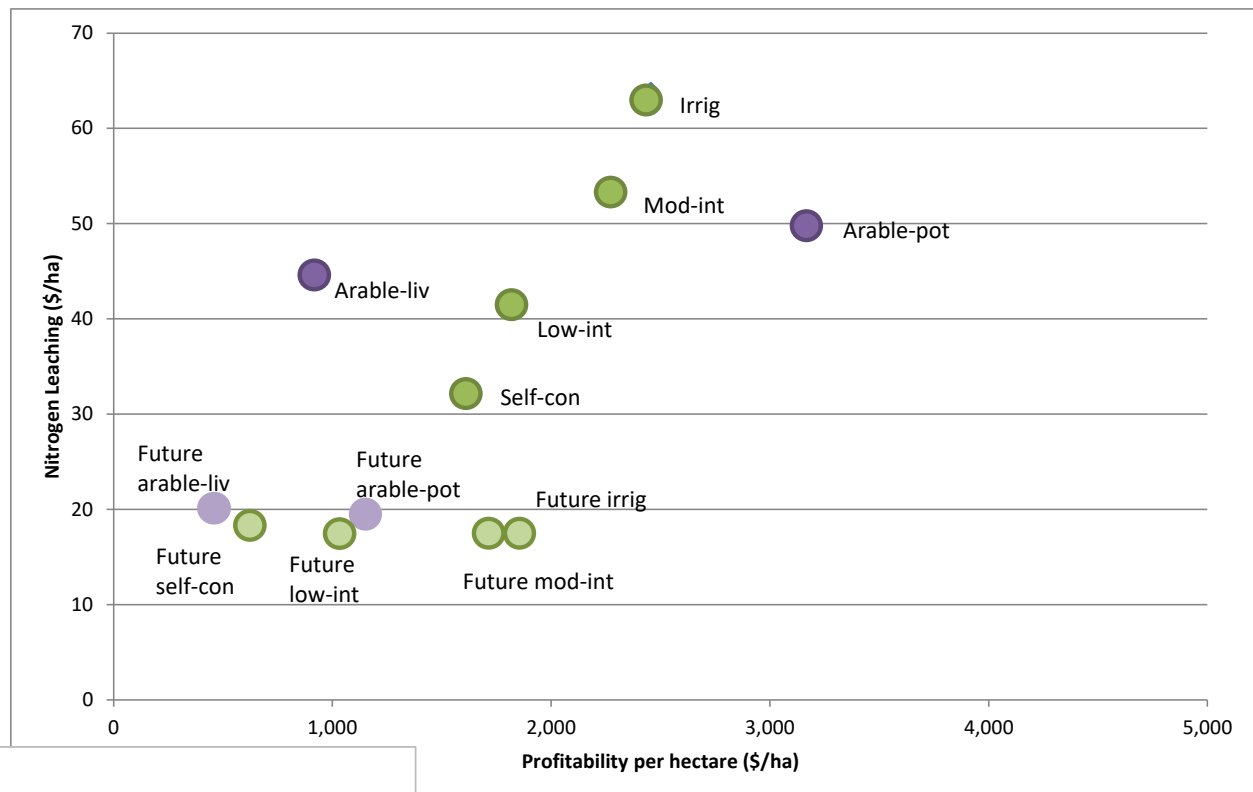
Farmers are annually required to provide information to Horizons so that the Council can monitor their consent conditions. If farm consultants provide this for their clients the cost could be about \$1500 per farm.

The costs for individual farmers obtaining a consent may be able to be reduced if the fertiliser companies and milk processing companies provide the base farm information and annual monitoring services for their clients. It may be that the owners of the Overseer Company decide not to introduce charging, and it may be possible for all the farms in a subzone to share a single environmental assessment. Industry groups may be able to provide templates for completing an assessment of mitigations not included in Overseer.

9. Discussion and Conclusions

There were six farm models developed in this study. The summarised results are shown in Figure 3. The figure is a graph of profit (\$/ha) related to nitrogen leaching (kgN/ha). In the graph the lowest leaching farm in its initial state is the self-contained dairy farm. That farm has a profit of \$1,627/ha and nitrogen leaching of 32 kgN/ha. The highest leaching farm is an irrigated highly intensive dairy farm with a profit of \$2,456/ha and nitrogen leaching of 64 kgN/ha.

Figure 3. A graphical representation of the model farms before and after they have been adjusted to meet the nitrogen caps in year 20 of Table 14.2 of the One Plan



Legend

- Self-contained dairy farm
- Low-intensity dairy farm
- Moderate intensity dairy farm
- Irrigation and high intensity dairy farm
- Arable farm with livestock
- Arable farm with potatoes

The graph also displays in striped colours where each of the farms moves towards after they have been adjusted to meet the requirements of Table 14.2. In that case, all the dairy farms on soils in the Tararua District are below 18 kgN/ha. Both the arable farms on soils in the Rangitikei District are below 20 kgN/ha.

The significance of these changes can be determined from how much they might affect the adaptability, the sustainability, and the viability of farms like these in the region. Their adaptability could be influenced by how much change in management intensity these farms require. The more intensive the management, the less opportunity there is for farmers to explore new ways of doing things. In this report, any farms that have to reduce the amount of labour they can employ and that

have to increase pasture utilisation can be considered to be becoming less adaptable. Diversifying their product range can also increase the adaptability of farming systems.

The sustainability of the farm systems can be related to the efficiency with which they utilise available natural resources. In this report farms that are able to increase their nitrogen efficiency can be considered to be becoming more sustainable in their use of natural resources.

The viability of the farm businesses will be related to their profitability and their ability to service their debt and achieve sufficient return on investment to provide financial security for their owners.

Self-Contained dairy farm

This farm model has all the heifers grazed off the farm for 12 months from 9 months of age. It assumes that there has already been some adjustment to reducing its environmental footprint by grazing half the dairy cows off the farm over winter. Regular soil tests are taken and maintenance phosphate fertiliser is applied. A summer forage crop of turnips is grown to manage a possible risk of a dry summer. On average 30kg N/ha is applied in early spring and autumn to extend pasture production in those seasons.

To meet Table 14.2 in the One Plan, the farm has to reduce the number of dairy cows from 270 to 140 animals. It can no longer apply nitrogen fertiliser and must stop all cropping. The farm is expected to no longer bring in feed supplements for the cows. Instead it harvests 288 tonnes of pasture DM and sells most of this off the farm. The sale of surplus feed is a very important part of pasture management on this farm because animal consumption has dropped to almost 6,000 kgDM/ha/yr. Without harvesting surplus feed, the quality of the pasture would fall and in a few years pasture composition would suffer.

The farm started with leaching 32 kgN/ha and was modified to be leaching only 18 kgN/ha, a reduction of 44%. These changes reduced the expected farm profit from \$1,627/ha to \$629/ha, a drop of over 60%. The return on assets dropped from 5.3% to 2.0%.

The self-contained farm model has had to reduce its labour but it has surplus pasture available for alternative landuses, and therefore its adaptability might increase overall. Nitrogen conversion efficiency has increased to 66% and so it can be expected to be more sustainable in its use of natural resources. However, its profitability is not enough to support the level of debt found on many farms in this region. The return on assets is insufficient to attract off-farm investment, should that be required for future improvements. Unless farms like this have less than half the amount of debt as the model farm, they will not survive the changes required to address Table 14.2 .

Low-intensity dairy farm

The low-intensity dairy farm is very common in the Tararua District and in the region generally. In this model there are more cows and they have greater production than the self-contained farm. On this farm there is more supplementary feed (260 tonnes DM) brought onto the farm and greater use is made of cropping in both winter and summer. Over the whole farm more than 100 kgN/ha is applied, mainly to lengthen the grass growing season in spring and autumn.

To meet Table 14.2 in the One Plan, the farm has to reduce the number of cows from 400 to 250 animals. They will also need to reduce nitrogen fertiliser applications to an average of 5 kgN/ha/yr and stop importing supplementary feed and growing a winter crop. The summer crop remains, and

443 tonnes of DM are conserved. Three quarters of the conserved feed is sold off the farm to maintain pasture quality.

The farm started with leaching 42 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of 60%. These changes reduced the expected farm profit from \$1,848/ha to \$1,064/ha, a drop of over 40%. The return on assets dropped from 6.4% to 3.7%.

The low intensity farm model has not reduced its labour and it has surplus pasture available for alternative landuses. It's adaptability might increase overall. Nitrogen conversion efficiency has increased to 56% and so it can be expected to be more sustainable in its use of natural resources. However, its profitability is not enough to pay tax and support the level of debt found on many farms in this region. The return on assets is insufficient to attract off-farm investment, should that be required for future improvements. Unless farms like this can reduce the amount of debt below that of the model farm they will not survive the changes required to address Table 14.2 .

Moderate-intensity dairy farm

This farm has 600 cows and achieves high production. The farm imports 757 tonnes DM, grows winter and summer crops and applies an annual application of over 150 kgN/ha.

To achieve Table 14.2 in the One Plan this farm has a covered barn installed for all the cows so that they can be housed all year. Although inside for much of the time, the cows are grazed outside for fixed periods throughout the year – 8 hours per day while lactating and 2 hours per day over winter. The farm imports the same amount of supplementary feed as it did previously and harvests another 38 tonne of supplements to maintain production. Dairy effluent is applied across the whole of the milking platform and nitrogen fertiliser applications reduced to 50 kgN/ha.

The farm started with leaching 54 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of almost 70%. These changes reduced the expected farm profit from \$2,283 /ha to \$1,745/ha, a drop of almost 25%. The return on assets dropped from 7.0% to 5.0%.

The moderate intensity farm model has not reduced its labour but it has had to increase its overall pasture utilisation. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency only increases slightly to 27% and so there is not much improvement expected in the sustainable use of natural resources. However, the profitability of this farm is sufficient to support its expected level of debt and it has sufficient return on assets to provide financial security for its owners.

Irrigated high-intensity farm

The irrigated high intensity dairy farm in the base model has 640 cows and has a centre pivot irrigator and a feed pad. The farm imports 757 tones DM per year as a supplement or 1,180 kgDM/cow. It uses 187 kgN/ha of nitrogen a year.

To meet the requirements of Table 14.2 in the One Plan this farm has built housing for the cows so that they can be kept inside all year. The farm already had a feed pad and so the effluent system for housing the animals was already in place. While they are lactating, the cows are grazed outside for up to 8 hours per day. The amount of imported supplements on this farm is increased to 1,170 tonnes DM and 22 tonnes of supplements are made on the farm.

The farm started with leaching 64 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of over 70%. These changes reduced the expected farm profit from \$2,456/ha to \$1,850/ha, a drop of 25%. The return on assets dropped from 6.8% to 4.8%.

The irrigated high intensity farm model has not reduced its labour but it has had to increase its overall pasture utilisation. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency only increases slightly to 28% and so there is not much improvement expected in the sustainable use of natural resources. However, the profitability of this farm is sufficient to support its expected level of debt and it has sufficient return on assets to provide financial security for its owners.

Arable farm with livestock

Both the arable farms are larger than the typical farms to be found in the Manawatu. Making them larger makes it easier to compare these farms with the dairy farms that have a similar size. This farm specialises in grain production over summer. It has been able to do that without irrigation. Half of the farm is used for growing barley and in winter it has been growing ryegrass for finishing livestock. The farm finishes lambs and heavy cattle over a 12 month period. Over the year 150 kgN/ha is applied to the cropping area or an average of 60 kgN/ha across the whole farm.

The changes required to meet Table 14.2 in the One Plan are to dispose of all the livestock and harvest as silage and hay the permanent pasture and ryegrass green crop. The area in barley had to be reduced from 100ha to 70 ha. Over a whole year 1,399 tonnes of pasture dry matter was made and exported from the farm.

The farm started with leaching 39 kgN/ha and was modified to be leaching only 24 kgN/ha, a drop of almost 40%. These changes decreased the expected farm profit from \$915/ha to \$477/ha, a decrease of 47%. The return on assets dropped from 2.6% to 1.3%.

The arable with livestock farm model has not reduced its labour but it has become dependent on the supplementary feed market. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency has increased to 89% and so natural resource sustainability has also increased. The profitability of this arable farm is insufficient to support its expected level of debt and it has insufficient return on assets to provide much financial security for its owners.

Arable farm with potatoes

This model farm was again large for a cropping farm. This time there were no livestock and instead two different rotations were modelled. The second rotation of potatoes and brussels sprouts required a total application of 428 kgN/ha over a year. The other rotation of maize silage and winter oats for forage only needed 110 kgN/ha. Irrigation was used over summer on the potato crop and 500mm/yr was used.

The changes required for meeting Table 14.2 in the One Plan included reducing the amount of nitrogen fertiliser going on to the potato rotation (332 kgN/ha) and better timing fertiliser applications to align with crop requirements. A new rotation growing barley for grain was introduced to replace some of the area originally in a high nitrogen feeding crop (potatoes). To

reduce drainage from excess irrigation a moisture probe was installed and a water budget put in place. This reduced the amount of water needed to 380mm/yr.

The farm started with leaching 60 kgN/ha and was modified to be leaching only 25 kgN/ha, a drop of almost 60%. These changes reduced the expected farm profit from \$3,192/ha to \$1,152/ha, a drop of over 64%. The return on assets dropped from 8.2% to 3.0%.

The arable with potato farm model has some reduction in casual labour and it has had to increase the range of crops being grown. Its adaptability might therefore increase overall. Nitrogen conversion efficiency has increased to 94%, a big improvement in the sustainable use of its natural resources. However, the profitability of this farm is insufficient to support its expected level of debt and it has insufficient return on assets to provide financial security for its owners.

Future farming systems

It is likely that the farming systems described here will be greatly modified after their first few years under consented conditions. It is likely that dairy farms with cows grazing outside all year will develop contracts for supplying surplus supplementary feed to other farmers with their cows housed indoors. The housed cow farmers are likely to expand the size of their operations until constrained by the efficiency of their effluent systems and the maximum loading of effluent that they are able to apply to land.

Some farmers may choose to winter some dairy cows on what would otherwise be arable farms growing grain. These farmers will need to use well designed stand-off pads to minimise the leaching of nitrogen over the winter months.

Consent Applications

The model farms above have been developed to show how these farms could be adapted to meet the nitrogen caps in Table 14.2 of the One Plan. They may need a number of years to put all the identified mitigations in place, in which case they will need to apply for a restricted consent to enable them to operate outside Table 14.2 over a transition period.

10. Assumptions, Limitations and Further Work

I have written this report in a style that is without references. The conclusions are evidenced based from a number of sources, using the information contained within the reported material, the client information held in company databases owned by KapAg Ltd, BakerAg Ltd and RD Consulting and the experience of the author. In addition, some of the costs used in this report were sourced from Dairy Base a national database of dairy farm physical and financial performance.

Further information about the author's experience is contained on the KaAg website listed under further reading.

At the time of preparing this report the costs of the consenting process were drawn from those associated with the processing of existing consents and estimates based on possible future requirements. A process for making an Assessment of Environmental Effects (AEE) had not been suggested by staff at Horizons. For this study it was assumed that the AEE could be carried out by a suitably qualified farm consultant that had received additional training from NIWA to be able to use the extended Stream Health Monitoring and Assessment Kit – ESHMAK. If there was a surface waterway available, the most significant of these on each property would be measured at two points along it. The results of the waterway assessment would be included in the AEE describing the effects of the farming activities on Table B1 values and Table E2 targets. These results in the AEE would be conveyed in narrative form using numeric scores from the ESHMAK where these were available.

The nutrient budgeting software – Overseer, is currently available 'free' to registered users. In this report a cost is assumed. The Farmax[®] charging policy has been used, that is: \$200 per farm and unlimited scenarios per farm. If a farm system has significant changes made a new charge would be generated and three 'farms' have been used in the costing section of this report.

This report has not considered all the combinations of farm systems and nitrogen loss rates in the region but the results should still be indicative of the likely ranges of these. While the author has made full use of the information available at the time, this report can undoubtedly be enhanced by further input from industry experts.

11. Further Reading

Dairybase web site: <https://www.dairynz.co.nz/business/dairybase/>

DairyNZ 2010. Facts and Figures: For New Zealand dairy farmers

Denzin NK (Ed), 2009. Sociological Methods: A Sourcebook. Transaction Publishers, New Jersey.

Denzin NK and Giardina MD (Eds), 2008. Qualitative Inquiry and the Politics of Evidence. Left Coast Press Incorporated, California.

Farmax web site: <http://www.farmax.co.nz/>

KapAg Ltd web site: <http://kapag.nz/>

Overseer web site: <https://www.overseer.org.nz/>

Parminster TG, 2013. Of my own free will: voluntary approaches to environmental policy. LAP Lambert Academic Publishing, Germany.

Parminster TG and Grinter J 2016. Farm-scale Modelling Report: Ruamāhanga Whaitua Collaborative Modelling Project. Ministry for Primary Industries, Wellington, New Zealand.

Waikato Regional Council. Menus of practices to improve water quality:
<https://www.waikatoregion.govt.nz/community/your-community/for-farmers/healthy-farms/farm-menus>

12. Appendix A. Glossary

Table 14.2 sets the nitrogen caps for farmers and growers operating in the Manawatu Wanganui Region.

Nitrogen caps for intensively farmed land, from Section 14.3 of the One Plan

Period (from the year that the rule has legal effect)	LUC I	LUC II	LUC III	LUC IV	LUC V	LUC VI	LUC VII	LUC VIII
Year 1	30	27	24	18	16	15	8	2
Year 5	27	25	21	16	13	10	6	2
Year 10	26	22	19	14	13	10	6	2
Year 20	25	21	18	13	12	10	6	2

Model Farm: Self-contained farm. The farm is described as self-contained although to start with there is some feed imported and some cows are grazed off the farm for two months over winter. Milk production in this model is not dependent on imported feed. Although clearly a system II farm, it approaches the type 1 system defined by the industry.

Model Farm: Low intensity. This farm is described as low intensity because it has a low level of imported feed. It fits a system II farm although it does support the lactation over summer and autumn with supplements and a summer crop.

Model Farm: Moderate intensity. This farm imports feed to support lactating cows and grazes dry cows off during the winter. The farm was considered to be a system IV farm.

Model Farm: High intensity. This farm feeds supplements to the cows through most of the year.

13. Appendix B. Project Brief

The following are abridged selections from the project brief supplied by email on the 6th June 2017.

“Horizons Policy and Regulatory teams are undertaking a review of the policy and rule framework for nutrient management and intensive landuse provisions.

This work is required to address the need for applications to contain fuller assessments of environmental effects, including cumulative effects which consider impacts on the wider catchment. Consideration must also be given to all of the relevant objectives and policies in the One Plan, as well as, the capacity to maintain or enhance Schedule B values and Schedule E targets.

Additionally, the consent must contain an assessment against the objectives and policies of the National Policy Statement for Freshwater Management, ... section 105 of the RMA, and the National Environmental Standard for Sources of Human Drinking Water.

It is important for Council to understand all issues of cost and practicability in respect of consenting requirements for intensive land use activities. To this end, Council wishes to obtain advice through assessing the on-farm economic impacts on future consent applicants to compile, lodge and implement a land use consent for intensive agriculture or horticulture in the target catchments which fully address effects , and fully addresses the relevant objectives, policies, rules, schedules of the One Plan and the provisions of other relevant legislation.

The purpose of this study is to calculate the costs associated with applications for intensive farming land use activities and the economic impact of mitigations to reduce nitrogen leaching likely to be incurred as a result of the recommended improvements to the consenting process.”

14. Appendix C. Farming practices introduced to the Livestock Farms

Remove winter applications of nitrogen (May to July inclusive)

Farmers apply nitrogen fertiliser in winter (typically May or late July) if they have insufficient feed and if conditions are suitable. Only the high intensity farm with irrigation applied nitrogen during this time and these applications have been removed as a mitigation.

Reduce nitrogen to a maximum of 100kg/ha/yr

Although the extra feed grown may be needed to support a farming system, reducing the amount of nitrogen fertiliser applied through a year reduces the amount of nitrogen leached. This was applied across all farms as a mitigation. As nitrogen fertiliser is decreased, so is the amount of pasture grown which requires either a decrease in stocking rate or a decrease in per cow performance.

Aggressive summer culling of cows

Removing cull cows in Autumn (around March) when the non-pregnant (empty cows) are known, reduces feed demand during a time when feed may be limiting. The reduced numbers also reduces nitrogen leaching. This was applied across all farms.

Replace high protein feed with a low protein feed

Replacing high protein feeds (nitrogen boosted pasture, high quality grass silage) with a low protein feed (starch based grains, maize silage) reduces urinary nitrogen and therefore decreases nitrogen leaching. The low protein feeds have to be 'imported' onto farms to replace the 'homegrown' feeds and they generally cost more to purchase. This change was applied to the moderate intensity and the high intensity with irrigation farms as a mitigation.

Spread effluent to reduce rates to 100kgN/ha

Reducing effluent nitrogen loadings from the consented 150 kgN/ha towards 100 kgN/ha application generally leads to a reduction in nitrogen leaching. This was applied to the self-contained farm and the low intensity farm. However, this was unable to be implemented on the other two farms because they had insufficient area available. This is due to the high effluent loading created with cows in a barn and higher rates of effluent nitrogen applied over the farms. On the two more intensive farms the effluent areas had to be increased to 85% of the farm to meet the consented 150kgN/ha N limit.

Remove all nitrogen fertiliser and export surplus feed

Reducing or eliminating nitrogen fertiliser reduces nitrogen leaching. However, as discussed, it also reduces grass growth and therefore stocking rate has to be reduced accordingly. This was applied as a mitigation to the self-contained and low intensity farms.

Export surplus feed

Where farms are forced to reduce stocking rate to meet nitrogen leaching limits, pasture demand is also reduced. Uneaten surplus pasture can lead to a decline in pasture quality and pasture species. To maintain pasture quality, silage or hay is made which can either be stored on farm, or sold off farm. In this report, unwanted surplus feed is sold off farm. This strategy was applied over the self-contained and low intensity farms.

Optimise Irrigation

Optimising water efficiency and therefore minimising drainage through the soil profile reduces nitrogen leaching. This mitigation was only applicable and applied to the high intensity farm with irrigation and the arable farm with potatoes.

Winter cows off the farm

Grazing dry cows off the farm during winter is a significant nitrogen mitigation, assuming that cows are grazed outside catchment. This mitigation was applied to the self-contained and low intensity farms.

Reduce cow numbers and bring grazed off heifer's home to replace cows

Reducing lactating cow numbers and replacing them with heifers reduces stocking rates and the cost of off-farm grazing. This is a nitrogen leaching mitigation was applied to the self-contained and low intensity farms.

Reduce Overall Stocking Rate

Reducing overall stocking rate is a significant nitrogen mitigation. This was implemented on the self-contained and low intensity farms to a major degree. Farmers with housed cows are able to adjust their effective stocking rate through controlling the duration of time that their cows are grazing outside. Because of this there was only a minor decrease required in stocking rate on the moderate intensity and high intensity with irrigation farms.

Use a standoff pad in wet winter weather

This mitigation enables cows to be held off paddocks for significant time during the winter and when it is wet. This prevents pugging and captures urinary nitrogen for treatment through a farm effluent system. This mitigation was applied to the moderate intensity and high intensity with irrigation farms.

Build a covered feed pad/ area

This mitigation enables supplementary feeds to be fed to cows when off paddocks. Feed pads are typically made of concrete. They are suitable to feed cows on, but are not suitable for stand cows on for long periods of time. This mitigation was applied to the rate on the moderate intensity and high intensity with irrigation farms.

Housed cows with duration controlled grazing

This mitigation allows cows to graze on pasture for short periods and then be kept in a barn with a soft litter area during the times of the year when the risks of urinary nitrogen leaching are high. During this time they may also have access to supplements fed on a concrete apron. In the modelled farm systems they grazed on pastures for eight hours per day in February, March, April and May, two hours in June and July and twelve hours in August. As a purpose-built barn it combines the “use a standoff pad in wet weather” and “a covered feed pad” during lactation.

Effluent from the housed cows is captured and along with bedding material is applied to paddocks during low risk periods of nitrogen leaching. This mitigation has been applied to the moderate intensity and high intensity with irrigation farms.

15. Appendix D. Farming Practices on Arable Farms

Minimal tillage

Minimal tillage and direct drilling are used to reduce the amount of cultivation applied between crops. The reduced cultivation reduces farm costs and nitrogen leaching from organic matter breakdown in the soil. In the arable models conventional tillage was used to cultivate pasture in both the base and modified models and minimal tillage between crops.

Minimal nitrogen applications

Nitrogen applications can be reduced to replace the amount of nitrogen being removed in produce and losses incurred during crop growing. There was limited ability to reduce applications in the model base farms although some reduction was applied to the arable with potatoes model.

Nitrogen fertiliser applied in side dressings

Nitrogen fertiliser can be applied to horticultural crops as side-dressings near the plant roots to improve uptake efficiency. This was not possible to model in Overseer but was assumed to be applicable on the arable farm with potatoes.

Spread nitrogen applications

Instead of applying nitrogen fertiliser in one dressing at heavy rates (over 45 kgN/ha) leaching will be reduced if the same amount of fertiliser is spread over a number of weeks or even months. There is limited ability to model this in Overseer, but both arable farms had large applications split over more than one month.

Bunding to capture runoff

There are advantages on bare ground of capturing stormwater to hold back sediment, nutrients and pathogens. On both arable farms bunds were assumed to be put in place, reducing the cultivatable area for cropping.

Active water management

To reduce annual water use on the modelled arable-with-potatoes farm a moisture probe was introduced to monitor soil moisture and establish a water budget. Using a water budget reduces water use to calculated deficits and reduces nutrient losses.

Reduce fallow

Fallow periods of bare soil increase nitrogen leaching. By using a cover crop, when the land is next cultivated, surplus nitrogen is captured and returned to the soil in organic matter.

Remove livestock

Livestock on arable farms concentrate nitrogen when they urinate in patches. Removing livestock reduces this source of nitrogen leaching.

Export green crops

Harvesting green crops captures the nitrogen they contain and enables surplus to be exported off the farm. It is better than grazing with livestock if the intention is to reduce nitrogen leaching.

Reduce the area of heavy nitrogen feeding crops

Crops that have a high proportion of their biomass harvested have a high requirement for nitrogen fertiliser and so increased nitrogen losses. Replacing heavy nitrogen feeders with grain crops reduces nitrogen requirements and nitrogen losses. The arable-with-potato farm had a proportion of potatoes replaced with barley.

16. Appendix E. A summary of Commodity and Service Prices

Dairy	Amount	Notes
Milk solids payout (kg MS)	\$6.00	
Dividend	\$0.40	Assumes fully shared up Fonterra suppliers
Management fee	\$75,000 pa	Owners wage of management
Senior farm staff	\$60 - \$75,000 pa	2IC – farm manager
Farm hand	\$50,000 pa	
Fertiliser Phosphate	\$3.70 / kgP	High analysis fertiliser on arable farms used cost price
Fertiliser potash	\$1.50 / kgK	As above
Fertiliser Nitrogen (Urea)	\$700 / T incl spreading	As above
Off farm grazing - weaners	\$5 / head / week	
Off farm grazing – Rising 1yr May to May	\$8.50 / head / week	
Off farm grazing – winter mixed age cows	\$27 / head / week incl transport	
Feed Prices – PKE	\$280 / T delivered	
Pasture Silage Imported	\$250 / TDM	
Maize Silage Imported	\$320 / TDM	
Barley Grain	\$400 / TDM	
Hay	\$85 / bale delivered	
Sale Price of Exported Pasture Silage	\$150 / TDM	
Arable Farms	Sale Price / T	Crop Cost \$ / ha
Barley price	\$333 / T	\$1,344 / ha
Pasture silage	\$150 / TDM	NA
Oat Silage	\$150 / TDM	\$500 / ha
Maize silage	\$240 / TDM	\$2,400 / ha
Potatoes	\$300 / T	\$9,519 / ha
Brussel Sprouts	\$385.70	\$3,456 / ha
	Sale Price	Purchase Price
Finished lambs (average)	\$6.60 / kg cw	\$2.87 kg lw
Store cattle (average)	\$2.87 / kg LW	\$3.71 / kg lw
Finished cattle (average)	\$5.73 / kg cw	\$3.71 / kg lw
Other		
Farm consultants	\$150/hr	
Technical specialists	\$250/hr	
Council staff	\$100/hr	
Interest rate on annuity for additional capital requirements	7%	

17. Appendix F. Costs of Housing Dairy Cows

The following costs were used to estimate the costs of housing dairy cows.

