Waikato Regional Council Technical Report 2014/19

Upper Waikato drystock nutrient study

www.waikatoregion.govt.nz
ISSN 2230-4355 (Print)
ISSN 2230-4363 (Online)

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Prepared by:
Perrin Ag Consultants Ltd

For:
Waikato Regional Council
Private Bag 3038
Waikato Mail Centre
HAMILTON 3240

April 2013

Document #: 2387456

Approved for release by:
Alan Campbell Date March 2014

Disclaimer

Upper Waikato Drystock Nutrient Study

Prepared by

Perrin Ag Consultants Ltd

for the

Waikato Regional Council

and

Beef + Lamb NZ Inc.

REPORT PREPARED BY

PERRIN
AG CONSULTANTS

REGISTERED FARM MANAGEMENT CONSULTANTS

Perrin Ag Consultants Limited

106 Lake Road, P O Box 596, Rotorua

Phone: 07 349 1212 Fax: 07 349 1112

Mobile: 021 955 312 (D J Perrin) / 0292 955 312 (T Laan)

0293 955 312 (L Matheson) / 0273 403 984 (D Walker)

Email: consult@perrinag.net.nz

Report Dated: **22 April 2013**

DISCLAIMER

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.

EXECUTIVE SUMMARY

The Waikato Regional Council and Beef + Lamb New Zealand Inc were interested in undertaking further study to identify possible mitigations to round out the farm systems covered within the 2009 Upper Waikato Nutrient Efficiency Study, and to further understand cost-benefits on dry stock farms from reducing nutrient loss. Both parties were also interested in widening the scope of the original work to assess phosphorous losses as the earlier study was heavily focussed on nitrogen only.

Accordingly, Perrin Ag Consultants Ltd was engaged to undertake this supplementary work in November and December 2012, to be known as the Upper Waikato Drystock Nutrient Study.

The Upper Waikato Drystock Nutrient Study utilised a group of six case study farms across the Upper Waikato catchment. Baseline farm economic and nutrient loss performance was established through modelling in Farmax Pro and Overseer, with the results of three mitigation strategies analysed for each individual case study.

While the small sample size made definitive conclusions difficult to draw, several general trends emerged from the analysis:

(i) Depending on individual farm system, it would appear that the elimination of N fertiliser, the targeted use of DCD[1], altering livestock policies and afforestation provide the most efficacious suite of mitigations across the sample group – 5%-10% reduction in annual nitrogen loss with an associated loss of annual farm gate profitability of $2-$7/kg N loss reduction achieved.

(ii) The system changes considered, while varying depending on the individual nature of the case studies, delivered reductions up to 17% of current (status quo) losses within the constraint of reasonable system variation. While greater reductions might have been possible, it would have required significant system or land use change to achieve this.

(iii) Approximately half of the livestock policy changes considered was achievable with a net improvement in farm gate profitability, suggesting that a degree of farm system optimisation, even before productivity improvements are considered, might be possible to offset the negative economic impact of other

[1] The study was completed prior to the current cessation of the commercial sale of DCD in NZ due to residue issues in milk products.

mitigation options.. However this will be to some extent dependent on the relative medium term price outlooks between various livestock enterprises.

(iv) Other than afforestation or the cessation of large scale winter cropping practice, none of the mitigations resulted in meaningful reductions in assessed levels of phosphate from the farm systems.

To appreciate the impact that whole catchment implementation might have, further work needs to be undertaken to both identify the range and distribution of farm system and land uses across the Upper Waikato catchment and then ensure that sufficient representative case studies are analysed. This could be followed up with geospatial information system analysis to develop an appropriate methodology for extrapolating likely combination of mitigations across farm location and system types. The proposed combination of the existing 2009 Upper Waikato Nutrient Efficiency Study data set with this one would certainly provide access to additional properties at little cost.

As a result of the Upper Waikato Drystock Nutrient Study, the following recommendations are made:

(a) That Waikato Regional Council and Beef + Lamb New Zealand undertake a participant workshop following the submission of the final report.

(b) Utilising existing information and the feedback from farmer participants in both the Upper Waikato nutrient analysis projects, identify an appropriate suite of mitigations for extrapolation across the wider Upper Waikato catchment to assess the range of potential realistic results of wider scale adoption of nutrient loss mitigations in the target catchment.

(c) Given the apparent efficacy of afforestation as mitigation, particularly for both nitrogen & phosphorous, a separate piece of work is commissioned to more thoroughly investigate the implementation of this as a mitigation option. This would need to take into account the likely farmer push-back 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. Some consideration would also need to be given to the impacts on communities that large scale afforestation might create.

Table of Contents

LIST OF TABLES & FIGURES

1. Background and Terms of Reference

1.1. In 2009 the Waikato Regional Council ("WRC"), (then Environment Waikato) undertook the Upper Waikato Nutrient Efficiency Study ("UWNES")[2] alongside partners DairyNZ, Ballance AgriNutrients and Fonterra. This study undertook farm system and nutrient management analysis on ten dairy (plus one modelled average Waikato dairy farm) and four sheep and beef farms in the Upper Waikato catchment (see Figure 1 below). UWNES assessed both nutrient loss and mitigation strategies to lower N loss to hypothetical targets modelled in 2006 for the Waikato hydro lakes. These were 26kgN/ha for dairy and 12kgN/ha loss for sheep and beef systems.

1.2. Targets were based on earlier work by AgResearch[3] (2006) and mass loads from existing land uses into the Waikato hydro lakes. At the time of the UWNES this gave a better understanding on how to lift farm production/nutrient efficiency while lowering losses, and the relative cost-benefits on farm. One of the shortcomings of this study was the challenge of modelling sheep and beef farm systems due to the low numbers of farms (n = 4) and the variability of dry stock systems. The situation is further complicated by the large amount of dairy heifer and winter grazing that occurs on sheep and beef properties in this catchment.

1.3. Sheep & beef participant feedback from the original UWNES work[4] felt that their sector was under-represented in both scope and focus of the original study and that there was little readily available data on the environmental footprints of dry stock farm system types in the Upper Waikato catchment.

1.4. For these reasons, the WRC, along with Beef + Lamb New Zealand Inc. ("B+LNZ") were keen to undertake further study to identify possible mitigations to round out the farm systems covered within the UWNES, and to further understand cost-benefits on dry stock farms from reducing nutrient loss. Both parties were also interested in widening the scope of the original work to assess phosphorous losses as UWNES was heavily focussed on nitrogen only.

1.5. Perrin Ag Consultants Ltd ("PAC") was engaged by the WRC and B+LNZ to undertake this supplementary work in November and December 2012, to be known as the Upper Waikato Drystock Nutrient Study ("UWDNS").

---

[2] http://www.waikatoregion.govt.nz/Community/Your-community/For-Farmers/Integrated-catchment-management/Upper-Waikato-nutrient-efficiency-study/

[3] http://www.waikatoregion.govt.nz/PageFiles/5891/tr06-37.pdf

[4] http://www.waikatoregion.govt.nz/Services/Publications/Technical-Reports/TR-201031/

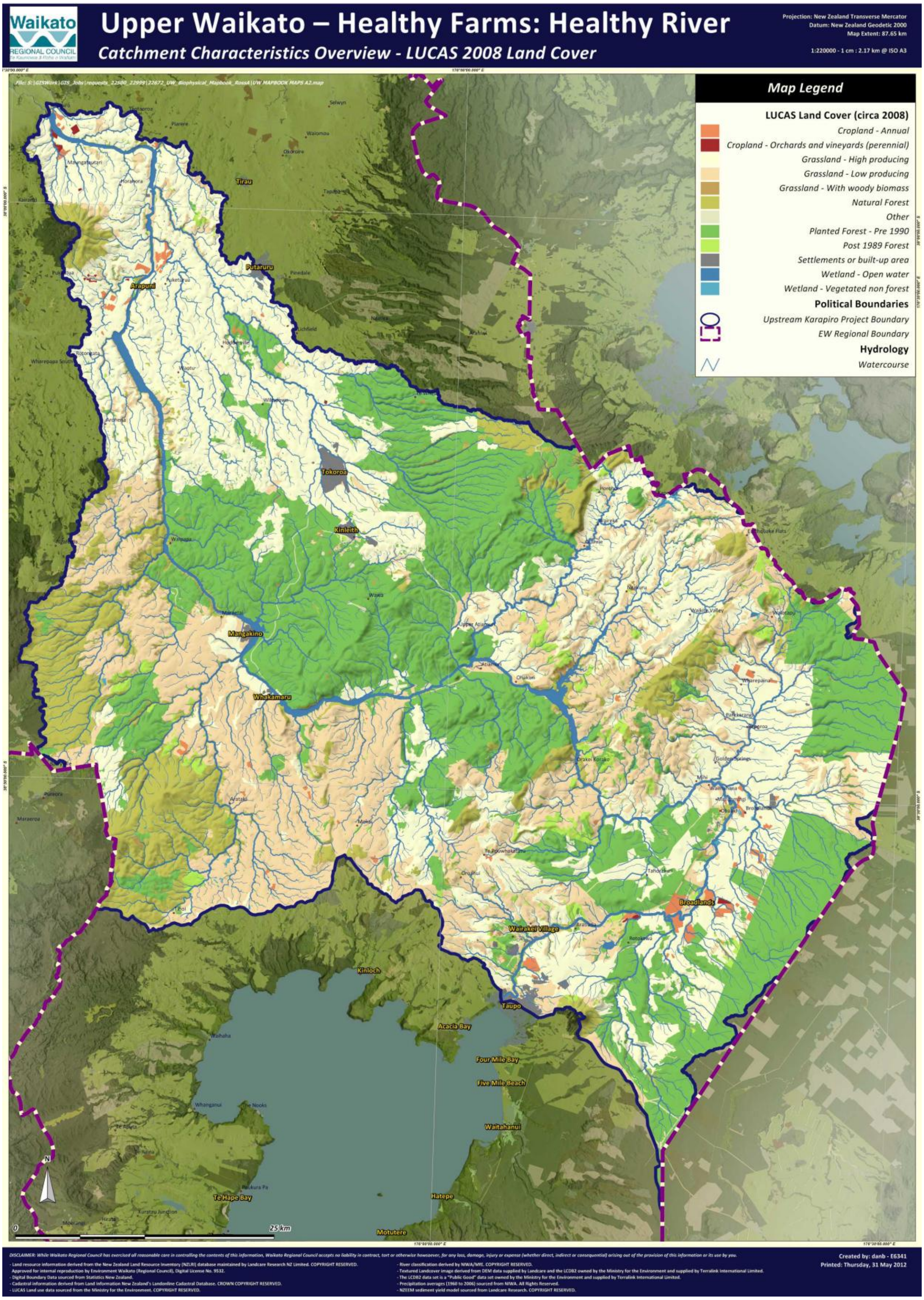

Figure 1: Map of the Upper Waikato Catchment

1.6. This work would complement the previous UWNES project, as well as prior work completed on integrated catchment management ("ICM").

1.7. It was desirous that the selected case study sample would include:

(i) Mixed sheep and beef farms.

(ii) Dry stock farms where a large portion of income comes from dairy grazing (heifers and winter grazing).

(iii) Intensive bull beef systems.

(iv) Maori farm incorporation with mixed sheep, beef (and/or deer)

1.8. Whereas UWNES had a defined N leaching target for the dry stock farms of 12kg N/ha/year, the approach for the UWDNS was to be slightly different, with the focus on examining the impact of implementing variable mitigation scenarios in existing farm systems, ranging from "easy" to "hard".

