Farmer Solutions Project

Prepared by

Perrin Ag Consultants Ltd

in association with

AgResearch

for the

Bay of Plenty Regional Council

REPORT PREPARED BY

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The information presented in this report is based on conservative current prices and returns to the best of the author's knowledge. No guarantees are given for the final result, which may be affected by factors outside the author's control.

Farmer Solutions Project - Directory

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Related Reports: This "main" Farmer Solutions Project (FSP) report should be read alongside the FSP Supplementary Paper dated 8 March 2013 and the FSP Farmer Feedback Summary dated 9 April 2013.

EXECUTIVE SUMMARY

The Farmer Solutions Project ("FSP") is an initiative of the Lake Rotorua Primary Producers' Collective ("LRPPC", "the Collective") funded by the Bay of Plenty Regional Council ("BOPRC") to improve the information available to BOPRC and the Collective about the potential economic impacts of land management and land use change as it relates to achieving reductions in nitrogen (N) loss to the Lake Rotorua catchment.

This report summarises the efficacy of appropriate N loss mitigation measures as applied to real farm operations within the catchment and estimates the market cost ($/kg N) of the reduction in N losses across the 12 participating farms by assuming each farmer is prepared to go to the edge of their comfort level. This individual case study analysis has then been used to extrapolate over the entire catchment.

The key findings from the report are:

(a) The combined "conditional" adoption of N loss mitigations modelled for the sample group provided a reduction of 62.3t of annual N losses, for an average economic impact of $559/kg N.

(b) Land management change from the sample group was estimated to deliver 31.7t of annual N loss reduction at an average cost of $171/kg N, while land use changes were estimated to provide an additional 30.6t of N reduction at an average cost of $960/kg N. Of the N loss savings associated with land use change, 71% were associated with dairy land, yet accounted for 94% of the economic impact.

(c) Separated into dairy land and sheep & beef, the combined dairy mitigations for the sample group provided 44.6t of N loss saving for $714/kg N. The sheep & beef properties were estimated to be able to deliver 17.6t of annual N loss reduction at a cost of $168/kg N.

(d) The sample group represented 43% of the dairy land in the Rule 11 catchment and 14% of the sheep & beef land, but there was some bias in the sample due in particular to the small sample size for the latter. Extrapolation of the sample analysis to the total ground water catchment based on independently derived biophysical GIS layers suggested a total reduction of 239.2t of annual N loss might be achieved from the dairy and sheep & beef sectors, on top of an estimated existing 17.8t reduction in annual N leaching from the dairy sector since 2001/04. The cost to achieve this reduction was estimated at

$88.1 million. When adjusted to align with the ROTAN GIS layers this implied a sustainable annual N load from the dairy and sheep & beef sectors of 281t.

It is important to recognise that the analysis conducted in the FSP and the conclusions thereof provide an opportunity to inform critical discussion as part of the on-going collaborative work to finding an enduring solution to the issue of water quality in Lake Rotorua, rather than presenting a definitive solution.

Modelling methodologies by their nature rely on a range of assumptions. In this case the assumptions were influenced by feedback from a subset of farmers and this was deemed appropriate because ultimately it is farmers who will be expected to change their land management and/or land use. Different sets of assumptions could have been explored in parallel however resource limitations precluded this. It would be useful for further analyses to be conducted using different sets of assumptions to test the robustness of the outputs and conclusions derived in this initial study.

As a result of the present analysis, the following recommendations are made:

(i) That the BOPRC recognises that land management change is likely to assist in providing some cost effective mitigation practices towards achieving the sustainable rural N allocation.

(ii) That the BOPRC commits to the proposed participant workshop following the submission of the final report.

(iii) Given the apparent efficacy of afforestation as a mitigation, particularly for sheep & beef farms, a separate piece of work be commissioned to more thoroughly investigate the implementation of this as a mitigation; this needs to take into account the considerable farmer opposition to afforestation, imperfect knowledge about its implications, the dichotomy of short-term cashflow versus long-term profitability and the fact that the cost-efficiency of afforestation can vary considerably between properties because of differences in land class and farm system type.

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1. Background and Terms of Reference

1.1. The Bay of Plenty Regional Council ("BOPRC") engaged Perrin Ag Consultants Ltd ("PAC") to conduct an analysis of the economic impacts of land use and land management change as it relates to reducing nutrient loss in the Lake Rotorua catchment, specifically nitrogen (N). This analysis was to be supported by geographic information system ("GIS") capability provided by AgResearch.

1.2. Modelling previously conducted by the BOPRC using the ROTAN (ROtorua and TAupo Nitrogen) model suggests that the rural sector needs to be able to operate within the constraints of an annual N load to the Rotorua catchment in the order of 280t N in order for the catchment to achieve the 435t N/year sustainable N load for Lake Rotorua. Some caution needs to be placed around the absolute number (280t) used here, given there are still on-going discussion around impact that other catchment mitigations might have on the eventual allowable rural load. The 280t N/year "rural target" is simply 435 t N/year minus the ROTAN-based loads from forestry, urban areas and rainfall on the lake, and assuming that separate mitigation actions reduce annual losses as follows: sewage/urban losses by 20 t N; Tikitere geothermal losses by 30t N; and gorse by 24t N[1].

1.3. To estimate the exact economic impact resulting from the range of identified land management and land use changes, all individual farmers within the catchment would need to have their existing farming system modelled using Farmax and Overseer and then have appropriate scenarios analysed for reductions in nutrient losses. This would require a significant amount of resources and funding.

1.4. Given the resources available it was decided that a target group of 15 farms representative of the catchment would be modelled. These would include both dairy and dry stock properties. In the end a total of nine dairy farmers and three sheep & beef farmers were interviewed and used as case studies. The sample size, as it relates to the relatively low number of sheep & beef farmers[2] participating, does warrant some caution when extrapolating to the entire catchment. However, the sample needs to also be put into the context of the relatively small size of the pastoral area of the Rotorua catchment (approximately 18,000ha based on Rule 11 catchment or 21,000ha based on ROTAN modelling).

[1] The 24 tN annual reduction assumed from gorse removal is less than the 41 tN maximum reduction calculated by BOPRC. Overall, the 280 tN/y target is considered a credible "rural target" within the context of the overall 435 tN/year target.
[2] Three out of the twenty farmers, which represent around 75% of all sheep & beef land in the catchment

1.5. The nine dairy case studies provide a good representation of the catchment's dairy activity, with a combined dairying area of 1,967ha (44% of Rule 11 catchment dairy land) across the three main soil types and in essentially all of the lake's sub-catchments. The participant farms had historical[3] N loss levels in line with the average of the catchment's dairy farms.

1.6. The three sheep & beef farms cover 1,686ha, or 14% of the 12,277ha of the Rule 11 catchment identified as being in sheep and beef farming. A lack of a case study farm involving deer or "lifestyle" farming activity is a clear gap in the representativeness of the sample, with deer farming (sometimes in combination with other stock types) occurring on about 12% (1,671ha) of the catchment's non-dairy pastoral land and lifestyle farming identified on 1,063ha. However, the greatest proportion (77%) of non-dairy pastoral agriculture in the catchment identifies as mixed sheep and beef farming, and the three case studies are certainly representative of this.

> A note on definitions
>
> Dry stock farming is considered to include any given combination of commercial sheep, beef and deer farming activity, whereas sheep & beef farming refers specifically to the farming of sheep and cattle only. The lack of any deer farming amongst participant farmers makes the "dry stock" case studies in this analysis strictly "sheep & beef" studies. For the purposes of this report, we will use the term "sheep & beef" to reflect the non-dairy pastoral land use analysed.

1.7. The first stage of the project, reported on the relationship between each farmer's level of comfort (or 'willingness to adopt') around possible mitigation options, the resources they would require to facilitate these changes and ultimately the economic impacts these changes would have on farm profitability and capital requirements.

1.8. The second stage summarised the efficacy of appropriate N-loss mitigation measures as applied to real farm operations within the catchment and estimated the market cost ($/kg N) of the reduction in N losses across the 12 participating farms by assuming each farmer was prepared to go to the edge of their comfort level (as identified in Stage 1).

1.9. The information from the sample farms was then used in Stage 3 to extrapolate out over the whole catchment to provide a more accurate estimate of the possible aggregate

[3] 2001-2004 levels as assessed for the purposes of nutrient benchmarking under Rule 11C

economic impact of the pastoral sector trying to reduce annual N losses to Lake Rotorua to a sustainable load of 280t N/year.

1.10. The project is not dissimilar to work completed in 2009 by the Waikato Regional Council ("WRC"), previously known as Environment Waikato ("EW"). The Upper Waikato Nutrient Efficiency Study ("UWNES") looked at the impact on profitability of mitigations on dairy and dry stock farms in the Upper Waikato catchment in order to achieve N loss targets of 26 and 12kg N/ha/year respectively. In the case of the FSP, a whole catchment target for annual N loss reduction is the driving factor behind the need to reduce N losses, and therefore complete land use change is a possible mitigation. In the UWNES, it was anticipated that only minimal land use change was available as a mitigation strategy, the focus being more to "prove" that aggressive N loss targets were achievable at minimal economic cost.

2. METHODOLOGY

STAGE 1 - FARMER PREFERENCE

2.1. A questionnaire was developed with 24 mitigation options to reduce N losses. These options ranged from profit-neutral land management changes to complete land use change.

2.2. The purpose of the questionnaire was primarily to assess each farmer's level of comfort with the proposed mitigation options by way of a ranking system; 1 being "no capacity for adoption" and 5 being "already doing it". The questionnaire then required farmers to state what their perceived "obstacles to adoption" were and identify "ways to facilitate the adoption" for each mitigation option using a matrix with a 1-5 scale.

2.3. Ten dairy and five dry stock farms with varying size, soil type, LUC class and intensity were approached across a range of sub-catchments to develop a representative sample of commercial pastoral farming activity in the Lake Rotorua catchment. Each farmer was sent an email asking for their participation, summarising the purpose of the project and explaining the attached questionnaire.

2.4. PAC then individually visited each farmer who responded affirmatively to participate to discuss any queries they may have with the project itself and to assist with completion of the questionnaire. Current farm management information for the 2011/12 farming season was also collected at this visit so current farming systems could then be modelled in Farmax and Overseer for the final report.

2.5. Information collected in the questionnaires was then collated into three tables (Tables 1-3) with all farmer comfort levels totalled and averaged for each mitigation option. All data was to be presented in an aggregate form, with no individual farmers to be identifiable within any of the preliminary or public reporting.

2.6. For each of the case study farms, representative status quo models were created in Farmax Pro 6.4.6.07 or Farmax Dairy Pro 6.5.0.4 and Overseer 5.4.11[4]. Operational data for the recent 2011/12 season were provided by the participants to create a validated feasible farm model in Farmax. "Normal" growth rates then replaced the interpolated actuals for the 2011/12 season and operational assumptions were adjusted to ensure "typical" production levels were achieved along with a pattern of normal average seasonal pasture covers. Associated Overseer models were then created to identify "current" levels of annual nitrogen loss.

2.7. Data from the Stage 1 interviews was then assessed for each case study participant in order to identify what N-loss mitigation measures might be possible within these businesses without causing farmers to move beyond their currently perceived limits of participation. The requirement for market compensation to offset expected reductions in annual profitability or loss of capital value was widely offered as a requirement for adoption of many of the presented mitigations.

2.8. Based on the individual farmer responses, a single scenario was then developed for each farm to identify the "cost" of reducing N loss for pastoral farming activity. This single scenario, which could potentially include a combination of mitigations was based on the initial interview data, and the authors' own experience in the catchment, to maximise the efficacy of the N reduction (i.e. the largest amount of reduction for the least cost).

2.9. This approach was taken due to:

(i) Limited funding meant that the preferred approach of developing optimised solutions for each property was not possible.

(ii) The anticipated public funds potentially available to compensate" farmers for N-loss reduction are limited hence it made sense to identify where the "biggest bang for buck" was likely.

(iii) Many of the known N loss mitigations result in proportional reductions when added to existing mitigations, and in doing so reduce significantly in efficacy compared with when used alone.

[4] Version 5.4.11 was used to ensure consistency with the recently completed Rule 11 benchmarks for the participant farms.

2.10. In order to try and identify which mitigations or combination thereof were most suitable, three of the dairy case studies were analysed on a single mitigation basis across a range of mitigations. In combination with the analysis of some sequential additions of mitigations for some of the other case studies, an estimate of the variation in efficacy of these techniques within the Rotorua catchment was able to be developed (see 2.11-2.19 below).

2.11. Land management mitigations evaluated for use were:

(i) Replace N fertiliser with low N feed

(ii) Replace high N feed with low N feed

(iii) Cease cropping

(iv) Reduce N fertiliser and reduce production

(v) Eliminate N fertiliser and reduce production

(vi) Partial or full changes in stock class

(vii) Partial wintering facilities (on/off)

As the majority of the sample group had already ceased winter (May, June, July) N usage, reduced quantity and increased frequency of fertiliser N applications and implemented direct drilling of summer crops, these strategies were not evaluated. The location of the farms made the efficacy of DCD use questionable based on independent research completed in the district. Full wintering facilities were discounted due to the limited numbers of farms with significant numbers of cows being wintered on farm. However, more research in this area is recommended in order to develop a more comprehensive assessment of the efficacy of this mitigation in the catchment[5].

2.12. Land use changes evaluated were:

(i) Retirement of the least productive land (5% of area) on sheep & beef farms;

(ii) Full conversion of dairy to sheep & beef;

(iii) Full conversion of sheep & beef to production forestry;

(iv) Full conversion of dairy to production forestry;

The limited potential for conversion of land for urban development meant subdivision was not included as a mitigation option. "Lifestyle" subdivision was also discounted due

[5] Previous analysis by the authors suggests that the high capital cost ($2,000/cow) is hard to justify as in that instance full wintering facilities didn't provide significant reductions in N loss over much cheaper uncovered loafing pads.

to the currently depressed market for this class of property. Conversion to production forestry was considered ahead of reversion to native due to the more favourable economics and a (marginally) higher preference by the sample group.

2.13. All mitigation scenarios were modelled in Farmax and Overseer and then assessed using partial budget analysis, based on the outputs of the Farmax and Overseer models used. Medium term input and output prices were used and a representative operating budget created for both a Rotorua dairy farm and sheep & beef operation. It was decided to assess dairy profitability on the basis of milk price only (excluding the impact of supplier shares), given that there are three milk supply options for Rotorua dairy farmers and that, currently, the dividend yield on a Fonterra share is similar to the opportunity cost of capital.

2.14. Key economic assumptions used are presented in Table 1 below.

2.15. Productivity mitigations (i.e. increase per cow production or reduce N and accept lower animal production) were not considered and land management change scenarios were modelled on the basis that per animal productivity was unchanged, with stock numbers reduced to accommodate reduced feed availability. This decision was made on the basis that a representative sample of farmers would in theory already be operating at the limit of their own individual capability to achieve productivity gains and that it is both difficult and inefficient to actively try to farm at a lower level of animal productivity. The sample group also had an average level of per cow production of 360kg MS/cow - well above both regional and national averages.

2.16. This differs from the approach taken in the 2009 Upper Waikato Nutrient Efficiency Study commissioned by the Waikato Regional Council, which saw productivity improvements as a key tool to reducing the economic impact of N mitigation strategies. The authors agree with this position, but contend that in reality these may be hard to achieve. The DairyNZ commissioned[6] work conducted in the Rotorua catchment had previously identified that improving productivity was an important way to maximise profitability in an N limited environment. However, even that study cast doubt on the capacity of the entire farmer group to practically achieve the necessary productivity gains.

[6] Ledgard S F and Smeaton D 2007. Rotorua Lakes catchment project: Nitrogen (N) leaching calculations. Final report to Dairy Insight. AgResearch, Hamilton. 11p.

2.17. In order to develop a "cost" per kg N loss reduction, the annual change in profitability was capitalised at a discount rate of 5% and then combined with any change in the capital position of the farm operation (investment, change in stock numbers). The selection of the 5% discount rate was arbitrary, reflecting a mid-point between current deposit and loan rates.