Items Included	\$/cow	\$/550 cows	\$/630 cows
Plastic covered shelter 8m ² per cow Redpath NZ	500	275,000	315,000
Earthworks, bedding and concrete feed lanes (covered)	300	165,000	189,000
Solids bunker	55	30,250	34,650
Effluent system – main line, pump, hydrants, irrigator		100,000	100,000
Pond for additional solids ¹		70,000	-
Total per farm		640,250	638,650
Total per cow (\$)		1,164	1,014

1. This is already in place for farm dairy effluent and the feed pad on Farm IV.

ATTACHMENT B



Selecting Representative Dairy Farms for the Upper Manawatu River Catchment

March 2018

Terry Parminter

Selecting Representative Dairy Farms for the Upper Manawatu River Catchment

March 2018

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The project was supervised by Tom Bowen and Kate McKinnon at Horizons.

My thanks to all these people.

Summary

The purpose of this report is to select and describe suitable representative dairy farms for the Upper Manawatu River catchment (through the gorge and above Hopelands) and to use these to assess the likely viability of dairying in that catchment under the current policies and rules of the One Plan. The representative farms are to be selected from a database containing 95% of the dairy farms in the catchment.

The resultant five representative farms meet the following criteria:

- Each of the representative farms is a “real farm” within the catchment¹. They have not been synthesised or created by modelling.
- An objective and repeatable process has been followed to identify the representative farms.
- Each representative farm is closely related to the other farms in its cluster and dissimilar to the other representative farms in the other clusters.
- None of the representative farms represents an average for the catchment; instead they provide a measure of the variation between farming systems within the catchment.
- Collectively the representative farms approximate the median² results for dairy farms in the catchment.
- Every farm in the catchment has a representative farm, “like them”.

The Manawatu River has the second largest catchment in the region and the upper reaches provide high quality water from rain falling on the eastern side of the Ruahine Ranges. Dairy farming is undertaken in the area on well drained soils under moderate to high annual rainfall. Only about 10% of the dairy farms there use irrigation.

The Tararua District where the catchment is situated has over one third of the dairy farms in the region (304) and the Upper Manawatu River catchment contains over half of these (133).

Information collected about individual farms by the Regional Council was used to describe the range of attributes associated with dairy farms in the catchment. The data was complete for 126 farms in the catchment. The variability between farms was such that there were no successful predictors identified from these attributes for production or nutrient losses.

The data from all of the farms was entered into a cluster analysis to identify the groups of farms that were simultaneously similar to other farms in their group and dissimilar to the farms in other groups. Cluster analysis is a particular method specifically used in statistics for “knowledge discovery in databases”³. By applying the cluster method to recognise patterns in the data, six clusters of dairy farms were identified in the catchment. The smallest cluster was of only seven farms and so this cluster was combined with the nearest other cluster to make five clusters overall.

¹ Every effort has been made to keep farm owners’ identities confidential in this report.

² In this report results for the *average* (mean) and the *median* are presented. The average is a single value used to represent a point mid-way between the highest and lowest results in the data. The mean is used to represent the point in the data where there are as many instances above it as below it. When there is enough data points and they are “normally distributed” the average and the mean become almost the same value.

³ János Abonyi and Balázs Feil 2007. *Cluster Analysis for Data Mining and System Identification*. Birkhäuser Verlag AG, Berlin.

The descriptions of the farms in each of the clusters are provided in Table (i)⁴. The patterns in the data linking farms within clusters were “discovered” by the clustering process. The first three clusters contain farms on the minority soil orders in the catchment: allophanic, recent and gley. Cluster 4 contains the farms in lower rainfall areas that are more intensively farmed than is general. Clusters 5&6 are farms on both brown and pallic soils and are of a farm size often found in the catchment.

In Table (i) the last two rows provide the medians estimated from the clustering results and the medians of the actual farms in the catchment.

After the farms had been grouped together into their clusters, within each cluster a median farm was identified to meet the criteria in the bullet points above. These farms are listed in Table (ii)⁵. Although the collective data from these farms contain some differences when compared with the overall results for farms within the catchment, the five farms have been “discovered” in the data using an objective and repeatable statistical method already used in a number of policy studies in New Zealand⁶. This is still the best way for a limited number of actual farms to be used to represent the catchment in further analyses for policy development.

The financial impact on dairy farm systems of Table 14.2 ‘Cumulative nitrogen leaching maximum by Land Use Capability Class’ in the One Plan was described in an earlier report to the Manawatu Wanganui Regional Council. This report updates that information by applying the financial information in the earlier report to the farm clusters developed in this report. The farm system descriptions in the earlier report were compared with the cluster medians in this report (shown in Table (i)). That enabled the appropriate farm system financial data to be aligned with the cluster farm medians. The farm system data was then adjusted to match the cluster median for “milking platform area”.

The resultant financially updated information is summarised in Table (iii). For the majority of dairy farmers in this catchment achieving the nitrogen reductions required for a Controlled Consent would require a reduction in their operational profit of 24-61%.

⁴ This Table is repeated as Table 3 later in the report.

⁵ This Table is repeated as Table 4 later in the report.

⁶ Joey Au, Andrew Coleman and Trudy Sullivan, 2015. A Practical Approach to Well-being Based Policy Development: What Do New Zealanders Want from Their Retirement Income Policies? New Zealand Treasury Working Paper 15/14. <http://www.treasury.govt.nz/publications/research-policy/wp/2015/15-14/twp15-14.pdf>.

**Table (i).** Clustering results for farms in the Upper Manawatu River catchment with their medians for selected attributes

Cluster	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
1	Allophanic	1376	116	370	327	896	III	40	0.9
2	Recent	1211	112	336	369	968	III	47	1.0
3	Gley	1241	99	256	340	917	II	26	1.3
4	Brown	1255	131	385	387	1136	IV	47	1.0
5&6	Brown & Pallic	1354	108	270	336	830	II	39	0.9
Median of cluster medians	NA	1190	95	220	305	829	III	43	1.5
All farms in the catchment	Brown	1298	111	309	340	902	II	39	1.0

Table (ii). Representative farms for the Upper Manawatu River catchment selected from the median farms within each cluster

Cluster	Farm	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
1	16	Allophanic	1551	179	530	258	765	IV	58	0.9
2	25	Recent	1176	197	510	360	933	IV	33	1.8
3	14	Gley	1588	74	220	309	921	II	32	1.8
4	112 (irrigated)	Brown	1255	86	250	369	1068	III	32	0.8
5&6	54	Brown	1082	113	260	362	829	III	27	0.6
Median of representative farms		NA	1255	113	260	360	921	III	32	0.9
All farms in the catchment		NA	1298	111	309	340	902	II	39	1.0

Table (iii). Financial Impact of Applying Table 14.2 (One Plan) to Dairy Farming Clusters in the Upper Manawatu River Catchment⁷

Cluster	Number of farms affected	System Type	Median Milking Platform Area (ha)	Initial Farm Profit (\$)	Final Farm Profit (\$)	Reduction in Profit (%)
1	27	Self-contained	108	189,432	73,245	61
2	10	Low-intensity	116	276,769	159,326	42
3	18	Moderate-intensity	99	282,135	215,652	24
4	16	Moderate-intensity	131	373,968	285,845	24
5&6	55	Self&Low-intensity	112	226,826	115,756	49

This table builds on the results presented in Table 4 in Parminter 2018. An impact assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Region. A Client Report for Manawatu Wanganui Regional Council.

⁷ This Table is repeated as Table 8 later in the report.

1. Purpose

The purpose of this report is to select and describe suitable representative dairy farms for the Upper Manawatu River catchment (above the Manawatu Gorge) and to use these to assess the likely viability of dairying in that catchment under the current policies and rules of the One Plan.

In order to address the purpose this report brings together a number of data sources and the results of applying cluster analysis to the known farm data. The first data source is a description of the natural resources in the region and their variability at catchment and farm scales. The second is a description of the dairy farming systems being used by the dairy industry within the district and the catchment to adapt farm practices and management strategies for achieving farmer, community and industry goals. Information from these two approaches are brought together at the farm scale in this report using a cluster analysis to select suitable farm examples that can be used to represent the dairy industry when evaluating the impact of natural resource policy in the Upper Manawatu River Catchment.

2. Approach

The context for this report is the Manawatu Wanganui Region and the Tararua District where streams in the Upper Manawatu River catchment provide the headwaters for the Manawatu River. The Upper Manawatu River catchment comprises only a small portion of the region and is only a part of the Tararua District. However, a lot of the natural resource information used in this report has been collected at a regional scale and/or a district scale. This more general information about the region and the district is covered first before the report focusses on the specific catchment of interest and how it compares with the other catchments in the region.

The Regional chapters of this report describe its physical resources, its rainfall, soils and dairying statistics. The Tararua District is then introduced and describes these same resources in further detail.

DairyNZ have established that there are five types of dairy farming systems commonly being used in New Zealand. Although these systems use resource inputs quite differently, they are able to achieve similar levels of operating profit (Shadbolt 2012)⁸. These systems have been used in a range of other studies to explore the impacts of changes in industry strategies, along with regional policies on farming profitability, and farmer resilience and innovation.

The section in this report describing dairying in the Upper Manawatu River catchment examines some of the farm variables often associated with waterway contamination. These are used to establish the key components that underpin the representative farms selected from this part of the study. The farm results are used to make an assessment of dairy system viability and these results are applied to the Tararua District. Finally in the discussion and conclusions, the results are further developed for application by the Regional Council.

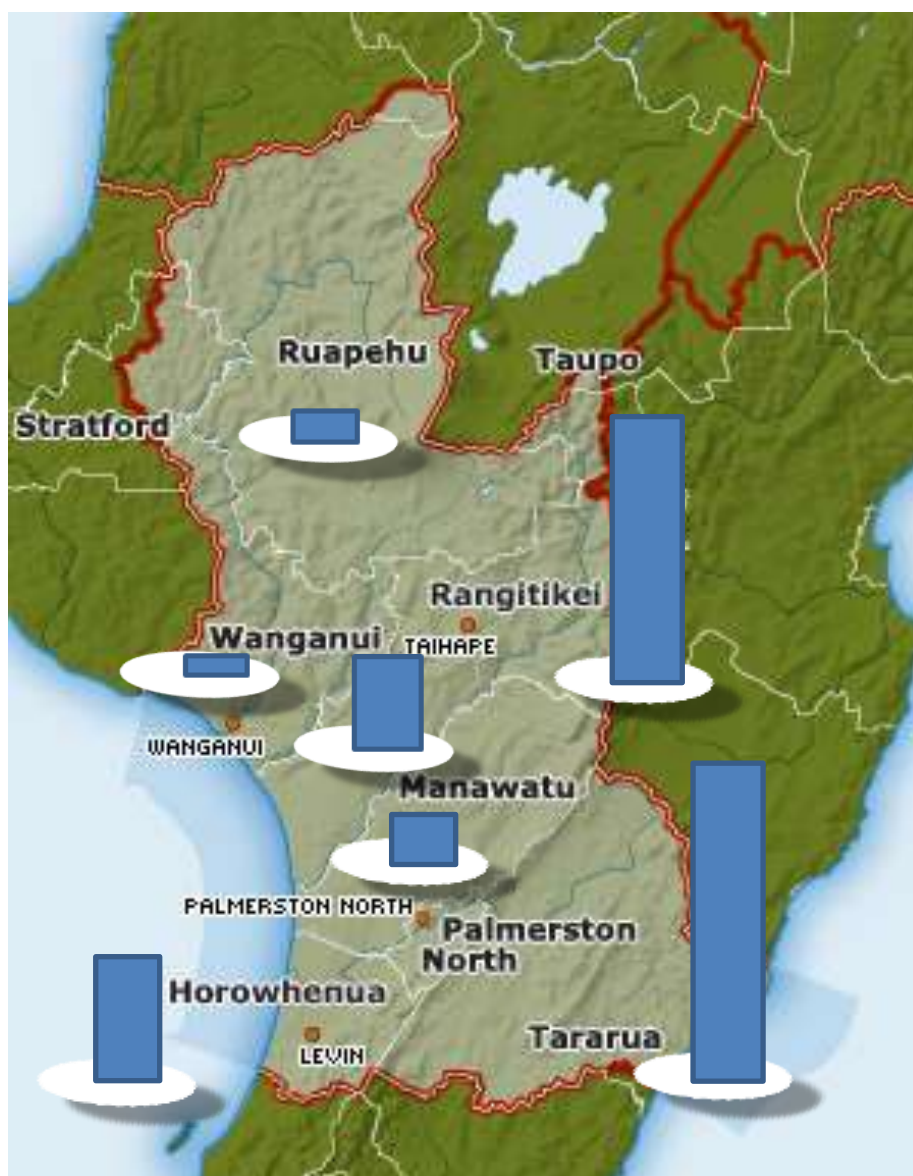
⁸ N. Shadbolt 2012. Competitive strategy analysis of NZ pastoral dairy farming systems. International Journal of Agricultural Management, Volume 1 Issue 3 pp19-27.

3. Regional Dairying Statistics⁹

In the 2015-16 there were 837 dairy farms in the Manawatu Wanganui Region (Figure 1). Palmerston North City and Ruapehu and Wanganui Districts each had 50 herds or less. Horowhenua and Rangitikei Districts had about 100 dairy farms each. The districts with the greatest number of dairy farms were Tararua District with 304 dairy farms and the Manawatu District with 255 dairy farms.

The average farm in the region had an effective area for the milking platform of 137 ha and 376 cows in the herd and an average stocking rate of 2.73 cows/ha. Milk production averaged 362 kgMS/cow or 990 KgMS/ha.

Figure 1. Distribution of dairy farms across Manawatu Wanganui Districts



http://www.localcouncils.govt.nz/lcip.nsf/wpg_url/Profiles-Councils-by-region-Manawatu-Wanganui

⁹ The industry information is sourced from: New Zealand Dairy Statistics 2015-16. Livestock Improvement Ltd and DairyNZ Ltd, and personal communication with DairyNZ.

4. The One Plan and Sensitive Catchments

The Manawatu Wanganui Region is described in Appendix A. In that description it is apparent that there are a number of catchments to be addressed in policy documents and that the natural resources with the catchments vary considerably from each other. To bring all that variety together under one set of principles, the regional statement and regional plan for the Manawatu Wanganui Region have been combined into one plan. The One Plan became fully operative in 2014. Across the region the One Plan identified sensitive catchments where “collectively, land use activities [*specifically intensive farming*] are significant contributors to elevated contaminant levels in groundwater or surface water” (Policy 5-7). These sensitive catchment zones are described in Table 1 and shown in Figure 2.

Table 1. Sensitive catchment zones listed in the One Plan (where they are shown in Table 14.1)

Catchment	Water Management Sub-zone	Colour in Figure 3	Total number of dairy farms requiring a landuse consent	Number of farms consented 31 st Dec 2017
Mangapapa	Mangapapa Mana_9b	Purple	5	5
Waikawa	Waikawa West_9a Manakau West_9b	Plum	8	8
Other south-west catchments (Papaitonga)	Lake Papaitonga West_8	Light blue	1	1
Mangatainoka	Upper Mangatainoka Mana_8a Upper Mangatainoka Mana_8b Upper Mangatainoka Mana_8c Makakahi Mana_8d	Blue	83	72
Other coastal lakes	Northern Manawatu Lakes West_6 Kaitoki Lakes West_4 Southern Wanganui Lakes West_5	Light green	33	17
Coastal Rangitikei	Coastal Rangitikei Rang_4	Dark green	77	58
Lake Horowhenua	Lake Horowhenua Hoki_1a Hoki Hoki_1b	Yellow	10	10
Upper Manawatu River above Hopelands	Upper Manawatu Mana_1a Mangatewainui Mana_1b Mangatoro Mana_1c Weber-Tamaki Mana_2a Mangatera Mana_2_b Upper Tamaki Mana_3 Upper Kumeti Mana_4 Tamaki-Hopelands Mana_5a Lower Tamaki Mana_5b Lower Kumeti Mana_5c Oruakeretaki Mana_5_d Raparapawai Mana_5e	Khaki	133	35
Manawatu above gorge	Hopeland Tiraumea Mana_6 Upper Gorge Mana_9_a Mangaatua Mana_9c	Brown	34	11
Total number of dairy farms			384	217

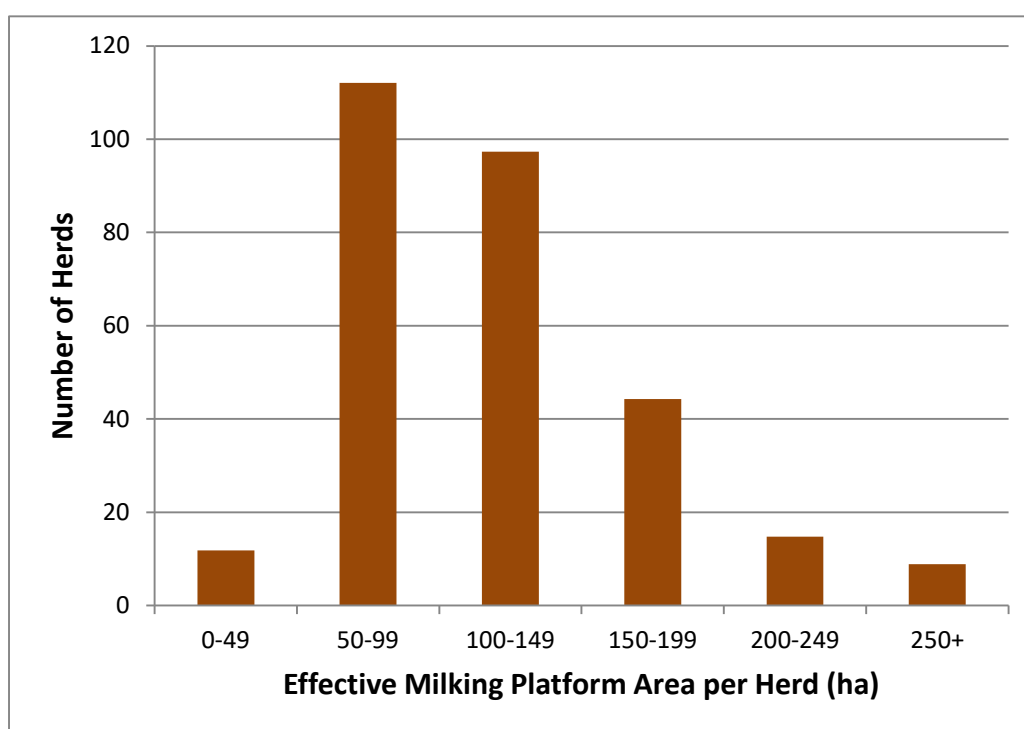
The Upper Manawatu River catchment is important to the Region for its trout fishery and natural state values (Appendix A).

Table 1 also shows the number of dairy farms in each sensitive catchment and therefore that under the One Plan that also require an intensive landuse consent to continue operating. About half the dairy farms in the Manawatu Wanganui Region require a consent, and of these almost 60% had received a consent by 31st December 2017. The largest number of outstanding consents remaining to be completed is for dairy farms in the catchments of the Tararua District. These dairy farms include a number with high relative annual rainfall and those on free-draining brown soils (Appendix A).

5. Dairy Industry Statistics for the Tararua District

The distribution of farm size of dairy farms in the Tararua District as determined from dairy industry statistics is shown in Figure 3. The average area of the effective milking platform was 120ha in the Tararua District. This figure is well below the regional average farm size of 150ha (excluding Tararua). In the Tararua District the median area was 100ha therefore there were more farms smaller than the average for the district compared to the number of farms above the average¹⁰.

Figure 3. The Distribution of Dairy Farm Areas in the Tararua District (2015/16)



The average number of animals in dairy herds in the Tararua District was 324 cows (Figure 4). The median herd number was 250 cows. These figures are about 10% lower than regional results.

¹⁰ In this report results for the average (mean) and the median are presented. The average is a single value used to represent a point mid-way between the highest and lowest results in the data. The mean is used to represent the point in the data where there are as many instances above it as below it. When there is enough data points and they are “normally distributed” the average and the mean become almost the same value.

The average production being achieved in the Tararua District was 964 kg/ha of milk solids per year (Figure 5). This ranged from about 650kg MS/ha/yr to over 1300 kgMS/ha/yr and they are very similar to the regional results.

Figure 4. The Distribution of Dairy Farm Herd Sizes in the Tararua District (2015/16)

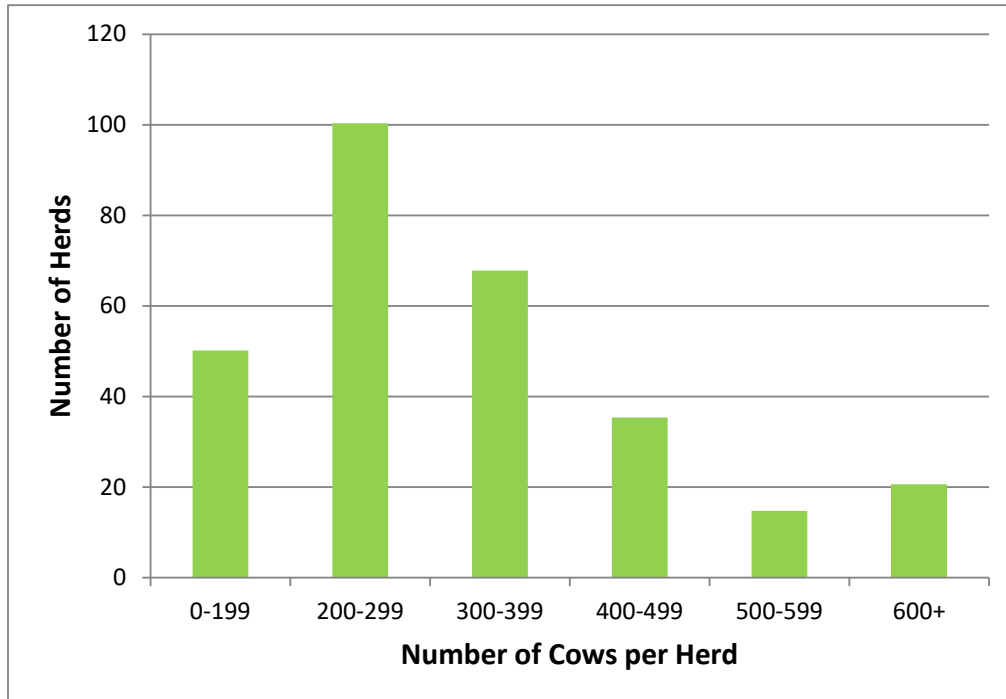
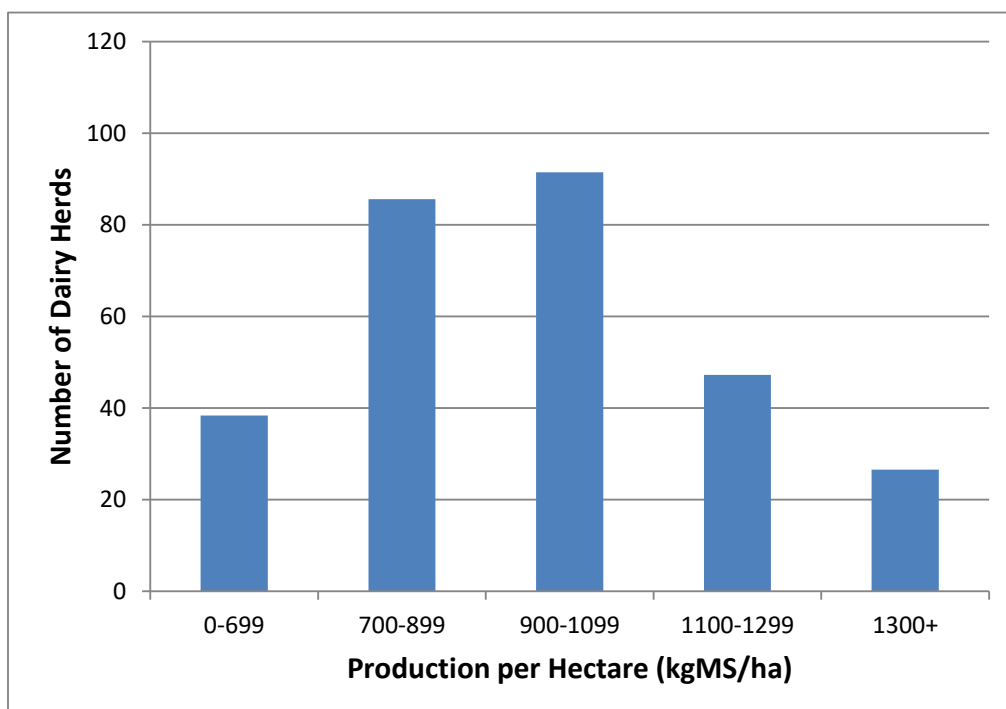


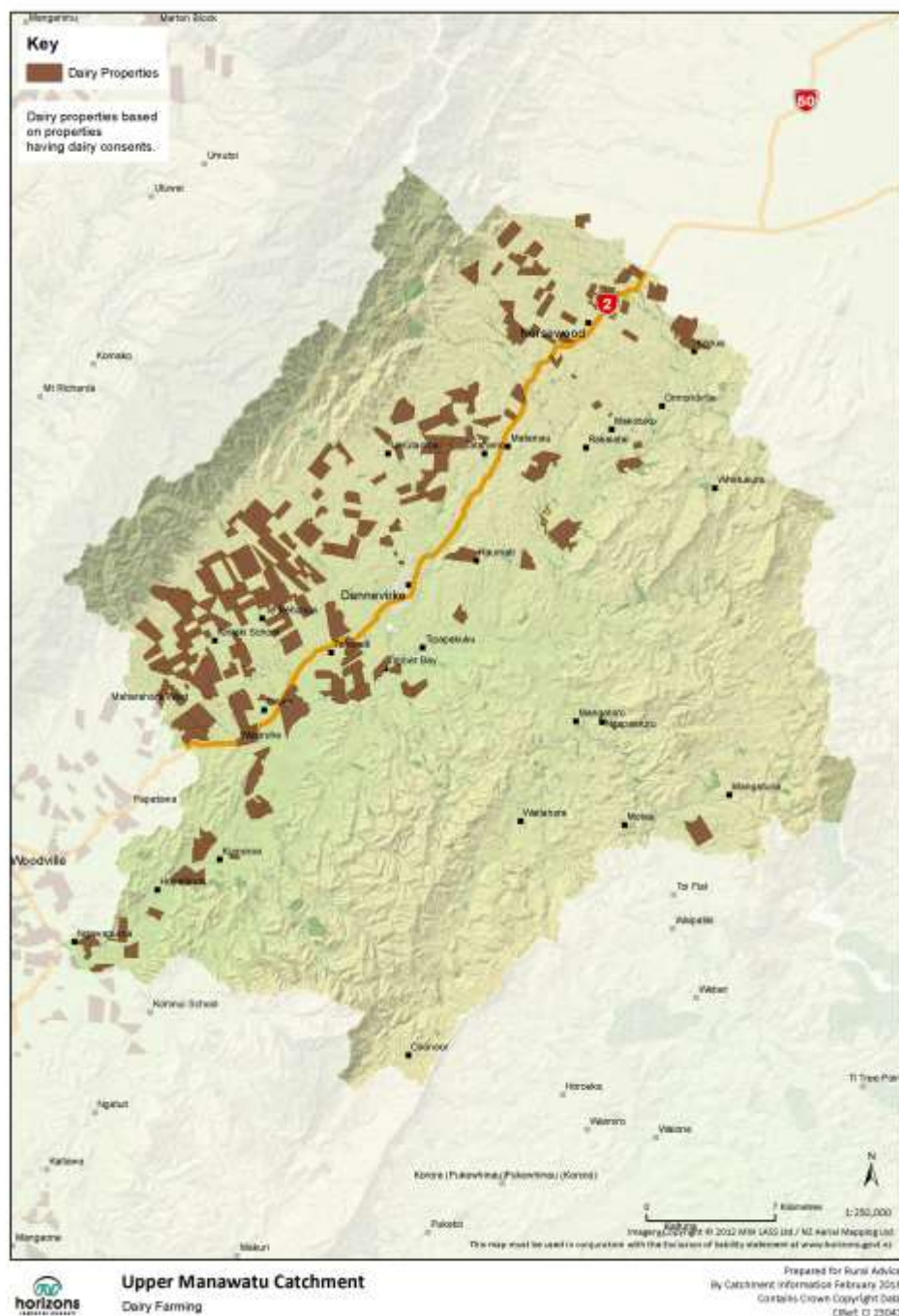
Figure 5. The Distribution of Dairy Farm Production in the Tararua District (2015/16)



6. Description of Dairy Farms in the Upper Manawatu River Catchment

In the Upper Manawatu River catchment, by the 31st December 2017, there were 51 dairy farms that had been issued with a landuse consent, and the Regional Council was waiting on landuse consent applications from a further 121 dairy farmers¹¹. The dairy farms in the catchment tend to be on the western side of the catchment between the main road and the foothills of the Ruahine Range (Figure 6).