1.9. In practice, cognisant that the "degree of difficulty" associated with mitigations depended greatly on each individual farm system, the mitigations were broadly initially defined as follows:

(i) Easy: expected profit neutral mitigations, sensible changes relating to what is conventionally considered "best management practice" and easily identified areas of nutrient use inefficiency where whole farm system impacts might be considered moderately low.

(ii) Moderate: afforestation on high risk land, changing male:female stock ratios, mixed land use, or the extension of existing land use policies (i.e. changing proportion of stock classes).

(iii) Hard: significant land use, significant management change (elimination of a stock class, introduction of a new stock class, adopting hogget lambing[5],) or major capital investment (construction of facilities)

1.10. All of the scenarios needed to be cognitive of the magnitude of management change possible and the stage of farm development etc. They also need to capture each business' medium term goals and limit operational change to that possible within the core business activity i.e. converting a high N loss dairy support business to a low N

[5] The authors have included the adoption of hogget lambing as a "hard" mitigation on the basis that while many farmers lamb their ewe hoggets with considerable success, our observations are that it is a practice often executed poorly and that there is still some considerable resistance to its use as a practice. We note that B+LNZ provide a number of high quality resources to assist farmers with implementation of this technique, such as "Hogget performance – unlocking the potential", edited by Prof. Paul Kenyon, Feb 2012.

loss extensive breeding property is not a useful scenario to model, but construction of a wintering barn to house overwintered cattle might be.

1.11. Accordingly, not all case studies would necessarily have three appropriate mitigations that fell into the given categories, or what was considered easy for one system might be considered moderately difficult for another.

2. METHODOLOGY

2.1. Six farm properties, case studies A through F, were selected from the author's wider network, with assistance from the WRC, to ensure that an appropriate cross-section of farm location, ownership structures and operating policies were analysed.

2.2. Farms were located within the appropriate direct hydro-dam catchment or sub-catchments within the greater Upper Waikato catchment (see Figure 2 below).

2.3. Participating farmers supplied evidence of 2011/12 livestock transactions, soil fertility assessments, fertiliser applications and livestock reproductive data, as well as farm spatial data where it was available.

2.4. Where possible a field inspection was undertaken for each of the case study farms to validate the data provided by each of the participating farms and ensure that the mitigation scenarios to be analysed were appropriate for the individual properties.

2.5. For each of the case study farms, representative long-term status quo models were created in Farmax Pro 6.4.6.07 ("Farmax Pro") and Overseer 6.0 Build 2 ("Overseer 6"). The requirement to base the analysis on status quo farm systems was important given two of the base assumptions in Overseer being the assumption of near equilibrium conditions and the use of annual average data. Operational data for the recent 2011/12 season provided by the participants was used to create a validated feasible long-term 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.

2.6. In some cases this required the use of professional judgement to ascertain representative livestock policies for those farms with often quite variable trading policies, as well as for properties where capital livestock numbers demonstrated a degree of variation between the start and finish of the financial year.

2.7. Associated Overseer models were then created to identify "current" levels of annual nitrogen loss and phosphorus run-off.

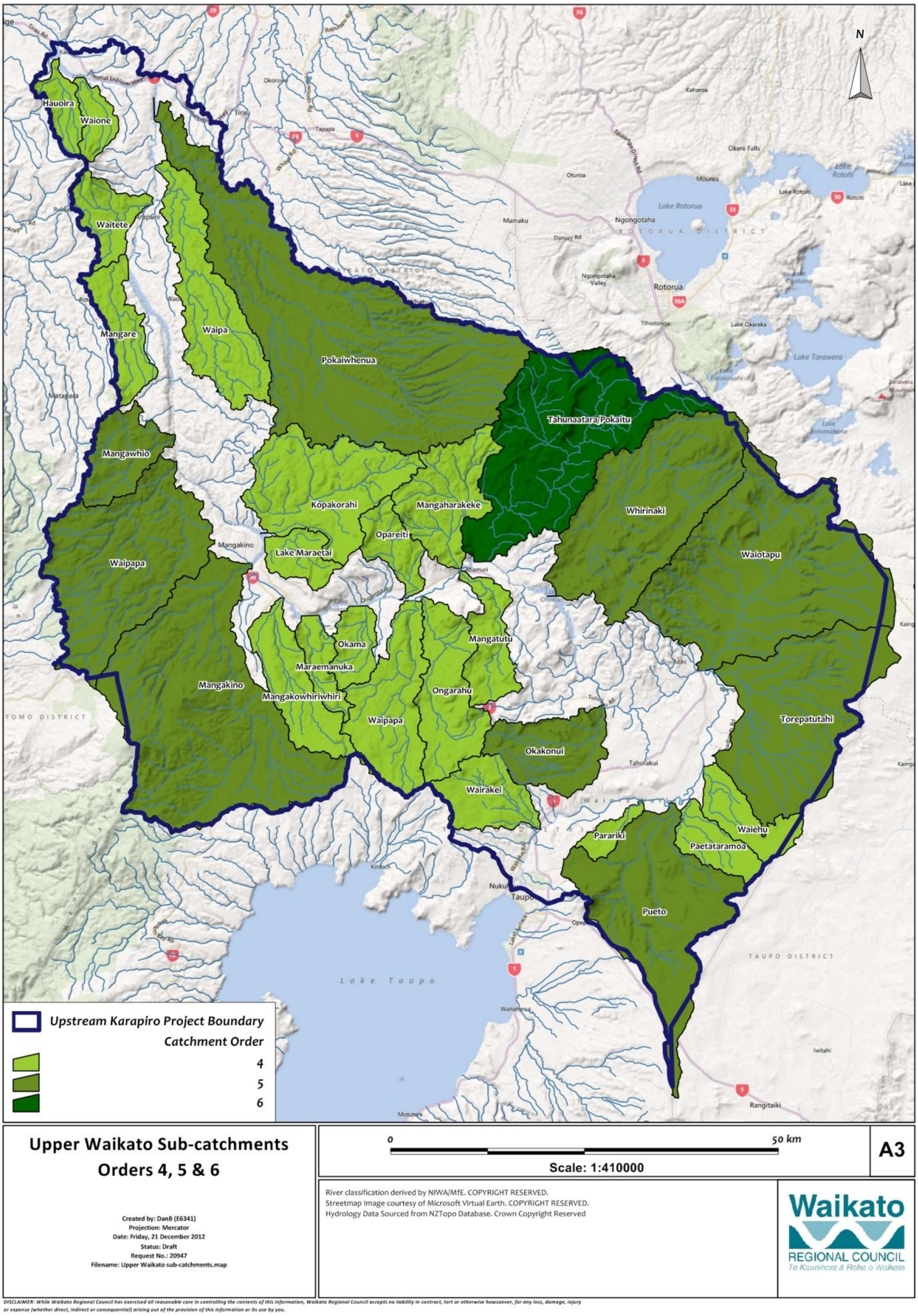

Figure 2: The sub-catchments of the Upper Waikato

2.8. Given the implications for estimates of P loss, anomalous soil test data was disregarded for a number of case studies where the other validated production data and field observations called into question the representativeness of the soil samples of the greater functional area[6].

2.9. Standardised status-quo financial analysis was also conducted for each of the case studies. Livestock revenues were generated from long-term pricing schedules in Farmax Pro 6.4.6.07, as were livestock-related marginal operating costs (such as animal health expenditure, shearing costs). These were combined with standardised fixed operating expenses appropriate to each modelled production system and based on appropriate national or regional indicators (see *Appendix 1* for the underlying livestock schedules and direct operating costs used). Individual fertiliser programs were used to provide the specific fertiliser and urea costs for each of the properties. The use of market based wages of management and allowances for depreciation were included to provide a comparable profit measure across all of the case study farms.

2.10. Where selected mitigations involved the one-off release of or need for additional capital, such as the requirement for new infrastructure or sale of capital livestock, this was identified in the analysis.

2.11. The economic analysis completed on each property was undertaken in a manner broadly consistent with the original Upper Waikato Nutrient Efficiency Study (2009) to allow direct comparison between the case study farms in each respective piece of work, notwithstanding differences in long term pricing assumptions that may exist due to the 38 month time difference between them.

2.12. One significant difference between this analysis and that of the UWNES was in regards to the treatment of debt. Rather than use either actual or a standardised level of liabilities for each case study, the UWDNS analysis excluded the direct impact of balance sheet composition, but instead reported on the likely level of term debt that could be internally supported by each case study in its status quo situation and as mitigations were adopted. This was based on an assumption that 70% of pre-tax profit (EBIT) would be available for both debt-servicing and repayment on the basis of a 15 year table mortgage at an average interest rate of 7%.

2.13. Once base-line physical and financial performance was established, scenarios were analysed in line with the three mitigations categories. Successive scenarios

[6] Defined as "blocks" in Overseer.

incorporated the changes implemented as a result of the previous "easier" mitigations where such cumulative treatment was appropriate.

2.14. Note that the economic impact of any 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.

2.15. Detailed descriptions of the participating farms were compiled, ensuring that all descriptors were presented in such a way as to prevent the easy identification of the participating farmers, all of whom agreed to participate on the basis of anonymity. In a departure from the case study descriptions presented in the UWNES, total land area and absolute stock numbers have been excluded from any information presented in or appended to the report.

2.16. To allow some valid comparison with wider properties in the catchment, participant case studies have been categorised into one of three farm size categories – small, medium or large (see *Table 1: Farm size categories used in the UWDNS* below).

Table 1: Farm size categories used in the UWDNS

UWDNS Category	Farm size	Case studies
Small	<500ha	E, F
Medium	500-1,000ha	A,C
Large	>1,000ha	B, D

2.17. Productivity mitigations (i.e. increase per SU production or reducing fertiliser N usage and accepting lower animal production) were generally 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 one exception was the lambing of ewe hoggets, which in combination with a reduction in overall ewe numbers was considered for one of the case studies.

2.18. We note that the 2009 UWNES work considered 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[7] 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.

2.19. Unlike the UWNES, the scope of this analysis was expanded to consider P reductions as well. While nitrogen losses tend to be mitigated via changes to operating policies, particularly in relation to livestock numbers, the risk of phosphorus run-off tends to be linked to the physical soil properties of a farm – particularly contour (which can't be altered) or soil phosphate status. The timing of application of phosphate containing fertilisers can be a factor in the risk of direct losses to the environment, but other changes to farm operating policies tend to have little impact on P losses, except where they have a direct reduction in the risks of soil loss. Apart from afforestation, there are few mitigations that are likely to reduce both N & P losses farming activity.

2.20. Lowering soil Olsen P status provides one of the most powerful mitigations as regards reducing P loss that is quantifiable in Overseer. Morton and Roberts (1999) state that near maximum pasture production is achieved at soil Olsen P levels of 38 on pumice soils. However, on rolling contour, soil Olsen P levels of this nature massively increase the risk and extent of P loss. Given both the typical utilization of pasture grazed in situ on dry stock properties and the economic returns from dry stock farming activities, it is questionable as to whether there is an economic return from maintaining soil P reserves at these levels, particularly at current fertilizer prices.