2.18. The efficacy of the mitigation scenarios were then sequentially combined, moving from land management change to land use change. This order of combination was chosen as it largely reflected the preferences of the farmer sample group.

2.19. Note that the economic impact of these mitigation scenarios was considered inside the farm gate only. Estimation of the secondary impacts within the wider community was beyond the scope of the project.

Table 1: Key assumptions for the economic analysis

Key analysis assumptions		
Milk price	$ 6.00	/kg MS
Lamb price	$ 5.50	/kg cwt
Prime bull price	$ 3.75	/kg cwt
Wool price (37 micron)	$ 2.80	/kg greasy
Price of applied N (10:1 response)	$ 2.17	/kg N applied
PKE	$0.32	/kg DM delivered
Maize silage (purchase)	$0.34	/kg DM stacked
Grass silage (purchase)	$0.34	/kg DM stacked
Grass silage (make)	$0.12	/kg DM stacked
Cow Value	$1,800.00	/hd
R2 Heifer Value	$1,600.00	/hd
R1 Heifer value	$1,000.00	/hd
Cull cow price	$400	/hd
R2yr Steer/Bull price	$1,000	/hd
Weaner Bull price	$70	/ha
Average annual per cow costs	$ 355	/cow
Dairy farm working Expenses	$4.15	/kg MS
Sheep & beef farm working expenses	$63	/SU
PKE	90% utilisation, 11.5MJ ME/kg DM	
Maize silage	75% utilisation, 10.8MJ ME/kg DM	
Silage on feed pad	90% utilisation, 10.8MJ ME/kg DM	
Winter cow grazing	$23	/hd/wk
Yerling heifer grazing	$8	/hd/wk
Calf grazing	$6	/hd/wk

2.20. *Treatment of forestry options*

2.20.1. The partial or total conversion of pastoral land to forestry as a means to reduce N loss was suggested to participants as a mitigation option. The majority of the participants felt they had already engaged to some extent in the conversion of marginal land to forestry, although for soil conservation or riparian management rather than to reduce N loss.

2.20.2. As to further partial or complete conversion to forestry, the survey data showed that farmers are essentially 100% opposed to full afforestation. This is likely to be influenced by a lack of knowledge, lack of understanding about the complexity of the forestry business model and poor experiences with forestry.

2.20.3. However, the reality is that forestry provides a well-recognised method for the reduction of N losses from land activity and it is likely that afforestation will have a role in the medium to long term achievement of significant reduction in N losses within the catchment. Accordingly, the economic impact of this change in land use needed to be captured within the project.

2.20.4. While discounted cashflow analysis is typically used to compare the long-term profitability of forestry with other land uses, it doesn't adequately capture the actual cashflow impacts on adopting farmers. Upon retiring pastoral land for afforestation, there are number of immediate up-front costs of establishment and initial tending regimes, before a long period of neither cost nor income until harvest occurs. Coupled with a potential loss of annual profit from the retired land, the concept of forestry can appear non-compelling to a farmer, even if the long-term profitability is better than the marginal returns from the same piece of land in pastoral agriculture. While the Emissions Trading Scheme ("ETS") potentially provided carbon revenue to make such investment cash positive earlier, the current carbon price of $2.70/tonne[7] provides little value at present.

2.20.5. As a result, it was decided for the purposes of this study that as an alternative to using a per hectare net present value (NPV) profit measure to compare forestry with pastoral agriculture, an annual forestry right rental would be used instead. Market data[8] indicates that forestry rights for normal Pinus radiata plantations are currently valued at $150+GST per hectare in the Rotorua region (NPV $2,234 over 27 years at 5%) compared with an equivalent NPV of $4,703+GST/ha based on a clear wood

[7] Source: https://www.commtrade.co.nz/, 16 November 2012
[8] Source: Marty Craven, Telfer Young Rotorua, *pers. comm*.

management 28-year rotation and net stumpage of $42,000+GST per hectare (see Table 2 below). A forestry rental was used because:

(i) Its annual, "risk free" income stream provides a direct comparison with the income stream from pastoral farming;

(ii) It removes any capital requirement from the farm for forest establishment;

(iii) There are indications that there are potential investors who would be interested in forestry rights for smaller sized non-contiguous forestry lots.

2.20.6. For comparison, the analysis of scenarios where conversion to forestry has been utilised has been carried out for both the forestry rental and more traditional NPV approaches. The current NPV of a forestry investment is equivalent to that of an annuity of $315.71. However, it is important to note:

(i) Establishment costs are higher when pest plants (i.e. gorse, blackberry) are present;

(ii) Economies of scale, spatial location of the forest and proximity to port will have an effect on net stumpage rates;

(iii) If pruned (clear wood) stands can be marketed at optimum times, returns may be better.

2.20.7. It is recognised that this is a simplistic way of providing an assessment of forestry against pastoral agriculture. This approach does not incorporate the other issues that afforestation in the catchment needs to consider such as phasing, landscape planning, aesthetics and the potential land aggregation that might be required to ensure the retention of economic farm units amongst a patchwork of afforestation.

Table 2: NPV analysis of commercial plantation *Pinus radiata* forestry in the Rotorua district (Source: BOPRC, PF Olsen, Perrin Ag Consultants Ltd)

FORESTRY INVESTMENT - CLEAR WOOD MANAGEMENT REGIME

AREA to be replanted (ha) 1	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12 - 27	YEAR 28
Pre-plant release	$ 833												
Supply, plant and release	$ 667												
Releasing													
Survival and Releasing Assessment		$ 8											
Pruning					$ 800	$ 800	$ 800						
Thinning								$ 800					
Management/Protection/Maintenance													
Mapping & Stand Records	$ 27	$ 2	$ 1	$ 1	$ 49	$ 10	$ 10	$ 10	$ 2	$ 2	$ 2	2	
Fire Levy & Water Points			$ 2	$ 2	$ 2	$ 2	$ 2	$ 2	$ 2	$ 2	$ 2	2	
Forest Health & Dothistroma Control			$ 4	$ 4	$ 22	$ 4	$ 4	$ 24	$ 4	$ 4	$ 4	4	
Pest & Weed Control	$ 18	$ 18	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	7	
Property Maintenance	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	5	
Road & Track Maintenance	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	5	
Insurance	$ 5	$ 10	$ 10	$ 10	$ 10	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	
Rates	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	$ 100	
Management	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	$ 7	7	
Total cost $ per Hectare	**$ 1,667**	**$ 155**	**$ 141**	**$ 141**	**$ 1,007**	**$ 956**	**$ 956**	**$ 976**	**$ 147**	**$ 147**	**$ 147**	**$ 147**	
TOTAL COST	**$ 1,667**	**$ 155**	**$ 141**	**$ 141**	**$ 1,007**	**$ 956**	**$ 956**	**$ 976**	**$ 147**	**$ 147**	**$ 147**	**$ 147**	**$ -**
estimated stumpage(net log revenue)/ha													42,000
TOTAL INCOME	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 42,000**
CASHFLOW	-$ 1,667	-$ 155	-$ 141	-$ 141	-$ 1,007	-$ 956	-$ 956	-$ 976	-$ 147	-$ 147	-$ 147	-$ 147	$ 42,000
capital for land													$ -
TOTAL CASHFLOWS	**-$ 1,667**	-$ 155	-$ 141	-$ 141	-$ 1,007	-$ 956	-$ 956	-$ 976	-$ 147	-$ 147	-$ 147	-$ 147	$ 42,000

NPV	$4,703.51
discount rate	5.0%
internal rate of return	**7.84%**

NPV per ha	$4,703.51
Equivalent annuity over 28 years	$315.71
Current forestry right payment	$150.00

2.21. *Area of analysis*

2.21.1. It was requested that analysis be confined to land within the Lake Rotorua groundwater catchment as used by NIWA for ROTAN modelling (e.g. Rutherford et al., 2011). A groundwater catchment file was supplied by Bay of Plenty Regional Council. It should be noted that this catchment area is dissimilar to both the Lake Rotorua surface water catchments and the Rule 11 land use layer[9] (Figure 1).

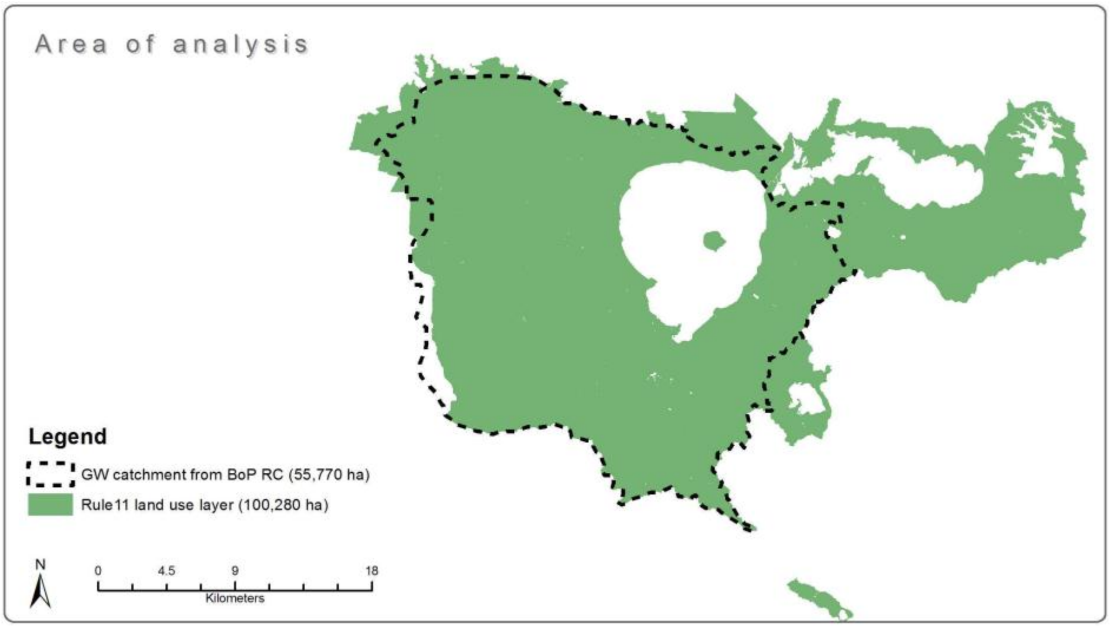

Figure 1: Area of analysis relative to Rule 11 land use layer.

2.21.2. The nature of the GIS layers used for the analysis resulted in the areas assigned to the two land use types of interest (dairy and sheep & beef) including a degree of non-effective area. However, the effective area within these total FSP areas was very close to the respective effective areas used in ROTAN (see Table 3 below).

2.21.3. The Overseer analysis used to generate nitrogen losses was modelled at the whole farm (total area) level10. In combination with the use of total farm areas (effective plus non-effective) for the extrapolation, the same net change in N losses were generated as if effective N losses were extrapolated over effective area. This is because all the

[9] Acknowledging that the Rule 11 layer illustrated includes other lake catchments.
[10] This was done to ensure consistency with the Rule 11 benchmarking modelling.

system changes considered were applicable to the effective area only (i.e. N losses from non-effective areas were consistent).

Table 3: Comparison of pastoral land use[1] in FSP compared with ROTAN

Land use	Total FSP area (ha)	Effective FSP area (ha)	ROTAN area (ha)
Dairy	6,215	5,278	5,050
Sheep & beef	15,717	12,276	13,401
Other farm types	2,563	2,005	2,671

[1] See Table 4 below for the definition of the pastoral land use types in FSP cf. the Rule 11 GIS layer

2.22. *Location of case study farms*

2.22.1. The 12 case study farms were located into a GIS environment according to maps supplied by BOPRC. In most cases these corresponded with legal parcels from the Core Record System maintained by Land Information NZ. Exceptions included Farms J and L where boundaries were delineated off farm maps.

Table 4: Rule 11 land use categories into four simplified classes

New classification	Rule 11 land use categories used (+ some Agribase)
Dairy	DAI, Dairy, Dairy/sheep/beef
Other farm type	Alpaca, Cropping, DEE, Deer, Deer/beef, Deer/beef/horses, Deer/sheep/beef, Deer/sheep/beef/dairy grazers, Deer/sheep/beef/goats, Deer/sheep/beef/Horses, Horses, Horses/pigs, Horses/sheep/beef, Poultry
Unfarmed	Bare ground, Bush, FOR, Gorse, Indigenous/Dairying, LIF, Lifestyle lawn, NAT, NOF, Pines, Scrub, Scrub/Dairying, Scrub/Horses, TOU, Urban, Water, Wetlands
Forestry (as a subset of 'Unfarmed')	*FOR, Pines*
Sheep and/or beef	BEF, Cattle, Cattle/dairy grazers, Cattle/dairying/cropping, Cattle/pigs, Dairy grazers, Dairy grazers/cropping, Dairy grazers/Deer, Dairy grazers/pigs, DRY, Sheep, Sheep/beef, Sheep/beef/dairy grazers, Sheep/beef/deer, Sheep/beef/goats, Sheep/beef/pigs, Sheep/dairy grazers, Sheep/deer, Sheep/horses, Sheep/pigs/poultry, SHP, S&B
Cattle farming (as a subset of 'Sheep and/or beef')	*BEF, Cattle, Cattle/dairy grazers, Cattle/dairying/cropping, Cattle/pigs*
Dairy grazing (as a subset of 'Sheep and/or beef')	*Dairy grazers, Dairy grazers/cropping, Dairy grazers/Deer, Dairy grazers/pigs*

2.23. *Land use*

2.23.1. Rule 11 land use was supplied by BOPRC as a GIS layer. No metadata was supplied. The small area of the ground water catchment not covered by the Rule 11 land use layer (see previous Figure 1) was in-filled using Agribase farm type classifications supplied by BOPRC. Land use classes were simplified into four primary types and three sub-types (Table 4 above) that more closely related to the case study farm types.

2.23.2. Analysis of mitigation and economic impacts on the case study properties has been performed on a whole-of-farm basis. The Rule 11 land use layer does not describe land use by farm (farm boundaries are excluded to maintain anonymity). An alternative is the Agribase, but considerable gaps and misrepresented farm boundaries were evident within the catchment. As a proxy for the extrapolation analysis, land use was "back-inherited" into legal parcels from the Core Record System (Figure 2). Parcels were assigned the dominant land use by area.

2.23.3. The main reason for using parcels is that they provide a better representation of Overseer outputs. For example, we could not use block outputs for the extrapolation exercise because the location and character of farm Overseer blocks would be unique to individual farms (e.g. with respect to effluent blocks). Further, block values could not be validly extrapolated because Overseer is a whole farm model. Hence, whole-of-farm Overseer outputs should be used (where block outputs from trees, pasture, effluent blocks, etc are aggregated into a single value). As the parcel summarises all this type of information, the parcel provides a better representation rather than the discrete land uses and covers recorded in the Rule 11 land use layer.

2.23.4. Additional reasons for employing this approach include the fact that legal parcels are more-readily tradable entities than amorphous 'areas of land use', and can thus be used to provide a more realistic representation of some types of land use change.