Figure 6. A map of the Upper Manawatu River catchment showing the distribution of dairy farms



¹¹ At 31st December 2017

A comparison of Figure 6 and the map in Figure 7 shows that dairying is the main landuse for all the flat and rolling country in the catchment. That is where moderately well drained silt loams and clay loams can be found (Figure8 and Appendix B).

Figure 7. A map of the Upper Manawatu River catchment showing the distribution of land slope

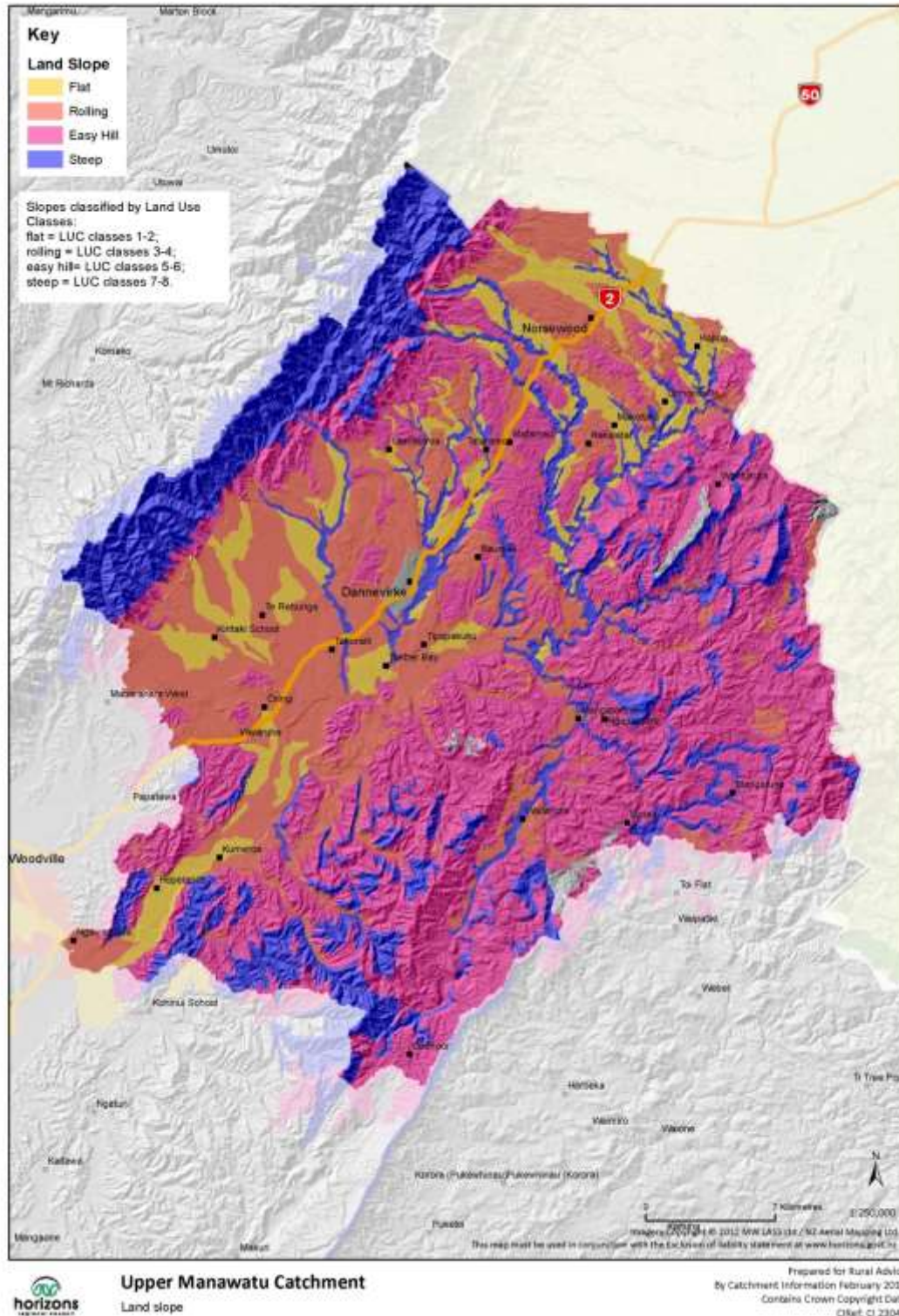
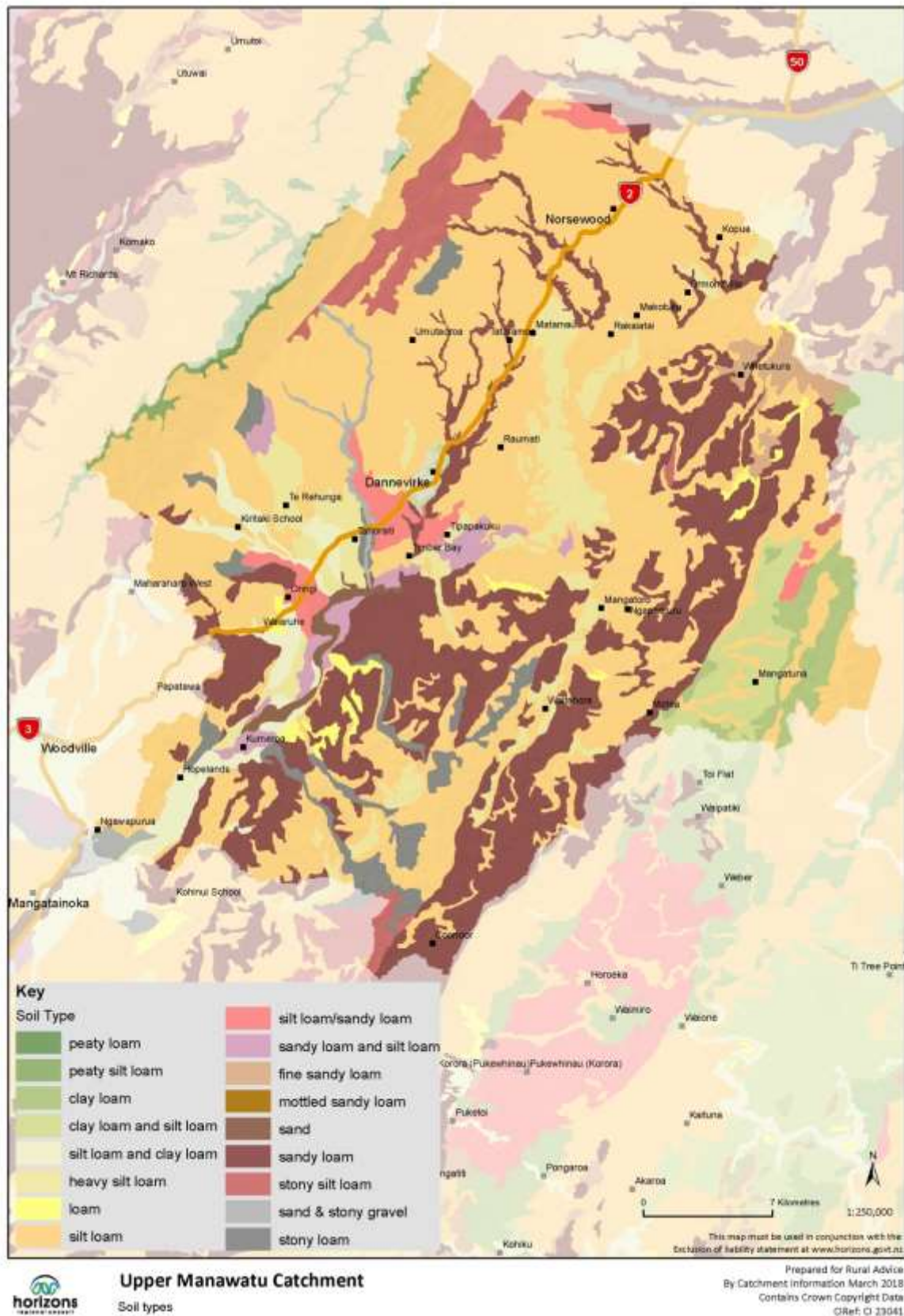


Figure 8. A map of the Upper Manawatu River catchment showing the distribution of soil textures



7. Analyses of Dairy Farm Attributes

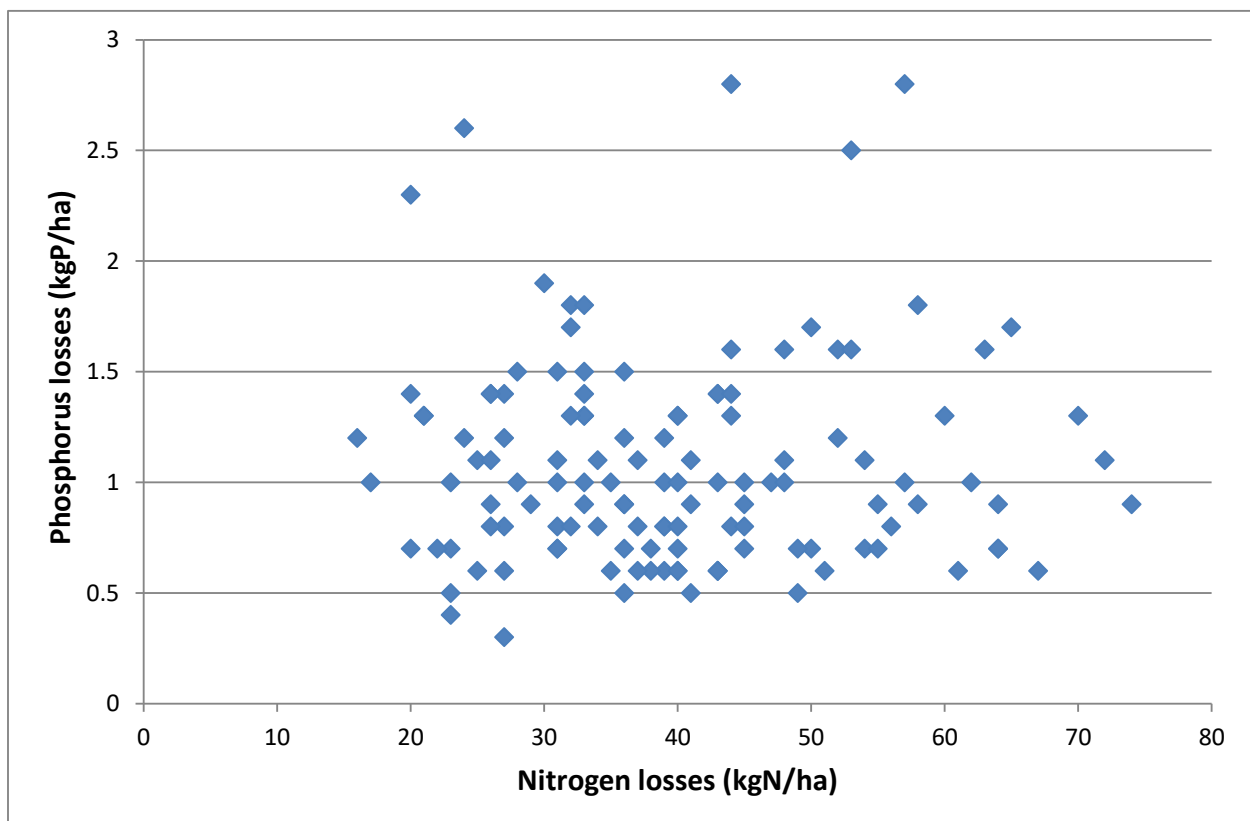
From the total number of dairy farmers in the Upper Manawatu River Catchment, there were 126 farmers that had provided DairyNZ and the Regional Council with enough information for this report to be prepared. These farms became part of a project database for further analysis.

All the dairy farms together had a total area of 23,000ha. Of this the milking platform area was 72%. The average farm milking platform area was 130 ha; the median was 110 ha, and they ranged in size from 39 to 355 ha.

The average farm had 345 milking cows. The median was 310 cows and the range was from 100 to 1,110 cows. These figures are higher than the industry results reported earlier in this report for the whole of the Taranaki District. The average farm was producing 915 kg milk solids per hectare per year (kgMS/ha/yr). Median production was 900 kgMS/ha/yr and the farms ranged from 460 to 1450 kgMS/ha/yr. On average, farms grazed 50% of their cows off-farm over winter.

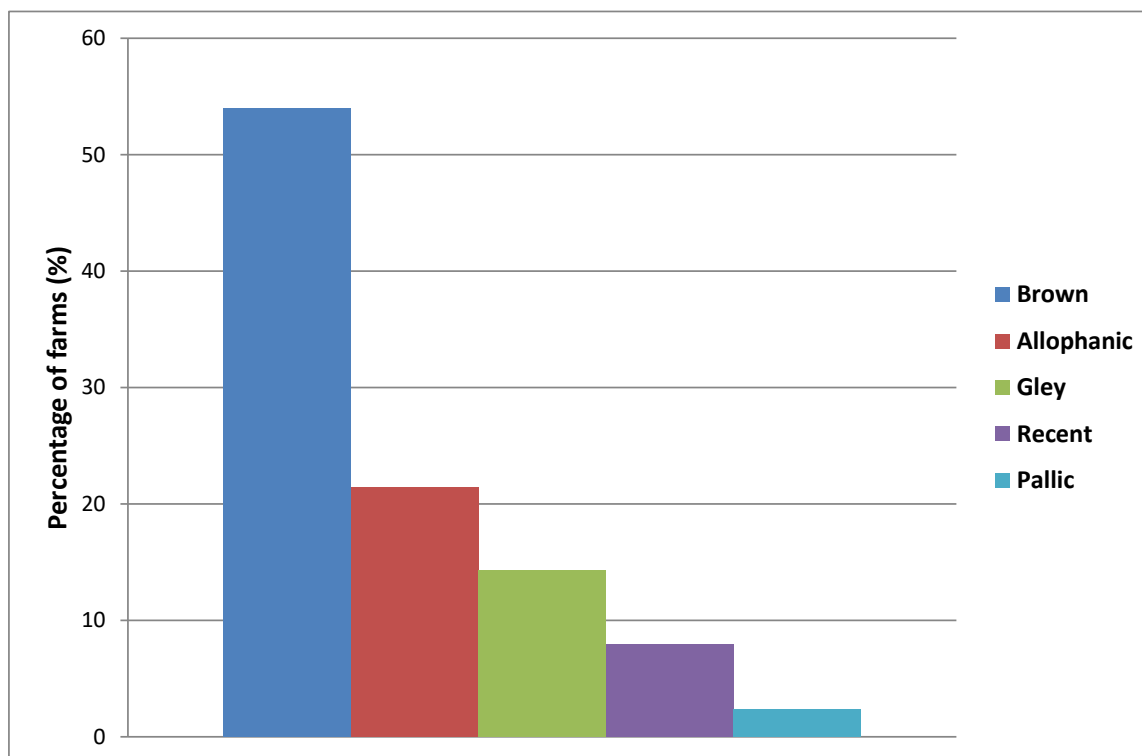
The estimated average 'whole farm' loss of phosphorus to water was 1.08 kgP/ha/yr. The average 'whole farm' loss of nitrogen to water was 40 kgN/ha/yr. This is also shown in Figure 9 where the losses of the two nutrients are shown to be unrelated to each other, highlighting that different farm risk factors are involved in generating each of them.

Figure 9. Estimated dairy farm nutrient losses – nitrogen and phosphorus.



Most of the farms in the catchment are on Brown soils (silt – clay loams), which are free to moderate draining and easily leached (Figure 10). The farms on the Brown soils had an average rainfall of 1350mm and nitrogen losses of 40 kgN/ha/yr. The average rainfall and nitrogen losses for farms on all the soils shown in Figure 12 were similar except that dairy farms on Gley Soils had a lower average rainfall of 1260mm/yr and average nitrogen losses of 30 kgN/ha/yr.

Figure 10. The percentage of farmers with their primary soil type



The stocking rate of milking cows on these farms did not have statistically significant relationships with their milk production or their nitrogen losses (Figures 11, 12 and 13). Only when stocking rate and intake were considered together was it possible to estimate their milk production and their expected nitrogen losses with enough confidence (Equations 1&2).

Equation 1. Regression relationship of stocking rate and cow intake with milk production¹²

$$\text{Milk production (kgMS/ha)} = 218 * \text{cows/ha} + 70 * \text{total DMintake/cow} \dots R^2=0.97$$

Equation 2. Regression relationship of stocking rate and cow intake with nitrogen loss

$$\text{Nitrogen loss (kgN/ha)} = 9.7 * \text{cows/ha} + 2.8 * \text{total DMintake/cow} \dots R^2=0.91$$

¹² Total DMintake is the total amount of feed (including pasture) estimated in 'dry matter' (DM) that the cows are consuming each year.



Figure 11. Milking cow stocking rate and milk production

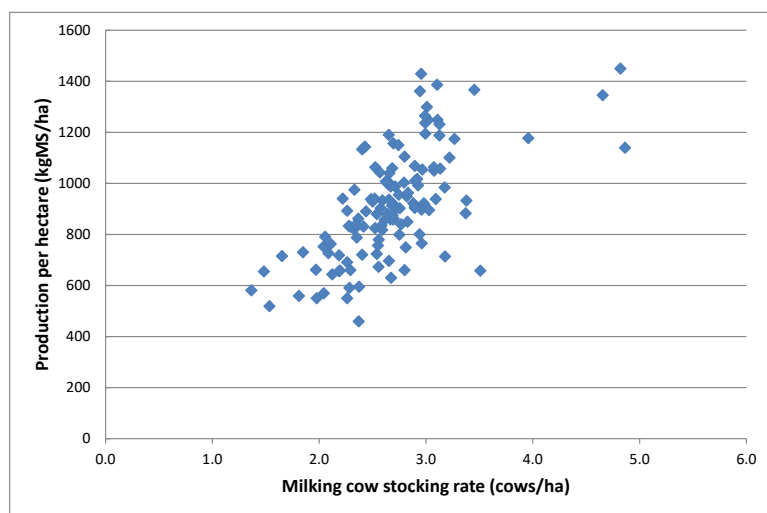


Figure 12. Milking cow stocking rate and nitrogen losses

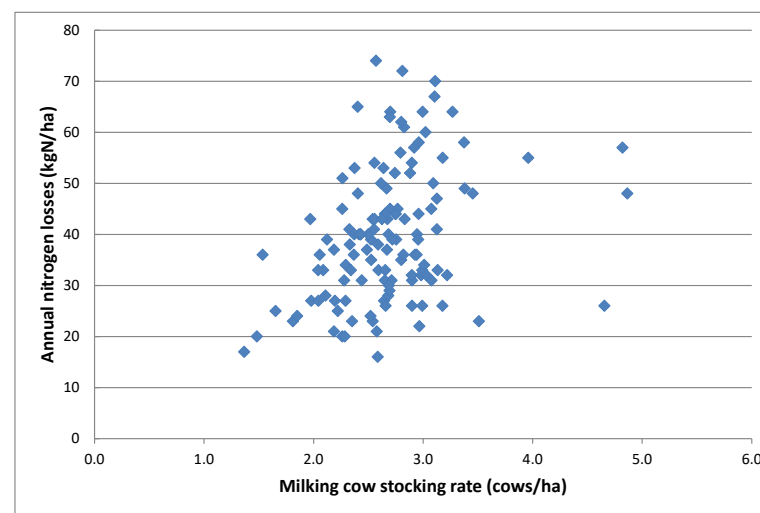
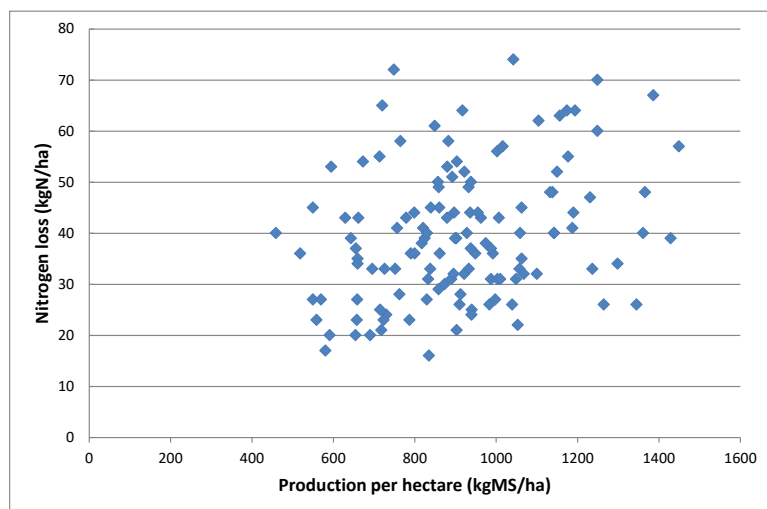
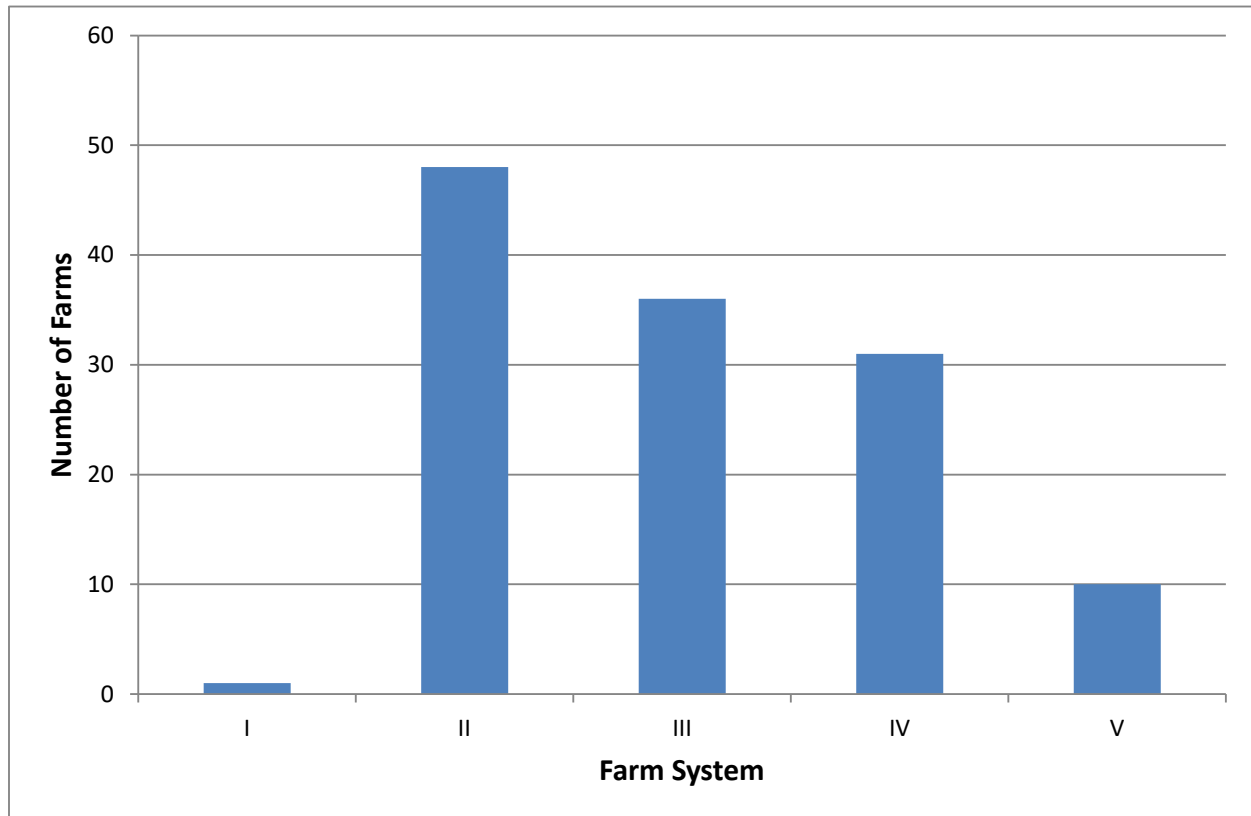


Figure 13. Production per hectare and nitrogen losses per hectare



The effects on the environment of dairy farming landuse is moderated through the farm management practices and the intensity of inputs used. DairyNZ has developed a typology of dairy systems that encapsulates some of these factors (Appendix C). The least intensive and most self-contained dairy systems (Type 1) only had one example in the catchment (Figure 14). Most farms were dairy systems II or III.

Figure 14. The percentage of dairy farms estimated to be operating in dairy systems I to V



The dairy systems III and IV in Figure 15 had very similar average milk production to each other (kgMS/ha/yr) and different from dairy systems II and V ($P > 95\%$). In Figure 16, all of the systems have similar nitrogen losses to each other, although system II has significantly lower nitrogen losses compared with systems IV and V but not system III ($P < 0.95$).