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

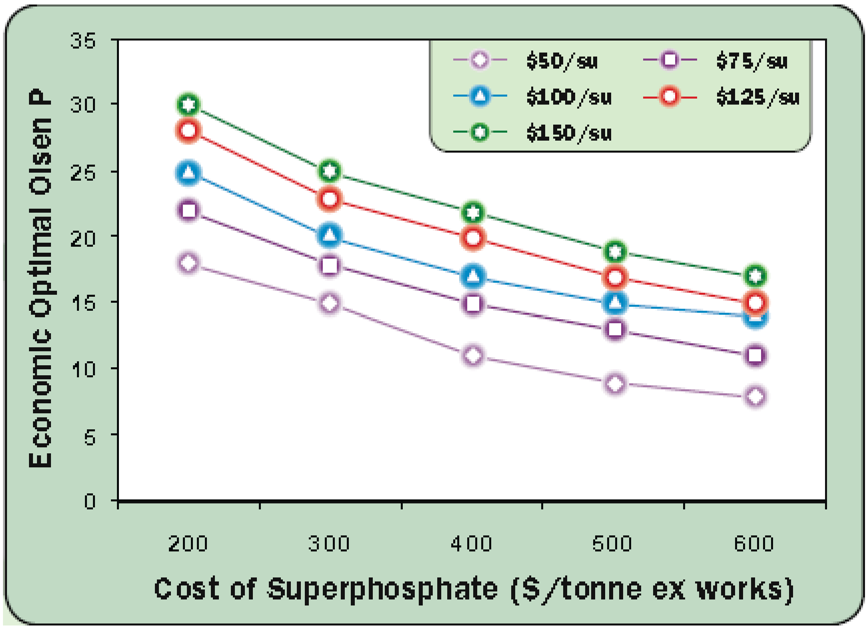

Figure 3: Comparison of optimal Olsen P relative to superphosphate price

2.21. Econometric analysis presented by Edmeades in 2008 (*Figure 3: Comparison of optimal Olsen P relative to superphosphate price* above) indicated that the economically optimal soil Olsen P level at a superphosphate price of $400/t can vary between 10 and 24 depending on the level of underlying farm profitability (as expressed in terms of gross margin).

2.22. However, we note that most of the case study properties had average soil Olsen P levels broadly in line with the appropriate econometric optimum or existing fertiliser applications were likely to result in a fall towards these levels, so further reductions in soil Olsen P levels were not considered as mitigation strategies for the UWDNS project.

A note on P losses

While Overseer modelling estimates average P losses from farming activity, the reality is that such losses are neither uniform across the relevant parts of the property, either spatially or seasonally. It is recognized that 80% of all P losses from a pastoral operation come from 20% of the property (Gburek & Sharpley, 1988), particularly those areas where transport mechanisms (i.e. water flows) and contaminant sources coincide. These have been defined by McDowell & Srinivasan (2009) as critical source areas (CSAs). Good examples of CSAs include gateways, stock camps, tracks, trough surrounds and other areas of high nutrient load and reduced vegetative cover that lie in ephemeral water courses or are subject to storm water flows – most land above 16° slope can probably classed in this way.

Of course, it is impossible to eliminate the creation of these CSAs within a pastoral farming environment. However, McDowell & Srinivasan (2009) concluded that excluding stock from permanent stream channels and implementing mitigation strategies that target runoff from these nutrient dense areas provided a good mechanism to managing the impact of P losses from these CSAs. Such strategies either slow the movement of storm water through ephemeral channels (to facilitate sediment deposition) or break the connectivity between ephemerals and these risk areas. The extent to which such strategies are either applicable or practical on the case study farms was not considered as part of the analysis due to a lack of time and resources. However, outside of ensuring soil P levels are maintained at an appropriate level, managing CSAs within a farm environment perhaps provide the best mechanism to eliminating the extent of actual P run-off reaching the wider environment, even if the application of these methods are not all quantifiable in Overseer. Such strategies include:

- The use of riparian buffers;
- Moving troughs and gateways out of storm flow channels;
- Creation of detention dams;
- Excluding stock from major ephemerals during periods of high risk ; and
- Extension of the existing wetland areas to accommodate increased run-off area.

2.23. *Treatment of forestry options*

2.23.1. The partial or total conversion of pastoral land to forestry as a means to reduce N & P loss is considered a viable mitigation option for some of the case studies.

2.23.2. A recent survey of farmers in the Rotorua catchment[8] indicated that those farmers were essentially 100% opposed to full afforestation. Farmer commentary from the survey suggested this position was influenced by a lack of knowledge, lack of understanding about the complexity of the forestry business model and poor experiences with forestry. It is reasonable to expect that similar sentiments may exist amongst farmers in the Upper Waikato. The possible impact that wide scale afforestation might have on existing communities might also be a valid concern.

2.23.3. However, the reality is that forestry provides a well-recognised method for the reduction of N and P losses from land activity and it is likely that afforestation will have a role in the medium to long term achievement of reduction of nutrient losses to the catchment.

2.23.4. 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 $2.67/tonne[9] provides little value at present.

2.23.5. 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: an approach used in the recently completed Bay of Plenty Regional Council's Farmer Solutions Project ("FSP"). Market data[10] indicates that forestry rights for normal *Pinus radiata* plantations are currently valued at $150+GST per hectare in the Central Plateau region (NPV $2,234 over 27 years at 5%) compared with an equivalent NPV of $4,703+GST/ha based on a clear wood management 28-year rotation and net stumpage of

[8] Perrin Ag Consultants Ltd. 2012. *Farmer Solutions Project*. Bay of Plenty Regional Council.
[9] Source: https://www.commtrade.co.nz/, 8 January 2013
[10] Source: Marty Craven, Telfer Young Rotorua, *pers. comm.*

$42,000+GST per hectare (see *Table 2: Forestry investment profit calculation* below). A forestry rental approach was used because:

(i) Its annual, “risk free” income stream provides a direct comparison with the alternative 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.

2.23.6. 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 $316. 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.

2.23.7. 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 a 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. Nor are the environmental impacts associated with planting and harvesting directly considered, although expected nutrient losses from farming activity estimated by Overseer do take into account the life-cycle nutrient losses from forestry activity.

Table 2: Forestry investment profit calculation

AREA to be replanted (ha) 1

	FORESTRY INVESTMENT - CLEAR WOOD MANAGEMENT REGIME												
	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

3. THE CASE STUDY FARMS

3.1. Summary

3.1.1. Each case study farm is described below in terms of its status quo production resources and operating system, followed by the description of each of the mitigation scenarios used and the associated analysis of the physical, economic and environmental outcomes the adoption of these changes had on the farm system.

3.1.2. Each of the individual case study reports have been designed to allow separation and distribution to each of the participating farmers. As a result, there is some duplication of explanation where identical or similar mitigations are being analysed.

3.1.3. The base line data for the six case study farms is summarised in *Table 4: Summary of status quo data for the six UWDNS case study farms* below.

3.1.4. The mitigation scenarios considered for each case study are presented *in Table 3: Mitigation scenarios analysed*.

Table 3: Mitigation scenarios analysed

Case Study	"Easy"	"Moderate"	"Hard"
A	Eliminate fertiliser N usage, DCD on crop	No fert N + Cease use of winter crop for dairy grazing	No fert N + Increase area under deer farming
B	DCD on crop	DCD + Afforestation of poorest land[11]	DCD + Reduce beef cows, replace with steers
C	Eliminate fertiliser N usage, DCD on crop	No fert N, DCD + Swap heifers for steers	No fert N + DCD + Reduce ewe numbers & mate hoggets
D	Eliminate fertiliser N, usage DCD on crop	DCD + Afforestation of poorest land	DCD + Reduce beef cows, replace with steers
E	Eliminate fertiliser N, import feed	Cease use of winter crop for dairy grazing	No fert N + cease cropping + create facility for wintering
F	Reduce age class of cattle, increase sheep:cattle ratio	Reduce maize area + increase sheep policy + sell grass silage	Eliminate maize cropping + sell grass silage + increase

[11] This would typically be the steep, southern faces which have the lowest inherent pasture growth potential.

Table 4: Summary of status quo data for the six UWDNS case study farms

	Case study ID	A		B		C		D		E		F	
		per SU	per ha	per SU	per ha	per SU	per ha	per SU	per ha	per SU	per ha	per SU	per ha
Profit	Total asset value	$1,265	$14,790	$1,426	$10,267	$797	$11,237	$2,500	$20,504	$1,440	$12,238	$2,380	$29,515
	Gross Farm Income (GFI)	$94	$1,098	$60	$430	$78	$1,098	$64	$528	$132	$1,125	$206	$2,555
	Farm Working Expenses (FWE)	$56	$653	$48	$346	$43	$609	$59	$482	$66	$564	$130	$1,616
	Total Operating Expenses (TOE)	$63	$738	$58	$420	$48	$683	$68	$556	$75	$638	$136	$1,690
	Total Operating Profit (EBIT)	**$31**	**$360**	**$1**	**$11**	**$29**	**$415**	**-$3**	**-$27**	**$57**	**$488**	**$70**	**$865**
	per kg N leached	**$33**		**$2**		**$28**		**-$4**		**$41**		**$43**	
	ROA %	**2.4%**		**0.1%**		**3.7%**		**-0.1%**		**4.0%**		**2.9%**	
Efficiency	Stocking rate	11.7		7.2		14.1		8.2		8.5		12.4	
	Tonnes net pasture grown	6.1		4.1		7.9		4.6		4.6		7.8	
	kg net product per ha	249		116		326		133		111		261	
	kg LW wintered	891		442		775		517		752		935	
	kg DM/kg product	24.4		35.3		24.2		34.6		41.4		29.9	
	Average Olsen P												
	Gross margin[1]/SU	$59		$36		$56		$30		$117		$116	
Risk	Operating profit margin	33%		2%		38%		-5%		43%		34%	
	FWE/ %GFI	59%		80%		55%		91%		50%		63%	
Solvency	Debt able to be serviced ($/ha)	$2,294		$68		$2,646		$0		$3,110		$5,514	
	Minimum equity %	84%		99%		76%		100%		75%		81%	
Environmental	kg N leached/ha												
	total ha	11		6.2		15		7.0		12		20	
	efffective ha	13.8		9.0		18.1		7.1		13.6		20	
	kg P runoff/ha												
	total ha	1		3.4		5.3		0.6		1		0.4	
	efffective ha	1.3		6.1		6.4		0.6		1		0.4	

[1] As calculated in Farmax Pro

3.2. Case Study A

3.2.1. Description of operation

Farm A is a medium sized Maori-owned property located in the Whirinaki sub-catchment. It is operated as an integrated breeding and finishing business, complemented with winter cow dairy grazing. The business is split into a moderately intensive sheep & beef farming operation and a deer breeding and finishing unit. The intensity of the sheep & beef unit is greater than that of the deer operation by virtue of the presence of dairy cows being wintered on this part of the property. Across the total area, the property winters 11.7 SU/ha at an average live weight per hectare of 891kg/ha. The overall stock ratio is 47% sheep, 28% cattle and 25% deer.

FARMAX

Annual Report Demand for Case study A - Sheep & beef
Status quo

	Area		
	Grazing	Effective	Whole
Total Feed Eaten (tDM/ha)	6.78	6.33	6.33
Demand from Supplements (%)	13.6	13.6	13.6
Standardised Stocking Rate (SU/ha)	12.3	11.5	11.5
Live wt. Wintered (kg/ha)	1047	979	979
Net Product (kg/ha)	301	282	282
Feed Conversion Efficiency	22.5	22.5	22.5
Sheep:Beef:Deer Ratio	63:37:0	63:37:0	63:37:0

FARMAX

Annual Report Demand for Case Study A - Deer
Status quo

	Area		
	Grazing	Effective	Whole
Total Feed Eaten (tDM/ha)	7.13	6.78	6.78
Demand from Supplements (%)	9.4	9.4	9.4
Standardised Stocking Rate (SU/ha)	13.0	12.3	12.3
Live wt. Wintered (kg/ha)	639	607	607
Net Product (kg/ha)	152	144	144
Feed Conversion Efficiency	47.0	47.0	47.0
Sheep:Beef:Deer Ratio	0:0:100	0:0:100	0:0:100

Figure 4: Annual demand summary for Case study A

3.2.1.1 Contour

The effective area on the property comprises 7% flat contour, 16% rolling contour, 60% easy hill and 17% of steep hill country.