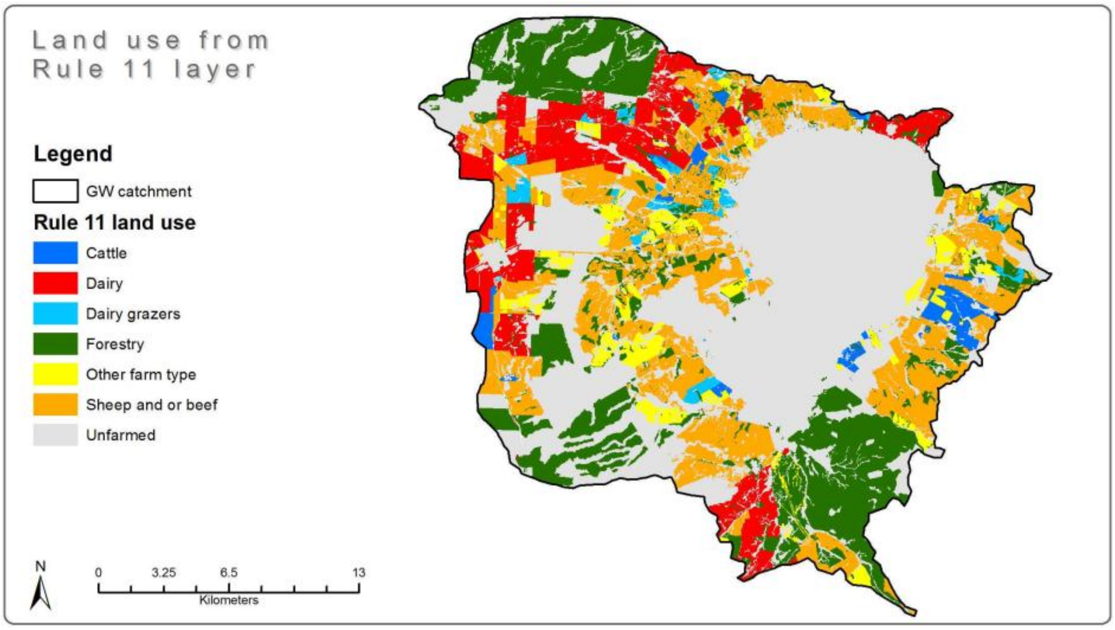

Figure 2: Land use from Rule 11 land use layer.

2.23.5. Slight differences appear between the land areas generated by the raw GIS data (see Table 5) and those used in the extrapolation analysis (see Table 4 above) because case study farm classifications take precedence over classifications from the Rule 11 land use layer (Figure 3).

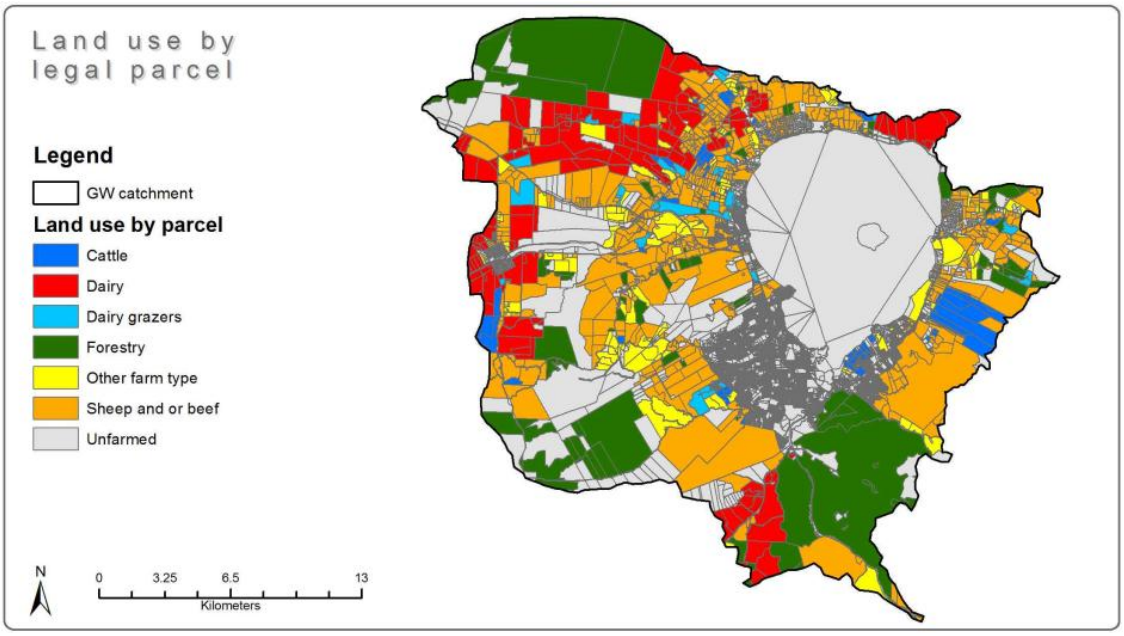

Figure 3: Land use by legal parcel.

Table 5: Land use summary

Land use	Hectares
Cattle	1,324
Dairy	6,209
Dairy grazers	858
Production forestry	10,261
Other farm type	2,563
Sheep and or beef	13,414
Unclassed	21
Unfarmed (incl. lake)	21,118
Total	55,769

2.24. *Farming zones for dairy*

2.24.1. Farming zones were constructed as a basis for extrapolating dairy farm results. The premise is that the case study dairy farms were broadly representative of local farming landscapes, climates and conditions (the zones), and that case study findings could be broadly extrapolated to similar farms located within the same zones.

2.24.2. Several wholly quantitative methodologies and datasets (e.g. Land Environments NZ) were considered, but most did not adequately capture the locally recognised farming environments. This is not surprising as it can be difficult assigning absolute boundaries and thresholds to colloquially recognised landscapes (e.g. 'hill country', 'high country', and for this project plateaus).

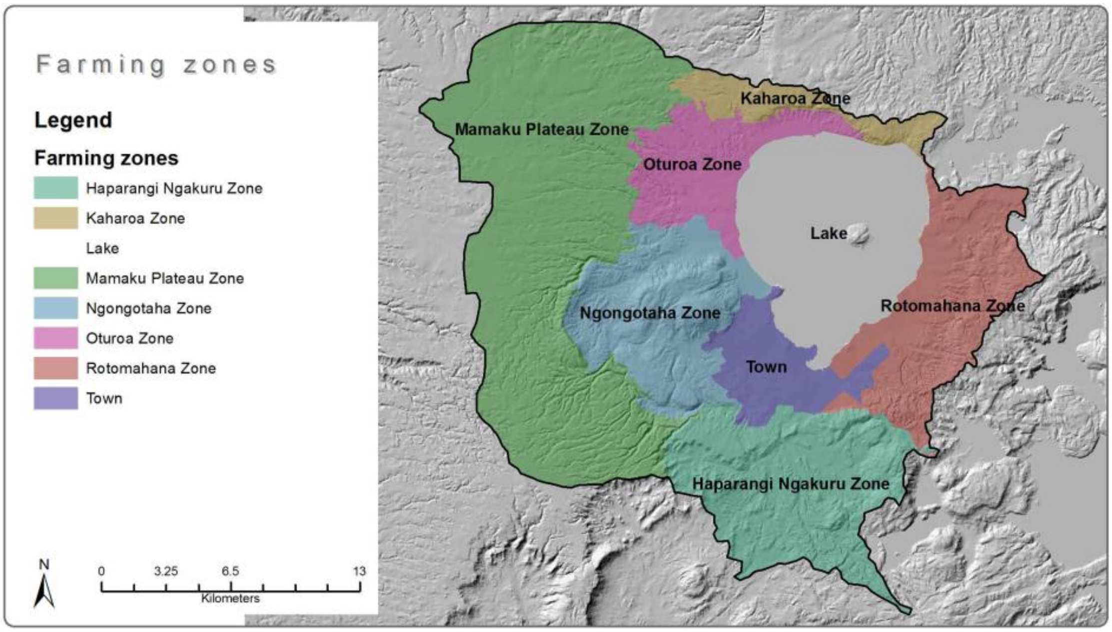

Figure 4: Farming zones

2.24.3. Zones have therefore been constructed using a combination of quantitative and qualitative methods. Most were based on characteristic soils (where soils are the sum result of many environmental variables interacting over time) such as the Mamaku zone (Podzols) and the Rotomahana zone (unique influence of Rotomahana mud). Boundaries were modified to better represent locally recognised boundaries (e.g. reference was made to Beveridge et al., 2009 when delineating the Mamaku Plateau boundaries). Five farming zones were identified (Figure 4). Case study farms and all dairy land use parcels were assigned to farming zones (Table 6 below).

2.25. *Slope classes for sheep and beef farming*

2.25.1. The sample of case study sheep and beef farms ("S&B") was considerably smaller than that for dairy (3 cf. 9), and the representation of the previously discussed farming zones was sparse and heavily biased (90% of the S&B case studies by area were located in the Rotomahana Zone). An alternative basis for extrapolating S&B results using slope and topography to differentiate the more traditional and more extensive types of S&B farms from S&B farms where cattle (dairy grazers or beef) might be grazed more intensively was chosen.

Table 6: Summary of dairy farm parcels according to case study farming zones.

Zone	Area (ha)	# of parcels	Extrap. N-loss (kg N/ha/yr)[1]
Haparangi Ngakuru Zone	948	36	47.5
Kaharoa Zone	601	29	36.7
Mamaku Plateau Zone	3,956	128	41.8
Oturoa Zone	704	39	52.8
Ngongotaha Zone[2]	-	0	0
Rotomahana Zone[2]	-	0	0
Grand Total	6,209	232	

[1] Where more than one case study farm falls within a farming zone, the average across these farms is used. Note that the two dairy farms in the Kaharoa Zone have very different N-leaching losses. Also note that the Mamaku zone farms straddling into the Oturoa Zone tend to have lower N-losses relative to those farms located wholly in the Mamaku zone. Also note that case study farms retain their original N-loss values (i.e. averages are not used for the case study farms). Values refer to status quo N-loss values.

[2] No dairy case study farms, nor any Rule 11 land use dairy farms, appear to be present in either the Ngongotaha or Rotomahana Zones (Wharenui no longer has a dairying operation).

2.25.2. Two topographical categories were generated based on reported methods for classifying NZ hill country (e.g. de Klein et al., 2009; Basher et al., 2008) to classify parcels into hill and non-hill (Figure 5) and to differentiate sheep and beef into hill and non-hill S&B (Table 7).

2.25.3. The two categories were Flat to easy (≤15°) and Hill (>15°)[11].

2.25.4. Given that the three sheep & beef farm case studies were clearly identifiable based on their topography and operating policies as being either intensive[12] non-hill ("Flat to easy") or extensive hill ("Hill"), the case study N losses were used to assign the status quo N losses to the respective topographical categories.

2.25.5. Despite the small sample size, given that on an area-weighted basis the average N loss from the effective farming area at 16kg N/ha/year was identical to that which had been assumed in ROTAN improved the confidence levels associated with using these N loss figures.

[11] These equate with the Overseer slope classes of Flat + Rolling (≤15°) and Easy + Steep (>15°)
[12] Including dairy grazing

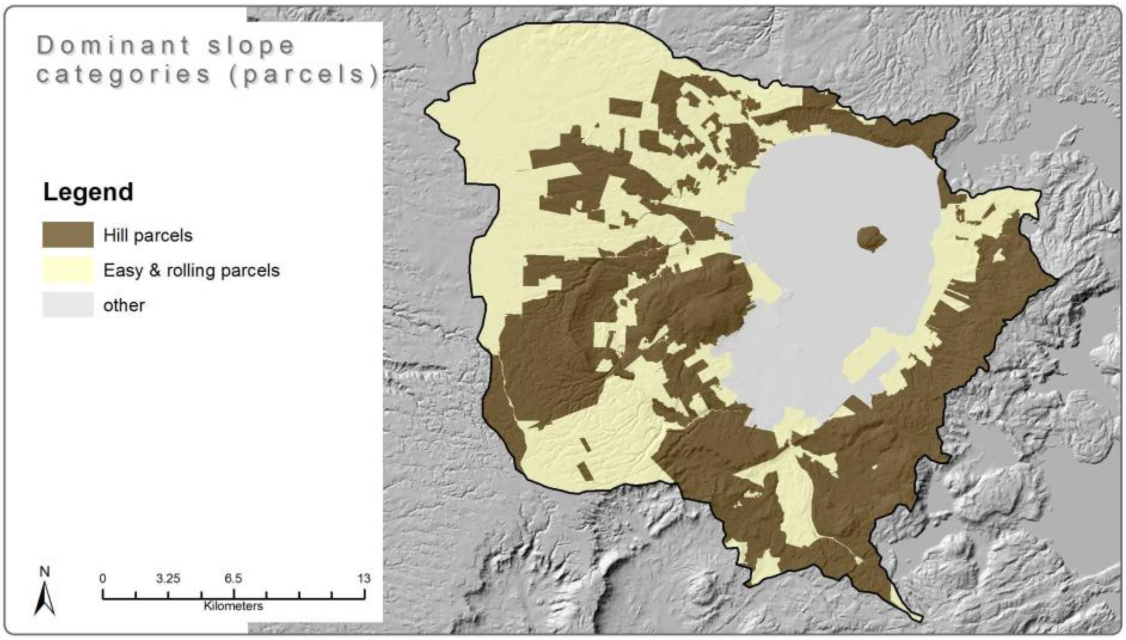

Figure 5: Slope categories by parcel.

Table 7: Summary of S&B parcels by dominant slope class

S&B type	Area (ha)	# of parcels	Topo class	% in topo class	N-loss (kg N/ha/yr)
Dairy grazers	858	105	Flat to easy	70%	25.9
Other cattle intensive	646	216	Flat to easy	100%	25.9
Other cattle extensive	677	21	Hill	100%	11
S&B intensive	4,650	749	Flat to easy	100%	25.9
S&B extensive	8,764	570	Hill	99%	11
Totals	15,596	1661			

2.26. *Mitigation scenarios*

2.26.1. Four aggregate N-loss mitigation scenarios based on the case study farms were then applied in a successive and accumulative manner.

2.26.2. The aggregate economic cost associated with implementing the mitigations was then calculated for each of the scenarios.

3. THE SAMPLE FARMS

3.1. Farmer participation in the project was on the basis of the public anonymity of participants, partially due to the small size of the catchment, but also due to the perceived consequences of individual farm N leaching data being in the public domain before a suitable framework for the on-going management of nutrient losses from pastoral agriculture in the catchment is in place. In order to provide a better picture of the businesses involved, a representative farm model was created for both the dairy and sheep & beef sample group.

3.2. There is a risk of inherent bias within the sample group, as participation was voluntary and the properties selected exhibit productive indices higher than national or regional standards. Based on personal knowledge of the participants, it is likely that above average operators formed the sample group for both farm systems. Without a full catchment survey it is unwise to describe the remainder of farmers in the Rotorua catchment as having lower productivity or profitability characteristics. However, taking a long term view of land tenure and management, it is realistic to expect that over the medium term, farm performance over the whole catchment will perform at a lower level than the sample group.

3.3. On the basis that the sample group typically have higher productivity and profitability than average, we would expect that the financial impact of land management change at an aggregate catchment level might potentially be greater than that modelled (as higher management ability is to likely result in a lesser financial cost when adopting mitigations). The converse applies for land use change, where the cessation of farming activity at a lesser level than that modelled will probably result in a reduced negative economic impact forecast.

3.4. These factors have been excluded from the extrapolation however, as without a full survey of all farmers in the catchment, such variation is impossible to quantify.

3.5. Dairy

3.5.1. The sample group had an average milking platform of 219ha milking 612 cows for an average stocking rate of 2.8 cows/ha (range 2.3-3.2 cows/ha). Milk production averaged 1,008kg MS/ha (range 812-1,168 kg MS/ha). All replacements were grazed off the milking platform and about half of all cows were wintered off for eight weeks.

None of the sample group fully wintered on the milking platform. External supplement usage averaged 1.3t DM/ha (range 0. 9-1.8t DM/ha) and the farms used an average of 135kg/ha of fertiliser N (range 45-218kg N/ha/year).

3.5.2. Current whole farm (including forestry and contiguous run-off) N loss averaged 30.8kg N/ha/year (range 16.9kg-56.5kg N/ha/year), with N-losses just from the milking platform of 41kg N/ha/year. This outcome was significantly biased by the inclusion of Farm J in the sample, which would be considered atypical for N loss within the catchment.

3.5.3. It is important to note that on a weighted average basis, only 86% of the effective dairying areas of the sample group fall in the Rotorua catchment as defined by Rule 11C, the balance draining to neighbouring catchments. The percentage of the dairying area within the ROTAN groundwater catchment is likely to be higher. The impact of this would be to lower the "cost" of N loss mitigations as they are presented in this report.