Figure 15. The relationship between dairy farm systems and milk production (kgMS/ha/yr)

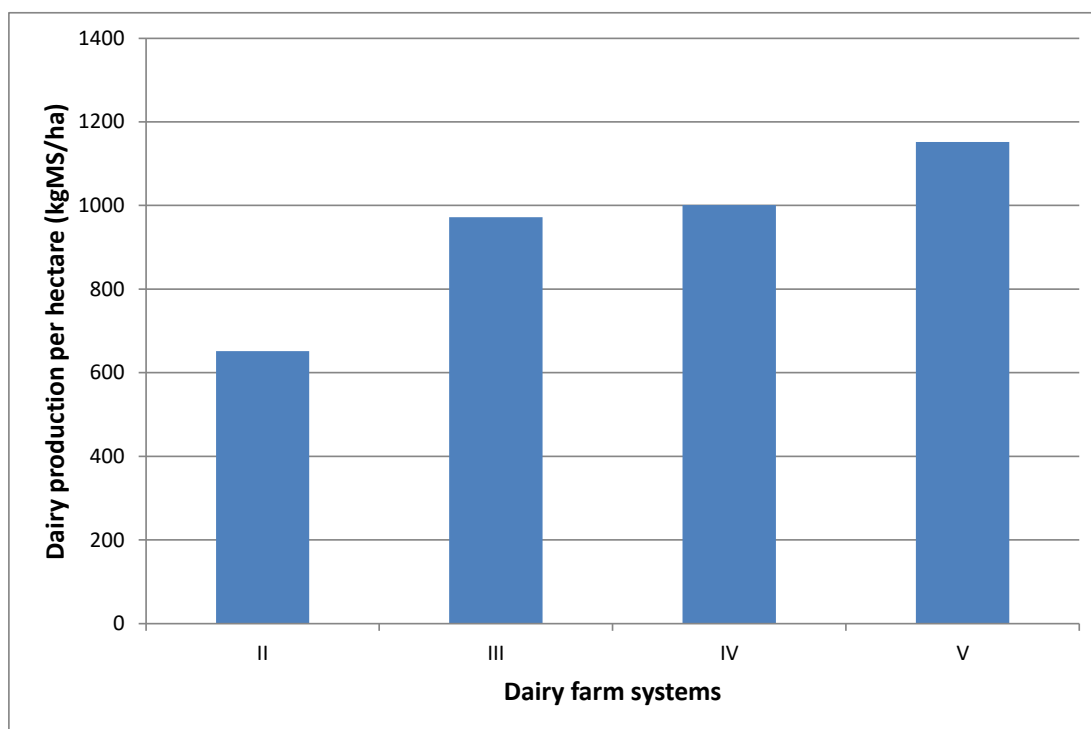
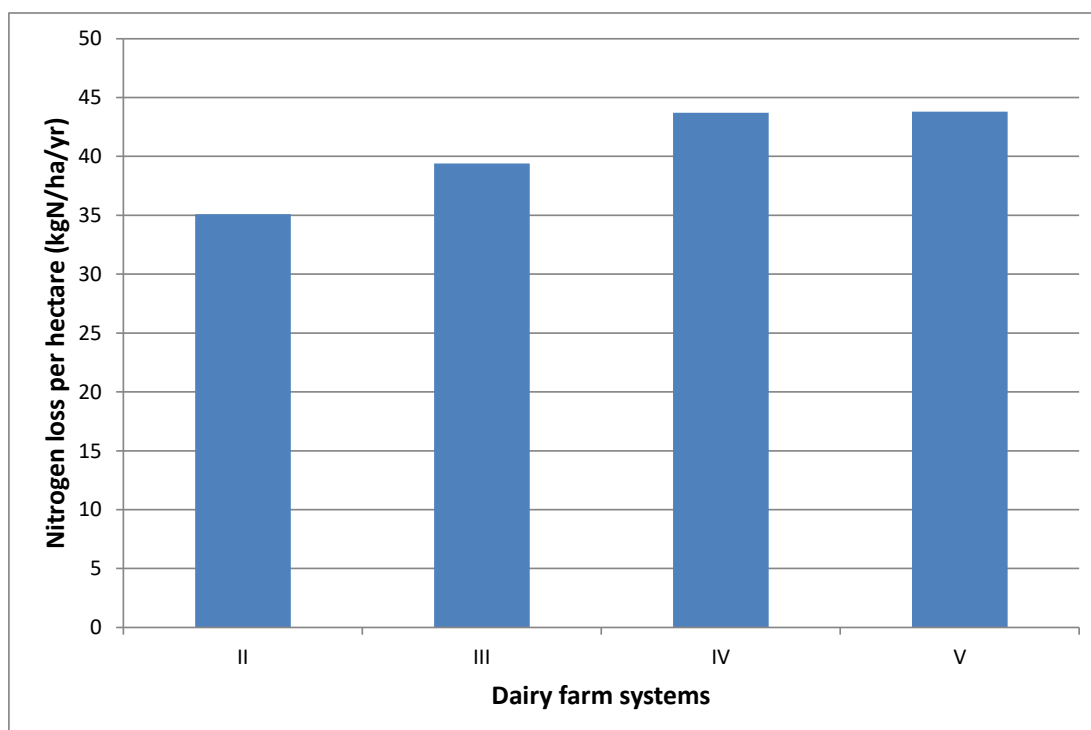


Figure 16. The relationship between dairy farm systems and nitrogen losses (kgN/ha/yr)



8. Cluster Analyses

All of the farms in the project database were entered into a cluster analysis to identify groups of farms that were similar enough to provide representative dairy farms for the Upper Manawatu River catchment¹³.

Cluster analyses are used widely in policy and marketing organisations to assist in recognising patterns and to analyse complex and large data bases¹⁴. The attributes used for clustering the farms in this study are shown in Table 2. For an understanding of the distribution of the main soil orders and dairy types referred to in this report go to Figures 10 and 14 respectively.

Table 2. Statistical data summary of the attributes contributing towards the cluster analysis (126 farms, 15 with irrigation)

Variable	Mean	Minimum	Median	Maximum	Included in Cluster Analysis
Size of milking platform (ha)	131	39	111	355	Yes
Average annual rainfall (mm/yr)	1346	1023	1298	1827	Yes
Percentage platform irrigated (%)	61	21	63	94	Yes
Peak number of milking cows	343	100	309	1110	No
Production per cow (kgMS/a/yr)	343	187	340	483	No
Stocking rate (cows/ha)	2.7	1.4	2.7	4.9	Yes
Production per area (kgMS/ha/yr)	915	459	902	1449	Yes
Percentage of feed imported (%)	18	1.0	16	54	Yes
One Plan nitrogen allocation 2014 ¹⁵ (kgN/ha)	22	14	22	27	Yes
Nitrogen loss to water (kgN/ha/yr)	40	16	39	44	Yes
Main soil order	54% brown				Yes
Dairy type	48% II				Yes

Taken from Tables 1 and 2 in Newman and Harvey 2018.

¹³ Newman & Harvey, 2018. Dairy Farm Cluster Analysis for Horizons Regional Council. A DairyNZ client report for KapAg Ltd

¹⁴ Joey Au, Andrew Coleman and Trudy Sullivan, 2015. A Practical Approach to Well-being Based Policy Development: What Do New Zealanders Want from Their Retirement Income Policies? New Zealand Treasury Working Paper 15/14. <http://www.treasury.govt.nz/publications/research-policy/wp/2015/15-14/twp15-14.pdf>.

¹⁵ From Table 14.2 and based on average LUC for farms. Flatter land as greater allocations, i.e. larger numbers

Some of the variables in Table 2 have very similar distributions and these correlations can unduly influence results. For that reason, in the Table, the “No” entries in the last column identifies those variables that were analysed but not included in the final clustering.

Every farm was included in the cluster analysis and they are all listed in Figure 17. The Figure (technically a dendrogram) shows all the unclustered farms (from 1 to 126) on the right and the connections between the farms to the left.

The length of the connections vertically within the clusters shows the degree of similarity of the farms within clusters. Within the clusters, the farms widely apart are more dissimilar than farms close together. The length of the connections horizontally in the Figure indicates the degree of connection between clusters. The connections on the left become increasingly weaker the further they are from the list of individual farms on the right.

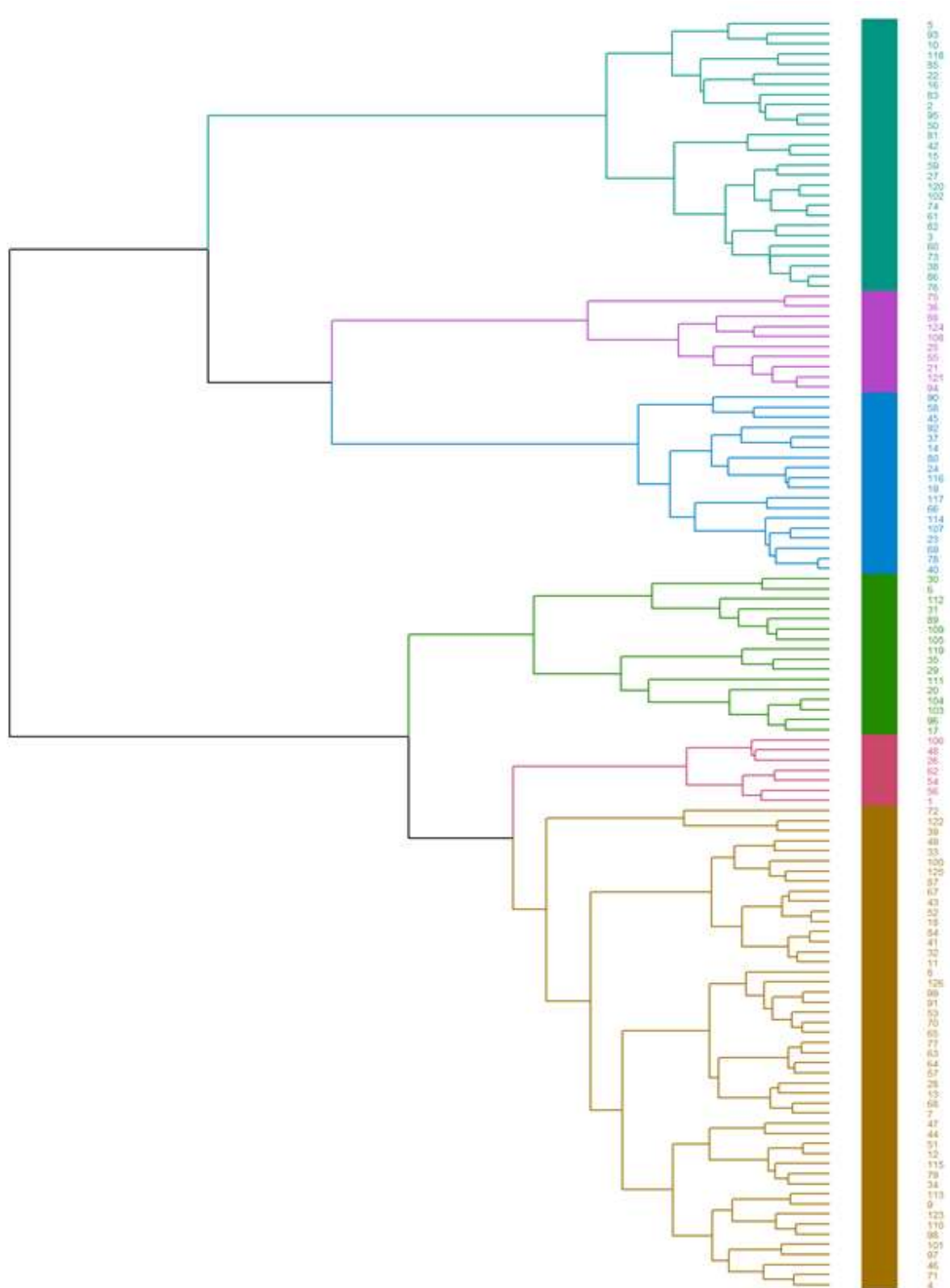
Figure 19 uses different colours to highlight six clusters with similar levels of connectivity across the population. In the Figure, increasing the levels of connectivity by moving one step towards the right increases the number of clusters from six to twelve. Decreasing the level of connectivity by one step to the left would decrease the number of clusters to two and lose a lot of the similarity within clusters. The six clusters are a compromise between being able to discriminate between different farms and the level of parsimony required for catchment scale analysis.

The selected six clusters contain the following numbers of farms and the colours can be found in Figure 17:

- Cluster 1. Teal green, twenty seven farms.
- Cluster 2. Purple, ten farms.
- Cluster 3. Blue, eighteen farms.
- Cluster 4. Green, sixteen farms.
- Cluster 5. Red, seven farms.
- Cluster 6. Brown, forty eight farms.

Cluster five only contains a limited number of farms and the six clusters were reduced to five clusters by combining clusters five and six. This addressed the relatively low number of farms in cluster 5.

Figure 17. A diagram of the results from clustering dairy farms in the Upper Manawatu River catchment



The descriptions of each of the five clusters are provided in Table 3. The first three clusters are of farms on the minority soil orders in the catchment: allophanic, recent and gley. Cluster 4 contains the farms in lower rainfall areas that are more intensively farmed than is general. Clusters 5&6 are farms on brown and pallic soils and are of a farm size often found in the catchment.

A median farm was identified within each one of the five clusters by calculating the medians for every farm and every attribute within each cluster. The farm nearest the centre of each cluster was identified as a representative farm for that cluster (Table 4). Together, these provide representative farms for the whole of the catchment in further catchment scale analyses. The resultant five representative farms meet the following criteria:

- Each of the representative farms is a “real farm” within the catchment¹⁶. They have not been synthesised or created by modelling.
- An objective and repeatable process has been followed to identify the representative farms.
- Each representative farm is closely related to the other farms in its cluster and dissimilar to the other representative farms in the other clusters.
- None of the representative farms represents an average for the catchment; instead they provide a measure of the variation between farming systems within the catchment.
- Collectively the representative farms approximate the median results for dairy farms in the catchment.
- Every farm in the catchment has a representative farm, “like them”.

¹⁶ Every effort has been made to keep farm owners’ identities confidential in this report.

**Table 3.** Clustering results for farms in the Upper Manawatu River catchment with their medians for selected attributes

Cluster	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
1	Allophanic	1376	116	370	327	896	III	40	0.9
2	Recent	1211	112	336	369	968	III	47	1.0
3	Gley	1241	99	256	340	917	II	26	1.3
4	Brown	1255	131	385	387	1136	IV	47	1.0
5&6	Brown & Pallic	1354	108	270	336	830	II	39	0.9
Median of cluster medians	NA	1190	95	220	305	829	III	43	1.5
All farms in the catchment	Brown	1298	111	309	340	902	II	39	1.0

Table 4. Representative farms for the Upper Manawatu River catchment selected from the median farms within each cluster

Cluster	Farm	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
1	16	Allophanic	1551	179	530	258	765	IV	58	0.9
2	25	Recent	1176	197	510	360	933	IV	33	1.8
3	14	Gley	1588	74	220	309	921	II	32	1.8
4	112 (irrigated)	Brown	1255	86	250	369	1068	III	32	0.8
5&6	54	Brown	1082	113	260	362	829	III	27	0.6
Median of representative farms		NA	1255	113	260	360	921	III	32	0.9
All farms in the catchment		Brown	1298	111	309	340	902	II	39	1.0

The five representative farms are described in summary form in Table 4. The farm numbers are not related to any on-farm identifier. Although the collective data from these farms contains some differences when compared with the overall results for farms within the catchment, the five farms provide the best way for a limited number of actual farms to represent the catchment.

Each of the clusters still contains a range of farming systems around the representative farms and this diversity is consistent with the diversity present in the original population. Tables 5 and 6 illustrate this by showing the diversity for two attributes: farm area (milking platform) and nitrogen losses. Individually the representative farms highlighted in the table include examples that are high and low for each attribute. Collectively the representative farms also approximate the median for the population.

Table 5. The percentage of farms within each cluster and the areas of their milking platforms (%). The coloured cells highlight the representative farm results.

Clusters	Farm Areas (ha)						Total (%)
	<100 ha	100-149 ha	150-199 ha	200-249 ha	250-299 ha	>299 ha	
1	41	22	26	4	7	0	100
2	30	40	20	10	0	0	100
3	50	28	22	0	0	0	100
4	31	25	13	6	19	6	100
5&6	38	35	15	7	2	4	100

Table 6. The percentage of farms within each cluster and their annual nitrogen losses (%). The coloured cells highlight the representative farm results.

Clusters	Annual Nitrogen Losses to Water (kgN/ha/yr)				Total (%)
	15-29 kgN/ha/yr	30-44 kgN/ha/yr	45-59 kgN/ha/yr	60-74 kgN/ha/yr	
1	4	59	30	7	100
2	10	40	30	20	100
3	67	28	6	0	100
4	0	44	25	31	100
5&6	27	49	18	5	100

Examining Table 6 shows that one representative farm (farm 54 from cluster 5&6) is within the lowest leaching quartile of farms (<31 kgN/ha/yr). Another representative farm (farm 16 from cluster1) is within the quartile with the highest losses of nitrogen to water (>48 kgN/ha/yr). Despite the large variation, there are no consistent differences in management between the five farms in Table 4 to explain the differences.

9. Assessment of Changes in Dairy Profitability from One Plan

Application of Table 14.2

In late 2017 the impact was assessed of nutrient allocations through Table 14.2 in the One Plan for dairy farms in the Upper Manawatu River catchment (Parminter 2018). That assessment was made using models of four dairy farming systems.

- A Self-contained farming system using limited inputs (Dairy Type II)
- A Low-intensity farming system using limited inputs (also Dairy Type II)
- A Moderate intensity farming system using a range of farm inputs (Dairy Type III)
- A High-intensity farming system that incorporated irrigation and a feed pad (Dairy Type IV)

In Table 7a and Table 7b the statistics for all the farms in the catchment are compared to the results for farms in the clusters and for the dairy farming system models in the 2018 report.

The dairy farming system models tended to be larger farms and all four were mainly on allophanic soils. The most intensive dairy farming system (system IV) has levels of production higher than the median results for any of the clusters.

In Table 8 the systems models are aligned with the clusters that they most approximate. Although the same process described earlier for selecting the representative farms was used for this process, the representative farms themselves were not used in this step. Two clusters can be associated with the Moderate intensity models. Cluster 5&6 can be associated with the medians of the Self-contained system and the Low-intensity system, so the only system model not applied is the High-intensity farming system.

In Table 8 the financial returns from the four farming systems reported in Parminter (2018) have been adjusted according to the median areas of the farms in each cluster. This assumes that the adjusted farms are able to maintain the integrity of their production systems and use the same management mitigations.

These results in Table 8 show that the dairy farms within the catchment would typically need to be prepared to reduce their annual operational profitability by \$600 to \$1,000 per hectare if they are to meet the year 20 allocations in Table 14.2 of the One Plan.

**Table 7a.** Clustering median results for farms in the Upper Manawatu River catchment

	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
All farms in the catchment	Brown	1298	111	309	340	902	II	39	1.0
Clusters									
1	Allophanic	1376	116	370	327	896	III	40	0.9
2	Recent	1211	112	336	369	968	III	47	1.0
3	Gley	1241	99	256	340	917	II	26	1.3
4	Brown	1255	131	385	387	1136	IV	47	1.0
5&6	Brown & Pallic	1354	108	270	336	830	II	39	0.9

Table 7b. Median results for farm systems in the Tararua District

	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
Farm system types									
Self-contained	Allophanic	1271	120	270	319	718	II	32	0.6
Low-intensity	Allophanic	1271	150	400	361	962	III	42	0.7
Moderate-intensity	Allophanic	1271	200	600	401	1203	III	54	0.7
High intensity	Allophanic	1174	200	640	440	1407	IV	64	0.8

Parminter 2018. An impact assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Region. A Client Report for Manawatu Wanganui Regional Council

Table 8. Financial Impact of Applying Table 14.2 (One Plan) to Dairy Farming Clusters in the Upper Manawatu River Catchment

Cluster	Number of farms affected	System Type	Median Milking Platform Area (ha)	Initial Farm Profit (\$)	Final Farm Profit (\$)	Reduction in Profit (%)
1	27	Self-contained	108	189,432	73,245	61
2	10	Low-intensity	116	276,769	159,326	42
3	18	Moderate-intensity	99	282,135	215,652	24
4	16	Moderate-intensity	131	373,968	285,845	24
5&6	55	Self&Low-intensity	112	226,826	115,756	49

Information taken from Table 4 in Parminter 2018. An impact assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Region. A Client Report for Manawatu Wanganui Regional Council

10. Conclusions

Dairying in the Upper Manawatu River catchment is a significant landuse within the catchment and within the Tararua District. An impact assessment of the nitrogen loss maximums in Table 14.2 has previously been carried out focussed on four of the main dairy systems being used in the District.

This report has identified that by undertaking a clustering analysis of almost all the farms in the catchment (95%), it has been possible to identify five representative farms for the catchment. These representative farms can now be used to carry out further assessments of policy options for natural resource management.

Information from the previous report and the 5-6 clusters themselves have been used to calculate the on-farm financial impacts of Table 14.2 across all the farms in this catchment.

Appendix A. Regional Description of Natural Resource Management

The Region's Catchments

The Manawatu Wanganui Region spans three major river catchments in the centre of the North Island. The largest catchment, the Whanganui River Catchment (7,380 km²) begins in Ruapehu District and extends 290 km south to Wanganui and the South Taranaki Bight. The Manawatu River Catchment (5,898 km²) begins on the East Coast of the North Island in the Tararua District and flows westward 235 km through the Manawatu Gorge to the Tasman Sea at the Horowhenua Coast. The Rangitikei River Catchment (3,948 km²) begins just south of Lake Taupo and flows 253 km along the length of the Rangitikei District to the Tasman Sea. In each catchment, the rainfall and soils can change markedly from the mountainous headwaters until they reach the river mouths.

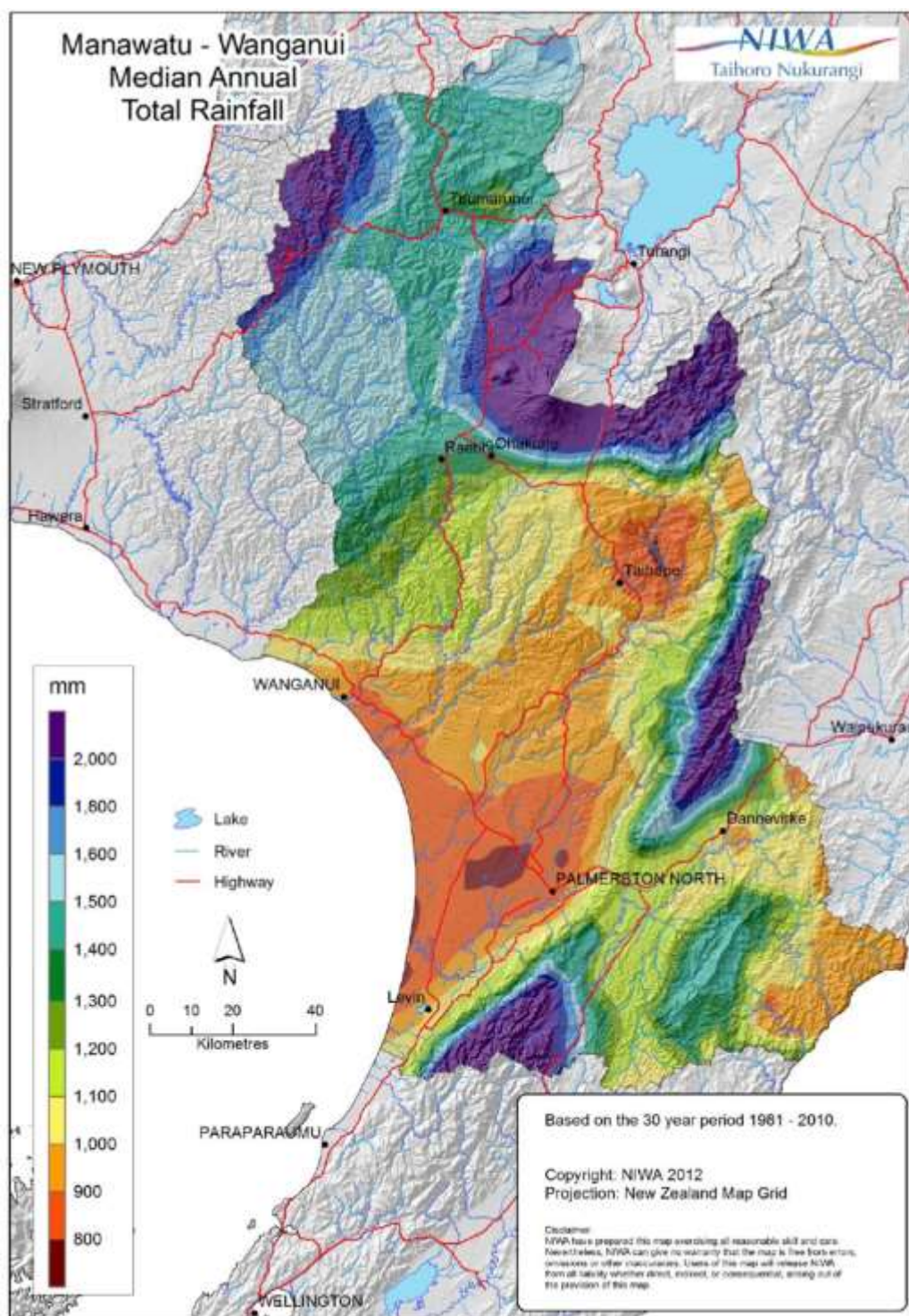
Regional Rainfall Distribution

The geographical distribution of annual total rainfall is shown in Figure 18. The headwaters of all three major rivers include hilly areas with annual rainfall over 2000 mm/yr. The coastal plains, where the three rivers flow into the Tasman Sea, receives less than 1000 mm/yr on average.

Regional Soil Distribution

The Region has a number of soil groups derived from volcanic rock, sedimentary rock (sandstone, mudstone and greywacke), organic material and sands (Figure 19). The *Allophanic soils* are formed from volcanic rock. They are found in the mountainous area to the north of the region. *Brown soils* formed from sedimentary rock and sands can be found across the Manawatu Plain, on river terraces and valley bottoms; under moderate rainfall. These soils have good water holding capacity and are generally free draining although that also means that they have high levels of nitrate losses when intensively farmed. *Pallic soils* are formed from the loess of windblown sedimentary rock that built up around the hills in the centre and to the east of the region. They are found on poorly drained terraces and have a water impeded sublayers of clay. When they are artificially drained, pallic soils can have high nitrate losses under intensive farming. *Organic (peat) soils* are formed from organic parent material. They are generally wet and poorly drained with high water storage. They have very low nitrate leaching. *Sandy Recent soils* along the west coast are generally well drained with moderate levels of nitrate leaching. *Orthic Recent soils* to the north west have high natural fertility, high plant-available water capacity and moderate levels of nitrate leaching.