3.2.1.2 *Soil*

The soils on the property are either Haparangi & Ngakuru hills soils or Taupo sandy loam on the flats. All are pumice soils, formed out of Taupo pumice overlaying older ash deposits. They are low in natural fertility, tend to be well drained and subject to wind erosion when cultivated.

The farm has generally high levels of soil Olsen P levels, averaging 30-35mg/L on the hill country and 35-45mg/L on the better down land and flats. Recent liming over all of the areas where bulk fertiliser could be spread has resulted in pH of 5.8-6.0 in these areas, while pH on the hill country is still low at 5.4.

Soil P levels are now considered to be close to the agronomic optimum given the relatively high level of intensity that the farm is being operated at. Note that fertiliser applications over the past few years have been deliberately at sub-maintenance levels to allow for a reduction in higher than necessary available soil phosphate levels.

3.2.1.3 *Climate*

Mean annual rainfall on the property is typically in the vicinity of 1,400-1,500mm.

3.2.1.4 *Pasture and crops*

Regular regrassing over the last ten years, including an extensive summer cropping program in the period between 2005 and 2008, and regular above-maintenance fertiliser applications, has resulted in large areas of the farm having improved ryegrass and white clover based pastures. Much of the hill country is still dominated by browntop, but a high degree of subdivision (average paddock size 7.6ha) and moderate fertility levels help control the development of a thick browntop thatch.

The farm currently sows 5% of the farm area into winter crop annually, predominantly swedes. This is used for wintering dairy cows (47% of area), ewes (30%), hinds (17%) and trading cattle (6%).

Whole farm potential pasture growth is estimated at 6.9t DM/ha/year, ranging from 9t DM/ha/year on the improved areas of the farm to 4.9t DM on the steeper hill areas.

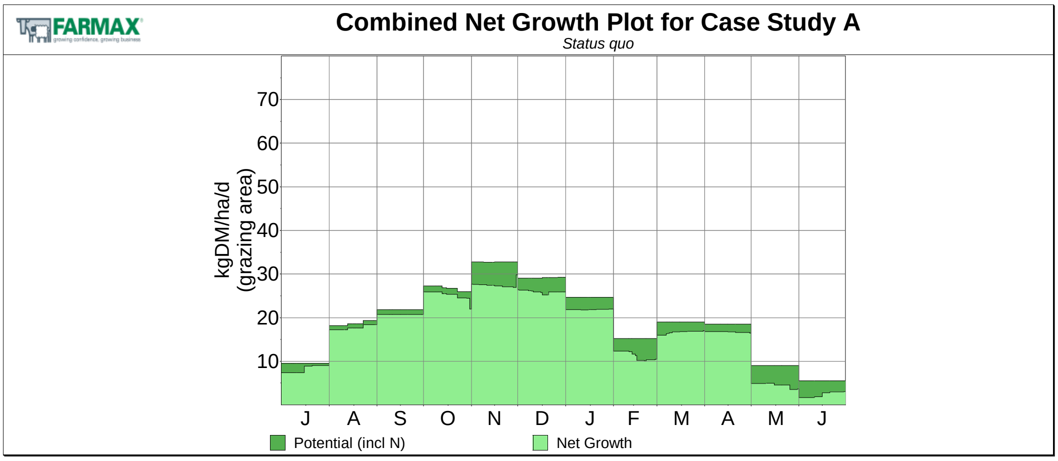

Figure 5: Pasture growth profile for Farm A

3.2.1.5 Fertiliser

Sub-maintenance fertiliser applications have been in place over the past two seasons to moderate previously higher soil fertility levels and manage cashflow.

Fertiliser is typically applied in the early spring pre-lambing and pre-calving.

An average of 8kg N/ha is used (restricted to the tractor accessible areas only) with 11kg P/ha applied annually. Note that this level of phosphorous applications is lower than the business accepts it will need to apply going forward.

3.2.1.6 Stock and production

(i) Sheep

The ewe flock on Farm A is a predominantly Romney flock, having been back-crossed from a Finn-dominant Composite flock over the past four years. The ewes average 69kg at tupping. Shearing has been moving from an eight-month shearing policy back to a full wool program since 2010.

The property aims to finish all of its lambs each year. The business lambs both its mature ewes (135% lambing) and approximately 75% of its ewe hoggets (91% lambing). Older ewes (18% of the flock) are mated to a terminal sire, with the main flock mated to a Romney ram. Mating occurs on 16 March for the terminal ewes, with the main flock commencing mating on 1 April.

After weaning in early December, non-replacement lambs are sold in a steady pattern from January through to May at an average carcass weight ("cwt") of 16.4kg.

(ii) Cattle

Five cattle policies exist at Farm A. A small breeding herd of Hereford x Friesian cows are maintained to condition lamb pasture and provide bulls for finishing. Mated to a Simmental bull, all heifer progeny are sold at weaning, with the males transferred into the finishing program. Friesian bull calves are purchased to complement the home born progeny, with all the weaner bulls taken through one winter and sold between January & April each year (260kg cwt). In addition, 22-month old bulls are purchased in the autumn for finishing over the winter & spring periods, with all of these cattle sold between October and January (318kg cwt).

(iii) Deer

A breeding herd of red deer hinds is run as a separate unit within the property. The bulks (64%) of the mixed-aged hinds are mated to a Wapiti terminal sire, with the remaining mixed aged hinds and first-fawners mated to a red stag to generate herd replacements. All of the non-replacement progeny are sold between November and May each year at an average carcass weight of 53kg. Fawning percentage is back to 85% after having recovered since the 2007/08 drought.

3.2.1.7 Standardised economic performance

Farm A is generating a status quo operating profit of $360/ha, or $31/SU. Farm working expenses are 59% of gross farm income and the business has operating profit margin of 33%. Current return on assets is 2.4%. This is summarised in *Appendix 2* below.

3.2.1.8 Constraints

The moderately high stocking rate and the fact that a significant area of winter crop needs to be sown each year to ensure adequate feeding levels over winter is a constraint of sorts. An increasing propensity in recent years for the property to dry out over summer has resulted in the cattle finishing program being adapted to reduce summer feed demand. With Farm A being owned in conjunction with a number of dairy assets, there is a degree of compulsion about the requirement to winter dairy cows. A large proportion of the land area has already been retired from grazing and is either in production forestry or conservation planting. Consequently there is little appetite for further substantial afforestation.

3.2.1.9 Status quo nutrient loss

Modelling of the status quo farm system in Overseer 6 estimated annual N losses of 11kg N/ha/year and annual P run-off of 1kg P/ha/year. These nutrient losses included the impact of 329.5ha of existing plantation forestry and soil conservation plantings within the total farm area. Excluding the impact of the afforested areas, annual N & losses from the effective areas are 13.8kg N/ha and 1.3kg P/ha/year.

3.2.2. Mitigation scenarios

The following mitigation scenarios were considered for Farm A:

3.2.2.1 Elimination of N fertiliser to pasture, improve timing of P fertiliser and usage of DCD on all winter crops (A1)

The use of nitrogenous fertiliser, even when applied in line with best management practices has a contributory impact on increasing nitrogen losses from the farm system. This occurs through both increasing the quantity of N cycling through the farm system and typically allowing higher stock intensities to be farmed, normally through the higher risk winter leaching period. The elimination of N in dairy systems might be managed through the importing of additional feed. However, in dry stock systems where the returns per kg DM eaten are typically lower than the cost per kg DM of imported feed, it is typically more profitable to lower feed demand (i.e. reduce stock numbers) than increase feed supply (i.e. purchase more feed).

The risk of significant rainfall events in the period April-October makes direct applications of phosphate fertiliser during this time subject to increase risk of direct loss from overland flow.

While the use of DCD across a whole farm system has a low level of efficacy, particularly when used on a system with low pre-existing levels of nitrogen leaching, its use on N loss “hot spots”, such as winter crops, is likely to be more efficient. Shepherd *et al.* (2012) reported that the use of DCD applied within two days of grazing and then again six weeks after grazing at a rate of 12kg DCD/ha resulted in reduction of measured nitrate loss in drainage of 20-27%. Assuming the lowest reported reduction of 20%, using DCD on crops at Farm A in this manner might reduce N leaching from these areas an average of 63kg N/ha to 51kg N/ha[12]. The estimated costs of the application are $97/ha, based on application by farm staff ahead of the grazing animals and a contracted application after grazing has been completed. Note that the use of DCD specifically to crop areas is not currently available mitigation in Overseer 6

The implementation of these mitigations on Farm A resulted in a reduction in whole farm average annual N losses of 1.4kg N/ha, and with whole farm EBIT reducing by $1/ha. Phosphate losses are unchanged.

3.2.2.2 *Elimination of crop for cow wintering (A2)*

The use of a forage crop for wintering grazing dairy cows is favoured by Farm A due to the lessened impact that it has on overall farm management, compared with building up sufficient feed from pasture alone ahead of the winter grazing period.

The elimination of winter crop specifically for the dairy cow grazing would require adjustments to the stocking rates of the existing cattle policies and potentially result in a reduction in feed conversion efficiency of the operation, as a reduction in winter stock numbers in the other cattle policies reduced feed demand in the spring and summer periods, resulting in the accumulation of surplus pasture which will rapidly decline in quality. This could be partially offset by allocating this surplus feed to the ewes, with a likely increase in lamb weaning weight or by cutting more silage.

Removing the winter crop as a means grazing the contracted dairy cows is forecast to result in a reduction in annual N losses of 2.4k/ha, with EBIT falling 2% to $352/ha. Again phosphorous losses are forecast to be unchanged.

[12] On the basis that the majrity of N leaching occurs during and after crop defoliation.

3.2.2.3 *Replacement of bull finishing for deer finishing (A3)*

The existing deer operation on Farm A provides scope to reduce the number of bulls finished on the property and replace them with weaner deer for finishing from Apr/May through December. The adoption of this policy would eliminate the need to build additional handling facilities, although it would require a significant capital investment in deer fencing an estimated 11% of the farm area, specifically those areas currently utilised for the bull finishing enterprise at a capital cost of $2,560/ha. These deer would be purchased at between 45-55kg live weight in April and May, and then targeted to be killed in the premium chilled October sale window at >55kg cwt. The necessary growth weights to achieve this sale profile are not currently achieved on Farm A. Accordingly the scenario analysis assumes similar growth rates to those currently being achieved.

Based on the size of the bull finishing enterprise, the sheep:cattle:deer ratio would change to 48:27:25 as the weaner stags replaced the bulls.

Assuming the use of nitrogen fertiliser was already eliminated, farm nitrogen losses would reduce slightly to 13kg N/ha, while farm P run-off would again remain unchanged; an unusual observation given the impact that deer tend to have on soil loss from fence walking, which would be associated with higher P losses. Farm EBIT is forecast to increase to $434/ha – an increase of 20%, but approximately $2,560/ha of term debt would be required to fund the necessary fencing and take the business to the edge of its assumed debt servicing capacity. Overall return on assets increased to 2.9% (after taking into account the required investment in livestock and fencing).