3.5.4. The "model" farm is presented in Table 8 below. The "model" dairy farm operating budget is presented in Figure 6.

Table 8: Model dairy farm for Rotorua catchment

KPI		Average Dairy Farm
Total area	ha	365
Total area in Rotorua catchment	ha	241
Total eff area	ha	219
Total eff area in catchment		188
Peak cows		612
Milk production	kg MS	220,327
per cow	kg MS/cow	360
per ha	kg MS/ha	1,008
Stocking rate	cows/ha	2.8
Imported supplement fed	kg DM/ha/year	1,364
Total N applied/ha	kg N/ha/year	135
Annual N loss/total ha		31
per effective milking platform	kg N/ha/year	41

3.6. Sheep & beef

3.6.1. The sample group had an average pastoral area of 562 ha, wintering 6,072 stock units[13]. This included an element of dairy support, although no mature dairy cows were wintered on any of the sample farms. Stocking rate averaged 11.9 SU/ha (range 9.8-

13 These are annualised stock units, equivalent to annual consumption off 6000MJ ME of 11 MJ ME/kg DM pasture.

22.9SU/ha). The sample average wintered 617kg live weight (range 568– 958kg) and produced 297kg of net product per year (range 223– 560kg). The sheep to cattle ratio averaged 55:45. The farms used an average of 19kg fertiliser N/ha/yr.

3.6.2. Annual N losses average 13kg N/ha/year (range 10-25.9kg N/ha/year), with losses from the effective pastoral area averaging 16kg N/ha/year.

3.6.3. The "model" farm is presented in Table 9 below, with its model operating budget presented in Figure 7.

Table 9: Model sheep & beef farm for Rotorua catchment

KPI		Average drystock
Total area	ha	725
Total area in Rotorua catchment	ha	725
Total eff area	ha	562
Total eff area in catchment		562
Stock units	SU	6706
Stocking rate	SU/ha	12
Liveweight wintered/ha	kg/ha	617
Net kg product per hectare	kg/ha	297
Cattle %		45
Total N applied/ha		19
Current N loss per hectare	kg N/ha/year	13
per effective grazing hectare	kg N/ha/year	16

OPERATING BUDGET

Farmer Solutions Project model dairy farm

				Model dairy
Area (ha)				219
Peak cows milked				612
Stocking rate (cows/ha)				2.80
Total production (kg MS)				220,327
INCOME				
Milksolids		$6.00 /kg MS		$1,321,959
Cattle sales & purchases				
		$400 /cull cow		$41,727
		$12 /bobby		$4,252
TOTAL INCOME				**$1,367,939**
			/ha	$6,256
			/kg MS	$6.21
EXPENDITURE				
Labour	FTEs (incl. unpaid management)			3.2
	Permanent (incl mgmt, ACC & Kiwisaver)			$196,106
Animal Health			$70 /cow	$42,817
Breeding Expenses				
	AB (5 weeks)		$17 /cow	$10,398
	Herd testing, MINDA, tail paint		$14 /cow	$8,563
	Natural mating (lease bull costs after 5 weeks AB)		$22 /cow	$13,624
Electricity			$44 /cow	$26,913
Freight				$2,700
Feed				
	Calf rearing		$23 /cow	$14,068
	Hay & silage (incl.fertiliser)		$599 /ha cut	$13,097
	Cropping (incl. fertiliser)		$830 /ha cropped	$13,611
	Maize cropping		$3,151 /ha cropped	$7,005
	Imported feed			
		Grass silage	$340 /t DM	$33,811
		Maize silage	$340 /t DM	$33,811
		PKE	$320 /t DM	$31,822
		Grain	$530 /t DM	$0
	Grazing			
		Winter cow	$23 /head/week	$56,273
		Yearing heifer:	$8 /head/week	$56,160
		Calves	$6 /head/week	$16,200
Fertiliser incl. cartage & spreading				$90,554
Pasture urea (fert only)			$1,000 /t applied	$64,358
Regrassing (incl. fertiliser) ex-crop			$890 /ha cropped	$14,595
Regrassing (ex maize)			$370 /ha cropped	
Repairs & maintenance			$244 /ha	$53,349
Shed expenses			$21 /cow	$12,845
Sundry expenses				$2,000
Vehicles			$61 /cow	$37,312
Weed & pest			$35 /ha	$7,653
Overheads				
	Accounting & communications			$6,000
	Corporate overheads		$30 /cow	$18,350
	Lease			
	Rates		$91 /ha	$19,897
	Insurance		$52 /ha	$11,370
TOTAL FARM WORKING EXPENSES				**$915,262**
			/ha	$4,186.07
			/kg MS	$4.15
TOTAL OPERATING SURPLUS				**$452,677**
less	Depreciation based on IRD rates			$58,305
OPERATING PROFIT (EBIT)				**$394,371**
			/ha	$1,803.71
			/kg MS	$1.79
			/kg N losss	$44

Figure 6: Representative Rotorua catchment sample dairy farm operating budget

OPERATING BUDGET

Farmer Solutions Project model sheep & beef farm

			Model dry stock farm	MAF national model farm
Area (ha)			562	772
SU (as per farmax) [1]			6,706	6,907
Stocking rate (SU/ha)			11.93	8.95
Sheep: cattle ratio			55:45	
INCOME				
Net sheep revenue	$5.50	/kg lamb	$233,453	$323,703
Net cattle revenue	$3.75	/kg prime bull	$256,789	$102,856
Wool	$3.40	/kg greasy	$52,517	$67,927
Grazing revenue			$84,805	$25,930
Other			$0	$22,548
TOTAL INCOME			**$627,564**	**$542,964**
		/ha	$1,117	$703
		/SU	$94	$79
FARM WORKING EXPENSES				
Labour expenses				
Permanent wages (incl. superanuation)	$18.56	/SU	$124,468	$91,579
PRR				
Casual wages	$1.48	/SU	$9,925	$7,334
ACC	$1.06	/SU	$7,109	$5,402
Animal health	$5.00	/SU	$33,531	$18,651
Breeding	$0.45	/SU	$3,018	$2,219
Cash crop expenses	$4.00	/ha	$2,248	$2,933
Electricity	$7.00	/ha	$3,934	$5,251
Grazing expenses			$0	$1,548
Feed expenses				
Grass silage/hay	$599	/ha cut	$19,213	$9,766
Feed crops	$830	/ha cropped		$3,611
Palm kernel expeller meal/other				$3,062
Calf feed				
Farm stores				$3,148
Fertiliser & lime	$15	/SU	$100,594	$59,638
Freight	$8	/ha	$4,497	$5,773
Pasture urea	$1,000	/t applied	$10,556	$0
Regrassing	$10	/ha	$5,621	$7,407
Repairs & Maintenance	$31	/ha	$17,424	$27,972
Shearing			$27,908	$20,722
Vehicle expenses	$30	/ha	$16,862	$10,519
Weed & pest control	$11	/ha	$6,183	$8,728
Overheads				
Accounting/secretarial charge	$6	/ha	$3,372	$4,319
Communications	$3	/ha	$1,686	$2,629
Direct consultancy/supervision	$3	/ha	$1,686	$2,637
General administration	$9	/ha	$5,059	$3,277
Insurance	$10	/ha	$5,621	$7,170
Rates	$16	/ha	$8,993	$11,522
TOTAL FARM WORKING EXPENSES			**$419,507**	**$326,817**
		/ha	$746.36	$423.34
		/SU	$62.55	$47.32
TOTAL OPERATING SURPLUS			**$208,057**	**$216,147**
less Depreciation based on IRD rates	$27	/ha	$15,176	$19,556
OPERATING PROFIT (EBIT)			**$192,881**	**$196,591**
		/ha	$343.16	$254.65
		/SU	$28.76	$28.46
		/kg N loss	$21	

[1] Stock are annualised stock units as per Farmax & Overseer. MAF SU have been adjusted from wintered stock units

Figure 7: Representative Rotorua catchment sample sheep & beef farm operating budget

4. ANALYSIS AND RESULTS

STAGE 1 – FARMER PREFERENCE SURVEY

4.1. Farmer response to the survey was quite varied with many not fully understanding the reasoning behind the project and that the mitigation strategies were hypothetical and unrelated to the Rule 11 benchmarking project they had previously been involved in. There was also hesitance of some farmers to fill out the questionnaire for fear of their individual responses being revealed to the BOPRC. This uncertainty meant it was essential for PAC to visit each farmer individually to help farmers complete the questionnaire and especially give reassurance the questionnaire was confidential.

4.2. Of the 15 farmers approached, twelve completed the questionnaire (and formed the sample case study group), one farmer did not wish to participate and the remaining two were either not able to complete the questionnaire before the initial report or did not reply.

4.3. The raw results are presented in Appendices 1-3.

4.4. Comfort with adoption

4.4.1. As this part of the questionnaire was answered on a scale of 1-5 (1 being no capacity for adoption to 5 indicating existing adoption), each mitigation option could be averaged over the applicable farms to give an indication of the average level of comfort for each option.

Score	Description
1	No capacity for adoption
2	High degree of discomfort
3	Partially uncomfortable
4	Comfortable with change
5	Already doing it (voluntary adoption)

4.4.2. This section needed to be further explained to all farmers as many were simply answering each question from a financial point of view, i.e. most farmers would answer

‘1 - no capacity for adoption’ to option 15 (full wintering facilities), as they knew they could not afford to build one. However once explained that they could state the ‘obstacle to adoption’ in the next section as ‘financial constraints’, some changed their answers to ‘3 - partially uncomfortable or ‘4 - comfortable with change’.

4.4.3. Figure 8 below summarises the average comfort with adoption for the 12 farmers who participated in the project.

4.4.4. There was no significant pattern in this section other than all (dairy) farmers were happy to or believed they had already optimised their effluent system therefore the average comfort level of the applicable farmers was a score of 5 out of a possible 5.

4.4.5. Ceasing winter N usage and using lower rates of N fertiliser more frequently scored the next highest in terms of farmer comfort with scores of 4.42 and 4.30 respectively. In completing the interviews, it generally felt as if farmers were happy to adopt change and alter their systems as long as they can achieve the same end result, i.e. applying the same annual amount of N but more frequently at lower rates.

4.4.6. As can be seen in Appendix 1 below, Farmer F answered ‘1 – No capacity for adoption’ when responding to mitigation option 1, ‘Cease winter N usage’. This answer is contrary to the rest of the farmers interviewed and is clearly not well represented by the average score of 4.42 / 5. This demonstrates, despite a high average level of comfort, there will potentially be some farmers who are completely opposed to the adoption of specific mitigation options.

4.4.7. Extending existing riparian areas and ceasing cropping also recorded a high level of farmer comfort, both averaging 4.0 / 5. These options were not applicable for some farms therefore these averages are over twelve and ten farms respectively.

4.4.8. Creating artificial wetlands and if cropping move to a nil cultivation regime averaged scores of 3.70 and 3.88 respectively for the applicable farms. Many farmers had already adopted these practices as they wanted to be “pro-active about the issue”, resulting in farmers who answered ‘5 – Already doing it’ increasing the average for each of these mitigation option significantly.

4.4.9. Average comfort levels in the partial land use change section were relatively high with the lowest average in this section being 2.83 for option 16. ‘Forestry’. This suggests that farmers are somewhat prepared to retire/subdivide/reduce intensity on parts of their farms. However given that the areas targeted for this mitigation were not specified in this process, land which farmers were prepared to retire/subdivide might already be unproductive or too small to make a significant difference in nutrient loss reduction.

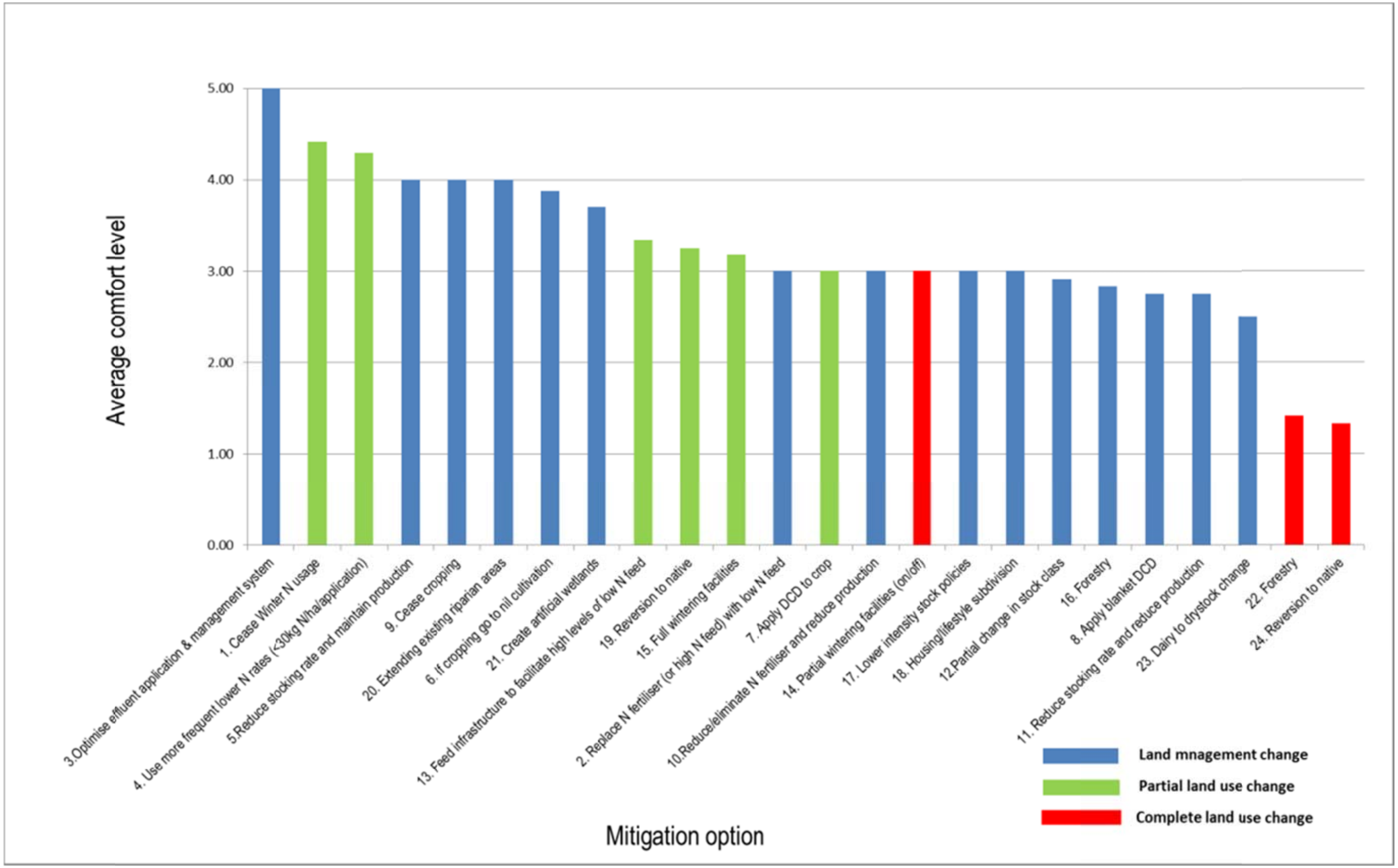

Figure 8: Farmer comfort with adoption

4.4.10. Complete land use change option 23. ‘Dairy to dry-stock change’ averaged 2.5 for the applicable farms. This was a relatively high level of comfort when compared to the complete land use change options 22. ‘Forestry’ and 24. ‘Reversion to native’, which scored 1.42 and 1.33 out of 5 respectively. This suggests that the surveyed farmers are partially comfortable with complete land use change as long as they are still able to farm animals as opposed to trees.

4.5. Obstacles to adoption

4.5.1. This section of the questionnaire was not ranked on a scale but rather a matrix where farmers could choose one or more obstacles to adoption for each mitigation option.