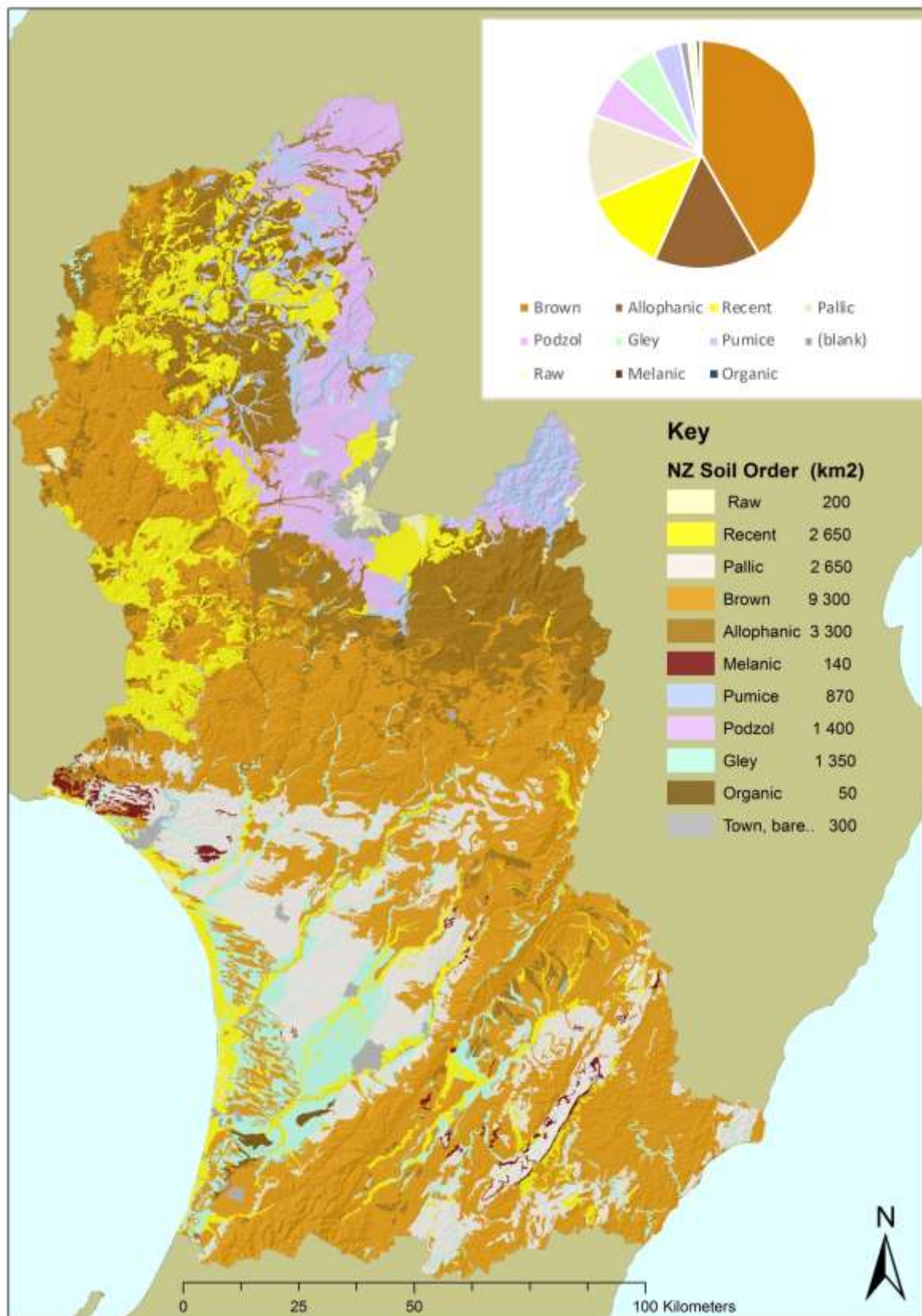
Figure 18. Median annual rainfall across the Manawatu Wanganui Region¹⁷



¹⁷ From a map of median annual total rainfall for the Manawatu-Wanganui Region, printed by Horizons Regional Council with permission from NIWA. Source NIWA report on the Climate and Weather of the Manawatu Wanganui Region (Chappel, 2015).

<http://www.horizons.govt.nz/HRC/media/Media/Agenda-Reports/Catchment-River-Management/16-16%20-%20Presentation%20NIWA%20-%20Annex%20A.pdf>

Figure 19. Manawatu Wanganui Regional soil groups



Water Quality in the Upper Manawatu River

The One Plan addresses surface water quality by establishing water quality targets for rivers and lakes, in order to give effect to the values associated by the Council with those waterways. The One Plan aims to maintain water quality in those Water Management Sub-zones that meet their water quality targets, and improve water quality over time, in those Water Management Sub-zones that do not.

The middle reaches of many rivers in the One Plan were considered “unsafe to swim in because of bacterial contamination, or are unpleasant to swim in because of slime (periphyton) growth. The slime also impacts on fish and instream invertebrate communities.” “The lower reaches of many rivers have high concentrations of bacteria, nitrates, phosphates and sediments, and these levels are increasing.”

“Nitrate levels are high in shallow groundwater in parts of the Region, but the levels have not changed during the period of monitoring.”

There are a number of values shared by all waterways in the catchments within the Tararua District (One Plan, Schedule B):

- Life supporting capacity
- Aesthetics
- Contact recreation
- Mauri
- Industrial abstraction
- Irrigation
- Stock water
- Existing infrastructure
- Capacity to assimilate pollution

Other values are zone specific. In the Tararua District the most common of these are:

- Natural state
- Sites of significance – aquatic
- Trout spawning
- Trout fishery, including some that are considered outstanding for the region
- Flood control and drainage

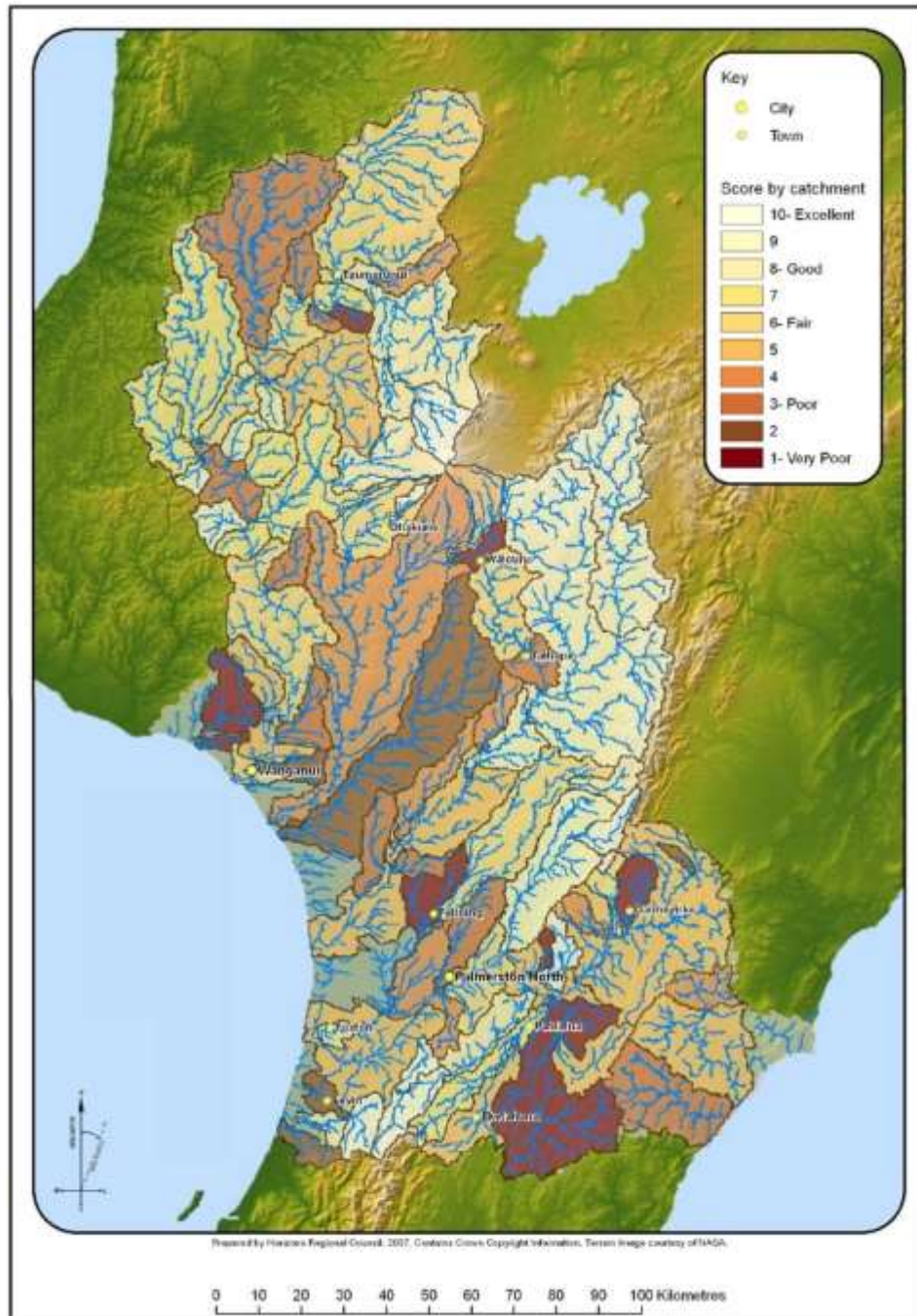
In the One Plan, the water quality standards associated with these values are listed in One Plan Schedule E.

A map of water quality in the Manawatu Wanganui Region is included in Chapter 5 of the One Plan. The map shows the distribution of water quality results relative to the value of ‘contact recreation’ in the first list of values above (shown here in Figure 20).

The map in Figure 20 highlights that for ‘contact recreation’, there is “very poor quality” water in the Mangatainoka, Mangapapa and Mangatera Streams, (all in the Tararua District) and associated with a number of land uses, including dairying.

According to LAWA, “the Mangatainoka at SH2 monitoring site sits within the [best] 25% of all lowland rural sites for visual clarity, dissolved reactive phosphorus and total phosphorus. It is within the [best] 50% of lowland rural sites for E. coli and ammoniacal nitrogen but is within the worst 50% for both measures of nitrogen shown on the website [total nitrogen and total oxidised nitrogen]”¹⁸.

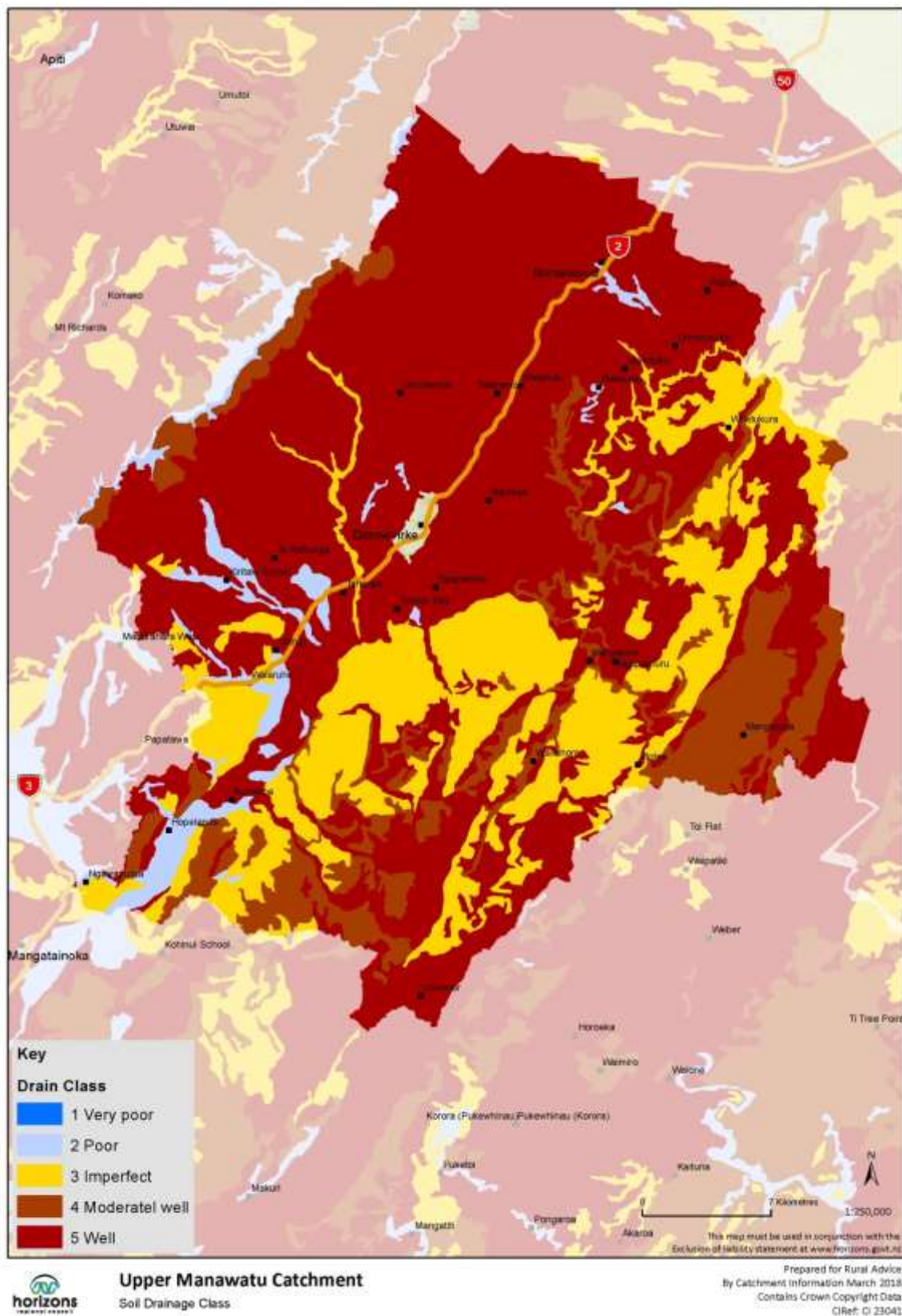
Figure 20. A map of the Manawatu Wanganui Region highlighting the water quality for contact recreation differences between sub-catchments



¹⁸ <https://www.lawa.org.nz/get-involved/news-and-stories/horizons-regional-council/2014/october/mangatainoka-river-of-the-month/> . Accessed February 2018.

Appendix B. Soil drainage classes

Figure 21. A map of the Upper Manawatu River catchment showing the distribution of drainage classes





Appendix C. Pasture-based dairy systems

The definition of the dairy farm systems used in this report has been developed from the systems described on page 24 of DairyNZ Facts & Figures.

Type of System	Imported Feed (%)	Dry cow grazing	Milking cow grazing	How imported supplements used
I	0%	On effective milking area	On pasture with some home-grown grass supplements	NA
II	1 - 10%	On effective milking area with imported supplements, crops and/or grazed-off	On pasture with some home-grown grass supplements	Wintering dry cows
III	11 – 20%	On effective milking area with imported supplements, crops and/or grazed-off	On pasture with some home-grown grass supplements and/or crops or imported supplements	Extending the lactation further into Autumn
IV	21 - 30%	On effective milking area with imported supplements, crops and/or grazed-off	On pasture with some home-grown grass supplements and/or crops or imported supplements	Extending both ends of the lactation (Spring and Autumn)
V	31 – 50% plus	On effective milking area with imported supplements, crops and/or grazed-off	On pasture with some home-grown grass supplements and/or crops or imported supplements	Used throughout the lactation

ATTACHMENT C



A Comparison of Changes to Nitrogen Loss Allowances on Dairying in the Upper Manawatu River Catchment

May 2018

Terry Parminter

A Comparison of Changes to Nitrogen Loss Allowances on Dairying in the Upper Manawatu River Catchment

May 2018

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This report would not have been possible without access to a large amount of regional and dairy industry information provided by staff at Horizons and DairyNZ.

The farm analyses were undertaken by Stefan Bryant of BakerAg, Scott Ridsdale of RD Consulting and myself. Never-the-less I take full responsibility for any remaining errors and any opinions that appear in this report.

The project was supervised by Tom Bowen and Lynette Baish at Horizons. Ian McNab (also with Horizons) has made some helpful suggestions along the way.

My thanks to all these people.

Summary¹

The dairy farms in the Upper Manawatu River catchment can be grouped into five clusters (Parminter 2017):

- Farm #1. These are farms predominantly on allophanic soils and they typically have an initial nitrogen loss of about 40kgN/ha/yr
- Farm #2. These are farms on primarily recent soils and they typically have an initial nitrogen loss of about 46kgN/ha/yr
- Farm #3. These are farms on gley soils and they typically have an initial nitrogen loss of about 26kgN/ha/yr
- Farm #4. These are farms on brown soils that are more intensively farmed than the others. They typically have an initial nitrogen loss of about 47kgN/ha
- Farm #5. These are farms on brown and pallic soils and they typically have an initial nitrogen loss of about 39kgN/ha/yr.

All these farms have slightly differing nitrogen cap trajectories to follow if they are to apply to Horizons Regional Council for a controlled landuse consent under the original Table 14.2 One Plan (2014) conditions. The on-farm implications of following that trajectory are compared in this report with a trajectory to meet the conditions in a revised Table 14.2(R).

There are just over about 20% of farms in the Upper Manawatu River catchment that are similar to Farm#1. As well as their initial nitrogen loss of 40kgN/ha/yr they typically have an initial operational profit of just under \$2,000/ha/yr. For Farm #1 to comply with the original Table 14.2 in the One Plan (2014) the results are expected to be:

- The farm continuing to make operational profits of \$1,000/ha or more
- At typical debt levels in the industry this farm would have to make greater than \$1,300/ha and so it could not meet the table and remain financially viable (see Parminter 2017 for more on industry debt levels)
- Whilst the calculations in Overseer® indicate that this farm system could be modified to operate within the nitrogen loss required in the table, Overseer calculations also indicate that it can only do so by operating in a nitrogen deficit, and this would not be sustainable beyond the short term²

For Farm #1 to comply with the proposed Table 14.2(R) the results are expected to be:

- The farm making an operational profit of over \$1,500/ha or more
- The farm has sufficient operational income to cover typical debt levels and remain financially viable
- The farm being able to sustainably achieve the nitrogen reductions required to operate with in its nitrogen cap

¹ A glossary follows.

² This is considered likely to be the situation when over one third of the pasture produced is being harvested and removed from the farm.

There are less than about 10% of farms in the Upper Manawatu River catchment similar to Farm #2. As well as their initial nitrogen loss of 46kgN/ha/yr they typically have an initial operational profit of just over \$2,000/ha/yr. For Farm #2 to farm within the nitrogen cap of the original One Plan (2014) Table 14.2 the result is expected to be:

- Having an operational profitability of over \$1,200/ha
- At typical industry debt levels this would enable the farm to meet its debt requirements (about \$1,100/ha)
- The farm can stay within the nitrogen caps but it has insufficient soil reserves to do so sustainably beyond the short term

For Farm #2 operating within the proposed Table 14.2(R):

- It would be able to make operational profits of \$2,000/ha or more
- This would enable most farmers like this farm to service their current debt
- From year twenty, in order to stay within the nitrogen cap, some pasture would need to be harvested and sold off-farm

There are about 15% of farms in the Upper Manawatu River catchment similar to Farm #3. As well as their initial nitrogen loss of 26kgN/ha/yr they typically have an initial operational profit of just over \$1,200/ha/yr. For Farm #3 to farm within the nitrogen cap of the original One Plan (2014) Table 14.2 it would:

- Have an operational profitability of generally over \$1,000/ha (Year 5 an exception)
- At typical industry debt levels this would enable the farm to meet its debt requirements of about \$900/ha
- The farm can stay within the nitrogen caps, but beyond Year 10 its soil nitrogen reserves become very low

For Farm #3 to operate within the proposed Table 14.2(R):

- It would make operational profits of more than \$1,200/ha
- This would enable most farmers to service their current debt
- It could meet the nitrogen caps sustainably over the long term

There are over about 10% of farms in the Upper Manawatu River catchment similar to Farm #4. As well as their initial nitrogen loss of 47kgN/ha/yr they typically have an initial operational profit of just over \$3,000/ha/yr. The consequences of the farming system in Farm #4 being modified to achieve the nitrogen caps in the original Table 14.2 are:

- Operating profit each year is expected to be above \$1,500/ha
- At typical debt levels in the industry (about \$1,300/ha) the farm can remain financially viable
- The farm can achieve the nitrogen cap in the original Table 14.2 and do so sustainably

If Farm #4 complies with the nitrogen cap in Table 14.2(R) there are expected to be the following consequences:

- Operating profits are expected to be greater than \$1,500/ha
- Typical debt levels can be serviced
- The farm can sustainably achieve the nitrogen cap

The largest group of farmers within the catchment are represented by Farm #5 (45%). As well as their initial nitrogen loss of 39kgN/ha/yr they typically have an initial operational profit of just over \$1,500/ha/yr. For Farm #5 complying with the original Table 14.2 in the One Plan (2014) would result in:

- The farm only just clearing its operational expenses with an annual profit of less than \$500/ha. Income from an alternative land use (or other source of income) is necessary for this farm to remain profitable
- Typical debt payment levels in the industry would be more than \$1,000/ha for this farm. Farm #5 would not be able to meet the nitrogen caps in the original table and remain financially viable
- Whilst the calculations in Overseer® indicate that this farm system could be modified to operate within the nitrogen loss required in the table, it is only possible by running less than 1cow/ha and harvesting about half the pasture for off-farm sale

For Farm #5 to comply with the proposed Table 14.2(R) the result would be:

- The farm making an operational profit of over \$1,000/ha or more
- The farm having just enough operational income to cover typical debt levels in the industry and remain financially viable
- The farm would be able to sustainably achieve the nitrogen reductions that are required to operate within its nitrogen cap

In conclusion, the group of Cluster Farms representing about 65% of dairy farms in the Upper Manawatu River catchment are not financially viable after management practices have been introduced to enable them to operate within the original nitrogen cap of Table 14.2 in the One Plan (2014). A greater number of farms would only be able to operate within the nitrogen cap by depleting their soil nitrogen reserves. That situation would not be sustainable over time.

If the revised Table 14.2(R) is introduced all Cluster Farms are able to remain financially viable although Farm #5 could not service high levels of debt. Farm #2 is expected to continue running down its nitrogen reserves in order to operate within Table 14.2(R).

This study highlights the importance of continued improvements in production per cow within the industry. There are benefits from also improving nitrogen efficiency on-farm so that low-loss systems become more sustainable. The study reinforces the opportunities for off-farm winter grazing of cows and providing them with sheltered feed pads or barns. The latter topic has been developed already in Parminter (2017).

1. Glossary

Clustering: farm systems are very diverse and at a catchment scale it is hard to capture both the consistency and diversity of their operation. This study has drawn upon previous research that has established that there are five clusters of farm types within the Upper Manawatu River catchment. The farms within each cluster are more similar to each other than the farms in any other cluster and taken together the clusters can be used (as here) to ensure that all the farms in the catchment have contributed towards the analytical results.

Nitrogen loss: these are the losses of nitrogen from farm systems calculated in Overseer. They are principally as losses of ammonia into the atmosphere and nitrate into waterways.

Nutrient sustainability: ... nutrients are removed from farms by selling products, exporting waste material and losses to air and to water. These losses are replaced by “importing” feed stuffs, fertiliser (artificial and organic), nutrient transfer (e.g. rain), nutrient fixation (e.g. clover rhizobium) and nutrient reserves in plant material and organic and inorganic soil reserves. The nutrient status of a farm may become unsustainable if the plant and/or soil reserves are in deficit.

Off-farm sales of pasture: ... as stocking rates are reduced it becomes more difficult for farmers to maintain first the quality of their pastures, then the quantity of pasture production, and finally pasture composition. In this study, surplus and potentially uncontrolled pasture was harvested and sold off-farm. Selling pasture provides a way of efficiently “exporting” nitrogen from the farm but is unlikely to be a very profitable landuse, particularly if it is widely practiced. There may also be other landuse options such as growing arable crops on part of the farm.

Operational profit: this is the gross income of the farming business from which the cash costs of generating that income have been deducted. It has not included the owner’s salary or drawings, tax, depreciation or costs of borrowing.

Overseer®: is a computer software model that estimates nutrient use and movement within a farm system. In the One Plan (2014) the use of Overseer is the prescribed way of producing required nutrient management plans. Although Overseer is best suited to modelling stable farming systems in equilibrium, in this study it has been used to describe farm systems in transition. In particular any delayed or lagging effects from earlier farm systems have not been accounted for.

Table 14.2: can be found in the One Plan (2014) where it is associated with Policy 14-5, and Rules 14-1 and 14-2 requiring consents for existing intensive farming landuse activities, as well as Rule 14-3 for new intensive farming landuse activities. Table 14.2 establishes the cumulative nitrogen leaching maximum values for intensive farming in the Manawatu Wanganui Region. The values have been established according to principles of “natural capital” and are based on Land Use Capability Classes and intervals of 5-10 years. The change in values between years is described in this report as a “nitrogen cap trajectory”.

Table 14.2 (R): this table is a revision of the original Table 14.2 to account for changes in Overseer over time, but still to address the same catchment objectives and policies.

2. Purpose

The purpose of this report is to assess and compare two tables of nitrogen leaching maxima for dairy farms in the Upper Manawatu River catchment, using representative farming clusters from previous research.

Table 1 is drawn from Chapter 14 of the One Plan (2014). Table 2 is a possible revision of the original table to reflect changes in versions of Overseer®. It has been drawn from Hanly, Hedley and Horne, 2018 “Sensitivity of values in Table 14.2 of the ‘One Plan’ to a change in the version of OVERSEER: Part B: Recalculation of the nitrogen (N) transmission coefficient using N loss to water estimates from the current version of OVERSEER® (v6.2.3)”.

Table 1. Original cumulative nitrogen leaching maximums by land use capability class (LUC), taken from Table 14.2 of the Manawatu Wanganui One Plan (kgN/ha/yr)

	LUC I	LUC II	LUC III	LUC IV	LUC V	LUC VI	LUC VII	LUC VIII
Year 1	30	27	24	18	16	15	8	2
Year 5	27	25	21	16	13	10	6	2
Year 10	26	22	19	14	13	10	6	2
Year 20	25	21	18	13	12	10	6	2

Table 2. Revised cumulative nitrogen leaching maximums by land use capability class (LUC), taken from Table 14.2 of the Manawatu Wanganui One Plan (kgN/ha/yr)

	LUC I	LUC II	LUC III	LUC IV	LUC V	LUC VI	LUC VII	LUC VIII
Year 1	50	44	36	26	23	22	11	3
Year 5	45	41	32	23	19	15	8	3
Year 10	43	36	29	20	19	15	8	3
Year 20	42	34	27	19	17	15	8	3

3. Background

There are two previous reports in this series and that are referred to in this report. The first report, “An Impact Assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Wanganui Region, August 2017” describes the impact that applying the original rules in the One Plan on nitrogen allocation could have on dairy farming systems in the Tararua District. Four farming systems were described:

- A self-contained dairy farm system model that started with leaching 32 kgN/ha and was then modified to be leaching only 18 kgN/ha, a reduction of 44%. These changes reduced the expected farm profit from \$1,627/ha to \$629/ha, a drop of over 60%. The return on assets dropped from 5.3% to 2.0%. About 10% of farms in the Upper Manawatu Catchment are tending towards this type of farming system.
- A model of a low-intensity dairy farm system that started with leaching 42 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of 60%. These changes reduced the expected farm profit from \$1,848/ha to \$1,064/ha, a drop of over 40%. The return on assets dropped from 6.4% to 3.7%. About 30% of farms in the Upper Manawatu Catchment are tending towards this type of farming system.
- A moderate-intensity dairy farm system that started with leaching 54 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of almost 70%. These changes reduced the expected farm profit from \$2,283 /ha to \$1,745/ha, a drop of almost 25%. The return on assets dropped from 7.0% to 5.0%. About 25% of farms in the Upper Manawatu Catchment are tending towards this type of farming system.
- A high-intensity dairy farm system that started with leaching 64 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of over 70%. These changes reduced the expected farm profit from \$2,456/ha to \$1,850/ha, a drop of 25%. The return on assets dropped from 6.8% to 4.8%. About 25% of farms in the Upper Manawatu Catchment are tending towards this type of farming system.