Table 5: Summary of Case Study A mitigations

	Case Study A	SQ		A1		A2		A3	
		per SU	per ha	per SU	per ha	per SU	per ha	per SU	per ha
Profit	Total asset value	$1,265	$14,790	$1,277	$14,771	$1,331.35	$14,684	$1,297	$15,154
	Gross Farm Income (GFI)	$94	$1,098	$94	$1,086	$95	$1,046	$99	$1,163
	Farm Working Expenses (FWE)	$56	$653	$55	$642	$52	$609	$55	$644
	Total Operating Expenses (TOE)	$63	$738	$62	$727	$59	$694	$62	$729
	Total Operating Profit (EBIT)	**$31**	**$360**	**$31**	**$359**	**$30**	**$352**	**$37**	**$434**
	Change from SQ	**-**		**-0.3%**		**-2%**		**20%**	
	Change in EBIT/change in kg N loss			**-$0.73**		**-$3.62**		**$89.68**	
	ROA %	**2.4%**		**2.4%**		**2.4%**		**2.9%**	
Efficiency	Stocking rate (SU/ha)	11.7		11.6		11.0		11.7	
	Tonnes net pasture grown	6.08		5.9		5.9		5.9	
	kg net product per ha	249		247		234		245	
	kg LW wintered	891		883		845		891	
	kg DM/kg product	24.4		23.9		25.1		24.1	
Risk	Operating profit margin	33%		33%		32%		37%	
	FWE/ %GFI	59%		59%		55%		55%	
Solvency	Capital released (required)	-		$19		$106		-$2,685	
	Debt able to be serviced	$2,294		$2,288		$2,242		$2,764	
	Minimum equity %	84%		85%		85%		82%	
	Can system change be funded?	n/a		Yes		Yes		Yes	
Environmental	kg N leached/ha								
	efffective ha	13.8		12.4		11.5		13.0	
	change from SQ		-	-1.4		-2.3		-0.8	
	kg P runoff/ha								
	efffective ha	1.34		1.34		1.34		1.34	
	change from SQ			0		0		0	

ROA % - return on assets EBIT – earnings before interest & tax LW – live weight DM – dry matter SU – stock unit

3.3. Case Study B

3.3.1. Description of operation

Farm B is a large, extensive breeding unit located in the main Taupo-Ohakuri sub-catchment. Predominantly south facing in aspect and at moderately high altitude (average 500m a.s.l.), the property has a relatively low carrying capacity at 7.2SU/ha.

Annual Report Demand for Case study B
Status quo

	Area		
	Grazing	Effective	Whole
Total Feed Eaten (tDM/ha)	4.03	3.97	3.97
Demand from Supplements (%)	3.1	3.1	3.1
Standardised Stocking Rate (SU/ha)	7.3	7.2	7.2
Live wt. Wintered (kg/ha)	448	442	442
Net Product (kg/ha)	118	116	116
Feed Conversion Efficiency	34.1	34.1	34.1
Sheep:Beef:Deer Ratio	59:41:0	59:41:0	59:41:0

Figure 6: Annual demand summary for Case study B

3.3.1.1 Contour

The effective area on the property comprises 7% rolling, 48% easy hill and 45% of steep hill country.

3.3.1.2 Soil

The soils on the property are either Oruanui hills soils (formed directly out of Taupo Ash) on the easier hill country or Tauhara steepland soils (derived from Ngatuku lapilli) on the steep hill country. The small and scattered pockets of more gently contoured land are likely to be Atiamuri silty sand. As is typical of the eastern Upper Waikato catchment, all are pumice soils in low natural fertility and well drained. The Tauhara steepland soils are particularly susceptible to erosion under pasture, less so under trees.

In the relatively limited areas where cropping or pasture conservation can occur, soil fertility ranges between Olsen P levels of 25-30mg/L, while the majority of the hill country tends to be lower at between 10-20 mg/L. Soil pH tends to range between 5.4 and 5.6.

3.3.1.3 Climate

The nominal annual rainfall on the property is in the vicinity of 1,300-1,400mm. However, the farm's aspect and elevation might result in a higher rainfall in some years. With estimates of nitrogen losses particularly sensitive to variation in rainfall, improved accuracy in rainfall data will allow for more robust estimates of N losses.

3.3.1.4 Pasture and crops

With a small area of land suitable for cropping, the extent of improved pasture across the property is low. Browntop dominates the sward, with significant amounts of sweet vernal also observed during the field inspection.

<1% of the available effective area is sown into winter feed crops each year, approximately half in a brassica mix, the other half in an annual grass crop. Both are used to winter the young replacement heifers, which allows any additional feeding out to this stock class to occur on the safer, flatter areas of the farm.

Annual pasture production potential has been estimated at 5t DM/ha, with the best contoured areas growing up to 6.6t DM/ha/year, while the highest and steepest southerly faces growing as little as 3.5t DM/ha/year.

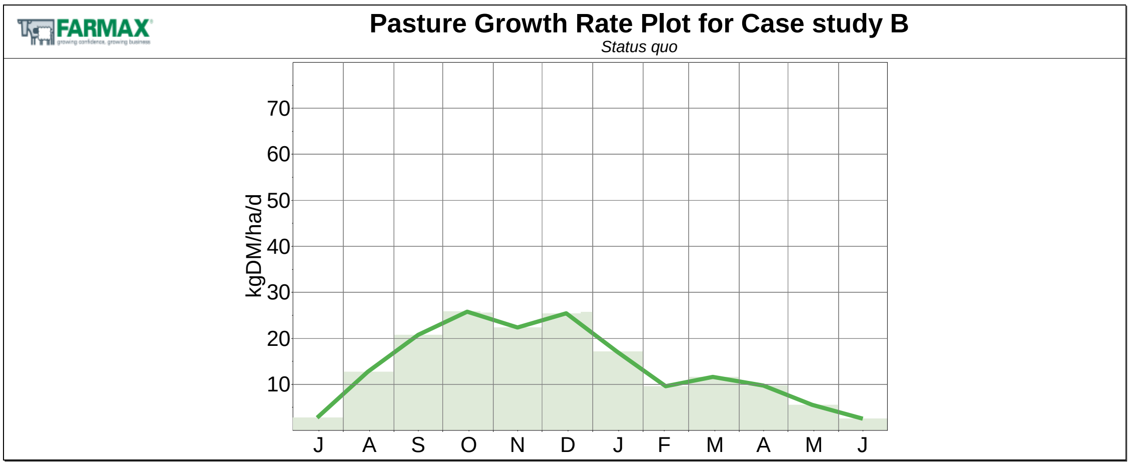

Figure 7: Pasture growth profile for Farm B

3.3.1.5 Fertiliser

The farm typically receives an average of 7kg P/ha/year, via an application of sulphur gain 15S (0 8.5 0 14.7) in a single aerial dressing in December. Note that this is currently at a level below what is considered may be necessary to maintain the current levels of available soil phosphate.

Nitrogen fertiliser use is restricted to the limited areas of silage country and on the winter crops – the total average annual application is less than 0.5kg N/ha.

3.3.1.6 Stock and production

(i) Sheep

The ewe flock on Farm B is Romney flock with the ewes averaging 63kg at tupping on 14 April. The shearing policy is completely tailored around the need to maximise lamb survival and minimise handling. Accordingly ewes are shorn pre-lamb in July and again at weaning in early December. The flock lambs at 142%

The property is solely focussed on store lamb production for a sister business. This sets the requirement for an early December wean, despite the fact that average weaning weights are around 23kg. All of the wether lambs are sold store through December, with a tail in January and February. The majority of the non-replacement ewe lambs sold in February, with a further draft in April as winter numbers are confirmed. Ewe hoggets are not mated.

(ii) Cattle

As with the ewe flock, Farm B's cattle policy is operated to produce store cattle for a related finishing operation. The Angus cow herd is mated from the 10th of January each year for 2.5 cycles. Weaning takes place in early May, at which point all of the steer and non-replacement heifer calves are sold store at an average of 210kg. Calving percentage is relatively low at 79% (calves weaned/cows mated)

3.3.1.7 Standardised economic performance

Farm B is generating a status quo operating profit of $11/ha, or $1/SU – essentially a break-even financial result. This is partially the result of profit effectively being transferred to the associated finishing property through the necessity of sub-optimum weaning dates in the ewes. Farm working expenses are 80% of gross farm income and the business has operating profit margin of 2%. This is summarised in *Appendix 2* below.

3.3.1.8 Constraints

Aspect, contour and elevation clearly limit pasture production, which prohibits the adoption of any large scale finishing operation. The distribution of pasture growth requires moderately late lambing and calving dates to ensure peak pasture demand coincides with the spring flush. However, without the internal requirement to wean lambs at 83 days of age, later weaning would probably occur, with a resultant higher weaning weight and potentially higher average lamb values. The absence of the limited cropping program would make the achievement of adequate weight gains in the replacement heifers over winter difficult.

The exclusive farming of capital livestock on the property also provides little in the way of risk management as it relates to significant feed deficit during the growing season, such as from drought. In the event that destocking is required, such reductions need to occur from capital livestock, which has implications for economic performance in future seasons, as well as the immediate one.

3.1.1.2 Status quo nutrient loss

Modelling of the status quo farm system in Overseer 6 estimated annual N losses of 6kg N/ha/year. Estimated annual P run-off of 3.1kg P/ha/year is high. Given phosphorus losses are generally associated with soil loss, the steep contour of the farm is contributing to Overseer's assessment of high to extreme risk associated with P loss from both fertiliser application and existing soil fertility.

Note that these nutrient losses included the impact of losses from areas of plantation forestry and conservation woodlots equivalent to 90% of the effective farm area. Excluding afforested areas, annual nitrogen & phosphorus losses from the pastoral area only would be approximately 8.8kg N/ha and 5.7kg P/ha respectively.

3.3.2. Mitigation scenarios

The following mitigation scenarios were considered for Farm B:

3.3.2.1 Use of DCD on all winter crops (B1)

While the use of DCD across a whole farm system has a low level of efficacy, particularly when used on a system with low pre-existing levels of nitrogen leaching, its use on N loss "hot spots", such as winter crops, is likely to be more efficient. Shepherd *et al.* (2012) reported that the use of DCD applied within two days of grazing and then again six weeks after grazing at a rate of 12kg DCD/ha resulted in reduction of measured nitrate loss in drainage of 20-27%. Assuming the lowest reported reduction of 20%, using DCD on crops at Farm A in this manner might reduce N leaching from these areas an average of 84kg N/ha to 67kg N/ha[13]. The estimated costs of the application are $97/ha, based on application by farm staff ahead of the grazing animals and a contracted application after grazing has been completed. Note that the use of DCD specifically to crop areas is not currently available mitigation in Overseer 6

The implementation of this mitigations on Farm B resulted in a reduction in whole farm average annual N losses of 0.1kg N/ha, and a reduction in whole farm EBIT by 8% to $10/ha. The extremely low proportion of cropping relative to the size of the property accounts for the low efficacy of this mitigation.

3.3.2.2 Afforestation of worst 8% of farm (B2)

An area of nominally lower producing hill country has already been set aside by the owners for afforestation. This area, currently 8% of the effective area, has been estimated (through the baseline modelling process) to have annual growth potential of 3.5t DM/ha. Its removal from the available grazing area would necessitate a reduction in capital stock numbers.

As a result of the proposed afforestation, overall stock numbers are forecast to need to drop by 6% (cf. an 8% reduction in land area).