4.5.2. Of the 195 responses in this section, 143 (75%) of the responses identified ‘financial constraints’ as an obstacle to adopting a given mitigation, either partly or exclusively. Mitigation options that were answered with a ‘5 – Already doing it’ in the first section, did not have corresponding answers in the second and third sections meaning this percentage will be overstated when looking at the entire survey pool. In total there are 288 possible answers in this section, of which 143 were due to financial constraints, equating to 50%. Either way this suggests that the primary obstacle to adoption of nutrient loss mitigations for the farmer sample is the potential financial impact on their businesses. These mitigation options may impact on their profitability as a result of reduced income or increased expenses (including debt servicing) or on their capital position, as a result of increased borrowings from constructing low N leaching feed infrastructure such as a feed pad, or loss of capital value, through land use change to lower value land-use activity, such as conversion from dairy to dairy support or because the ability to farm is strongly constrained by BOPRC imposed environmental limits

Code	Description
1	Knowledge/capacity to change
2	Financial constraints (perceived/actual loss of income or capital value)
3	Political/ethical/moral objection
4	Land/soil/climate unsuitable
5	Other (please specify)

4.5.3. Knowledge and capacity to change totalled 43 out of 195 answers (22%). Although this scored low compared to the financial constraints this is a relatively inexpensive obstacle to overcome. Of the 8 applicable farms, 7 farmers said they would consider using DCD if there was more robust information supporting the benefits of the product.

4.5.4. Political/ethical/moral objections totalled 24 out of 195 answers (12%). Complete land use change to forestry, either native or exotic, and housing subdivision counted for the majority of this obstacle. Many respondents said their "land had only been cleared of forestry in the last few decades" and they "weren't in the business of farming people".

4.5.5. Perceived unsuitability of land/soil/climate totalled 25 out of 195 answers (13%).

4.5.6. Other reasons, which varied from not fitting with their share-milking agreement to keeping peace with neighbours, totalled 27 out of 195 answers (14%).

4.6. Ways to facilitate adoption

4.6.1. This section was answered with a matrix of 1-5 where farmers could choose one or more answers. A response was only required if the mitigation technique was yet to be adopted by the farmer.

Code	Description
1	Information/training
2	Market compensation /sale of NDA
3	Above market compensation/sale of NDA
4	See others adopt first
5	Other (please specify)

4.6.2. There was a very clear pattern in this section, with 136 out of 163 answers (83%) either partially or exclusively answered with '2. Market compensation'. This information suggests that the clear majority of respondents who have not adopted given mitigation options require compensation to reduce N losses from their current system if such mitigations resulted in reduced profitability or capital loss.

4.6.3. Of interest was the fact that there were very few farmers who required 'above market compensation (4 out of 163 answers) to adopt the presented mitigation options. These answers related to partial change in stock class, partial and full wintering facilities and complete land use change to forestry.

4.6.4. Information and training accounted for 50 out of 163 answers (31%) which is a significant amount considering the relatively inexpensive cost associated with providing this means of adoption. However this answer was often answered in conjunction with other answers such as ‘market compensation’ and ‘see others adopt first’, meaning information and training may not exclusively provide a means to adoption for 31% of farmers.

4.6.5. There were a small percentage of farmers that wanted to see other farmers adopt certain mitigation options before they would consider adoption (4%). This suggests that the majority of farmers interviewed are willing to be innovative or industry leaders.

4.7. Efficacy of individual mitigation options

4.7.1. As per 2.10 above, the process for identifying an appropriate single mitigation scenario for analysis required the evaluation of individual mitigations over a range of properties and farm systems within the sample groups.

4.7.2. The efficacy of these individual mitigations was assessed in the same way as the final scenarios through the use of partial budget analysis. The percentage reduction in whole farm N losses from the implementation of the mitigations was evaluated, along with the operational economic impact of each change. Where a mitigation was evaluated on more than one farm, the impact was averaged across all the properties

4.7.3. A summary of the mitigations is presented in Table 10 below, with the mitigations ranked from the least to greatest reduction in N losses at a whole farm level. The stated efficacy is the change in whole farm N loss resulting from changes within the effective area only. The results of similar mitigation assessments, as reported in the 2009 UWNES report, is included in Table 10.

4.7.4. The modelled results are largely consistent with the Upper Waikato Nutrient Efficiency Study ("UWNES"), with both pieces of work indicating that there is considerable variation between the efficacies of a given technique on different farm properties with different biophysical characteristics.

4.7.5. The complete land use change options provided the greatest reduction in nitrogen losses, but had the largest assessed economic impact. The exception was the conversion of sheep & beef properties to forestry under the modelled assumptions.

Table 10: Individual efficacy and cost of nitrogen mitigations for the Lake Rotorua catchment

Mitigation	Average reduction in whole farm N losses	"Cost"	Comment	Reduction of comparable mitigation in the UWNES
Reduce milking cows, graze replacements on	-9%	N/A	This actually increased N losses. This would appear to be due to the reduced quantumn of N leaving the farm in product for no reduction in the number of female cattle liveweight wintered.	
Retirement of 5% of sheep & beef for forestry	4%	-$389	This is higher than the implied cost of total land use change. This probably reflects the relative weighting of the case studies within the "average" model. As it happens, this mitigation varied from extremely unprofitable to very profitable, depending on actual sytem and land retired.	3%
Swap PKE for Maize on feed pad	7%	-$454	Relatively low impact, despite the difference in protein levels between the feeds. High cost relative to the low impact.	3%
Use of wintering pad (uncovered) for half the herd	12%	-$405	The efficacy of seemed to vary depending on the underlying operating policies. More work on how to accurately model in Overseer needs to be done.	9%
Cease cropping (winter or maize)	24%	-$173	Note that impact of growing maize on effluent paddocks isn't captured using Overseer 5.4.11. This would need to be reassessed using Overseer 6.	n/a
Reduce to 100kg N/ha, replace feed with maize silage	26%	-$93	This mitigation actuallly led to an improvement in economic outcomes for one case study. Dependent on overall dairy system. Overall probably the best management mitigation, as the low N content of the maze leads to an overall improvement in system N efficiency.	n/a
Reduce N usage to 100kg N/ha (if currently above 150kg N/ha)	33%	-$292	The reduction in feed associated with this mitigation has been managed via reduction in stocking rate.	15%
Eliminate N Usage (10:1 response for last 100kg N)	42%	-$276	Complete cessation of fertiliser N may lead to sward compositional changes, with a lowering of overall pasture growth potential. On this basis the cost of N elimination is exacerbated (represented by a 15:1 assumed response rate). Reduction in growth managed by reduction in stocking rates.	n/a
Eliminate N Usage (15:1 response for last 100kg N)	43%	-$354		n/a
Dairy support to bull beef (cattle 70% SU)	49%	-$227	This is the shift from grazing heifer replacements to a conventional 15 month bull beef policy.	
Conversion from dairy to drystock	61%	-$966	This assumes a shift in land use from the average dairy scenario to the average sheep & beef scenario.	n/a
Complete land use change to forestry from drystock	81%	-$143	Use of NPV-based annuity of $315/ha for forestry implies that afforestation actually increase profitability. Gap between profit analysis & market price derived from land values	n/a
Complete land use change to forestry from dairy	93%	-$688	The "cost" not dissimilar to the market gap between dairy and forestry land values based on the average N loss figures used. The property market implies a value of $579/kg N	n/a

4.8. Aggregate economic impact of mitigations across the sample

4.8.1. As per the case study interview form, mitigations were considered on the basis of land management change and land use change, both partial and full. The impact of conditional farmer adoption of these is presented below.

4.8.2. Note that given the clear preference of the survey sample for adopting land management changes ahead of partial land use change and then finally total land use change, the impact from adoption of the mitigations by sample farmers have been considered in this order.

4.8.3. Land management mitigations - dairy

(a) When considered on an individual farm basis, the nature of the land management mitigations that were decided upon for "adoption" on the dairy farms was limited across the sample group. By way of summary:

- (i) Two farms adopted the use of wintering pads (for up to 16 hours per day[14])
- (ii) Four farms ceased cropping (winter crop or maize);
- (iii) Six farms reduced N to 100kg N/ha/year (from an average of 178kg N/ha/yr) and replaced the feed with maize silage, one building a feed pad;
- (iv) One farm eliminated the use of N and replaced the feed with grass silage;

(b) The limited number of mitigations employed, albeit some in combination, reflect the relative similarity of the operating policies within the sample group. The construction of a wintering pad was only considered on farms where greater than 80% of cows were wintered on and only the practices of winter cropping or maize cropping were evaluated as mitigations due to the high levels of N loss associated with feeding of winter crops or cultivation and fertilisation for maize.

(c) The use of DCD was largely ignored, due to the high level of rainfall experienced by many of the sample group (rendering it ineffective) and the low efficacy of the product once other mitigations had been employed.

(d) Overall, the implementation of these mitigations resulted in a reduction in whole farm N losses of 26.8t N/year, at an economic impact of $164/kg N loss reduction achieved.

(e) It is important to remember that for the case studies as an aggregate, 14% of the effective dairying area of the sample group is outside the Rule 11 Rotorua catchment,

[14] This still allows the cows to graze as part of their diet.

which dilutes the nutrient gains to the Rotorua catchment based on a whole farm basis. Based on the individual catchment splits within the sample group, the actual catchment N savings are 22.8t N/year at an average economic impact of $193/kg N. As mentioned in 3.4.3 above, if the ROTAN ground water catchment is considered instead of the topographical Rule 11 catchment, then this dilution effect is likely to be lessened and the economic impact reduced.

(f) Figure 9 and Table 11 below show the variation in the economic impact (as calculated here) compared with the extent of N loss reduction achieved of the proposed mitigation scenarios between the nine participant dairy farms and three sheep & beef farms. Despite an average land management mitigation "cost" of $172/kg N (see 4.7.7 (c) below), the range of "cost" varies from a "profit" of $31/kg for Farmer H to a cost of almost $600/kg N for Farmer J and the reductions in N loss achieved between 0 and 16.6kg N/ha/year

(g) These variations in the financial impacts are highly dependent on the individual farmer's existing production system and the biophysical properties of their farm, as well as relative changes in input and output prices.

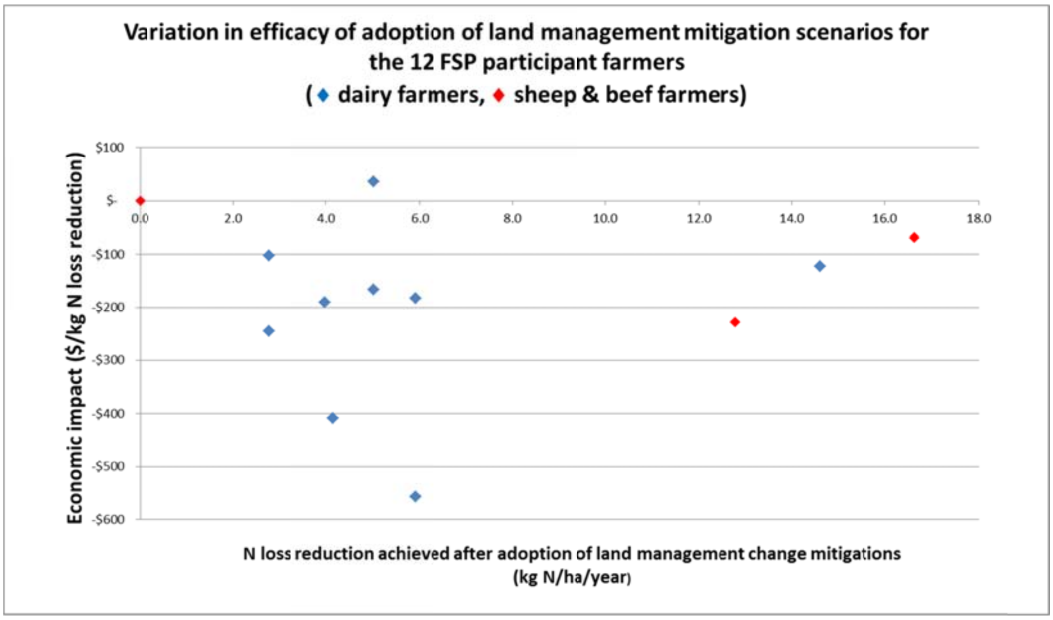

Figure 9: Variation in the efficacy of the adoption of the land management mitigation scenarios for the 12 FSP participant farmers.

Table 11: N loss reduction achieved through land management change and associated economic impact

Farmer	N loss reduction achieved (kg	Economic impact of N ($ cost/kg N)
Farmer A	5.0	-$166
Farmer B	5.9	-$183
Farmer C	2.8	-$103
Farmer D	0.0	$0
Farmer E	4.2	-$409
Farmer F	16.6	-$68
Farmer G	4.0	-$190
Farmer H	5.0	$37
Farmer I	12.8	-$227
Farmer J	5.9	-$557
Farmer K	2.8	-$245
Farmer L	14.6	-$122

4.8.4. Land management mitigations – sheep & beef

(a) The land management scenarios for the sheep & beef sample group were limited, with the contour and aspect of the farms often setting limits on the extent of possible management changes. In fact, with one farm it was decided that no "conditional" further management changes were possible.

  (i) One farm changed cattle policy from heifer grazing to bull beef.

  (ii) One farm ceased cropping (maize);

(b) Again, the use of DCD was largely ignored, due to the high level of rainfall experienced by many of the sample group and the relatively low levels of existing leaching – using DCD to achieve a 10% decrease in annual N loss equivalent to 1.6 kg N/ha is an extremely costly mitigation approach.

(c) Overall, the implementation of these mitigations resulted in a reduction in whole farm N losses of 8.9t N/year, at an economic impact of $118/kg N loss reduction achieved. With none of the sheep & beef sample group having pastoral land crossing catchment boundaries, no adjustment for shared catchments [as per 4.7.2 (e)] was required.

(d) Note that the extrapolation of these management changes across a whole catchment may be impractical or have wider implications. For example, the cessation of heifer grazing within the catchment and replacement with male cattle only may see the local dairy industry having to source alternate grazing for approximately 2,400 heifers in alternative watersheds, given dairy grazing nominally occurs on 858ha within the catchment (average stocking rate 2.8 heifers/ha).

4.8.5. Partial land use change mitigations – sheep & beef

(a) In regard to the sheep & beef sample group, the partial land use change assessed was limited to the establishment of production forestry.

(b) Farmers in the sample group each indicated they had already undertaken retirement into forestry in the worst areas of their farms. The authors contend however, that most farm properties still contained areas where the economic impact of afforestation might be less than over the majority of the property. This is less definitive with dairy properties that are often relatively homogenous in nature, whereas sheep and beef properties typically have more extreme variation in contour, aspect and altitude.

(c) In the absence of LUC and LCDB maps for all of the sample farmers, it was assessed that the sheep & beef farmers in the sample would realistically be able to find, on average, at least 5% of their effective area for "conditional" retirement. Hence a 5% retirement area was used for this mitigation.

(d) Where good contour data was available, steeper areas of the farm were targeted for afforestation, on the basis that relative productivity was lower and that any reduction in annual N losses from this activity would be more cost efficient.

(e) Given that in isolation this limited afforestation provided relatively small net reductions in annual nitrogen losses, this mitigation strategy was considered only after other land management change had occurred.

(f) For the sample group, the adoption of this mitigation across the sample on top of likely management changes only delivered a further reduction of 520kg N at a marginal cost of $4/kg N. While this only had a small impact on N losses, the average cost was remarkably low.

(g) In reality, the adoption of such a strategy was estimated to have a significant economic cost on one property, while delivering an increase in profitability on another. This was essentially due to the combination of the relative profitability of the two operations that the forestry was replacing and the relative productivity of the land being converted into forestry. The relatively small reductions in N loss achieved through this mitigation also make the cost/benefit analysis subject to greater disparity between farm operations – even a small economic impact considered over a small denominator can be large on a per unit basis.

(h) These scenarios illustrate the dangers in using aggregate data to determine policy, such as specifying mandatory practices or establishing an N "price". The disparity in the application of this mitigation to even a sample group of three suggests that there may be greater value in targeted mitigations, recognising that some businesses may be more significantly affected by a mitigation technique than others.

4.8.6. Total land use change mitigations – dairy

(a) A total of four of the dairy farm sample group were prepared to consider whole farm land use change to a sheep & beef operation, on the basis that current market compensation for the change was provided. Three dairy farmers were amenable to complete afforestation.

(b) When considering land use change to sheep & beef farming, the analysis was considered on the basis of the average dairy farm operation converting to an average sheep & beef operation. The reality is that such change would likely be to a 100% bull beef or dairy heifer grazing policy, largely to eliminate the need for significant infrastructural development like woolsheds. However, initial analysis of conversion to dairy support (i.e. heifer grazing) suggests that reduction in N loss was limited, given 100% of cattle would be female and less N would be sent off the property by way of product. This is certainly the case when milking cow numbers are reduced to allow replacement heifers to be grazed on the milking platform.