An additional report produced in 2017 on dairying in the Tararua District was prepared by Barry Riddler of Kikorangi Farm Systems Analysis on “The feasibility of nutrient leaching reductions (N leaching) within the constraints of minimum impact on the profitability and production of three dairy farms in the Horizons Region”. Its purpose was, “to determine if it was possible for a dairy farm in a sensitive catchment to have acceptable N leaching and make a profit using a whole-farm modelling approach.” This report addressed the three pasture-based farming systems in Pariminter 2017 and came to similar conclusions. These were that requiring all remaining dairy farms in the Tararua District to achieve the 20 year targets in Table 14.2 would result in many of them being no-longer economically viable. The report by Riddler also showed that even if typical dairy farms in the Tararua District operated above the nitrate leaching limits in Table 14.2, they were still able to achieve considerable reductions in nitrate losses and these were expected to be at little cost to each of the three farm systems. Riddler’s report expressed a need for further research to be undertaken so that future impact analyses could use farm models that were more representative of farms in the Tararua District.

The second report by Pariminter, “Selecting Representative Dairy Farms for the Upper Manawatu River Catchment, March 2018” described the results of applying a process identifying the attributes

of farms suitable for representing those in the Upper Manawatu River catchment in the Tararua District.

In Table 3 all the dairy farms in the Catchment on the basis of their individual attributes, have been associated with one of five different clusters. The first three clusters contain farms on the minority soil orders in the catchment: allophanic (27 farms), recent (10 farms) and gley (18 farms). Cluster 4 contains the farms in lower rainfall areas that are more intensively farmed than is general (16 farms). Cluster 5 has farms on both brown and pallic soils and are of a farm size and system intensity often found in the catchment (55 farms).

Although the median values in Table 3 are middle values for the farms within each cluster, when they are all taken together they also represent the distribution of attribute values for the farms in the whole population of dairy farms in the Upper Manawatu River catchment. This is highlighted in Tables 4 and 5 for two example attributes.

Examining Table 4 shows that the cluster medians for milk solids production per hectare are spread across all quartiles except for the first quartile (where 25% of the farmers are).

Examining Table 5 shows that the cluster medians for nitrogen losses are spread across all quartiles except for the last quartile (where 25% of farmers are).

Table 3. The five farming clusters and the attribute medians used to describe all the dairy farms in the Upper Manawatu Catchment

Cluster	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Pasture Consumption (kgDM/ha/yr)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
1	Allophanic	1,376	116	370	327	896	III	10,513	40	0.9
2	Recent	1,211	112	336	369	968	III	10,903	46	1.0
3	Gley	1,241	99	256	340	917	II	10,843	26	1.3
4	Brown	1,255	131	385	387	1,136	IV	10,195	47	1.0
5	Brown & Pallic	1,354	108	270	336	830	II	9,520	39	0.9
Median of cluster medians	NA	1,190	95	220	305	829	III	10,513	43	1.5
Medians of all farms in the catchment	Brown	1,298	111	309	340	902	II	10,092	39	1.0

Taken from page 26 of Parminter, March 2018

Table 4. The percentage of farms from each cluster within each quartile for milk solids production per hectare. The coloured cells highlight the median results for each cluster.

Clusters	Annual production of milk solids (kgMS/ha/yr)				Total (%)
	459-761 kgMS/ha/yr	761-902 kgMS/ha/yr	902-1050 kgMS/ha/yr	1050-1449 kgMS/ha/yr	
1	18	33	19	30	100
2	-	20	40	40	100
3	28	17	33	22	100
4	-	13	6	81	100
5	39	28	26	7	100

Table 5. The percentage of farms within each cluster and their annual nitrogen losses (%). The coloured cells highlight the representative farm results.

Clusters	Annual Nitrogen Losses to Water (kgN/ha/yr)				Total (%)
	15-29 kgN/ha/yr	30-44 kgN/ha/yr	45-59 kgN/ha/yr	60-74 kgN/ha/yr	
1	4	59	30	7	100
2	10	40	30	20	100
3	67	28	6	0	100
4	0	44	25	31	100
5	27	49	18	5	100

4. Approach

The median figures from the five clusters of farms in the Upper Manawatu River catchment (shown in Table 3) were used to establish five model farms in Overseer® 6.3.0. Using the information in Table 1 (this report) the models were then matched to the nitrogen loss trajectory that they would be required to meet in order for them to obtain a controlled consent according to the One Plan (2014). Following that and starting from the same initial farm setup the farms were again matched to a nitrogen loss trajectory, this time from Table 2 (this report). The results of the two differing trajectories have been summarised and compared.

Three farm consultants from three different consultancy companies worked collaboratively to bring together the information in this report. The decision protocols were initially established at a joint meeting. The analyses for the five farms were then carried out with each consultant working separately and independently. Then finally all the results from the analyses were brought together and calibrated.

5. Initial Farm Results

The initial farm attributes for each of the cluster farms is shown in Table 6 along with the medians that were used to create them. There were over twice as many inputs as are shown here. The medians did not come from one farm and the Cluster Farm results haven't always matched them. A decision making protocol was used to ensure that coherent farming systems were developed for each of the cluster farms and entered into Overseer®. In consecutive order the steps were:

- Locate the farm according to median rainfall, soil types and topography (LUC).
- Match the area of the milking platform and the peak number of milking cows with the cluster medians. Use cow stocking rate median to adjust this up or down, always staying between the median and the average attribute results for the cluster.
- Match the production per cow, the imported supplements and the fodder crop yields to the median results. Adjust these up or down, always staying between the median and the average for the cluster.
- Add nitrogen fertiliser and calculate nitrogen loss to water. Adjust the farming system to match the nitrogen loss median.

After the initial farming systems had been established, a profit and loss account was drawn up for each farm (see Appendix A for an example). These were based on farm accounts for farms with these systems and known to each of the consultants doing the work. Each line item in each account was adjusted in a standard way for each farm based on their area, stocking rate, and milk production. Any changes introduced to each farm resulted in financial changes that followed a consistent protocol for all the farms.

Table 6. Cluster medians and farm results for selected attributes compared

Cluster and Farm Number	Number of farms	Effective area of milking platform (MP ha)	Runoff area (RO ha)	Peak number of milking cows	Milk production from MP (kgMS/ha/yr)	Production from cows (kgMS/cow/yr)	Proportion of imported feed (%)	Nitrogen fertiliser (kgN/ha/yr)	Nitrogen losses to water (kgN/ha/yr)
#1 medians	27	116	-	370	896	327	0.12	70	40
#1 farm		116	0	340	942	321	0.15	69	40
#2 medians	10	112	-	336	968	369	0.22	64	46
#2 farm		112	40	336	1107	369	0.14	70	45
#3 medians	18	99	-	256	917	340	0.13	66	26
#3 farm		99	40	256	880	340	0.13	70	28
#4 medians	16	131	-	385	1136	387	0.28	99	47
#4 farm		131	35	385	1137	385	0.19	105	46
#5 medians	55	108	-	270	830	336	0.16	55	39
#5 farm		108	0	270	840	336	0.13	58	39
All farms	126	111	-	309	902	340	0.16	62	39
Cluster farms' weighted averages		112	-	303	926	342	0.14	69	39

6. Mitigation Steps

The mitigations introduced to each farm model followed those outlined in the early report (Parminter 2017). The operational changes were introduced first. These were changes in management that can be introduced within production seasons. All farms were required to make the following operational changes:

- Remove all nitrogen fertiliser applications from the effluent application area.
- Remove winter applications of nitrogen (April to July inclusive).
- Reduce annual nitrogen applications to 70kgN/ha per year or less. This figure was set based on the population median shown in Table 6.
- Aggressively cull non-pregnant and poor performing cows by moving their cull-date one month earlier from April into March (17% of herd).
- Replace high-protein imported feeds with low-protein. In particular replacing grass supplements with maize silage.
- Remove all nitrogen applications except for one application in Spring, if required. Reduce herd numbers to balance.

After that system changes were introduced. The scale of these changes varied with each farm and version of Table 14.2.

- The effluent treatment field was increased to reduce effluent applications to the equivalent of 100 kgN/ha/yr. This required a capital investment.
- Irrigation applications (on Cluster Farm #4) were optimised to reduce drainage.
- Graze off-farm (and out of catchment) rising 2yr heifers and weaned calves. Graze off-farm dry cows although if it was possible, retain at least 0.5 cows/ha for winter grazing on the milking platform. Increase pasture conserved to maintain pasture production and reduce imported feed.
- Shorten lactation length first to 10th May and reduce herd numbers. Increase pasture conserved to maintain pasture production and reduce imported feed.
- Shorten lactation length to 30th April and reduce herd numbers. Increase pasture conserved to maintain pasture production and reduce imported feed.

As milking cow numbers were reduced whilst feed supply was maintained it was expected that milk production per cow would increase. The detail on those calculations is shown in Appendix B.

There was no investment made into feed-off pads and cow housing. It was assumed that Cluster Farm #2 and Cluster Farm #4 with Type IV systems would have had facilities to provide these however that was not included in the Overseer analyses. For more information about the effects of Type IV systems refer to the earlier report (Parminter 2017).

7. Results for Cluster Farm #1

The assumptions made to establish Cluster Farm #1 are shown in Table 7. All the results shown in the Table were drawn from the specific Overseer file before any potential changes had been made. The Table describes the structure of the farm, the parameters of the dairy herd, and how the dairy herd was being fed. On the basis of these inputs the next parts of Table 7 describe the nutrient losses to the environment and the financial results for a farm owner.

The next tables in this report describe the results for Farm #1 of making management changes to meet the nitrogen caps in Table 14.2 of the One Plan (2014) and in the revised Table 14.2(R). To meet both tables, cow numbers were reduced and to achieve the original table the lactation length was shortened by 10 days. The original table of nitrogen losses required removing the forage crop over summer and there was a small increase in the amount of imported feed required. The original table required that all the non-lactating cows were grazed off-farm (and out of the catchment) over winter.

Table 8 and Table 9 are summaries of the farming system results. The changes in these Tables are sufficient for the farmers involved to apply to Horizons Regional Council for a controlled consent (as long as they were also meeting all the other requirements in the One Plan (2014)).

Table 10 and Table 11 are the farming system results projected for year 20 applying the One Plan (2014) Table 14.2 and Table 14.2(R) respectively.

For Farm #1 complying with the original Table 14.2 in the One Plan (2014) would result in:

- The farm continuing to make operational profits of \$1,000/ha or more
- At typical debt levels in the industry this farm would have to make greater than \$1,300/ha and so it could not meet the table and remain financially viable (see Parminter 2017 for more on industry debt levels)
- Whilst the calculations in Overseer® indicate that this farm system could be modified to operate within the nitrogen loss required in the table, Overseer calculations also indicate that it can only do so by operating in a nitrogen deficit, and this would not be sustainable beyond the short term³

For Farm #1 to comply with the proposed Table 14.2(R) the results are expected to be:

- The farm making an operational profit of over \$1,500/ha or more
- The farm has sufficient operational income to cover typical debt levels and remain financially viable
- The farm being able to sustainably achieve the nitrogen reductions required to operate with in its nitrogen cap

³ This is considered likely to be the situation when over one third of the pasture produced is being harvested and removed from the farm.

Table 7. Farm #1 initial year farming system results

INFRASTRUCTURE					
Farm Area	122 ha	Milking platform	116 ha	Runoff area	0 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		18 ha
Rainfall	1351mm/yr	Irrigation system	N/A		
Soils	70ha	Dannevirke s.l.	Capital fert 31-51-09		
	46ha	Matamau s.l.	28-46-19		
HERD					
340 cows	68 replacements (grazed off for 18 months from 3 months of age)		Cow wintering	Half the herd grazed off-farm for 3 months	
Calving date	16 th August		Drying off date	10 th May	
109,269 kgMS	942 kgMS/ha MP		321 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			12,540 kgDM/ha/yr		
Imported feed			104 T DM – 50:50 PKE and silage	12 %	
Winter forage crop			N/A		
Summer forage crop			6 ha	Turnips	9 T/ha yield
NUTRIENTS					
Clover nitrogen	148 kg/ha	Fertiliser nitrogen – Aug, Nov, Apr.		68 kg/ha	
Other nitrogen	21 kg/ha	Available nitrogen		237 kg/ha	
Surplus nitrogen	177 kg/ha	Nitrogen conversion efficiency		26 %	
Lost nitrogen to water	41 kg/ha	Phosphorus losses		0.7 kg/ha	
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$710,249	Gross Farm Income		\$758,229	
Farm working expenses	\$522,321	Operational profit		\$235,908	
Farm working expenses	\$4.78/kgMS	Profit per eff. hectare		\$1,934	
Capital adjustment	0	Capital adjusted profit		\$235,908	

Table 8. Summary for Farm #1 of changes between years in One Plan Table 14.5

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	116				
Total Cows	340	230	180	150	150
Stocking Rate (cows/ha)	2.9	2.0	1.6	1.3	1.3
Stocking Rate (SU/ha)	24.3	14.6	14.4	12.7	12.0
Farm Labour (FTE)	2.5	2.0	1.5	1.5	1.5
Nitrogen Leaching	41	22	19	17	16
Pasture Consumption	12540	8056	6386	5417	5313
Production (kgMS/cow)	321	316	329	349	370
Production (kgMS/ha)	942	626	511	451	478
Total Milksolids (kgMS/yr)	109,269	72,616	59,220	52,350	55,500
Milk as a proportion of farm income (%)	94	87	81	79	79
Gross Farm Income	\$758,229	\$541,804	\$474,070	\$431,395	\$459,220
Farm Working Expenses	\$523,876	\$431,746	\$376,351	\$342,975	\$353,342
Operational profit	\$234,352	\$110,058	\$97,719	\$88,420	\$105,878
Capital Adjustments	-	\$20,676	\$29,095	\$33,796	\$31,971
*Surplus / Deficit	\$234,352	\$130,734	\$126,814	\$122,216	\$137,848
Profit per unit area (\$/ha)	\$1,934	\$902	\$765	\$724	\$868

**No drawings, depreciation, tax or principal payments included*

Table 9. Summary for Farm #1 of changes between years in Table 14.5(R)

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	116				
Total Cows	340	325	270	250	235
Stocking Rate (cows/ha)	2.9	2.8	2.3	2.2	2.0
Stocking Rate (SU/ha)	24.3	22.7	19.7	18.3	18.1
Farm Labour (FTE)	2.5	2.5	2.0	2.0	2.0
Nitrogen Leaching	41	32	28	25	24
Pasture Consumption	12540	11926	10392	9605	9488
Production (kgMS/cow)	321	325	340	360	400
Production (kgMS/ha)	942	911	791	776	810
Total Milksolids (kgMS/yr)	109,269	105,625	91,800	90,000	94,000
Milk as a proportion of farm income (%)	94	94	92	90	91
Gross Farm Income	\$758,229	\$732,863	\$650,010	\$648,220	\$671,920
Farm Working Expenses	\$523,876	\$500,325	\$454,341	\$455,754	\$447,684
Operational profit	\$234,352	\$232,537	\$195,669	\$192,466	\$224,236
Capital Adjustments	-	\$2,413	\$11,401	\$13,701	\$13,821
*Surplus / Deficit	\$234,352	\$234,950	\$206,167	\$206,167	\$238,057
Profit per unit area (\$/ha)	\$1,921	\$1,906	\$1,604	\$1,578	\$1,838

**No drawings, depreciation, tax or principal payments included*

Table 10. Farm #1 year 20 farming system results for One Plan table 14.2

INFRASTRUCTURE					
Farm Area	122 ha	Milking platform	116 ha	Runoff area	0 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		27 ha
Rainfall	1351mm/yr	Irrigation system	N/A		
Soils	70ha	Dannevirke s.l.	Capital fert 31.51.9		
	46ha	Matamau s.l.	28.46.19		
HERD					
160 cows	30 replacements (grazed off for 18 months from 3 months of age)		Cow wintering	All the herd grazed off-farm for 3 months	
Calving date	16 th August		Drying off date	30 th April	
64,000 kgMS	478 kgMS/ha MP		370 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			6,128 kgDM/ha/yr		
Imported feed			N/A		11 %
Winter forage crop			N/A		
Summer forage crop			N/A		
NUTRIENTS					
Clover nitrogen		152 kg/ha	Fertiliser nitrogen – Nov		18 kg/ha
Other nitrogen		2 kg/ha	Available nitrogen		172 kg/ha
Surplus nitrogen		44 kg/ha	Nitrogen conversion efficiency		74 %
Lost nitrogen to water		16 kg/ha	Phosphorus losses		0.5 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)		\$360,750	Gross Farm Income		\$459,220
Farm working expenses		\$353,342	Operational profit		\$105,878
Farm working expenses		\$5.52/kgMS	Profit per total hectare		\$868/ha
Capital adjustment		\$31,971	Capital adjusted profit		\$137,848

Figure 11. Farm #1 year 20 farming system results for table 14.2(R)

INFRASTRUCTURE					
Farm Area	122 ha	Milking platform	116 ha	Runoff area	0 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		18 ha
Rainfall	1351mm/yr	Irrigation system	N/A		
Soils	70ha	Dannevirke s.l.	Capital fert 31-51-09		
	46ha	Matamau s.l.	28-46-19		
HERD					
340 cows	68 replacements (grazed off for 17 months from 3 months of age)		Cow wintering	Half the herd grazed off-farm for 3 months	
Calving date	1 st August		Drying off date	10 th May	
109,269 kgMS	718 kgMS/ha MP		319 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			7,710 kgDM/ha/yr		
Imported feed			104 T DM – 50:50 PKE and silage	15 %	
Winter forage crop			N/A		
Summer forage crop			6 ha	Turnips	9 T/ha yield
NUTRIENTS					
Clover nitrogen	148 kg/ha		Fertiliser nitrogen – Aug, Nov, Apr.		68 kg/ha
Other nitrogen	21 kg/ha		Available nitrogen		237 kg/ha
Surplus nitrogen	177 kg/ha		Nitrogen conversion efficiency		26 %
Lost nitrogen to water	41 kg/ha		Phosphorus losses		0.7 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$611,000		Gross Farm Income		\$671,920
Farm working expenses	\$447,684		Operational profit		\$224,236
Farm working expenses	\$4.10/kgMS		Profit per total hectare		\$1,838
Capital adjustment	\$13,821		Capital adjusted profit		\$238,057

8. Results for Cluster Farm #2

The assumptions made to establish Cluster Farm #2 are shown in Table 12. All the results shown in the Table were drawn from the specific Overseer file before any potential changes had been made. The Table describes the structure of the farm, the parameters of the dairy herd, and how the dairy herd was being fed. On the basis of these inputs the next parts of Table 12 describe the nutrient losses to the environment and the financial results for a farm owner.

The next tables in this report describe the results for Farm #2 of making management changes to meet the nitrogen caps in Table 14.2 of the One Plan (2014) and in the revised Table 14.2(R). This farmer replaced imported feed with silage made on the “home farm” and removed the summer forage crop. Cow numbers were reduced and more cows were grazed off-farm. Lactation length was reduced by five days.

Table 13 and Table 14 are summaries of the farming system results. The changes in these Tables are sufficient for the farmers involved to apply to Horizons Regional Council for a controlled consent (as long as they were also meeting all the other requirements in the One Plan (2014)).

Table 15 and Table 16 are the farming system results projected for year 20 applying the One Plan (2014) Table 14.2 and Table 14.2(R) respectively.

For Farm #2 to farm within the nitrogen cap of the original One Plan (2014) Table 14.2 would result in:

- Having an operational profitability of over \$1,200/ha
- At typical industry debt levels this would enable the farm to meet its debt requirements (about \$1,100/ha)
- The farm can stay within the nitrogen caps but it has insufficient soil reserves to do so sustainably beyond the short term

For Farm #2 operating within the proposed Table 14.2(R):

- It would be able to make operational profits of \$2,000/ha or more
- This would enable most farmers like this farm to service their current debt
- From year twenty, in order to stay within the nitrogen cap, some pasture would need to be harvested and sold off-farm

Figure 12. Farm #2 initial year farming system results

INFRASTRUCTURE					
Farm Area	158 ha	Milking platform	112 ha	Runoff area	35 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		19 ha
Rainfall	1227 mm/yr	Irrigation system	N/A		
Soils	67 ha	Manawatu s.l.	Capital fert 30-51-21		
	45ha	Kopua s.l.	29-53-10		
	40	Kumera	29-0-15		
HERD					
336 cows	67 replacements (grazed on runoff from 3 months of age)		Cow wintering	40% of the herd grazed off-farm for 2 months	
Calving date	16 th August		Drying off date	20 th May	
123,984 kgMS	1107 kgMS/ha MP		369 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			11,866 kgDM/ha/yr		
Imported feed			88 T DM – 50:50 PKE and silage	11 %	
Winter forage crop			N/A		
Summer forage crop			7 ha	Turnips	9 T/ha yield
NUTRIENTS					
Clover nitrogen	144 kg/ha	Fertiliser nitrogen – Aug, Nov, Apr.		70 kg/ha	
Other nitrogen	16 kg/ha	Available nitrogen		230 kg/ha	
Surplus nitrogen	164 kg/ha	Nitrogen conversion efficiency		28 %	
Lost nitrogen to water	40 kg/ha	Phosphorus losses		1.6 kg/ha	
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$805,896	Gross Farm Income		\$853,136	
Farm working expenses	\$477,764	Operational profit		\$375,372	
Farm working expenses	\$3.85/kgMS	Profit per eff. hectare		\$2,376	
Capital adjustment	0	Capital adjusted profit		\$375,372	

Table 13. Summary for Farm #2 of changes between years in One Plan Table 14.5

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	112				
Total Cows	336	230	210	170	150
Stocking Rate (cows/ha)	3.0	2.1	1.9	1.5	1.3
Stocking Rate (SU/ha)	22.7	15.9	14.4	11.8	10.9
Farm Labour (FTE)	2.5	2.0	2.0	1.5	1.5
Nitrogen Leaching	42	24	22	19	18
Pasture Consumption	11,866	8,872	8,017	6,597	6,067
Production (kgMS/cow)	369	390	380	390	425
Production (kgMS/ha)	1107	801	713	592	569
Total Milksolids (kgMS/yr)	123,984	89,700	79,800	66,300	63,750
Milk as a proportion of farm income (%)	94	94	82	79	79
Gross Farm Income	\$853,136	\$680,750	\$634,040	\$543,450	\$523,795
Farm Working Expenses	\$476,014	\$399,335	\$389,911	\$320,232	\$312,253
Operational profit	\$377,122	\$281,415	\$244,129	\$223,218	\$211,542
Capital Adjustments	-	\$16,726	\$21,456	\$31,913	\$34,438
*Surplus / Deficit	\$375,372	\$298,141	\$244,129	\$223,218	\$211,542
Profit per unit area (\$/ha)	\$2,387	\$1,839	\$1,596	\$1,459	\$1,383

**No drawings, depreciation, tax or principal payments included*

Table 14. Summary for Farm #2 of changes between years in Table 14.5(R)

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	112				
Total Cows	336	336	326	310	260
Stocking Rate (cows/ha)	3.0	3.0	2.9	2.8	2.3
Stocking Rate (SU/ha)	22.7	23.7	23.2	21.2	19.3
Farm Labour (FTE)	2.5	2.5	2.5	2.5	2.0
Nitrogen Leaching	42	37	34	30	28
Pasture Consumption	11,866	12,078	11,343	10,999	10,168
Production (kgMS/cow)	369	357	366	362	425
Production (kgMS/ha)	1107	1071	1066	1002	987
Total Milksolids (kgMS/yr)	123,984	119,949	119,349	112,240	110,500
Milk as a proportion of farm income (%)	94	94	94	94	93
Gross Farm Income	\$853,136	\$826,909	\$822,109	\$773,560	\$771,950
Farm Working Expenses	\$476,014	\$499,045	\$488,559	\$430,573	\$396,144
Operational profit	\$377,122	\$327,864	\$333,550	\$342,987	\$375,806
Capital Adjustments	-	-\$1,677	-\$617	-\$600	\$7,846
*Surplus / Deficit	\$377,122	\$326,187	\$332,933	\$342,387	\$383,652
Profit per unit area (\$/ha)	\$2,387	\$2,075	\$2,111	\$2,171	\$2,379

**No drawings, depreciation, tax or principal payments included*

Table 15. Farm #2 year 20 farming system results for One Plan table 14.2

INFRASTRUCTURE					
Farm Area	158 ha	Milking platform	112 ha	Runoff area	35 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		30 ha
Rainfall	1227 mm/yr	Irrigation system	N/A		
Soils	67 ha	Manawatu s.l.	Capital fert 36-106-24		
	45ha	Kopua s.l.	35-120-14		
	40	Kumera	36-56-19		
HERD					
150 cows	30 replacements (grazed on runoff from 3 months of age)		Cow wintering	94 cows grazed off-farm for 3 months	
Calving date	16 th August		Drying off date	15 th May	
63,750 kgMS	569 kgMS/ha MP		425 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			6,067 kgDM/ha/yr		
Imported feed			N/A		8 %
Winter forage crop			N/A		
Summer forage crop			N/A		
NUTRIENTS					
Clover nitrogen	154 kg/ha		Fertiliser nitrogen – Nov		0 kg/ha
Other nitrogen	2 kg/ha		Available nitrogen		156 kg/ha
Surplus nitrogen	23 kg/ha		Nitrogen conversion efficiency		86 %
Lost nitrogen to water	18 kg/ha		Phosphorus losses		1.3 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$414,375		Gross Farm Income		\$523,795
Farm working expenses	\$312,253		Operational profit		\$211,542
Farm working expenses	\$4.90/kgMS		Profit per eff. hectare		\$1,339/ha
Capital adjustment	\$34,438		Capital adjusted profit		\$245,980

Table 16. Farm #2 year 20 farming system results for table 14.2(R)

INFRASTRUCTURE					
Farm Area	158 ha	Milking platform	112 ha	Runoff area	35 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		30 ha
Rainfall	1227 mm/yr	Irrigation system	N/A		
Soils	67 ha	Manawatu s.l.	Capital fert 33-56-22		
	45ha	Kopua s.l.	32-73-12		
	40	Kumera	34-4-18		
HERD					
260 cows	52 replacements (grazed on runoff from 3 months of age)		Cow wintering		153 cows grazed off-farm for 2 months
Calving date	16 th August		Drying off date		15 th May
110,500 kgMS	987 kgMS/ha MP		425 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			10,168 kgDM/ha/yr		
Imported feed			N/A		5 %
Winter forage crop			N/A		
Summer forage crop			N/A		
NUTRIENTS					
Clover nitrogen		162 kg/ha	Fertiliser nitrogen – Nov.		19 kg/ha
Other nitrogen		2 kg/ha	Available nitrogen		183 kg/ha
Surplus nitrogen		105 kg/ha	Nitrogen conversion efficiency		42 %
Lost nitrogen to water		28 kg/ha	Phosphorus losses		1.5 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)		\$718,250	Gross Farm Income		\$771,950
Farm working expenses		\$396,144	Operational profit		\$375,806
Farm working expenses		\$3.59/kgMS	Profit per eff. hectare		\$2,379
Capital adjustment		\$7,846	Capital adjusted profit		\$383,652

9. Results for Cluster Farm #3

The assumptions made to establish Cluster Farm #3 are shown in Table 17. All the results shown in the Table were drawn from the specific Overseer file before any potential changes had been made. The Table describes the structure of the farm, the parameters of the dairy herd, and how the dairy herd was being fed. On the basis of these inputs the next parts of Table 17 describe the nutrient losses to the environment and the financial results for a farm owner.

The next tables in this report describe the results for Farm #3 of making management changes to meet the nitrogen caps in Table 14.2 of the One Plan (2014) and in the revised Table 14.2(R). Farm #3 had the lowest initial level of nitrogen leaching of all the farms. To meet the original table Farm #3 had to remove its crop and reduce cow numbers by over 30%. To meet the revised table Farm #3 needed to maintain existing nitrogen losses. In the expectation that milk production would still increase Farm #3 reduced cow numbers by 8% and increased the proportion of imported feed used. The lactation had to be shortened by 10 days.