Including the assumed $150/ha income based on an assumed forestry right for the 8% of farm area afforested, annual EBIT is essentially unchanged from the status quo

[13] On the basis that the majority of N leaching occurs during and after crop defoliation.

situation, but nutrient losses are calculated to fall by 0.5kg N/ha over the original area – this is equivalent to an increase in whole farm EBIT of $2.66/kg N loss reduction achieved.

With the proposed afforestation, average farm P losses are expected to fall by 1.3kg P/ha/year over the original effective area.

3.3.2.3 Reduction in breeding cow numbers, replacement by steers (B3)

The hard steep hill country makes the use of breeding cows an essential component of the farming operation at Farm B. Farmax analysis undertaken by Smeaton (2008) has previously demonstrated the clear profitability advantage of the breeding cow over other classes of livestock to consume the low feed quality pasture that accumulates on browntop dominant hill country and convert it into saleable product. This analysis excluded the accepted additional benefit that the grazing of rough pasture by breeding cows or older cattle has improving the feed quality of the resultant regrowth for priority classes of stock, such as lambs.

Reducing the number of breeding cows is likely to have a positive impact on overall N losses, due to the higher N signature from mature breeding cows relative to all other classes of livestock.

The nature of Farm B requires that these cattle be replaced with an appropriate stock class to carry out the same pasture "clean-up" function, but with a lower contributory effect on nitrogen losses. The most immediately suitable class of stock would be rising two-year-old steers, albeit only capable of modest growth rates due to the poor quality of feed they would be consuming.

Reducing the breeding herd by 17% and utilising the resulting feed demand with two-year-old steers purchased in July at 365kg and sold in the late autumn at 485kg (accepting low levels of growth), is forecast to slightly lower annual N losses from the status quo situation (0.1kg N/ha/year) but at a significant reduction in whole farm EBIT by $14/ha.

Table 6: Summary of Case Study B mitigations

	Case Study B	**SQ**		**B1**		**B2**		**B3**	
		per SU	per ha	per SU	per ha	per SU	per ha	per SU	per ha
Profit	Total asset value	$1,426	$10,267	$1,426	$10,267	$1,501	$11,105	$1,418	$10,210
	Gross Farm Income (GFI)	$60	$430	$60	$430	$62	$419	$58	$418
	Farm Working Expenses (FWE)	$48	$346	$48	$347	$46	$333	$48	$346
	Total Operating Expenses (TOE)	$58	$420	$58	$421	$57	$407	$58	$420
	Total Operating Profit (EBIT)	$1	$11	**$1**	**$10**	**$2**	**$11**	**-$0.4**	**-$3**
	Change from SQ	-		**-7.8%**		**4%**		**-126%**	
	Change in EBIT/change in kg N loss			**-$5.71**		**$0.97**		**-$105.24**	
	ROA %	**0.1%**		**0.1%**		**0.0%**		**0.0%**	
Efficiency	Stocking rate (SU/ha)	7.2		7.2		7.4		7.2	
	Tonnes net pasture grown	4.1		4.1		4.1		4.0	
	kg net product per ha	116		116		120		117	
	kg LW wintered	442		442		455		410	
	kg DM/kg product	35.3		35.3		34.1		34.0	
Risk	Operating profit margin	2%		2%		3%		-1%	
	FWE/ %GFI	80%		81%		75%		83%	
Solvency	Capital released (required) [$/ha]	-		$0		$62		$57	
	Debt able to be serviced	$68		$63		$71		$0	
	Minimum equity %	99%		99%		99%		100%	
	Can system change be funded?	n/a		Yes		Yes		No	
Environmental	kg N leached/ha								
	efffective ha	9.0		8.8		8.5		8.9	
	change from SQ		-	-0.1		-0.5		-0.1	
	kg P runoff/ha								
	efffective ha	6.1		6.1		4.8		6.1	
	change from SQ			0		-1.3		0	

ROA % - return on assets EBIT – earnings before interest & tax LW – live weight DM – dry matter SU – stock unit

3.4. **Case Study C**

3.4.1. Farm description

Farm C is a medium sized sheep and cattle breeding and finishing unit. The business is a moderately intensive system which finishes its own progeny and also purchases additional stock for finishing. The farm winters approximately 5.1 beef stock units and 5.0 sheep stock units per effective hectare.

FARMAX Annual Report Demand for Case study C *Status quo*			
	Area		
	Grazing	Effective	Whole
Total Feed Eaten (tDM/ha)	8.16	7.76	7.76
Demand from Supplements (%)	4.9	4.9	4.9
Standardised Stocking Rate (SU/ha)	14.8	14.1	14.1
Live wt. Wintered (kg/ha)	815	775	775
Net Product (kg/ha)	343	326	326
Feed Conversion Efficiency	23.8	23.8	23.8
Sheep:Beef:Deer Ratio	53:47:0	53:47:0	53:47:0

Figure 8: Annual demand summary for Case study C

3.4.1.1 Contour

The effective area on the property comprises 19% flat/mowable contour, 17% easy hill, 49% moderate hill and 15% steep hill.

3.4.1.2 Soil

The soils on the property are comprised predominantly of Ngaroma sandy silt and Ngaroma hill soils. The Ngaroma sandy silt is a podzol soil formed as a result of the high annual rainfall, which is characterized by low natural fertility, low base saturation, and are strongly acid.

The property has moderate soil Olsen P levels averaging 20-40mg/L on the easy hill country and flats and 11-16mg/L on the moderate and steep hill country. Soil pH levels range from 5.2 to 6.1 over the property.

3.4.1.3 Climate

Rainfall on the property is estimated at 1800-2200mm per annum.

3.4.1.4 *Pasture and crops*

Pastures on the flat area of the property consist predominantly of ryegrass and white clover due to the cropping and re-grassing program. Pastures on the hill country are dominated by browntop. Due to the high rainfall, fertile soils and good management, pasture quality on the hill country is maintained at a high level throughout spring and summer.

The winter cropping policy consists of 2.7% of the effective area sown into a winter fodder crop and 2.7% into annual ryegrass. The fodder crop is used for wintering breeding cows while the autumn sown annual ryegrass is grazed with replacement heifer replacements and lambs through autumn and winter.

Cropping areas are rotated over the flat area of the farm and re-sown into permanent pasture in the following spring. Pugging can be an issue on this property due to the high rainfall and moderate drainage characteristics of the soil. Consequently the cropping areas are used to minimize the impact of pugging over the rest of the farm by concentrating larger cattle on the crop in times of heavy rain.

Whole farm potential pasture growth is estimated at 10.6t DM/ha/year, ranging from 13.8t DM/ha/year on the improved areas of the farm to 7t DM on the steeper hill areas

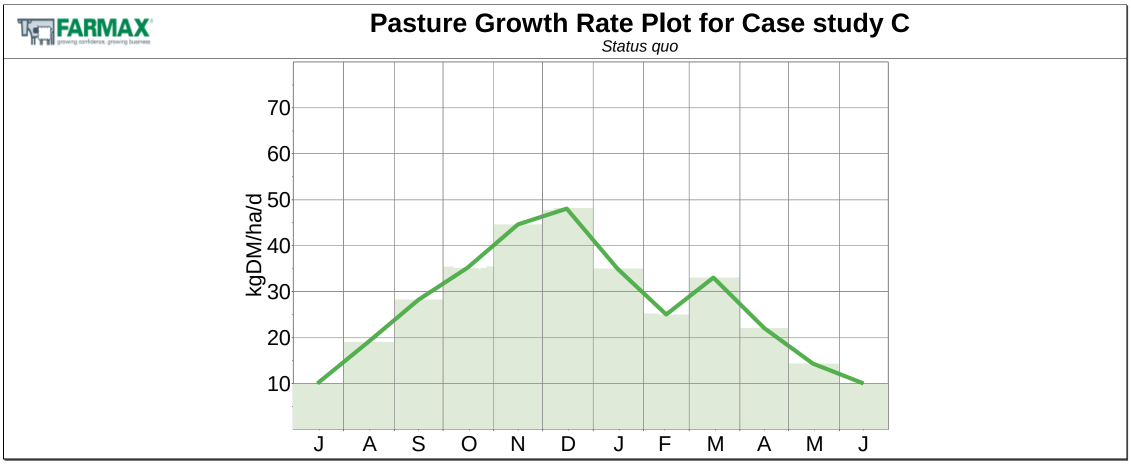

Figure 9: Pasture growth profile for Farm C

3.4.1.5 *Fertiliser*

Phosphate fertiliser applications are applied annually over the entire effective area of the property at an average of 18kg P/ha/year (including crop and silage fertiliser). Note that this is currently at a level below what is considered may be necessary to maintain the current levels of available soil phosphate.

An average of 20kg N/ha is used (restricted to the flats and easy hill country). Annual fertiliser is generally applied in the autumn.

3.4.1.6 Stock and production

(i) Sheep

Farm C operates a breeding and finishing system with its ewes. The breeding is predominantly Romney with a replacement rate of 35%. Replacement hoggets are not mated however the MA ewes achieve a lambing rate of 136%.

Lambs are weaned in mid-December with all non-replacement lambs sold as they reach a target live weight of 36kg from December through to May. Additional lambs (equivalent to c. 50% the number of lambs born each year on the property) are also purchased in at an average of 24kg live weight and finished to a target live weight of 36kg before May.

(ii) Cattle

The cattle policy is also a breeding and finishing system. Breeding cows are predominantly Angus, with a mating date of 20 December. Heifer replacements are mated as yearlings with an average empty rate of 10% over the breeding herd. All empties are culled before winter and there is a 91% calving rate on wintered numbers.

A number of weaner steers and heifers equivalent to 200% of home born progeny are purchased into the farm each year. All steer calves are grown through and sold as two-year olds at an average carcass weight of 329kg. Non-replacement heifer calves are sold for local trade consumption in their second autumn as yearlings at an average carcass weight of 222kg.

3.4.1.7 *Standardised economic performance*

Farm C is generating a status quo operating profit of $415/ha, or $29/SU. Farm working expenses are 55% of gross farm income and the business has operating profit margin of 38%. This is summarised in *Appendix 2* below.

3.4.1.8 *Constraints*

With a small percentage of mowable area (19%), larger cattle are required on-farm to maintain pasture quality on the hill country over summer. However due to the high rainfall, climate, and soils being moderately drained, this increases the risk of pugging. Cropping is used as a method of transferring feed into winter but also enables the farmer to manage the pugging risk by concentrating larger cattle classes on these crops over winter. These constraints make management changes difficult as altering stock numbers and/or classes will often have flow-on effects.

3.4.1.9 *Status quo nutrient loss*

Modelling of the status quo farm system in Overseer 6 estimated annual N losses of 15kg N/ha/year and annual P run-off of 5.3kg P/ha/year.

Note that these nutrient losses included the impact of losses from areas of plantation forestry and conservation woodlots equivalent to 20% of the effective farm area. Excluding afforested areas, annual nitrogen & phosphorus losses from the pastoral area only would be approximately 18.1kg N/ha and 6.4kg P/ha respectively.

It is also important to note that the dominance of a podzolised soil over much of the farm will result in higher assessments of P loss in Overseer than the non-podzolised pumice soils it is derived from. The combination of contour, soil type, annual P applications and existing levels of soil fertility result in very high levels of expected soil P losses.