(c) For the purposes of the analysis, the standardised representative profitability and N loss profiles for the sample group were used, but applied against the individual sizes of those farms where farmers indicated a willingness, reluctant or otherwise, to alter land use.

(d) The efficacy of these 'land use change" mitigations was considered on the basis that the farmers in question had a higher capacity to adopt land management change to reduce N losses and would have done so first. This means that the marginal impact of the land use change is lower and potentially more expensive than adoption directly from the status quo.

(e) The reality is probably different, with farmers amenable to land use change likely to do so directly, bypassing management changes. However, in terms of identifying the sequential "cost" of mitigations, this approach is useful. On this basis, with the four participant farmers electing to convert to sheep & beef farming, an additional cumulative 5.7t of annual reduction nitrogen loss would occur over and above that achievable through management change, for a marginal economic impact of $13.5 million – an implied N cost of $2,362/kg N. This is significantly higher than the $996/kg N presented in Figure 11 by virtue of the fact that the more cost effective N mitigations able to be employed on the converting dairy farms have been nullified by the conversion to sheep & beef farming. There is also a sharing of the N loss reductions with other catchments.

Taking this to the next step, the conversion to forestry of the three dairy farm operations prepared to potentially change land use in this manner would generate a further 16.1t reduction in N loss in the Rotorua catchment for a cost of $13.9 million – at $862/kg N, this is again higher than the implied value in Table 10 because of the loss of otherwise more cost effective mitigations and the impact again of a small % of N loss reduction benefitting other catchments.

4.8.7. <u>Total land use change mitigations – sheep & beef</u>

(a) Approximately 1,000ha of sheep & beef land in the sample was identified where farmers were receptive to complete land use change to forestry.

(b) It is estimated the net impact of this would generate an additional 8t of reduction in annual N loss for a cost of $232/kg N. Again, this is higher than the implied $143/kg N in Table 10, largely because this afforestation includes the more productive as well as the least productive land, as well as the unique situations of the properties the conversion would be "adopted" on.

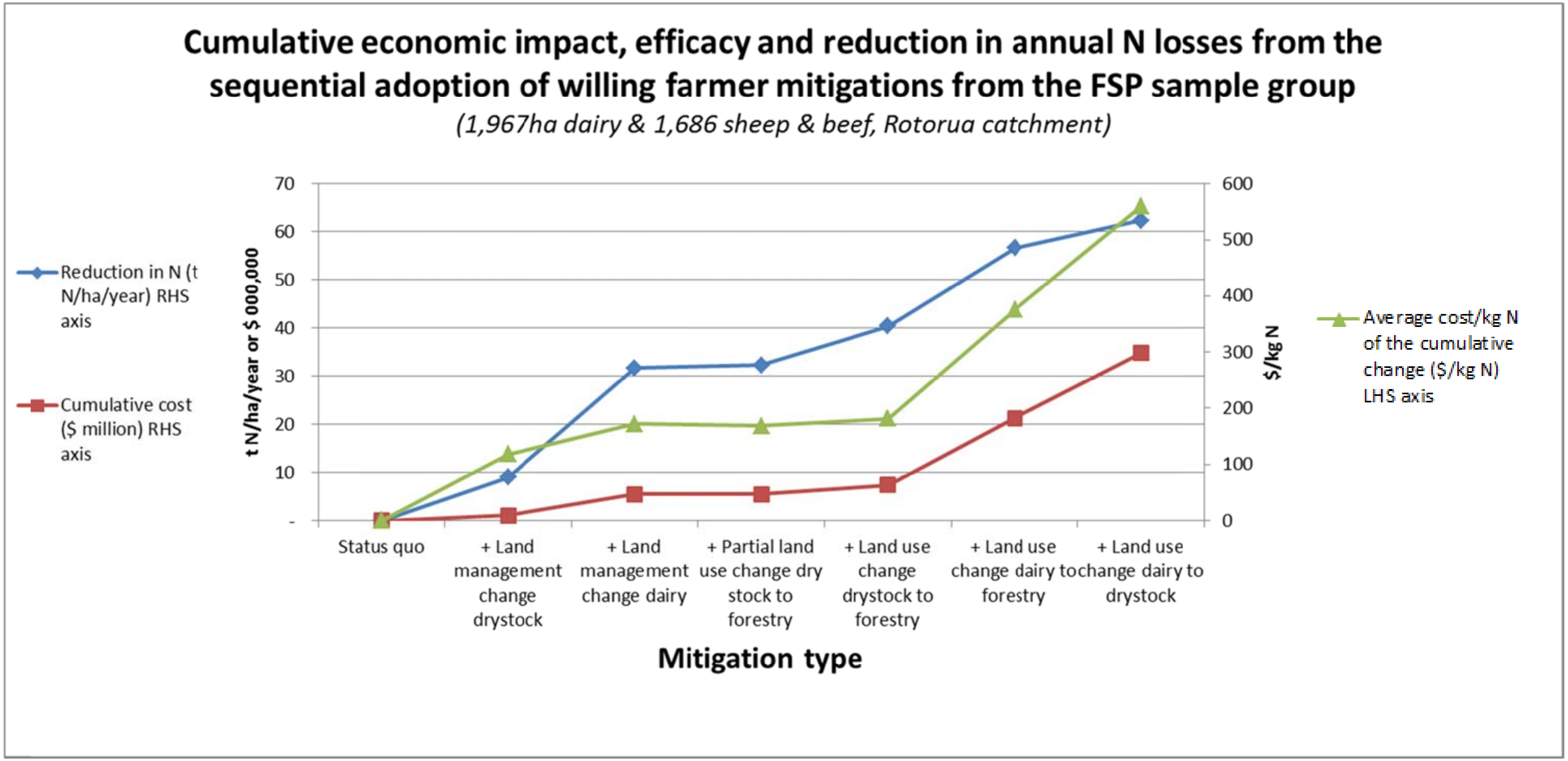

Figure 10: Cumulative economic impact, efficacy and reduction in annual N losses from the sequential adoption of conditional farmer mitigations from the FSP sample group

4.8.8. Aggregate impact of mitigations from the sample group

(a) The combined participant farmer group had current aggregate annual N losses of 104.9t to the Rotorua catchment as defined by Rule 11.

(b) The combined "conditional" adoption of N loss mitigations modelled for the sample group provide a reduction of 62.3t of annual N losses, for an average economic impact of $559/kg N.

(c) Land management change is estimated to deliver 31.7t of annual N loss reduction at an average cost of $172/kg N, while land use changes are expected to provide an additional 30.6t of N reduction at an average cost of $960/kg N. Of the N loss savings associated with land use change, 71% are associated with dairy land, yet account for 94% of the economic impact.

(d) Figure 10 above summarises the aggregate mitigations for the sample group.

(e) Separated into dairy land and sheep & beef, the combined dairy mitigations for the sample group provided 44.6t of N loss saving for $714/kg N. The sheep & beef properties were estimated to be able to deliver 17.6t of annual N loss reduction at a cost of $168/kg N.

(f) Based on the assumed discount rate of 5%, the $172/kg N cost associated with land management change is equivalent to an annual loss of operating profit of $9.65/kg N for dairy farms for an average 24% reduction in pastoral N losses and $5.40/kg N for the sheep and beef farms for an average 33% reduction. Figure 9 above clearly demonstrates the range of efficacy in the application of mitigation techniques to individual farms.

(g) This compares with the 2009 UWNES findings, where lowering N loss through management change for their sample of eight dairy farmers resulted in a range from a benefit of $9.40/kg N to a loss of $30/kg N, depending on farm intensity and the assumed milk price of $5.50/kg MS for a 45% reduction in N losses. By contrast, the same study averaged an annual loss of operating profit of $18/kg N in the sheep & beef properties surveyed for a 31% decrease in N losses.

4.9. Impact on nitrogen "cost" through a change in forestry methodology

4.9.1. Utilising an NPV derived figure of $315/ha for the annualised profitability from forestry, compared to the forestry right lease payments used in the analysis, results in the total cost of the "conditional" N loss reduction to $29.2 million from $34.8 million - a decrease to $469/kg N.

STAGE 3 – CATCHMENT EXTRAPOLATION

4.10. Four N-loss mitigation scenarios based on the case study farms were applied firstly singularly to the status quo extrapolation and then in a successive and cumulative manner.

(i) Management change (MC). N-mitigation strategies were applied to the case study farms and modelled through Overseer. Average N-losses post-implementation were assigned on the basis of the applicable dairy zone or S&B type.

(ii) Land use change scenario A: 21% of dairy farms in the catchment by area convert to sheep and beef ("D to S&B") with an average N-loss of 16 kg N/ha/yr. This is based on four of the nine dairy case study farmers having indicated that they would consider shifting to sheep & beef. By area[15], these four represent 21% of the combined sampled dairy area of the nine dairy farms. The N-loss value is an average of Overseer-calculated N-losses for the four farms.

(iii) Land use change scenario B: From the remaining pool of dairy farms, 20% by area are converted to forestry ("D to For"). This is based on three of the nine case study dairy farmers having indicated that they would consider a shift to forestry. By area, these three represent 20% of the combined total dairy area. An average 3 kg N/ha/yr leaching loss was assumed for forestry.

(iv) Land use change scenario C: 22% of S&B farms by area are converted to forestry ("S&B to For")[16]. This is based on one of the three S&B case study farmers indicating that they would consider a wholesale shift to forestry. By area, this represents a large 71% of combined S&B case study area, as the single farm is significantly disproportionate in size to the other two S&B farms. An adjustment factor of 0.33 is calculated as the proportional difference between

[15] Total farm areas as used for Overseer modelling are used in the calculation of land use change percentages.

[16] 22% of 15,717 ha = 3458 ha. Target farms are drawn from the extensive S&B category (i.e. 3458 ha drawn from 9562ha of extensive S&B) on the basis that hillier land is more suitable for forestry in a production sense.

the average within-catchment S&B farm size[17] (412 ha) and the single farm. An average 3 kg N/ha/yr leaching loss was assumed for forestry[18].

4.11. Less confidence can be assigned to these land use transitions because of the small sample sizes. Hence, while based on actual farmer preferences, they should be interpreted as 'what if?' scenarios for change.

4.12. A further limitation is predicting where land use change may occur (i.e. which farms?), which in real terms is dependent on a multitude of interacting factors including individual farmer preference which is not easily predicted. To deal with this, a stratified random sampling technique was implemented across eligible land use parcels (i.e. parcels randomly selected until the target area or percentage was achieved). This analysis was undertaken outside of the GIS framework so no maps were generated.

4.13. Status quo N-loss (SQ)

4.13.1. Results from case study Overseer modelling were extrapolated to similar farms in the catchment (see Figure 11).

4.13.2. Table 12 below summarizes the average N losses (per total ha) for each of the two land uses considered in the extrapolation. It is important to note that the average total farm N losses calculated are greater than those for the "average" farm models in 3.4 and 3.5 above. This appears to be primarily a result of (a) the non-sampled farms in the catchment having a greater proportion of their total area as effective grazing area compared with the sample group (a function of their location) and (b) significant negative bias to the sample's average N leaching figure resulting from one property (Farm J). It is important to note that the average N loss from the effective dairy area in the catchment as a whole is greater than 41.7kg N/ha/year.

Table12: Status quo summary of total and average extrapolated N-loss for dairy and sheep & beef

Land use	Area (ha)	Total N (kg N/yr)	Av N-loss (kg N/ha/yr)[1]
Dairy	6,215	259,117	41.7
Sheep & beef[2]	15,717	260,813	16.6

[1] Average catchment (ground water catchment) N-loss for each of the two land uses.

[2] Sheep and beef area (15,717 ha) differs by 121 ha from that reported in previous Table 5 because case study farm classifications trump classifications from the Rule 11 land use layer.

[17] Average S&B farm size within the catchment is estimated from Agribase 'farms' reclassified by back-inheriting Rule 11 land use data (to maintain consistency). Average is drawn from 54 SnB farms >50ha in size.

[18] While 3 kgN/ha/yr is the most commonly used forestry N loss rate for both production and native forest, consistent with Overseer output, it is noted that ROTAN used 4 kgN/ha/yr (except 2 kgN/ha/yr in the Puarenga catchment)

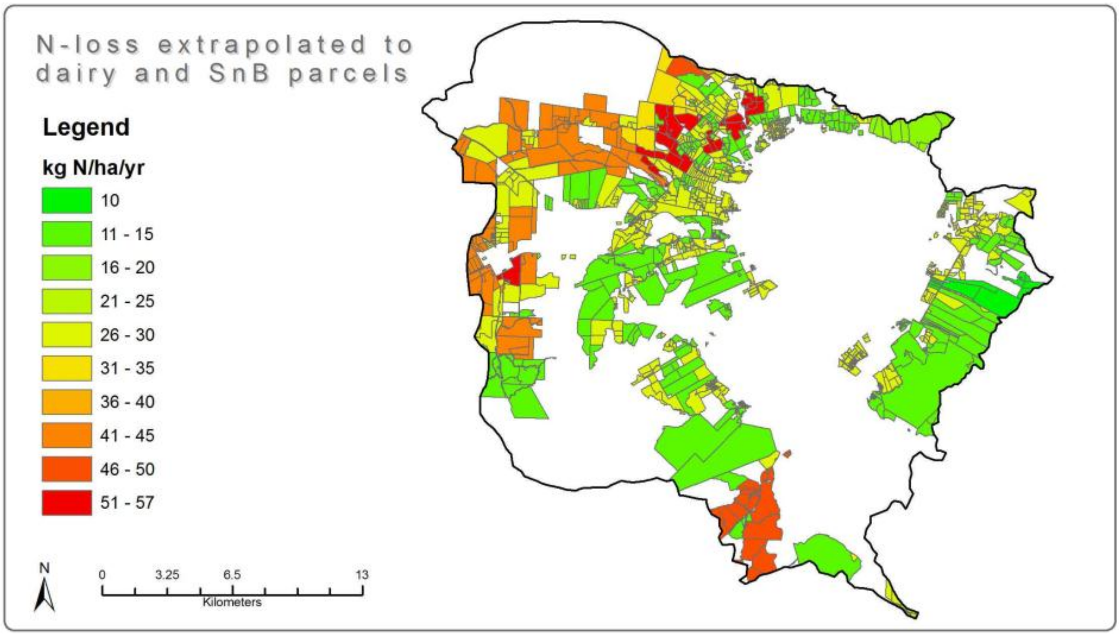

Figure 11: Status quo N loss extrapolated to dairy and S&B parcels.

4.14. Management change scenario (SQ + MC)

4.14.1. Results from case study N-mitigation Overseer modelling were extrapolated to similar farms in the catchment (see Fig. 12 below).

4.14.2. The estimated economic costs associated with the individual mitigations were applied to the catchment in the same way as the N-loss reductions in order to generate the aggregate costs of land management change mitigations.