Table 18 and Table 19 are summaries of the farming system results. The changes in these Tables are sufficient for the farmers involved to apply to Horizons Regional Council for a controlled consent (as long as they were also meeting all the other requirements in the One Plan (2014)).

Table 20 and Table 21 are the farming system results projected for year 20 applying the One Plan (2014) Table 14.2 and Table 14.2(R) respectively.

For Farm #3 to farm within the nitrogen cap of the original One Plan (2014) Table 14.2 it would:

- Have an operational profitability of generally over \$1,000/ha (Year 5 an exception)
- At typical industry debt levels this would enable the farm to meet its debt requirements of about \$900/ha
- The farm can stay within the nitrogen caps, but beyond Year 10 its soil nitrogen reserves become very low

For Farm #3 to operate within the proposed Table 14.2(R):

- It would make operational profits of more than \$1,200/ha
- This would enable most farmers to service their current debt
- It could meet the nitrogen caps sustainably over the long term

Table 17. Farm #3 initial year farming system results

INFRASTRUCTURE					
Farm Area	144 ha	Milking platform	99 ha	Runoff area	40 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		14 ha
Rainfall	1257 mm/yr	Irrigation system	N/A		
Soils	59 ha	Kairanga s.l.	Capital fert 24-1-15		
	40 ha	Dannevirke s.l.	30-25-6		
	40 ha	Kumeroa s.l.	32-0-16		
HERD					
256 cows	51 replacements (grazed on runoff from 3 months of age)		Cow wintering	69cows grazed off-farm for 2 months	
Calving date	16 th August		Drying off date	20 th May	
87,145 kgMS	880 kgMS/ha MP		340 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			9,158 kgDM/ha/yr		
Imported feed			110 T DM – 50:50 PKE and silage	9 %	
Winter forage crop			N/A		
Summer forage crop			3.5 ha	Turnips	9 T/ha yield
NUTRIENTS					
Clover nitrogen	105 kg/ha		Fertiliser nitrogen – Aug, Nov, Apr.		70 kg/ha
Other nitrogen	19 kg/ha		Available nitrogen		194 kg/ha
Surplus nitrogen	142 kg/ha		Nitrogen conversion efficiency		26 %
Lost nitrogen to water	28 kg/ha		Phosphorus losses		1.5 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$566,443		Gross Farm Income		\$602,603
Farm working expenses	\$416,454		Operational profit		\$186,149
Farm working expenses	\$4.78/kgMS		Profit per eff. hectare		\$1,293
Capital adjustment	\$0		Capital adjusted profit		\$186,149

Table 18. Summary for Farm #3 of changes between years in One Plan Table 14.5

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	99				
Total Cows	256	256	256	240	175
Stocking Rate (cows/ha)	2.6	2.6	2.6	2.4	1.8
Stocking Rate (SU/ha)	18.5	17.5	17.4	15.9	13.6
Farm Labour (FTE)	2.0	2.0	2.0	2.0	1.5
Nitrogen Leaching	28	24	22	19	17
Pasture Consumption	9158	8815	8582	8310	6969
Production (kgMS/cow)	340	331	323	323	425
Production (kgMS/ha)	880	855	834	782	752
Total Milksolids (kgMS/yr)	87,145	84,630	82,579	77,418	74,400
Milk as a proportion of farm income (%)	94%	94%	94%	94%	89%
Gross Farm Income	\$ 602,603	\$ 586,255	\$ 572,924	\$ 537,037	\$ 546,180
Farm Working Expenses	\$ 416,454	\$ 424,637	\$ 427,288	\$ 400,239	\$ 336,504
Operational profit	\$ 186,149	\$ 161,618	\$ 145,636	\$ 136,798	\$ 209,676
Capital Adjustments	-	\$ 1,083	\$ 468	\$ 2,488	\$ 9,114
*Surplus / Deficit	\$ 186,149	\$ 160,535	\$ 145,168	\$ 139,286	\$ 218,790
Profit per unit area (\$/ha)	\$ 1,293	\$ 1,122	\$ 1,011	\$ 950	\$ 1,456

**No drawings, depreciation, tax or principal payments included*

Table 19. Summary for Farm #3 of changes between years in Table 14.5(R)

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	99				
Total Cows	256	253	243	235	235
Stocking Rate (cows/ha)	2.6	2.6	2.5	2.4	2.4
Stocking Rate (SU/ha)	18.5	18.5	18.4	18.4	18.8
Farm Labour (FTE)	2.0	2.0	2.0	2.0	2.0
Nitrogen Leaching	28	28	28	28	28
Pasture Consumption	9,158	9,162	9,134	9,099	9,098
Production (kgMS/cow)	340	349	374	396	425
Production (kgMS/ha)	880	891	919	939	1,008
Total Milksolids (kgMS/yr)	87,145	88,250	91,000	93,000	99,800
Milk as a proportion of farm income (%)	94	94	95	95	95
Gross Farm Income	\$ 602,603	\$609,705	626,060\$	\$637,580	\$681,780
Farm Working Expenses	\$ 416,454	\$415,896	\$414,398	\$410,092	\$431,636
Operational profit	\$ 186,149	\$193,809	\$211,662	\$227,488	\$250,144
Capital Adjustments	-	\$782	\$1,116	-\$1,312	-\$4,372
*Surplus / Deficit	\$ 186,149	\$193,027	\$210,546	\$226,177	\$245,773
Profit per unit area (\$/ha)	\$ 1,293	\$1,346	\$1,470	\$1,580	\$1,737

**No drawings, depreciation, tax or principal payments included*

Table 20. Farm #3 year 20 farming system results for One Plan table 14.2

INFRASTRUCTURE					
Farm Area	144 ha	Milking platform	99 ha	Runoff area	40 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		21 ha
Rainfall	1257 mm/yr	Irrigation system	N/A		
Soils	59 ha	Kairanga s.l.	Capital fert 32-56-20		
	40 ha	Dannevirke s.l.	38-75-11		
	40 ha	Kumeroa s.l.	32-10-16		
HERD					
175 cows	35 replacements (grazed on runoff from 3 months of age)		Cow wintering	Half the herd grazed off-farm for 3 months	
Calving date	16 th August		Drying off date	20 th May	
74,400 kgMS	752 kgMS/ha MP		425 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			7,033 kgDM/ha/yr		
Imported feed			N/A	7 %	
Winter forage crop			N/A		
Summer forage crop			N/A		
NUTRIENTS					
Clover nitrogen		142 kg/ha	Fertiliser nitrogen – Nov		0 kg/ha
Other nitrogen		2 kg/ha	Available nitrogen		144 kg/ha
Surplus nitrogen		57 kg/ha	Nitrogen conversion efficiency		60 %
Lost nitrogen to water		18 kg/ha	Phosphorus losses		1.4 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)		\$483,600	Gross Farm Income		\$546,180
Farm working expenses		\$336,504	Operational profit		\$209,676
Farm working expenses		\$4.52/kgMS	Profit per eff. hectare		\$1,456/ha
Capital adjustment		\$9,114	Capital adjusted profit		\$218,790

Figure 21. Farm #3 year 20 farming system results for table 14.2(R)

INFRASTRUCTURE					
Farm Area	144 ha	Milking platform	99 ha	Runoff area	40 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		16 ha
Rainfall	1257 mm/yr	Irrigation system	N/A		
Soils	59 ha	Kairanga s.l.	Capital fert 24-0-14		
	40 ha	Dannevirke s.l.	30-16-5		
	40 ha	Kumeroa s.l.	33-0-16		
HERD					
235 cows	45 replacements (grazed on runoff from 3 months of age)		Cow wintering	52 cows grazed off-farm for 2 months	
Calving date	16 th August		Drying off date	10 th May	
99,800 kgMS	1008 kgMS/ha MP		425 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			9,098 kgDM/ha/yr		
Imported feed			145 T DM – 40:60 PKE and silage	15 %	
Winter forage crop			N/A		
Summer forage crop			3.5 ha	Turnips	9 T/ha yield
NUTRIENTS					
Clover nitrogen	106 kg/ha		Fertiliser nitrogen – Aug, Nov, Apr.		70 kg/ha
Other nitrogen	24 kg/ha		Available nitrogen		200 kg/ha
Surplus nitrogen	144 kg/ha		Nitrogen conversion efficiency		28 %
Lost nitrogen to water	28 kg/ha		Phosphorus losses		1.5 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$648,700		Gross Farm Income		\$681,780
Farm working expenses	\$431,636		Operational profit		\$250,144
Farm working expenses	\$4.33/kgMS		Profit per eff. hectare		\$1,737
Capital adjustment	\$4,372		Capital adjusted profit		\$245,773

10. Results for Cluster Farm #4

The assumptions made to establish Cluster Farm #4 are shown in Table 22. All the results shown in the Table were drawn from the specific Overseer file before any potential changes had been made. The Table describes the structure of the farm, the parameters of the dairy herd, and how the dairy herd was being fed. On the basis of these inputs the next parts of Table 22 describe the nutrient losses to the environment and the financial results for a farm owner.

The next tables in this report describe the results for Farm #4 of making management changes to meet the nitrogen caps in Table 14.2 of the One Plan (2014) and in the revised Table 14.2(R).

In the initial year this farm grazed its young stock and non-lactating cows on the runoff. In order to meet the original Table 14.2 in the One Plan (2014) they would need to be grazed off farm during winter and out of the catchment. With the revised table this would only be required after the fifth year. Many farms in the catchment similar to this farm are likely to have covered feed pads available. In those circumstances grazing off the farm would not be required as part of meeting the conditions in Table 14.2(R). In both situations this farm is expected to remove the winter crop. Table 23 and Table 25 are summaries of the farming system results. The changes in these Tables are sufficient for the farmers involved to apply to Horizons Regional Council for a controlled consent (as long as they were also meeting all the other requirements in the One Plan (2014)).

Table 25 and Table 26 are the farming system results projected for year 20 applying the One Plan (2014) Table 14.2 and Table 14.2(R) respectively.

The consequences of the farming system in Farm #4 being modified to achieve the nitrogen caps in the original Table 14.2 are:

- Operating profit each year is expected to be above \$1,500/ha
- At typical debt levels in the industry (about \$1,300/ha) the farm can remain financially viable
- The farm can achieve the nitrogen cap in the original Table 14.2 and do so sustainably

If Farm #4 complies with the nitrogen cap in Table 14.2(R) there are expected to be the following consequences:

- Operating profits are expected to be greater than \$1,500/ha
- Typical debt levels can be serviced
- The farm can sustainably achieve the nitrogen cap

Table 22. Farm #4 initial year farming system results

INFRASTRUCTURE					
Farm Area	172 ha	Milking platform	131 ha	Runoff area	35 ha
Feedpad	-	Effluent system and area	Sump, to pond and travelling irrigator		18 ha
Rainfall	1190mm/yr	Irrigation system	Pivot irrigation-Dec to Feb		65.5ha
Soils	52ha	Kairanga s.l.	Capital fert 24-0-8		
	114ha	Kopua s.l.	23-16-0		
HERD					
385 cows	77 replacements (grazed on runoff from 3 months of age)		Cow wintering	100 cows grazed on runoff for 2 months	
Calving date	10 th August		Drying off date	20 th May	
149,000 kgMS	1137 kgMS/ha MP		387 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			11,794 kgDM/ha/yr		
Imported feed			474 T DM – 33:33:33 PKE, maize and pasture silage	19 %	
Winter forage crop on ronoff			8.8 ha	Kale	10 T/ha yield
Summer forage crop			N/A		
NUTRIENTS					
Clover nitrogen	117 kg/ha		Fertiliser nitrogen – Aug, Nov, Apr.		105 kg/ha
Other nitrogen	55 kg/ha		Available nitrogen		277 kg/ha
Surplus nitrogen	206 kg/ha		Nitrogen conversion efficiency		26 %
Lost nitrogen to water	46 kg/ha		Phosphorus losses		0.9 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$968,500		Gross Farm Income		\$1,022,800
Farm working expenses	\$608,739		Operational profit		\$414,061
Farm working expenses	\$4.09/kgMS		Profit per eff. hectare		\$3,161
Capital adjustment	0		Capital adjusted profit		\$414,061

Table 23. Summary for Farm #4 of changes between years in One Plan Table 14.5

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	131				
Total Cows	385	380	350	320	300
Stocking Rate (cows/ha)	2.9	2.9	2.7	2.4	2.3
Stocking Rate (SU/ha)	25.3	20.9	19.8	18.5	17.4
Farm Labour (FTE)	2.5	2.5	2.5	2.5	2.5
Nitrogen Leaching	46	24	21	19	18
Pasture Consumption	11794	9349	8772	8030	7445
Production (kgMS/cow)	387	381	404	425	425
Production (kgMS/ha)	1137	1105	1079	1038	973
Total Milksolids (kgMS/yr)	149,000	144,715	141,300	136,000	127,500
Milk as a proportion of farm income (%)	95	95	95	95	95
Gross Farm Income	\$1,022,800	\$994,168	\$ 967,990	\$ 929,520	\$871,190
Farm Working Expenses	\$608,739	\$620,084	\$631,711	\$621,593	\$610,907
Operational profit	\$414,061	\$ 374,084	\$ 336,279	\$ 307,927	\$ 260,283
Capital Adjustments	-	\$ 1,574	\$ 5,198	\$ 9,428	\$ 13,738
*Surplus / Deficit	\$414,061	\$ 375,657	\$ 341,477	\$ 317,356	\$ 274,021
Profit per unit area (\$/ha)	\$2,407	\$2,175	\$1,955	\$1,790	\$1,513

**No drawings, depreciation, tax or principal payments included*

Table 24. Summary for Farm #4 of changes between years in Table 14.5(R)

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	131				
Total Cows	385	380	380	370	355
Stocking Rate (cows/ha)	2.9	2.9	2.9	2.8	2.7
Stocking Rate (SU/ha)	25.3	22.6	21.7	20.7	20.0
Farm Labour (FTE)	2.5	2.5	2.5	2.5	2.5
Nitrogen Leaching	46	30	27	24	22
Pasture Consumption	11794	10209	9764	9207	8565
Production (kgMS/cow)	387	390	390	390	399
Production (kgMS/ha)	1137	1131	1131	9207	1081
Total Milksolids (kgMS/yr)	149,000	148,222	148,222	148,115	141,553
Milk as a proportion of farm income (%)	95	95	95	95	95
Gross Farm Income	\$1,022,800	\$1,013,928	\$1,016,963	\$1,015,368	\$970,375
Farm Working Expenses	\$608,739	\$632,607	\$654,773	\$647,681	\$674,383
Operational profit	\$414,061	\$381,320	\$362,190	\$367,686	\$295,992
Capital Adjustments	-	\$662	\$482	\$1,394	\$4,682
*Surplus / Deficit	\$414,061	\$381,942	\$362,672	\$369,080	\$300,674
Profit per unit area (\$/ha)	\$2,407	\$2,221	\$2,109	\$2,146	\$1,748

**No drawings, depreciation, tax or principal payments included*

Table 25. Farm #4 year 20 farming system results for One Plan table 14.2

INFRASTRUCTURE					
Farm Area	172 ha	Milking platform	131 ha	Runoff area	35 ha
Feedpad	-	Effluent system and area	Sump, to pond and travelling irrigator		31 ha
Rainfall	1190 mm/yr	Irrigation system	Pivot irrigation-Dec to Feb		65.5ha
Soils	52ha	Kairanga s.l.	Capital fert 32-42-14		
	114ha	Kopua s.l.	31-62-5		
HERD					
300 cows	60 replacements (grazed off for 12 months from 9 months of age)		Cow wintering	Half the herd grazed off-farm for 3 months	
Calving date	16 th August		Drying off date	30 th April	
127,500 kgMS	973 kgMS/ha MP		425 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			7,445 kgDM/ha/yr		
Imported feed			20 T DM	9.5 %	
Winter forage crop			N/A		
Summer forage crop			N/A		
NUTRIENTS					
Clover nitrogen	127 kg/ha	Fertiliser nitrogen – Nov		28 kg/ha	
Other nitrogen	5 kg/ha	Available nitrogen		160 kg/ha	
Surplus nitrogen	110 kg/ha	Nitrogen conversion efficiency		32 %	
Lost nitrogen to water	18 kg/ha	Phosphorus losses		0.8 kg/ha	
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$828,750	Gross Farm Income		\$871,190	
Farm working expenses	\$610,907	Operational profit		\$260,283	
Farm working expenses	\$4.79/kgMS	Profit per eff. hectare		\$1513/ha	
Capital adjustment	\$13,738	Capital adjusted profit		\$274,021	

Table 26. Farm #4 year 20 farming system results for table 14.2(R)

INFRASTRUCTURE					
Farm Area	172 ha	Milking platform	131 ha	Runoff area	35 ha
Feedpad	-	Effluent system and area	Sump, to pond and travelling irrigator		18 ha
Rainfall	11m 90m/yr	Irrigation system	Pivot irrigation-Dec to Feb		65.5ha
Soils	52ha	Kairanga s.l.	Capital fert 32-42-14		
	114ha	Kopua s.l.	31-62-5		
HERD					
355 cows	71 replacements (grazed off for 12 months from 9 months of age)		Cow wintering	Half the herd grazed off-farm for 3 months	
Calving date	16 th August		Drying off date	30 th April	
141553 kgMS	1081 kgMS/ha MP		399 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			8,565 kgDM/ha/yr		
Imported feed			327 T DM – 50:50 PKE and maize silage	19 %	
Winter forage crop			N/A		
Summer forage crop			N/A		
NUTRIENTS					
Clover nitrogen	119 kg/ha		Fertiliser nitrogen – Oct.		28 kg/ha
Other nitrogen	36 kg/ha		Available nitrogen		183 kg/ha
Surplus nitrogen	126 kg/ha		Nitrogen conversion efficiency		31 %
Lost nitrogen to water	22 kg/ha		Phosphorus losses		0.8 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$920,095		Gross Farm Income		\$970,375
Farm working expenses	\$674,383		Operational profit		\$295,992
Farm working expenses	\$5.06/kgMS		Profit per eff. hectare		\$1,480
Capital adjustment	\$4,682		Capital adjusted profit		\$300,674

11. Results for Cluster Farm #5

The assumptions made to establish Cluster Farm #5 are shown in Table 27. All the results shown in the Table were drawn from the specific Overseer file before any potential changes had been made. The Table describes the structure of the farm, the parameters of the dairy herd, and how the dairy herd was being fed. On the basis of these inputs the next parts of Table 27 describe the nutrient losses to the environment and the financial results for a farm owner.

The next tables in this report describe the results for Farm #5 of making management changes to meet the nitrogen caps in Table 14.2 of the One Plan (2014) and in the revised Table 14.2(R).

Cow numbers would be reduced and the cows would need to continue to be grazed off farm. The lactation length would need to be reduced by 10 days to the end of April. Both farm scenarios include removing the summer crop of turnips, for the original table, there would be no imported feed used. For meeting Table 14.2(R) in Year 20, it would be replaced by imported feed.

Table 28 and Table 29 are summaries of the farming system results. The changes in these Tables are sufficient for the farmers involved to apply to Horizons Regional Council for a controlled consent (as long as they were also meeting all the other requirements in the One Plan (2014)).

Table 30 and Table 31 are the farming system results projected for year 20 applying the One Plan (2014) Table 14.2 and Table 14.2(R) respectively.

For Farm #5 complying with the original Table 14.2 in the One Plan (2014) would result in:

- The farm only just clearing its operational expenses with an annual profit of less than \$500/ha. Income from an alternative land use (or other source of income) is necessary for this farm to remain profitable
- Typical debt payment levels in the industry would be more than \$1,000/ha for this farm. Farm #5 would not be able to meet the nitrogen caps in the original table and remain financially viable
- Whilst the calculations in Overseer® indicate that this farm system could be modified to operate within the nitrogen loss required in the table, it is only possible by running less than 1cow/ha and harvesting about half the pasture for off-farm sale

For Farm #5 to comply with the proposed Table 14.2(R) the result would be:

- The farm making an operational profit of over \$1,000/ha or more
- The farm having just enough operational income to cover typical debt levels in the industry and remain financially viable
- The farm would be able to sustainably achieve the nitrogen reductions that are required to operate within its nitrogen cap

Figure 27. Farm #5 initial year farming system results

INFRASTRUCTURE					
Farm Area	114 ha	Milking platform	108 ha	Runoff area	0 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		18 ha
Rainfall	1351mm/yr	Irrigation system	N/A		
Soils	65ha	Matamau s.l.	Capital fert 26-36-18		
	43ha	Dannevirke s.l.	33-42-8		
HERD					
270 cows	54 replacements (grazed off for 18 months from 3 months of age)		Cow wintering	81 cows grazed off-farm for 2 months	
Calving date	16 th August		Drying off date	10 th May	
90,720 kgMS	840 kgMS/ha MP		336 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			11007 kgDM/ha/yr		
Imported feed			90 T DM – 50:50 PKE and silage	15 %	
Winter forage crop			N/A		
Summer forage crop			6.8 ha	Turnips	9 T/ha yield
NUTRIENTS					
Clover nitrogen	129 kg/ha	Fertiliser nitrogen – Aug, Nov, Apr.		58 kg/ha	
Other nitrogen	20 kg/ha	Available nitrogen		207 kg/ha	
Surplus nitrogen	153 kg/ha	Nitrogen conversion efficiency		26 %	
Lost nitrogen to water	39 kg/ha	Phosphorus losses		0.7 kg/ha	
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$589,680	Gross Farm Income		\$628,140	
Farm working expenses	\$453,423	Operational profit		\$174,717	
Farm working expenses	\$5.00/kgMS	Profit per eff. hectare		\$1,618	
Capital adjustment	0	Capital adjusted profit		\$174,717	

Table 28. Summary for Farm #5 of changes between years in One Plan Table 14.5

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	108				
Total Cows	270	185	155	120	100
Stocking Rate (cows/ha)	2.5	1.7	1.4	1.1	0.9
Stocking Rate (SU/ha)	21.5	14.9	12.6	10.4	9.4
Farm Labour (FTE)	2.5	2.5	1.5	1.5	1.5
Nitrogen Leaching	39	22	19	17	16
Pasture Consumption	11007	7150	5957	4779	4237
Production (kgMS/cow)	336	340	358	380	425
Production (kgMS/ha)	840	582	514	422	394
Total Milksolids (kgMS/yr)	90,720	62,900	55,490	45,600	42,500
Milk as a proportion of farm income (%)	90	91	87	82	81
Gross Farm Income	\$628,140	\$447,580	\$414,820	\$363,440	\$340,210
Farm Working Expenses	\$453,423	\$398,252	\$345,388	\$324,969	\$326,074
Operational profit	\$174,717	\$49,328	\$69,432	\$38,471	\$14,136
Capital Adjustments	-	\$15,642	\$20,505	\$26,552	\$29,242
*Surplus / Deficit	\$174,717	\$64,971	\$89,937	\$65,023	\$
Profit per unit area (\$/ha)	\$1,533	\$433	\$609	\$337	\$124

**No drawings, depreciation, tax or principal payments included*

Table 29. Summary for Farm #5 of changes between years in Table 14.5(R)

	Initial Farm	Year 1	Year 5	Year 10	Year 20
Area of Milking Platform (ha)	108				
Total Cows	270	261	230	230	230
Stocking Rate (cows/ha)	2.5	2.5	2.5	2.5	2.5
Stocking Rate (SU/ha)	21.5	20.4	18.7	18.5	18.5
Farm Labour (FTE)	2.5	2.5	2.5	2.5	2.5
Nitrogen Leaching	39	32	28	25	24
Pasture Consumption	11007	10423	9163	9036	8775
Production (kgMS/cow)	336	335	358	372	372
Production (kgMS/ha)	840	809	762	793	793
Total Milksolids (kgMS/yr)	90,720	87,420	82,340	85,620	85,620
Milk as a proportion of farm income (%)	90	94	94	95	95
Gross Farm Income	\$628,140	\$605,170	\$567,510	\$588,830	\$588,830
Farm Working Expenses	\$453,423	\$447,694	\$435,777	\$443,789	\$456,394
Operational profit	\$174,717	\$157,476	\$131,733	\$145,041	\$132,436
Capital Adjustments	-	\$1,606	\$5,850	\$4,866	\$4,866
*Surplus / Deficit	\$174,717	\$159,082	\$137,583	\$149,907	\$137,302
Profit per unit area (\$/ha)	\$1,533	\$1,367	\$1,104	\$1,230	\$1,119

**No drawings, depreciation, tax or principal payments included*

Figure 30. Farm #5 year 20 farming system results for One Plan table 14.2

INFRASTRUCTURE					
Farm Area	114 ha	Milking platform	108 ha	Runoff area	0 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		18 ha
Rainfall	1351mm/yr	Irrigation system	N/A		
Soils	65ha	Matamau s.l.	Capital fert 31.86.22		
	43ha	Dannevirke s.l.	38.94.12		
HERD					
100 cows	20 replacements (grazed off for 18 months from 3 months of age)		Cow wintering		20 cows grazed off-farm for 3 months
Calving date	16 th August		Drying off date		30 th April
42,500 kgMS	425 kgMS/ha MP		394 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			4,237 kgDM/ha/yr		
Imported feed			N/A		<1 %
Winter forage crop			N/A		
Summer forage crop			N/A		
NUTRIENTS					
Clover nitrogen		104 kg/ha	Fertiliser nitrogen – Oct		23 kg/ha
Other nitrogen		2 kg/ha	Available nitrogen		129 kg/ha
Surplus nitrogen		55 kg/ha	Nitrogen conversion efficiency		57 %
Lost nitrogen to water		16 kg/ha	Phosphorus losses		0.5 kg/ha
OPERATIONAL PROFIT					
Milk income (includes dividends)		\$276,250	Gross Farm Income		\$340,210
Farm working expenses		\$326,074	Operational profit		\$14,136
Farm working expenses		\$7.67/kgMS	Profit per total hectare		\$124/ha
Capital adjustment		\$29,242	Capital adjusted profit		-\$15,106

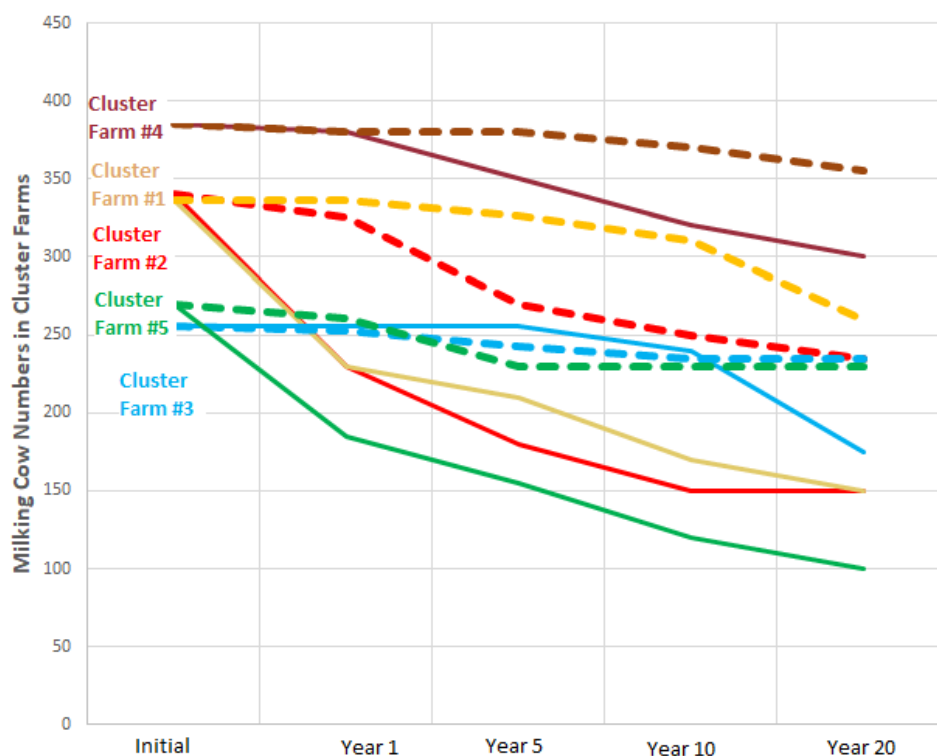
Figure 31. Farm #5 year 20 farming system results for table 14.2(R)

INFRASTRUCTURE					
Farm Area	114 ha	Milking platform	108 ha	Runoff area	0 ha
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator		22 ha
Rainfall	1351mm/yr	Irrigation system	N/A		
Soils	65ha	Matamau s.l.	Capital fert 25-40-17		
	43ha	Dannevirke s.l.	37-74-11		
HERD					
230 cows	46 replacements (grazed off for 17 months from 3 months of age)		Cow wintering	124 cows grazed off-farm for 3 months	
Calving date	1 st August		Drying off date	30 th April	
85,620 kgMS	793 kgMS/ha MP		372 kg MS/cow		
PASTURE AND FEED					
Pasture consumed by cows			7,710 kgDM/ha/yr		
Imported feed			75 T DM –PKE	12 %	
Winter forage crop			N/A		
Summer forage crop			N/A		
NUTRIENTS					
Clover nitrogen	128 kg/ha	Fertiliser nitrogen – Oct.		23 kg/ha	
Other nitrogen	18 kg/ha	Available nitrogen		169 kg/ha	
Surplus nitrogen	114 kg/ha	Nitrogen conversion efficiency		32 %	
Lost nitrogen to water	24 kg/ha	Phosphorus losses		0.6 kg/ha	
OPERATIONAL PROFIT					
Milk income (includes dividends)	\$556,530	Gross Farm Income		\$588,830	
Farm working expenses	\$456,394	Operational profit		\$132,436	
Farm working expenses	\$5.33/kgMS	Profit per eff. hectare		\$1,162	
Capital adjustment	\$4,866	Capital adjusted profit		\$127,570	

12. Discussion

The Cluster Farms initially had between 250 and 400 cows in both scenarios (the original Table 14.2 and 14.2 (R)) however it is easier to maintain herd numbers with the proposed revised table. See Figure 1.