3.4.2. Mitigations

The following mitigation scenarios were considered for Farm C:

3.4.2.1 *Elimination of N fertiliser to pasture and usage of DCD on all winter crops (C1)*

The use of nitrogenous fertiliser, even when applied in line with best management practices has a contributory impact on increasing nitrogen losses from the farm system. This occurs through both increasing the quantity of N cycling through the farm system and typically allowing higher stock intensities to be farmed, normally through the higher risk winter leaching period. The elimination of N in dairy systems might be managed through the importing of additional feed. However, in dry stock systems where the returns per kg DM eaten are typically lower than the cost per kg DM of imported feed, it is typically more profitable to lower feed demand (i.e. reduce stock numbers) than increase feed supply (i.e. purchase more feed).

While the use of DCD across a whole farm system has a low level of efficacy, particularly when used on a system with low pre-existing levels of nitrogen leaching, its use on N loss "hot spots", such as winter crops, is likely to be more efficient. Shepherd *et al.* (2012) reported that the use of DCD applied within two days of grazing and then again six weeks after grazing at a rate of 12kg DCD/ha resulted in reduction of measured nitrate loss in drainage of 20-27%. Assuming the lowest reported reduction of 20%, using DCD on crops at Farm C in this manner might reduce N leaching from these areas an average of 70kg N/ha to 56kg N/ha[14]. The estimated costs of the application are $97/ha, based on application by farm staff ahead of the grazing animals and a contracted application after grazing has been completed. Note that the use of DCD specifically to crop areas is not currently available mitigation in Overseer 6

The implementation of these mitigations on Farm C resulted in a reduction in whole farm average annual N losses of 1.7kg N/ha, and an increase in whole farm EBIT of 5% to $434/ha – suggesting that the existing nitrogen usage wasn't optimised. Given the high underlying levels of pasture growth on the property, the reduction in N usage hasn't resulted in a significant reduction in feed availability, but led to improved feed utilisation.

[14] On the basis that the majority of N leaching occurs during and after crop defoliation.

3.4.2.2 Swap heifers for steers (C2)

Farm C currently finishes all of its beef cow progeny in addition to purchasing in both additional steer and heifer calves. Given the higher N signature of female cattle relative to male cattle, moving to sell all female progeny store at weaning and purchasing exclusively male weaners was considered a possible approach to reduce nitrogen losses.

Building on the elimination of fertiliser N from the farm system, exclusively farming steers (instead of the current mixed sex policy) results in a reduction in EBIT of 12% from status quo to $365/ha, for a further reduction in N losses to 16kg N/ha/year. The reduction in EBIT appears to be derived from the opportunity cost of selling home-born female progeny, replacing them with more expensive male calves and then the relative reduction in efficiency of taking steers through their second winter, compared with selling heifers to local trade slaughter prior after 18 months of age.

P losses are unchanged from the status quo of 6.4kg P/ha/year.

3.4.2.3 Reduce ewe numbers and mate ewe hoggets (C3)

The high level of pasture production and good level of existing stock performance on Farm C makes this production system a good candidate for a reduction in ewe numbers but maintaining an identical amount of lamb production through the mating of ewe hoggets. The rationale for this suggested change is that a reduction in the overall number of ewes will deliver additional savings in N loss, without compromising income.

Such a policy change is considered moderately difficult to implement, given the additional requirements that mating ewe hoggets can impose on a production system. Not only do ewe hogget replacements need to have a higher feeding priority through until their second mating (as a two-tooth ewe) than would typically be afforded them, their lambs are often smaller as a result of a typically later mating date, which many properties struggle to extract a reasonable economic return from. Notwithstanding this, the benefits to the farm system from an increase in the overall lifetime performance of the ewe due to the improvement in her productivity are significant when implemented well, hence the suggested adoption of the policy here.

Combined with the mitigations in C2 above, this change will result in EBIT lifting back to $436/ha and whole farm N losses falling further to 15.4kg N/ha/year, a reduction of 2.7kg N/ha.

P losses are again unchanged from the status quo of 6.4kg P/ha/year.

Table 7: Summary of Case Study C mitigations

	Case Study C	SQ		C1		C2		C3	
		per SU	per ha	per SU	per ha	per SU	per ha	per SU	per ha
Profit	Total asset value	$797	$11,237	$796	$11,226	$819.01	$11,220	$797.93	$11,171
	Gross Farm Income (GFI)	$78	$1,098	$78	$1,094	$75	$1,052	$80	$1,122
	Farm Working Expenses (FWE)	$43	$609	$42	$586	$43	$613	$43	$612
	Total Operating Expenses (TOE)	$48	$683	$47	$660	$49	$687	$49	$686
	Total Operating Profit (EBIT)	**$29**	**$415**	**$31**	**$434**	**$26**	**$365**	**$31**	**$436**
	Change from SQ	**-**		**5%**		**-12%**		**5%**	
	Change in EBIT/change in kg N loss			**$11.31**		**-$25.08**		**$7.74**	
	ROA %	**3.7%**		**3.9%**		**3.3%**		**3.9%**	
Efficiency	Stocking rate (SU/ha)	14.1		14.1		13.7		14.0	
	Tonnes net pasture grown	7.9		7.8		7.6		7.9	
	kg net product per ha	326		326		306		321	
	kg LW wintered	775		775		781		779	
	kg DM/kg product	24.2		23.9		24.7		24.7	
Risk	Operating profit margin	38%		40%		35%		39%	
	FWE/ %GFI	55%		54%		58%		54%	
Solvency	Capital released (required)	-		$11		$16		$63	
	Debt able to be serviced	$2,646		$2,767		$2,325		$2,779	
	Minimum equity %	76%		75%		79%		75%	
	Can system change be funded?	n/a		Yes		Yes		Yes	
Environmental	kg N leached/ha								
	efffective ha	18.1		16.4		16.0		15.4	
	change from SQ		-	-1.7		-2.0		-2.7	
	kg P runoff/ha								
	efffective ha	6.4		6.4		6.4		6.4	
	change from SQ			0		0		0	

ROA % - return on assets   EBIT – earnings before interest & tax   LW – live weight   DM – dry matter   SU – stock unit

3.5. **Case Study D**

3.5.1. Description of operation

Farm D is a large scale sheep and cattle breeding unit located across the main Taupo-Ohakuri catchment and the Parariki & Pueto sub-catchments. The farm winters approximately 3.0 beef stock units and 5.2 sheep stock units per effective hectare (517kg live weight).

Annual Report Demand for Case study D
Status quo

	Area		
	Grazing	Effective	Whole
Total Feed Eaten (tDM/ha)	4.71	4.52	4.52
Demand from Supplements (%)	6.7	6.7	6.7
Standardised Stocking Rate (SU/ha)	8.6	8.2	8.2
Live wt. Wintered (kg/ha)	539	517	517
Net Product (kg/ha)	139	133	133
Feed Conversion Efficiency	34.0	34.0	34.0
Sheep:Beef:Deer Ratio	64:36:0	64:36:0	64:36:0

Figure 10: Annual demand summary for Case study D

3.5.1.1 Contour

The effective area on the property is of moderate contour comprising 37% flat/mowable contour, 15% rolling contour, 33% easy hill and 15% of steep hill.

3.5.1.2 Soil

The soils on the property are predominantly comprised of Taupo silty sand. The Taupo silty sand is a typical pumice soil, formed out of Taupo pumice overlaying older ash deposits. Like most pumice soils, it is low in natural fertility, tend to be well drained and subject to wind erosion when cultivated.

Olsen P levels range from 8mg/L on the poorest, least developed hills soils to >50mg/L on the flats that have been through a fertility improvement and pasture renewal program. pH ranges from 5.5-6.2.

3.5.1.3 *Climate*

Rainfall on the property has averaged 922mm per annum between 2009 and 2012.

3.5.1.4 *Pasture and crops*

Pastures on the flat area of the property consist predominantly of ryegrass and white clover due largely to the strict winter cropping program. The annual cropping policy consists of 4.4% of the flats sown into a winter fodder crop, 4.4% sown into annual ryegrass and 5.3% sown into a cash crop, currently potatoes. The fodder crop is used for wintering breeding cows while the autumn sown annual ryegrass is grazed with replacement heifers through autumn/winter.

Cropping areas are rotated over the flat area of the farm and are re-sown into permanent pasture in the following spring. Browntop pasture persistence requires full cultivation techniques to be implemented prior to each crop being sown. Pastures on the remainder of the property consist predominantly of browntop pasture. Whole farm potential pasture growth is estimated at 6t DM/ha/year, ranging from 7t DM/ha/year on the improved areas of the farm to 4.6t DM on the steeper hill areas.

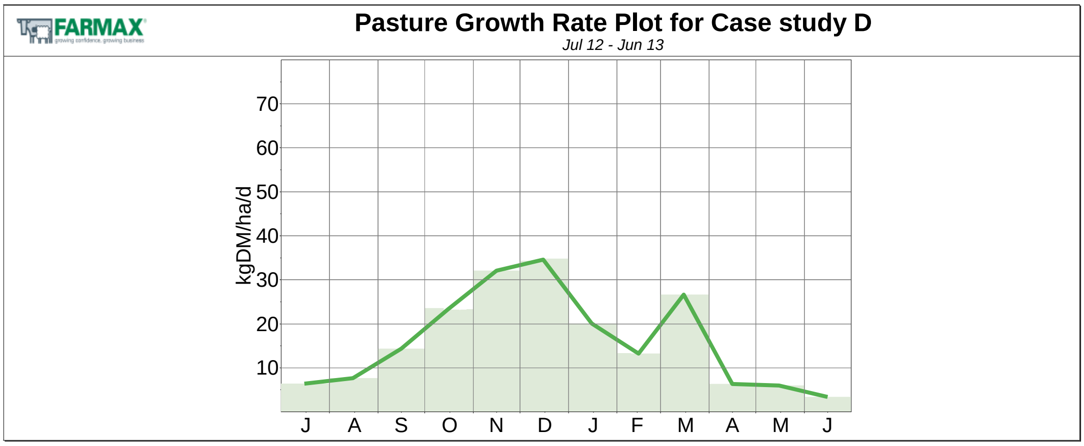

Figure 11: Pasture growth profile for Farm D

3.5.1.5 *Fertiliser*

Phosphate fertiliser at an average rate of 14kg P/ha is applied to the farm property in January each year. Note that this is currently at a level below what is considered may be necessary to maintain the current levels of available soil phosphate.

Nitrogen fertiliser usage outside of the cropping programs is limited to 15kg N/ha on the largely improved pastoral area on the flats.

3.5.1.6 *Stock and production*

(i) Sheep

The sheep policy is a strictly breeding system as the pastures and climate are not suitable for finishing lambs. The breeding is predominantly Romney with a replacement rate of 28%. Replacement ewe hoggets are not mated however the MA ewes achieve a lambing rate of 155%.

MA ewes go into the winter at an average weight of 68kg with the hoggets averaging 43kg. Lambs are weaned in mid-December with all wether lambs sold store at weaning. Ewe lambs are gradually sold store over December, January and February with only the replacement lambs left on farm by the 1st March.

(ii) Cattle

The cattle policy is also strictly breeding with all steer calves and non-replacement heifers sold at weaning in April. Heifer replacements are mated as yearlings with an average empty rate of 10% over the breeding herd. All empties are culled before winter and there is a 96% calving rate on wintered numbers.

Replacement heifers calves average 240kg, R2yr heifers average 400kg and the MA cows average 540kg at the beginning of winter.

3.5.1.7 *Standardised economic performance*

Farm D has been assessed as generating a status quo operating loss of $27/ha, or $3/SU – essentially a break-even financial result, given operational expenses could possibly be managed to ensure no loss was actually incurred. Note that this loss does include annual depreciation of $3/SU, which does allow for some on-going plant replacement and reinvestment in the business. Farm working expenses are 91% of gross farm income, the highest of all the case studies, and the business has operating profit margin of -5%. The large size of this property may also mean that some of the potential economies of scale (outside of labour) may not be captured in the standardised analysis. This is summarised in *Appendix 2* below.