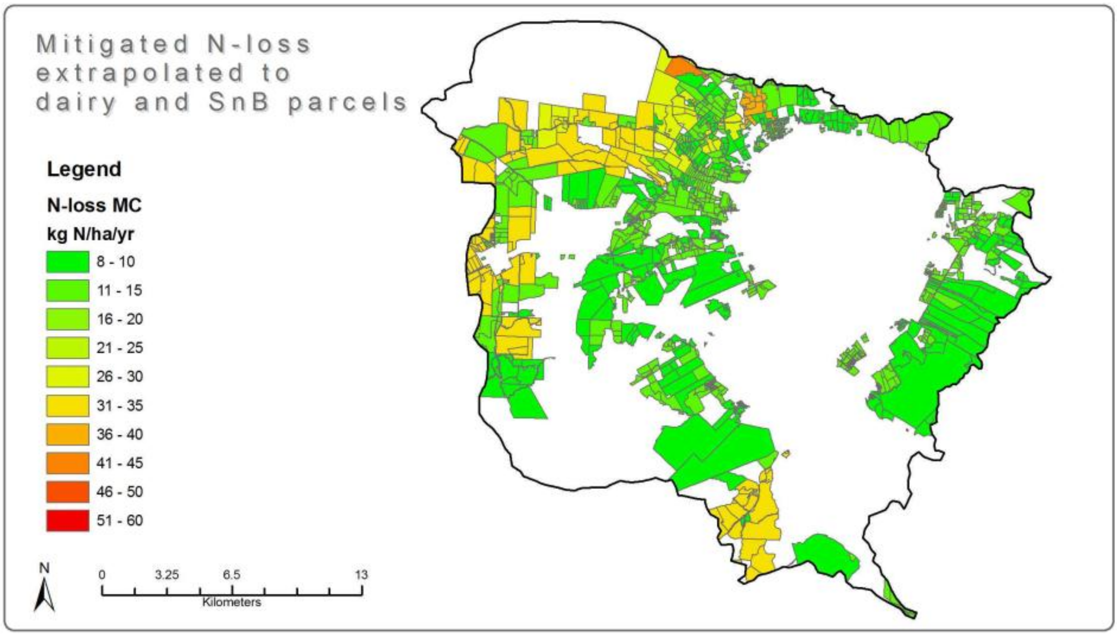

Figure 12: Management change N-loss extrapolated to dairy and S&B parcels.

4.14.3. As can be seen in Table 13 below, at a catchment scale, it is estimated that management change could generate 70.9t of annual N savings from dairy land use at a cost of $10.9 million ($153/kg N), while conditional land management change from the sheep & beef sector might generate 94.1t of annual N loss reduction at a cost of $18.4 million ($196/kg N). Note that these estimated costs are higher for the sheep & beef sector and lower for the dairy sector than the average costs for the sample group. This is largely due to the fact that:

(i) the wider catchment has a greater proportion of intensive sheep & beef farming than the sample (with an accompanying greater economic impact from N mitigation due to involvement with the dairy support sector); and

(j) the catchment has a much lower proportion of dairying activity in the Kaharoa dairy zone (which has a higher than average cost of N reduction due to the presence of one large farm that straddles multiple watersheds).

Table 13: Management change summary of total and average extrapolated N-loss for dairy and sheep/beef

Current land use	Area (ha)	Status quo N losses (kg N/year)	Total N losses post change (kg N/yr)	Av N-loss post change (kg N/ha/yr)[1]	Total cost of reduction
Dairy	6,215	259,117	188,213	30.3	$10,839,558
Sheep & beef[2]	15,717	260,813	166,717	10.6	$18,415,622

[1] Average catchment (ground water catchment) N-loss for each of the two land uses.

[2] Sheep and beef area (15,717 ha) differs by 121 ha from that reported in previous Table 5 because case study farm classifications take precedence over classifications from the Rule 11 land use layer.

4.15. Land use change scenario A (SQ + D to S&B)

4.15.1. This scenario sees 21% of dairy farms in the catchment by area convert to sheep and beef (D to S&B).

4.15.2. A total cost of $34.3 million is estimated from the 35.5t N loss reduction (cost of $966/kg N) (Table 14).

Table 14: Land use change scenario A summary (Status quo + D to S&B)

Current land use[1]	Area (ha)	Status quo N losses (kg N/year)	Total N losses post change (kg N/yr)	Av N-loss post change (kg N/ha/yr)[1]	Cost of reduction
Dairy	6,215	259,117	223,598	36.0	$34,311,354
Sheep & beef	15,717	260,813	260,813	16.6	
Total		519,930	484,412	22.1	$34,311,354

[1] Note that the original land use classifications and areas are retained to ensure direct comparability against status quo and management change scenarios (changing the areas and introducing additional classifications - e.g. forestry - would distort the calculation of average N-loss for comparison). If change in area is required, calculate from the percentage change (e.g. for dairy, 6215 – [0.21 x 6215])

4.16. Land use change scenario B (SQ + D to For)

4.16.1. From the remaining available pool of dairy farms, 20% by area of the land in dairy farming are converted to forestry.

4.16.2. This further reduction in annual N loss of 49.9t N has an associated cost of $34.3 million ($688/kg N) (Table 15)

Table 15: Land use change scenario B summary (status quo + D to For).

Current land use[1]	Area (ha)	Status quo N losses (kg N/year)	Total N losses post change (kg N/yr)	Av N-loss post change (kg N/ha/yr)[1]	Cost of reduction
Dairy	6,215	259,117	209,231	33.7	$34,321,568
Sheep & beef	15,717	260,813	260,813	16.6	
Total		519,930	470,045	21.4	$34,321,568

[1] Note that the original land use classifications and areas are retained to ensure direct comparability against status quo and management change scenarios (changing the areas and introducing additional classifications - e.g. forestry - would distort the calculation of average N-loss for comparison).

4.17. Land use change scenario C (SQ + S&B to For)

4.17.1. The final scenario considered the conversion to forestry of 22% of hill country S&B farms by area.

4.17.2. This generates 27.9t of annual N savings; however the economic impact of this is more difficult to define. The assumption that only hill country farms will be afforested results in this mitigation only generating 8kg N loss savings per hectare. In addition, based on the partial land use assessment analysis in 4.7.4 above, afforestation of this class of land has an economic cost of only $4/kg N, compared to the estimated of cost of $143/kg N when intensive (dairy support) land is included in any afforestation assumption.

Table 16: Land use change scenario C summary (Status quo + S&B to For).

Current land use[1]	Area (ha)	Status quo N losses (kg N/year)	Total N losses post change (kg N/yr)	Av N-loss post change (kg N/ha/yr)[1]	Cost of reduction
Dairy	6,215	259,117	259,117	41.7	
Sheep & beef	15,717	260,813	232,923	14.8	$111,560
Total		519,930	492,040	22.4	$111,560

[1] Note that the original land use classifications and areas are retained to ensure direct comparability against status quo and management change scenarios (changing the areas and introducing additional classifications - e.g. forestry - would distort the calculation of average N-loss for comparison).

4.17.3. On this basis, the 27.9t of N saving could be achieved at a cost of $111,000 (Table 16 above). However, it is important to remember that this average cost was generated by two sample farms with very different financial outcomes from afforestation.

4.18. Cumulative change

4.18.1. When the scenarios are applied across the catchment, the cumulative impact of the described management and land use changes are estimated to reduce the annual N load from the dairy and sheep & beef sectors from 519.9t N/year to 280.7t N/year (Table 17). **The total reduction is 239t N/year.**

4.18.2. Table 18 expresses the same information, but on a per hectare basis

4.18.3. The total economic impact of achieving this level of reduction in the manner proposed is estimated at **$88.1 million**, or an average cost of $368/kg N.

Table 17: Total cumulative changes in N-loss (tonnes N/yr).

	Area (hectares)	Status quo (kg N/yr)	With mgt changes (kg N/yr)	Plus D_to_S&B (kg N/yr)	Plus D_to_For (kg N/yr)	Plus S&B_to_For[1] (kg N/yr)		Total cost ($)
Dairy	6,215	259,117	188,213	169,107	134,549	134,549		75,028,258
Sheep & beef	15,717	260,813	166,717	166,717	166,717	146,181		13,104,478
Totals	21,932	519,930	354,930	335,824	301,266	280,730		88,132,736

[1] This final scenario represents the full N-reduction option (land use + management change).

Table 18: Total cumulative changes expressed on a per hectare basis (kg N/ha/yr)

	Area (hectares)	Status quo (kg N/ha/yr)	With mgt changes (kg N/ha/yr)	Plus D_to_S&B (kg N/ha/yr)	Plus D_to_For (kg N/ha/yr)	Plus S&B_to_For[1] (kg N/ha/yr)		Total cost ($/kg N)
Dairy	6,215	41.7	30.3	27.2	21.6	21.6		602
Sheep & beef	15,717	16.6	10.6	10.6	10.6	9.3		114
Totals	21,932	23.7	16.2	15.3	13.7	12.8		368

[1] This final scenario represents the full N-reduction option (land use + management change).

4.18.4. The majority of the economic impact is associated with reductions achieved in the dairy sector, which reflects the significantly higher profitability of dairying relative to sheep & beef farming.

4.18.5. This is highlighted by the previous Figure 10, which illustrates that while the adoption of land use change from dairy to either forestry or sheep & beef farming within the sample group generates significant N reductions, the average cost of N increases from $181/kg N to $558/kg N – an increase of 300%.

5. DISCUSSION

5.1. All farmers interviewed were very cooperative and it seemed most farmers had accepted there needed to be changes and regulations associated with farming in the Rotorua catchment or New Zealand as a whole. However, it may be argued that farmers who have conflicting views about these changes and regulations to farming in the catchment may not have wanted to participate in this project, therefore potentially introducing a bias to the results. This area may need to be investigated further to validate the conclusions in this report.

5.2. Of the various mitigation options presented in the interview stage, no option averaged 1.0 (i.e. essentially no chance of "conditional adoption") and only two options averaged a score below 2 on the comfort of adoption scale (being complete land use change to forestry or reversion to native). This suggests that if a score of 2 (high degree of discomfort) was considered the edge of farmer comfort and potential willingness, either reluctantly or with conditions attached, to adopt and the survey pool was representative of the catchment then one or more mitigation options could be adopted on all farms in the catchment.

5.3. The most convincing information to come out of the farmer interviews was confirmation that the majority of farmers will require compensation to voluntarily adopt N loss mitigation options if the changes are going to reduce profitability and/or require capital investment. However, such compensation was only required to be at market rates.

5.4. Although it appears partial land use change is at the higher end of the farmer comfort range, land areas available for this mitigation were not specified which may give an overstated result.

5.5. The Stage 2 analysis results clearly indicate that land management change provides an efficient suite of mitigations to reduce N losses. While the management changes have less impact than changing land use to a less intensive system (dairy to sheep & beef, sheep & beef to forestry), the extent of the reduction that appears possible from this analysis is significant i.e. in the order of 25-40%. Given the greater apparent willingness of farmers to embrace land management change ahead of land use change, it would appear important to investigate the use of both mitigation types to achieve the N loss reduction targets currently being suggested by the BOPRC.

5.6. Significant discussion points from this analysis include:

(i) The high efficacy of using maize silage to replace feed grown by nitrogen fertiliser. Not only does such a strategy reduce N cycling and lower the risks of direct application losses, the low protein content of the maize improves the N conversion of the farm system. The wider application of this strategy does however generate questions about the price/availability of maize silage should increasing demand arise and the environmental footprint generated wherever the maize is grown.

(ii) Wintering infrastructure doesn't appear to have wide application in the catchment for mitigating N losses from dairying. This is largely due to the significant number of cows wintered off the milking platform during the high risk N loss periods. However, at a whole catchment level, this might be important if the cows in question are being wintered in the catchment. Unfortunately our sheep & beef sample group didn't include any winter dairy cow grazers, so the efficacy of housing cattle in winter wasn't tested in a sheep & beef scenario.

(iii) The conversion of dairy land to sheep & beef farming has a higher cost per kg N loss reduction than converting dairy land to forestry. This is simply reflective of the fact that dairy farm operations are more profitable than sheep & beef farms when considered on an EBIT per kg N leached ($44/kg N versus $21/kg N). This sits in direct contrast with the difference between sheep & beef and forestry profitability[19] when compared on the same basis ($21/kg N versus $50/kg N).

(iv) The "cost" of land use change mitigations is higher when considered sequentially with land management change, compared with their adoption alone. This is essentially because of the significant (25-40%) reductions that appear to be achievable through land management mitigations at a relatively low "cost" ($150-$300/kg N). Given that farmers in the catchment have not yet adopted the suggested land management mitigations, the cost associated with the implementation of land use change are more likely to equate with those in Figure 11, compared with the marginal cost implied in Section 4 above. However, the fact remains that the cost of land management change for dairy farmers is likely to be much lower than direct land use change.

(v) The apparent economic cost of converting whole farms from sheep & beef to forestry was relatively low. This is consistent with the higher relative profitability of forestry on a EBIT/kg N leached basis under the assumptions used compared

[19] Based on the assumption of an annual forestry right lease rental of $150/ha/year

with sheep & beef farming in 5.6 (iii) above. In fact, if the NPV analysis was used to estimate the annualised per hectare value of forestry, under our assumptions conversion actually increased profit. This suggests that catchment N mitigation strategy targeting afforestation warrants further investigation, but significant farmer education and land management planning would be needed to overcome farmer aversion and address the issues identified in 2.20.2 above.

(vi) "Conditional" afforestation in the sheep & beef sample accounted for 67% of the sample area, but only accounted for one of the actual farms. This compares with the dairy sample where 20% of the sample area might be reluctantly planted but by three (33%) of the sample group.

(vii) It is important to note that the profit-based valuation methodology used here to calculate an effective N price does not take into account transaction costs, nor any premium that many exist for future flexibility in land use. As an examination of a market based valuation methodology below shows, there are some differences between methodologies.

5.7. Other areas of interest are expanded on below.

5.8. Implied land use change costs versus "market"

5.8.1. The methodology used to calculate the cost of land management and partial land use change was expanded to include total land use change.

5.8.2. However, the property market provides implied values for the differences in allowable nitrate losses from different classes of property. Table 19 below contrasts a market approach to valuing N compared with the income based analysis used here.

Table 19: Comparison of values for "N" between property market and FSP analysis

Land class	Current market value ($/ha)	Typical N loss (kg N/ha/year)	Implied value of N from market values ($/kg N)	Value of N using profit analysis ($/kg N)
Dairy	$25,000	41	$600	$966
Sheep & beef	$10,000	16	$538	$143
Forestry	$3,000	3		
Dairy versus forestry			$579	$688

5.8.3. Based on this comparison, it would appear that the property market is valuing the difference in allowable N more or less the same between dairy and sheep & beef land, despite the fact that dairying operations in the Rotorua catchment are in the order of two times more profitable per kg of N leached than sheep & beef farms.

5.8.4. Interestingly, based on the figures above, the market values the difference in N loss allowances between forestry land and dairy land at $579/kg N compared with the $688/kg N figure calculated under the FSP methodology analysis.

5.8.5. These calculations would suggest that the property market currently over-values sheep & beef land relative to its allowable N leaching losses under Rule 11. This could have a number of implications including:

(i) that sheep & beef land values have significant potential to reduce from current levels as the reality of an N limited catchment takes hold;

(ii) that sheep & beef farmers may be unwilling to accept a profit based compensation price for N loss reduction (i.e. $143/kg N) due to the fact that they will be forced to internalise a significant capital loss in land value relative to the current market once they permanently restrict land use to forestry.

5.9. Achievement of sustainable rural 280t N allocation

5.9.1. The GIS-based extrapolation above indicates that current land use activity from dairy and sheep & beef sectors in the Rotorua catchment could be altered to deliver 239.2t of annual N loss reduction from existing levels, but at a farm gate cost of $88 million. This "cost" would either need to be internalised or funded by the public. The results of the Stage 1 survey data clearly indicate that the sample group would require market compensation in order to "conditionally" effect the changes.

5.9.2. The actual sum required, based on farmers' mitigation costs being met, is likely to fall outside the current expectations of available funding. This is true even if: suggested reductions in the average N price are achievable due to lower average profitability of the catchment's farming operations relative to the sample group; the market accepts a higher relative profitability for forestry production or; the calculated costs of N fall in line with those implied by the property market. Given that the RPS envisages some mandatory regime to ensure the target is met and that funding for assistance is limited, the "cost" of "non-conditional" reduction may well have to be internalised by farmers if such additional mitigation is required.

5.9.3. The analysis has led to an interesting observation - the dairy sample appears on average to have annual N losses 9% lower than those provisionally benchmarked for the 2001-2004 period under Rule 11C of the operative regional plan[20]. Any economic impact of achieving these reductions has already been internalised by the farmers.

5.9.4. If this was representative of all of the dairy farms in the catchment, then the dairy sector would appear to be leaching approximately 17.8t/year less N than in the 2001/04 period. This would appear to have occurred, at least within the sample group, despite the conversion of some sheep & beef land to dairy. The sheep & beef farms in the sample are also known to be operating at lower levels of nitrogen loss than historically achieved.