Figure 1. Changes in cow numbers over time – a comparison between versions of Table 14.2



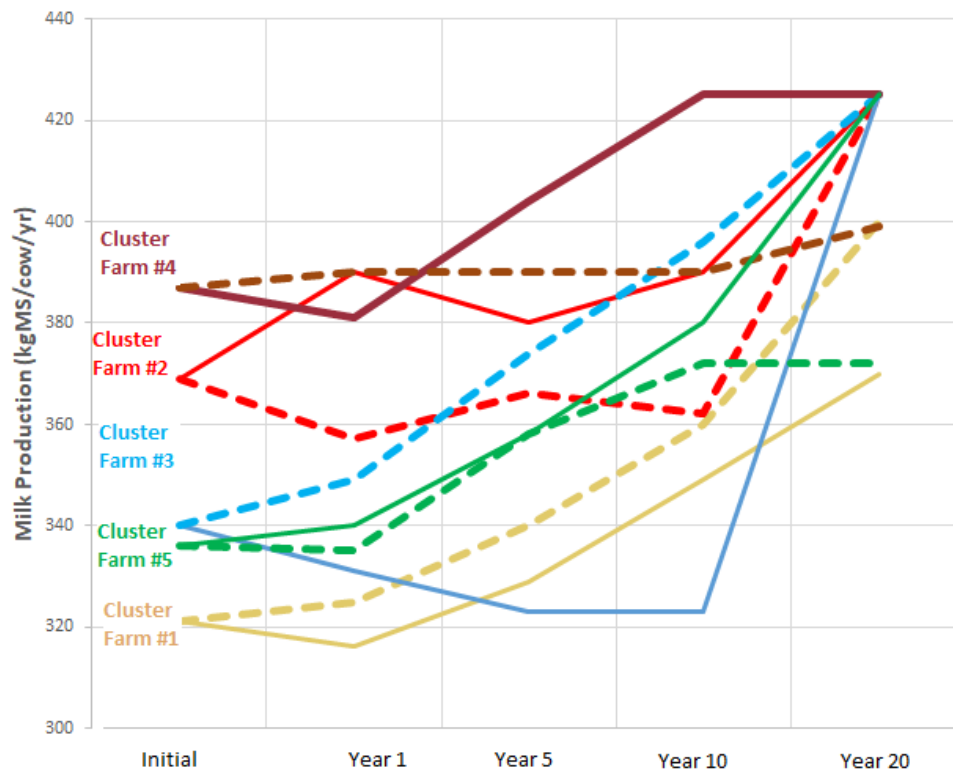
The solid lines represent the results for the original Table 14.2 and the dotted lines represent Table 14.2(R)

As cow numbers are reduced there are greater opportunities to increase production per cow (Figure 2). However as production is increased, nitrogen losses will not be reduced unless stocking rate (su/ha/yr) and annual pasture consumption are also reduced (Figure 3).

The introduction of an appropriate mix of mitigations can ensure that nitrogen losses remain capped (Figure 4). In the Figure all the cluster farms are shown to be reducing nitrogen losses to water over time. The exception is Cluster farm #3. With Table 14.2(R), Cluster farm #3 initially is already operating within its nitrogen cap. However, over time production per cow is expected to increase in-line with the other cluster farms and therefore additional mitigations will need to be introduced to keep it under the cap.

After applying the original Table 14.2 the operational profits are reduced for all the farms, except for Farm #3 that has income from sales of surplus pasture in Year 20 to supplement returns from dairying. Applying Table 14.2(R) improves the profitability of all the farms (Figure 5).

Figure 2. Changes in milk production(per cow) over time – a comparison between versions of Table 14.2



The solid lines represent the results for the original Table 14.2 and the dotted lines represent Table 14.2(R)

Figure 3. Changes in pasture consumption over time – a comparison between versions of Table 14.2

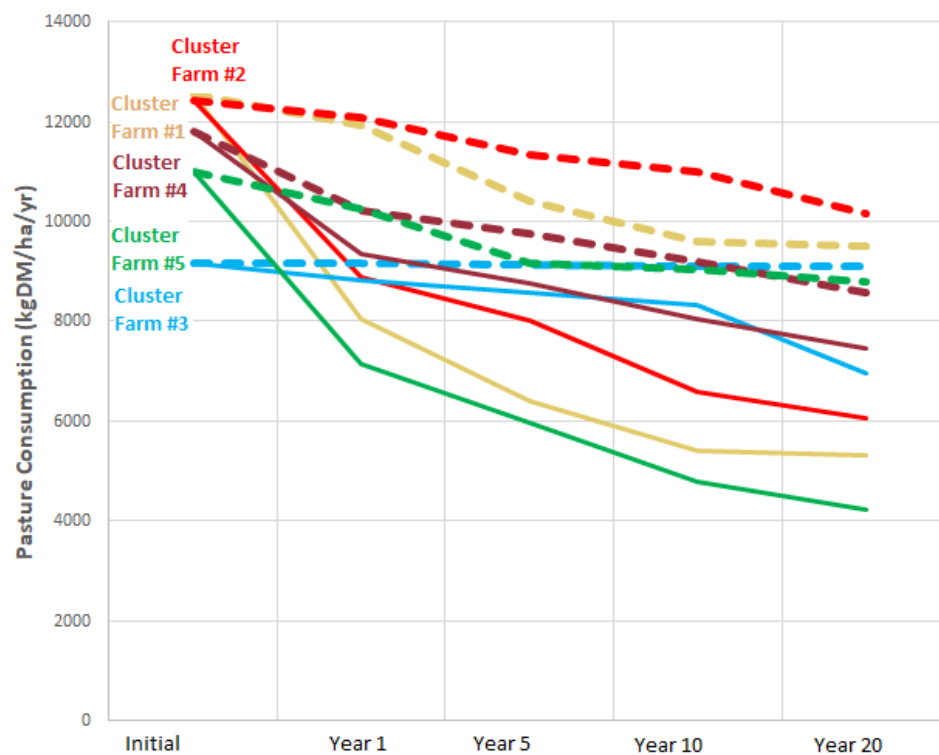
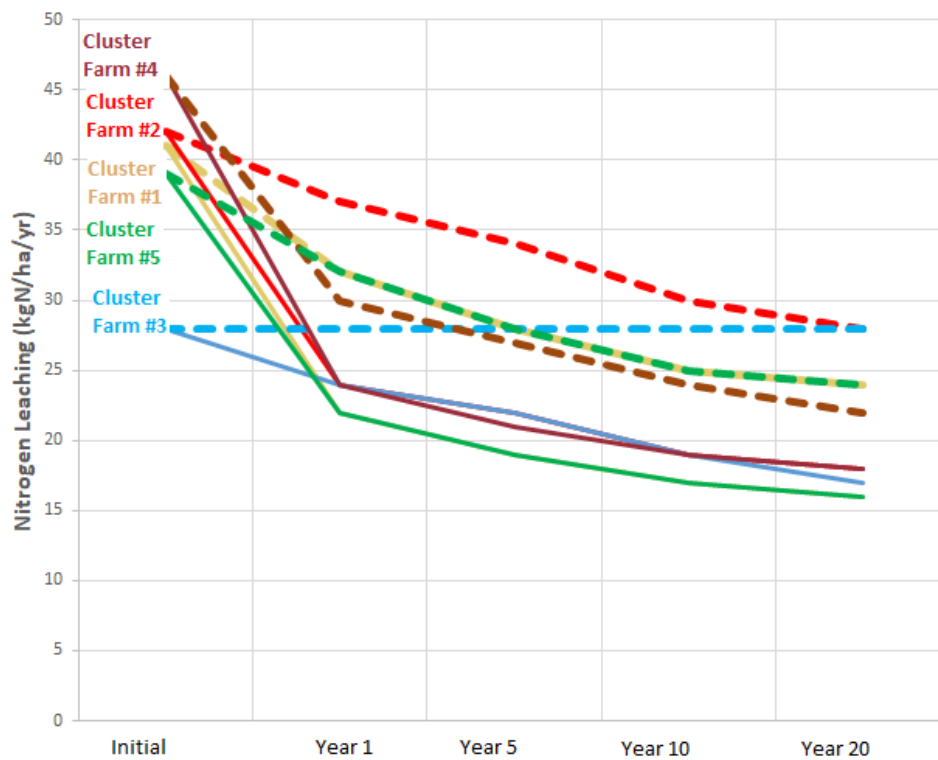
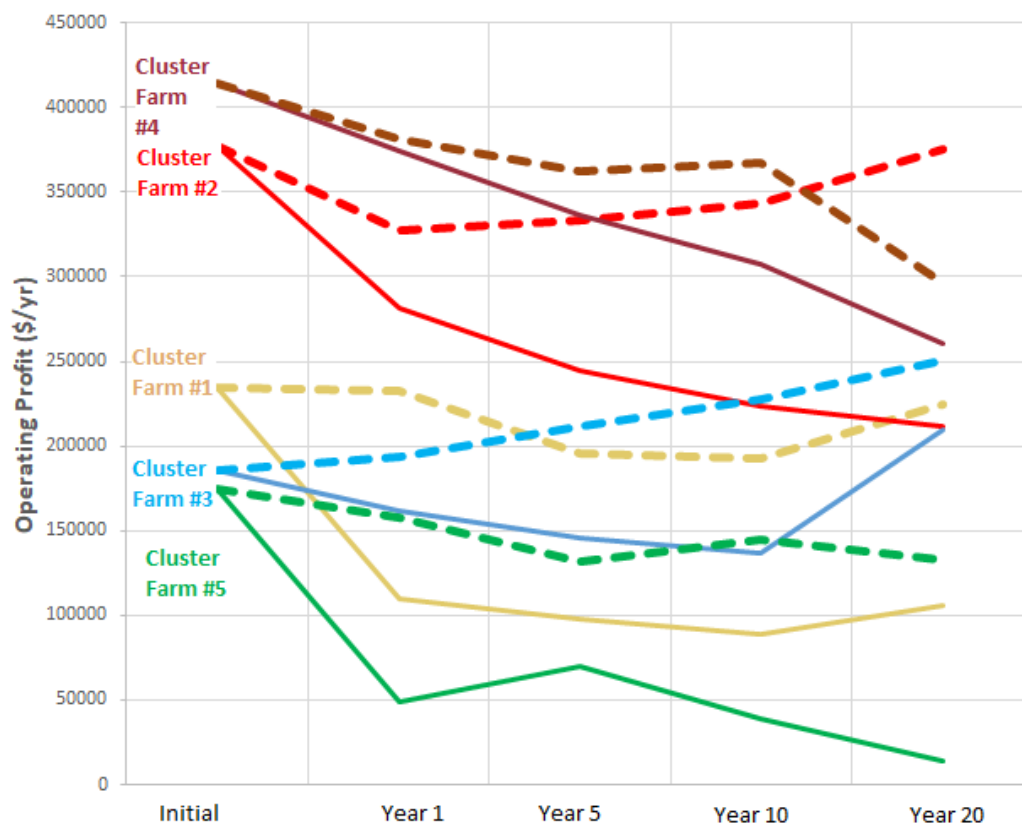


Figure 4. Changes in nitrogen leaching over time – a comparison between versions of Table 14.2

The solid lines represent the results for the original Table 14.2 and the dotted lines represent Table 14.2(R)

Figure 5. Changes in operating profit over time – a comparison between versions of Table 14.2

13. Conclusions

The Cluster Farms represent about 65% of dairy farms in the Upper Manawatu River catchment. These farms are unlikely to be financially viable after management practices have been introduced to enable them to operate within the original nitrogen cap of Table 14.2 in the One Plan (2014). A greater percentage of farms would only be able to operate within the nitrogen cap by depleting their soil nitrogen reserves. That situation would not be sustainable over time.

If the revised Table 14.2(R) is introduced, all Cluster Farms are able to remain financially viable although Farm #5 could not service high levels of debt. All farms are able to maintain sustainable nitrogen reserves under the scenarios developed for Table 14.2(R).

This study highlights the importance of continued improvement in production per cow. There are benefits from also improving nitrogen efficiency on-farm so that low-loss systems become more sustainable. The study reinforces the opportunities for off-farm winter grazing of cows and providing them with sheltered feed pads or barns. The latter topic has been developed already in Parminter (2017).

14. Limitations

The five farm models were drawn directly from the farm medians in Table 3. It was considered by the author that establishing them first as feasible systems in Farmax® (a step included in the first report), would not be needed in this study. The initial models were drawn from actual farm data, however the models were then changed considerably by introducing potential mitigations and these also were not checked in Farmax® for feasibility.

Each of the Cluster Farms was modelled by a different consultant applying similar principles and assumptions. A similar situation operates across the industry in practice. The main limitation for this study from taking this approach is that the timing and order of the introduced mitigations was not exactly comparable for each Cluster Farm. That means that the intermediate steps for the Cluster Farms between Year 1 and Year 20 in the tables may not be directly comparable. This is particularly visible in Figures 1 – 5.

Appendix A. Example Profit and Loss Account for Cluster Farm #5

				\$	Per ha	Per cow
Background						
	Effective Milking (ha)			108		
	Runoff (ha)			-		
	Non-productive (ha)			6		
	Effluent area (ha)			15		
	Peak cows milked			270	2.5	
	R1yr heifers	20% of herd		54	0.5	
	R2yr heifers	20% of herd		54	0.5	
	Milk production (kgMS)			90,720	840	336
	Staffing		2.5			
	Manager			85000		
	2IC	1.0		0.0		
	Farm assistant	1.0		48000		
	Relief milker	0.5		5000		
	Capital fertiliser (autumn)	Rate (kgP/ha/yr)	Area			
	Super 20%potash	30	86ha	14,889		
	Super phosphate	12	15ha	708		
	Nitrogen fertiliser					
	winter/spring (ammo)	30	108ha	5,292		
	spring/summer (urea)	30	108ha	3,733		
	autumn (urea)	0	0ha			
Heifer Grazing	Number	54	52weeks	25,272		
Calf Grazing	Number	54	21weeks	7,938		
Cow Grazing	Number	81	9weeks	18,225		
Calf rearing	Number	54	60kg/head	3240		
	Supplementary feed					
	baleage	225	round bales	22,500		
	hay	0	round bales			
	maize silage	0	T DM			
	PKE	45	T DM	10,800		
	Conserved feed					
	baleage	200	round bales	7,000		
	hay	0	round bales			
Income						
	Milk					
	Milk Income			562,464		
	Dividend Income			27,216		
	Stock Sales		number			
	Culls		49	30380		
	Calves		202	8080		
	Bulls		0			
	Other Farm Income:					
Total Income				\$ 628,140	\$ 5,816.11	\$ 2,326.44
Expenses						
Employment	Wages			138,000	1278	
Livestock	Livestock purchases		0	-		
	Bulls leased	6	\$700/year	4,200		
	Animal Health			24,030	223	89
	Herd Improvement			14,040	130	52
	Farm Dairy			6,750	63	25
	Electricity			12,150	113	45
	Livestock rearing & grazing			54,675	506	203
Pastures & Feed	Fertiliser			15,597	144	58
	Nitrogen			9,025	84	33
	Irrigation	Area	0ha	0	200	0
	Supplementary feed			33300	308	123
	Conserved feed			7000	65	26
	Cropping - summer	Area	7ha	2,720	25	10
	Cropping - winter	Area	0ha			
	Regrassing	Area	7ha	3,400	31	13
	Weed & Pest			3,888	36	14
Fixed	Repairs & Maintenance - buildings			22,050	214	82
	Repairs & Maintenance - equipment			9,273	90	34
	Vehicles			13,395	130	50
	Fuel			8,243	80	31
	Freight			5,152	50	19
	Other farm e.g. oversowing			-	0	
Administration	Administration			20,000	185	74
	Farm Insurance			15,000	139	56
	Rates			25,000	231	93
	Lease of Runoff Land					
	Industry good levy			3,084	29	11
	ACC			3,450	32	13
	Other administration			0		
Total Farm Working Expenses				\$ 453,423	\$ 4,198	\$ 1,679 72%
Net Surplus (EBITD)				\$ 174,717	1618	\$ 647 28%
Operational Capital Adjustments						
Capital Realised						
	Number	Value				
	Cows sold	0	\$ 1,600.00	0.00		
	Heifers sold	0	\$ 800.00	0.00		
	Shares sold	0	\$ 6.00	0.00		
Capital expense						
	Effluent field (ha)	-	\$ 350.00	0.00		
				0.00		
Total Capital				\$ -		0%
Personal				\$ -		
Total Personal				\$ -		
Total Other						
Surplus / Deficit				174,717		
Including Capital Adjustments				174,717		

The Profit & Loss account created in an Excel file for Cluster farm #5 is shown here in its initial state before modification.

The cells highlighted are to be input by the operator, although most of the pricing assumptions are called up from within the workbook from a shared pricing page.

Fixed costs are proportional to both farm area and changes in milk production.

For further information about the pricing assumptions refer to Parminter 2017.

Appendix B. Protocol for modifying milk production

Each of the farms had their milk production established initially from the population medians shown in Table 6. Each farm also had predetermined estimates of feed intake for the dairy cows. Both are drawn from individual farm Overseer data. These are both shown in Table B.1.

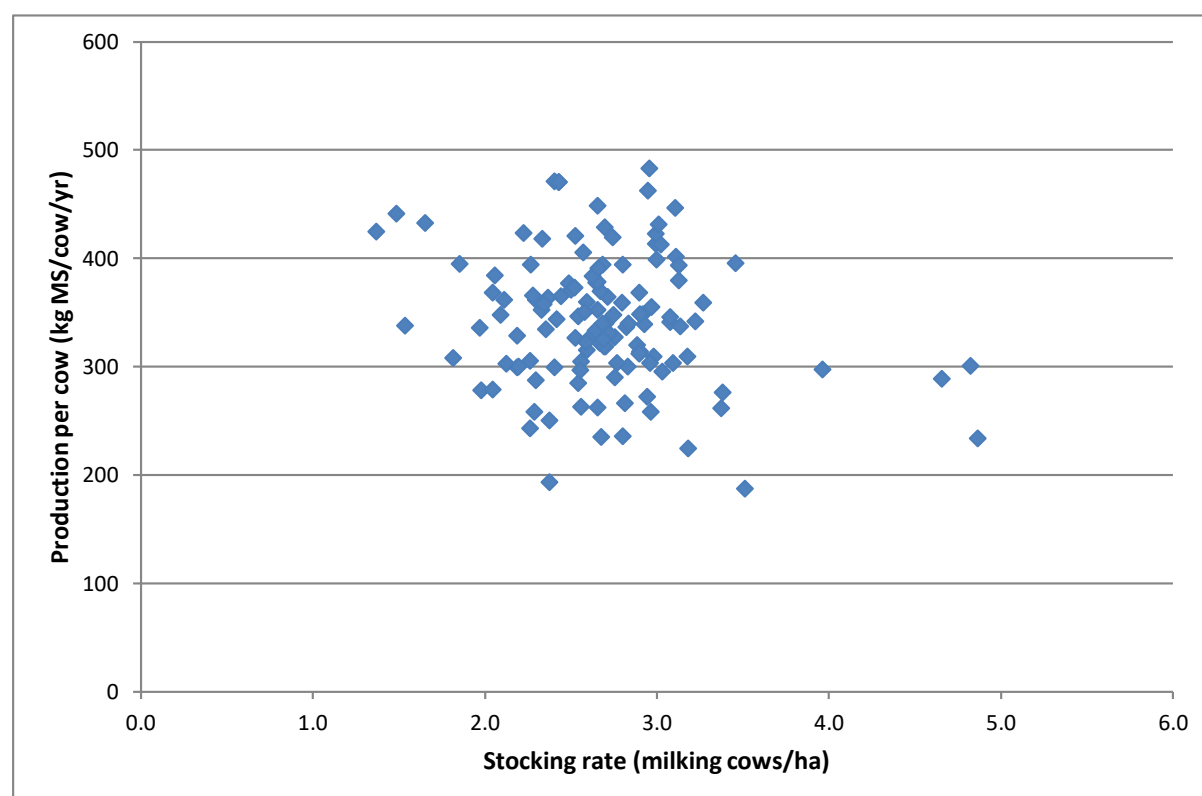
Table B.1 milk production and intake estimates

Cluster Farms	Feed Intake (kgDM/cow/yr)	Milk Production kgMS/cow/yr)
Farm #1	4793	321
Farm #2	5090	369
Farm #3	4751	340
Farm #4	5292	385
Farm #5	4704	336

Whenever farms reduced their herd numbers it was assumed that the amount of feed made available could be calculated from this table.

The amount of additional available feed was then allocated to increasing milk production. This was based on the distribution of farm milk production already known in the Upper Manawatu (Figure B.1).

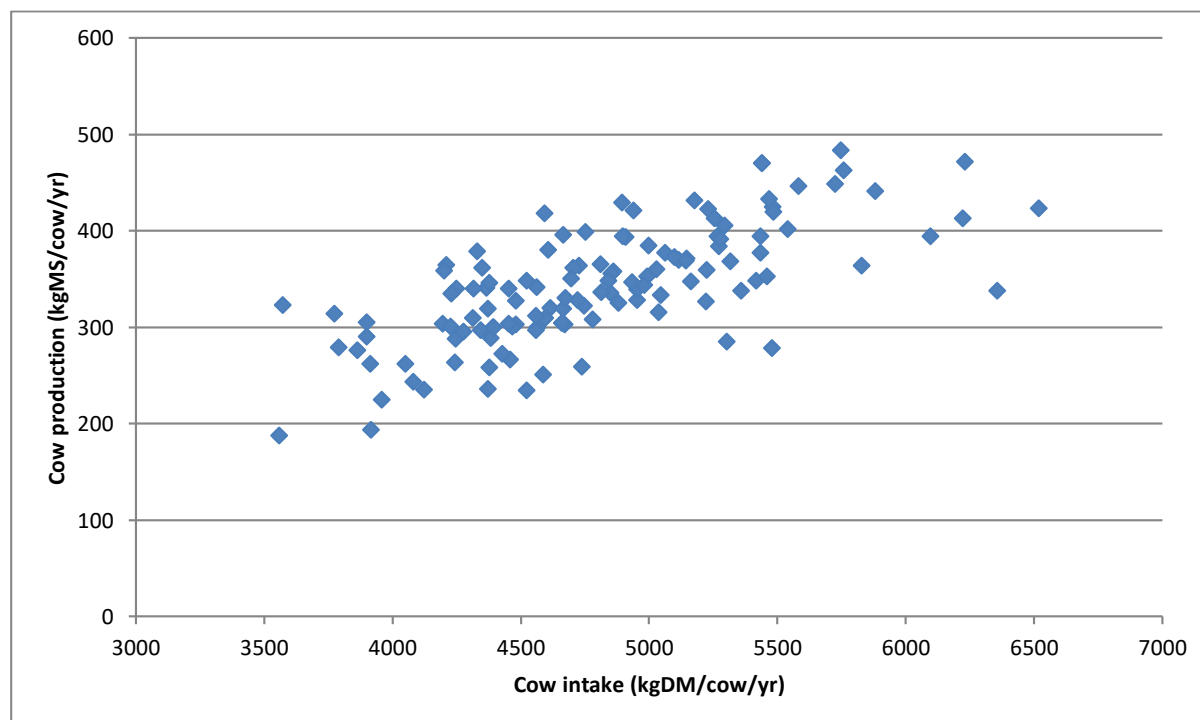
Figure B.1 The relationship between stocking rate and milk production



In Figure B.1 the herds of only 10% of farmers had achieved production results of more than 425 kgMS/cow/yr, so this figure was used as a maximum figure in the conversion of feed to production.

In Figure B.2 there is a significant relationship between cow intake and milk production ($P > 0.95$). However on its own, cow intake only explains about half of the between-farm variance in milk production ($R^2 = 0.49$). Using these results indicated that farmers could achieve 71.7gMS/kgDM⁴.

Figure B.2 Relationship between animal intake and milk production



Comparing the current median milk production in the catchment of 340 kgMS/cow with a maximum after twenty years of 425 kgMS/cow suggested that in this scenario, individual farms could achieve an increase of 1.25%/yr⁵.

So in the scenarios presented in this report the feed available from reducing stocking levels was converted into production per cow (71.7g/kgDM) to achieve a gain in milk production of 1.25% per year within a maximum of 425 kgMS/cow.

Lactation length has been found to be highly correlated with milk production in high producing herds (ML Ercolin 2002)⁶. Cows grazing pastures in late Autumn to extend lactations also contribute to winter losses of nitrogen into waterways. One of the mitigations included in this study was reducing lactation lengths from 277 days to 267 days and then 257 days. Subsequent milk production took the shortened lactations into account.

⁴ In Table 3.1 of the 'DairyNZ Economic Survey 2016-17' the range is from 73-80 gMS/kgDM intake

⁵ In Table 3.4 of the 'DairyNZ Economic Survey 2016-17' over the last 10 years dairy farmers nationally have achieved an average increase of 2.5% or twice the rate of increase used in this report and were doing 385 kgMS/cow/yr.

⁶ ML Ercolin, 2002. Lactation Curves in a Group of High Producing Dairy Farms in New Zealand. Masters Thesis, Massey University, New Zealand