5.9.5. Combined with the 239.2t of N loss reduction identified in this analysis, the pastoral sector could potentially deliver on 257t of N from the historical averages assumed in the ROTAN modelling. However, on the basis of the suggested change from current N losses alone, this extrapolation implies the existing dairy and sheep & beef sectors could achieve an annual N load to the catchment of 281t N (see Table 20 below).

Table 20: Summary of potential N loss reduction in Lake Rotorua catchment from FSP analysis

Current land use	Previous reductions post 2001/04 (t N/year)	Status quo (2012)losses (t N/year)	Reduction from FSP mitigations (t N/year)	Annual load post mitigation (t N/year)	Total potential reductions (t N/year)
Dairy	17.8	259.1	124.6	134.5	142.4
Sheep & Beef		260.8	114.6	146.2	114.6
Total	17.8	519.9	239.2	280.7	257

5.9.6. It is noted that the FSP extrapolation has been conducted on the basis of the combined dairy and sheep & beef catchments (including non-effective area), rather than the exclusively effective ROTAN pastoral areas, which also includes the deer farming and “lifestyle” farming excluded from this analysis by virtue of the participant group. Accordingly the total catchment N load will undoubtedly be higher than the 280t N from these two largest pastoral sectors[21].

[20] This is subject to verification once all benchmarks have been finalised.
[21] However, there will be an expectation that all rural sectors will need to equitably contribute to catchment N load targets.

5.10. Farmer response to the analysis

5.10.1. The "willingness" of farmers to adopt was a key assumption underlying the selection of mitigation options used in the individual and aggregate scenario analysis, with this underpinned by a clear farmer view that compensation for expected economic losses was a key factor in facilitating farmer adoption.

5.10.2. This analysis suggests that the assumed rural sustainable load of 280t N to Lake Rotorua is potentially not achievable without requiring farmers to adopt mitigations they are not comfortable with, even in the event that full compensation is available. However, if full compensation is not available, then there is likely to be considerable farmer resistance to adoption of the mitigations they are nominally "conditionally willing to adopt". Based on publically available information to date, it would appear that such available funds will be less than the $88 million figure estimated in 4.17.2 above.

5.10.3. How such a reality might change farmer perceptions about implementing N reduction mitigations wasn't addressed by this analysis, but it will probably have a considerable impact on how easily achieved the sustainable load target might be.

5.10.4. The extent of the afforestation required by both sheep & beef farmers based on this analysis is significant at 4,763ha, which would introduce the potential issues around afforestation addressed previously.

5.10.5. While the timing of this report makes obtaining and reporting on farmer feedback to this analysis impractical, it will be important that the BOPRC commit to undertaking some formal assessment of farmer reaction to the proposed suite of mitigations, the economic impact of the scenarios as they have been modelled and how their "willingness" to adopt might change in the context of less funding than required to fully offset the "cost" of achieving the required annual load.

5.10.6. It is suggested that a workshop with the participant farmers, the primary contractors (Perrin Ag & Headway Ltd) and the independent AgResearch peer reviewer be held to achieve this outcome.

5.10.7. This workshop and reporting thereof can be managed within the existing budget allocated for this project and therefore at no additional cost to the funder. The reporting can be considered an addendum to this report.

5.11. Further work to be considered

5.11.1. The additional works and analysis to increase the value of the FSP for stakeholders that should be considered include:

(i) Expansion of the farmer survey to improve representative extrapolation.

(ii) Independent reporting on farmer feed back to the analysis

(iii) Expansion of the forestry analysis component into a separate piece of work.

(iv) Inclusion of a deer farm case study, a "lifestyle" farm case study and a case study where dairy cows come onto the property for winter grazing.

(v) Sensitising the "cost" of N to changes in key product or input prices.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Voluntarily adoption of mitigation strategies has resulted in a net reduction of annual N loss from the participant dairy group since the 2001/04 period. However this is clearly insufficient to meet the current target expectations of the community as articulated by the BOPRC.

6.2. Based on the responses to the farmer participant survey in Stage 1 and the modelling and analysis completed in this Stage 2 report, the sample group of farmers appear to be conditionally willing to adopt sufficient land management and land use change strategies to achieve N loss reductions of 62.3t, albeit with an expectation of external compensation for the economic costs of doing so.

6.3. Initial acceptance and cooperation with the interviews was a good indication that farmers are prepared to do their part when it comes to environmental restoration. While there were varied results in terms of comfort levels and general attitude towards reducing nutrient losses in the catchment, on average farmers were prepared to make changes given their livelihood was not compromised.

6.4. It is important to recognise that land management change is estimated to deliver 31.7t of this forecast annual N loss reduction at an average cost of $172/kg N, while land use changes additional to these are expected to provide an additional 30.6t of N reduction at an average cost of $960/kg N. This high cost for land use change is due to the loss of otherwise more cost effective mitigations that have been assumed to have been adopted. Accordingly, direct land use change will deliver reductions in N loss at a lower cost than this, but will still be more expensive than some of land management mitigations analysed.

6.5. However, the overall average cost of $559/kg N to deliver 62.3t of reduction in N loss represents the net cost of the proposed mitigations, irrespective of their sequence of adoption.

6.6. There is considerable variability between the economic impact of implementing such mitigation strategies on individual farm properties due to differences in both the biophysical properties of the farms and their individual operating systems. Accordingly, the use of average economic impacts in setting a level for compensation needs to be carefully thought out.

6.7. Extrapolated to the catchment, this analysis implies a net catchment N loss reduction of 239.2t N, in addition to the 17t savings already estimated to have been made by the dairy sector. Based on the current N losses of the participant farmers, this implies a potential annual N loss from the sheep & beef and dairy sectors of 281t N. While this total N load includes contribution from non-effective area, with the addition of the extra parts of the pastoral sector not covered in this analysis (lifestyle farming and deer), the whole catchment annual N load from the pastoral sector is still likely to exceed the suggested 280t load allocation based on ROTAN values and the 435 tN/year target.

6.8. The Farmer Solutions Project clearly establishes the importance of land management change as a key part of the overall approach to reducing the annual N load assessed as being contributed from the pastoral sector, although afforestation of 22% of the area in the sheep & beef sample and 20% of the dairy sample area was required to achieve the calculated N loss reduction.

6.9. It is important to recognise that the analysis conducted in the FSP and the conclusions drawn provide an opportunity for critical discussion as part the on-going collaborative work to finding an enduring solution to the issue of water quality in Lake Rotorua, rather than presenting a definitive solution.

6.10. As a result of this analysis, the following recommendations are made:

(i) That the BOPRC recognises that land management change is likely to assist in providing some cost effective mitigation practices towards achieving the sustainable rural N allocation.

(ii) That the BOPRC commits to the proposed participant workshop following the submission of the final report.

(iii) Given the apparent efficacy of afforestation as a mitigation, particularly for sheep & beef farms, a separate piece of work be commissioned to more thoroughly investigate the implementation of this as a mitigation; this needs to take into account the considerable farmer opposition to afforestation, imperfect knowledge about its implications, the dichotomy of short-term cashflow versus long-term profitability and the fact that the cost-efficiency of afforestation can vary considerably between properties because of differences in land class and farm system type.

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APPENDICES

Collated farmer survey results

Appendix 1: Comfort with adoption

Appendix 2: Obstacles to adoption

Appendix 3: Ways to facilitate adoption

Appendix 1. Comfort with adoption

		Mitigation options to reduce farm N losses	Farmer A	Farmer B	Farmer C	Farmer D	Farmer E	Farmer F	Farmer G	Farmer H	Farmer I	Farmer J	Farmer K	Farmer L	Total	Average
Land management change	Profit "neutral"	1. Cease Winter N usage	4	5	5	3	5	1	5	5	5	5	5	5	53	4.42
		2. Replace N fertiliser (or high N feed) with low N feed	4	2	3	2	2	3	4	3	3	4	-	3	33	3.00
		3.Optimise effluent application & management system	5	5	5	-	5	5	-	5	-	5	5	5	45	5.00
		4. Use more frequent lower N rates (<30kg N/ha/application)	5	3	4	-	5	5	5	4	4	4	-	4	43	4.30
		5.Reduce stocking rate and maintain production	4	5	1	5	5	5	4	4	4	4	4	3	48	4.00
		6. If cropping go to nil cultivation	3	5	2	5	5	-	4	-	-	3	-	4	31	3.88
	Decrease net profit	7. Apply DCD to crop	4	3	2	-	4	-	1	-	-	4	-	3	21	3.00
		8. Apply blanket DCD	3	3	2	1	3	4	1	4	4	3	2	3	33	2.75
		9. Cease cropping	2	4	3	5	4	5	5	5	5	3	5	2	48	4.00
		10.Reduce/eliminate N fertiliser and reduce production	1	2	1	5	5	2	4	3	2	4	5	2	36	3.00
		11. Reduce stocking rate and reduce production	1	2	1	5	1	5	4	4	2	3	4	1	33	2.75
		12.Partial change in stock class	1	3	1	5	2	3	5	1	4	-	4	3	32	2.91
		13. Feed infrastructure to facilitate high levels of low N feed	4	1	4	-	2	4	-	3	4	4	-	4	30	3.33
		14. Partial wintering facilities (on/off)	3	5	3	1	3	2	-	1	4	3	4	4	33	3.00
		15. Full wintering facilities	4	3	3	1	3	2	-	4	4	3	4	4	35	3.18
Land use change	Partial	16. Forestry	1	2	3	4	5	5	4	2	2	3	2	1	34	2.83
		17. Lower intensity stock policies	2	2	1	5	5	5	4	2	4	-	2	1	33	3.00
		18. Housing/lifestyle subdivision	4	4	4	1	5	2	4	4	4	1	2	1	36	3.00
		19. Reversion to native	1	2	4	5	5	1	5	5	5	3	2	1	39	3.25
		20. Extending existing riparian areas	-	-	5	3	-	-	5	5	5	4	2	3	32	4.00
		21. Create artificial wetlands	-	4	4	4	5	4	5	-	5	1	2	3	37	3.70
	Complete	22. Forestry	1	2	1	1	3	1	2	1	1	1	2	1	17	1.42
		23. Dairy to drystock change	3	2	4	-	3	2	5	2	-	1	2	1	25	2.50
		24. Reversion to native	1	2	1	1	3	1	1	1	1	1	2	1	16	1.33
		25. Other													0	0

Appendix 2. Obstacles to adoption

Mitigation options to reduce farm N losses			Farmer A	Farmer B	Farmer C	Farmer D	Farmer E	Farmer F	Farmer G	Farmer H	Farmer I	Farmer J	Farmer K	Farmer L
Land management change	Profit "neutral"	1. Cease Winter N usage	4	-	-	5	-	-	-	-	-	-	-	-
		2. Replace N fertiliser (or high N feed) with low N feed	2	2	1	2,5	1,2	2,5	2	5	1,2	2	-	2
		3.Optimise effluent application & management system	-	4	-	-	-	-	-	-	-	-	-	-
		4. Use more frequent lower N rates (<30kg N/ha/application)	-	5	5	-	-	-	-	2,5	2	2	-	2,4
		5.Reduce stocking rate and maintain production	1	-	5	-	-	-	2	5	1	1,2	1,2,4	1,2,4
		6. If cropping go to nil cultivation	5	-	4	-	-	-	1	-	1	1,2	-	2,4
	Decrease net profit	7. Apply DCD to crop	1,4	1	1	-	1,2	-	-	-	-	1,2	-	2
		8. Apply blanket DCD	2,1	1	1,2	2,4	1,2	1,2	-	1,2	1,2	1,2	2	2
		9. Cease cropping	2	5	1,4	-	5	-	-	-	-	1,2	-	2
		10.Reduce/eliminate N fertiliser and reduce production	2	2	2	-	-	2,3	2	1,2	2	2	-	2
		11. Reduce stocking rate and reduce production	2	2	2	-	5	-	2	2	2	2	2	2
		12.Partial change in stock class	2	2	2,5	-	2	1,2	-	2,5	2	-	2	1,2,4
		13. Feed infrastructure to facilitate high levels of low N feed	2	4	2,1	-	2,4	2	-	2	1,2	1,2	-	1,2,4
		14. Partial wintering facilities (on/off)	2	-	2	4	2,5	2,3,4	-	-	1,2	2	2,4	1,2,4
		15. Full wintering facilities	2	2	2	4	2,5	2,3,4	-	2	1,2	2	2,4	1,2,4
Land use change	Partial	16. Forestry	2	2	2,3	5	2	-	-	2,4	2	5	2	2,3
		17. Lower intensity stock policies	2	2	2	-	-	-	2	2	2	-	2	2
		18. Housing/lifestyle subdivision	1	4	3	3	3	2	5	5	2	5	3	2,3
		19. Reversion to native	2	2	2	-	-	-	-	-	-	1	2	2,3
		20. Extending existing riparian areas	-	-	-	2,3,4	-	-	-	-	-	1	2	1,2
		21. Create artificial wetlands	-	2	1	2	-	1	-	-	-	5	2	1,2
	Complete	22. Forestry	2	2	3,5	2,3	2	2	3	2,3	3	5	2	2,3
		23. Dairy to drystock change	2	2	2	-	2	2	-	2	-	5	2	2,3
		24. Reversion to native	2	2	3,5	2,3	2	2	3	2,3	3	5	2	2,3
		25. Other												

Table 3. Ways to facilitate adoption

Mitigation options to reduce farm N losses			Farmer A	Farmer B	Farmer C	Farmer D	Farmer E	Farmer F	Farmer G	Farmer H	Farmer I	Farmer I	Farmer I	Farmer I
Land management change	Profit "neutral"	1. Cease Winter N usage	1	-	-	-	-	-	-	-	-	-	-	-
		2. Replace N fertiliser (or high N feed) with low N feed	2	2	1,2	2	2	2	1,2	1,2,4	1,2	-	-	2
		3.Optimise effluent application & management system	-	1	-	-	-	-	-	-	-	-	-	-
		4. Use more frequent lower N rates (<30kg N/ha/application)	-	2	2	-	-	-	-	1,5	2	-	-	1
		5.Reduce stocking rate and maintain production	4	-	5	-	-	-	2	5	1	-	1	1,2
		6. If cropping go to nil cultivation	2	-	2,4	-	-	-	1	-	1	-	-	2
	Decrease net profit	7. Apply DCD to crop	1	1	1	-	1,2	-	-	-	-	1,5	-	2
		8. Apply blanket DCD	2	1	1,2	-	1,2	1,2	-	1,2,5	1,2	1,5	2	2
		9. Cease cropping	1,2	2	1	-	-	-	-	-	-	1,5	-	2
		10.Reduce/eliminate N fertiliser and reduce production	4,2	2	2	-	-	2	2	4	2	1,5	-	2
		11. Reduce stocking rate and reduce production	4,2	2	2	-	-	-	2	2	2	1,5	1,2	2
		12.Partial change in stock class	4,2	2	3	-	2	1,2	-	2	2	-	1,2	1,2
		13. Feed infrastructure to facilitate high levels of low N feed	2	2,5	1	-	2	2	-	1,2	1,2	2,5	-	1,2
		14. Partial wintering facilities (on/off)	2	-	1,2	-	1,2	2,3	-	-	1,2	2,5	2	1,2
		15. Full wintering facilities	2	2	1,2	-	1,2	2,3	-	2	1,2	2,5	2	1,2
Land use change	Partial	16. Forestry	2	2	2	2	2	-	-	2	2	-	2	2
		17. Lower intensity stock policies	2	2	2	-	-	-	2	2	2	-	-	2
		18. Housing/lifestyle subdivision	1	2	1	5	-	2	-	2	2	-	2,5	2
		19. Reversion to native	2	2	2	-	-	-	-	-	-	2	2	2
		20. Extending existing riparian areas	-	-	-	2	-	-	-	-	-	2	2	1,2
		21. Create artificial wetlands	-	2	2	2	-	-	-	-	-	-	2	1,2
	Complete	22. Forestry	2	2	-	-	2	2	3	-	-	-	2	2
		23. Dairy to drystock change	2	2	2	-	2	2	-	2	-	-	2	2
		24. Reversion to native	2	2	-	2	2	2	-	-	-	-	2	2
		25. Other												