3.5.1.8 Constraints

The main constraint on this property is the persistence of browntop (*Agrostis capillaris*) pasture and the ability to keep these pastures under control over the summer period. Low summer rainfall combined with the free draining pumice soils present on the property means soils dry out relatively fast over summer. Inadequate moisture increases the dry matter content of the pasture and further decreases pasture quality.

This pasture quality issue limits the business in terms of the sheep to cattle ratio (currently 64:36) it is able to run. Currently breeding cows are used to clean up the surplus, low quality pasture on the property. Breeding cows are preferable to other classes of stock as they can consume large quantities of this pasture with live weight gain not as crucial at this time of year as it would be if the property was trying to finish steers or bulls.

3.5.1.9 Status quo nutrient loss

Modelling of the status quo farm system in Overseer 6 estimated annual N losses of 7kg N/ha/year and 0.6kg P/ha/year.

3.5.2. Mitigation scenarios

The following mitigation scenarios were considered for Farm D:

3.5.2.1 Eliminate N and use of DCD on all winter crops (D1)

While the use of DCD across a whole farm system has a low level of efficacy, particularly when used on a system with low pre-existing levels of nitrogen leaching, its use on N loss "hot spots", such as winter crops, is likely to be more efficient. Shepherd *et al.* (2012) reported that the use of DCD applied within two days of grazing and then again six weeks after grazing at a rate of 12kg DCD/ha resulted in reduction of measured nitrate loss in drainage of 20-27%. Assuming the lowest reported reduction of 20%, using DCD on crops at Farm D in this manner might reduce N leaching from these areas an average of 41kg N/ha to 33kg N/ha[15]. The estimated costs of the application are $97/ha, based on application by farm staff ahead of the grazing animals and a contracted application after grazing has been completed. Note that the use of DCD specifically to crop areas is not currently available mitigation in Overseer 6.

The limited amounts of fertiliser N applied annually (17kg N/ha) were also eliminated from the farm, with a resultant slight reduction in stock numbers.

The implementation of this mitigations on Farm D resulted in a reduction in whole farm average annual N losses of 0.3kg N/ha, and a reduction in whole farm EBIT of 11%.

3.5.2.2 Afforestation of 8% of the worst areas of the farm (D2)

An area of nominally lower producing hill country has already been set aside by the owners for afforestation. This area has been estimated (through the baseline modelling process) to have annual growth potential of 4.5t DM/ha. Its removal from the available grazing area would necessitate a reduction in capital stock numbers.

In combination with the use of DCD on crop, removal of this area from the grazing platform would result in annual losses of N and P falling by 0.5 and 0.1kg/ha/year respectively.

[15] On the basis that the majority of N leaching occurs during and after crop defoliation.

Whole farm EBIT is forecast to be marginally lower than the status quo situation, with a loss of $29/ha (vs $27/ha). The impact of the afforestation is less profitable than in Case Study B above due to the higher level of pasture production on the afforested land and a higher level of "sticky" costs that have not been forecast to change as a result of the afforestation (such as wages, regrassing and silage production)

3.5.2.3 Reduction in breeding cow numbers, replacement by steers (D3)

The hard steep hill country makes the use of breeding cows an essential component of the farming operation at Farm D as it was with Farm B. Farmax analysis undertaken by Smeaton (2008) has previously demonstrated the clear profitability advantage of the breeding cow over other classes of livestock to consume the low feed quality pasture that accumulates on browntop dominant hill country and convert it into saleable product. This analysis excluded the accepted additional benefit that the grazing of rough pasture by breeding cows or older cattle has in improving the feed quality of the resultant regrowth for priority classes of stock, such as lambs.

Reducing the number of breeding cows was expected to have a positive impact on overall N losses, due to the higher N signature from mature breeding cows relative to all other classes of livestock.

The nature of Farm D requires that these cattle be replaced with an appropriate stock class to carry out the same pasture "clean-up" function, but with a lower contributory effect on nitrogen losses. The most immediately suitable class of stock would be rising two-year-old steers, albeit only capable of modest growth rates due to the poor quality feed they would be consuming.

Reducing the breeding herd by 20% and utilising the resulting feed demand with two-year-old steers purchased in July at 365kg and sold in the late autumn at 485kg, is, as with Farm B, forecast to significantly reduce EBIT by $19/ha, however with Farm D more significant reductions in N losses of 0.7kg N/ha are forecast to be achieved.

Table 8: Summary of Case Study D mitigations

	Case Study D	SQ		D1		D2		D3	
		per SU	per ha	per SU	per ha	per SU	per ha	per SU	per ha
Profit	Total asset value	$2,500	$20,504	$2,500	$20,504	$2,648	$22,247	$2,618	$20,423
	Gross Farm Income (GFI)	$64	$528	$64	$528	$67	$514	$66	$513
	Farm Working Expenses (FWE)	$59	$482	$59	$485	$57	$470	$59	$485
	Total Operating Expenses (TOE)	$68	$556	$68	$559	$66	$544	$68	$559
	Total Operating Profit (EBIT)	-$3	-$27	**-$4**	**-$30**	**-$4**	**-$29**	**-$6**	**-$46**
	Change from SQ	-		**11.7%**		**8%**		**67%**	
	Change in EBIT/change in kg N loss			**-$11.71**		**-$3.82**		**-$25.29**	
	ROA %	**-0.1%**		**-0.1%**		**-0.1%**		**-0.2%**	
Efficiency	Stocking rate (SU/ha)	8.2		8.2		8.4		7.8	
	Tonnes net pasture grown	4.6		4.6		4.6		4.26	
	kg net product per ha	133		133		136		128	
	kg LW wintered	517		517		532		477	
	kg DM/kg product	35.3		34.6		34.1		33.3	
Risk	Operating profit margin	-5%		-6%		-5%		-8%	
	FWE/ %GFI	91%		92%		86%		90%	
Solvency	Capital released (required)	-		$0		$68		$70	
	Debt able to be serviced	$0		$0		$0		$0	
	Minimum equity %	100%		100%		100%		100%	
	Can system change be funded?	n/a		No		No		No	
Environmental	kg N leached/ha								
	efffective ha	7.1		6.8		6.5		6.3	
	change from SQ		-	-0.3		-0.5		-0.7	
	kg P runoff/ha								
	efffective ha	0.6		0.6		0.5		0.6	
	change from SQ			0		-0.1		0	

ROA % - return on assets EBIT – earnings before interest & tax LW – live weight DM – dry matter SU – stock unit

3.6. **Case study E**

3.6.1. Description of operation

Farm E is a small run-off property located in the direct Taupo-Ohakuri catchment. It is operated solely as a dairy support property for an associated dairy operation. The property winters 12.3 SU/ha at an average live weight per hectare of 793kg/ha. The overall stock ratio is 100% cattle.

FARMAX — Annual Report Demand for Case study E (*Status quo*)	Area		
	Grazing	Effective	Whole
Total Feed Eaten (tDM/ha)	4.91	4.66	4.66
Demand from Supplements (%)	12.3	12.3	12.3
Standardised Stocking Rate (SU/ha)	8.9	8.5	8.5
Live wt. Wintered (kg/ha)	793	752	752
Net Product (kg/ha)	117	111	111
Feed Conversion Efficiency	42.0	42.0	42.0
Sheep:Beef:Deer Ratio	0:100:0	0:100:0	0:100:0

Figure 12: Annual demand summary for Case study E

3.6.1.1 Contour

The effective area on the property comprises 20% flat contour, 65% rolling contour and 15% of steep hill country.

3.6.1.2 Soil

The soils on the flat and rolling areas of the property are Atiamuri silty sand, while the steep hill areas are Oruanui hill soils. All are pumice soils soil, formed out of Taupo pumice overlaying older ash deposits. They are low in natural fertility, tend to be well drained and subject to wind erosion when cultivated.

The farm has generally low levels of soil Olsen P levels, averaging 12mg/L. Recent liming activity has lifted soil pH to 6.0 over most of the farm.

Soil P levels, when considered on a conventional basis, are well below those regarded as optimum for pumice soils (35-40mg/L)[16] which we believe would be important to achieve given the level of carrying capacity on the farm. We note that the current owners are using a non-conventional soil fertility regime on the pastoral areas of the

[16] Morton 1999

property, which targets other soil chemistry indicators compared to the conventional use of soil Olsen P.

3.6.1.3 Climate

Mean annual rainfall on the property is typically in the vicinity of 1,300-1,400mm of rain per annum.

3.6.1.4 Pasture and crops

As a relatively recent purchase by the owners, the property is currently being developed out of low quality pasture, dominated by browntop and Yorkshire fog into improved ryegrass and white clover pastures. Approximately 50% of the farm area has now undergone this development.

The farm currently sows 4% of the farm area into winter crop annually, predominantly kale. This is used for wintering dairy cows. Two cuts of silage are taken every year for feeding out over winter.

Whole farm potential pasture growth is estimated at 5.8t DM/ha/year, in line with its existing soil fertility status, ranging from 6.5t DM/ha/year on the improved areas of the farm to 4.6t DM on the steeper hill areas.

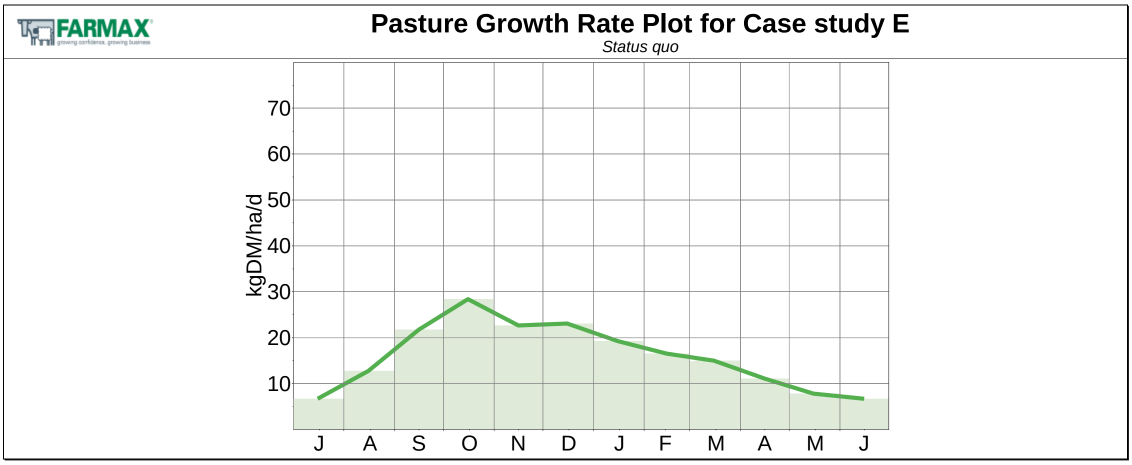

Figure 13: Pasture growth profile for Farm E

3.6.1.5 *Fertiliser*

As indicated above, a non-conventional fertiliser program ("Outgro") is being used on the pastoral area of the property. "Outgro soil revitaliser" (10N 0P 1K 2S)[17] is being applied at rate of 140kg/ha in September each year.

The cropped areas receive a conventional fertiliser application, while silage paddocks still receive 100kg/ha of urea after each cut.

3.6.1.6 *Stock and production*

(i) Cattle

The property is used exclusively for dairy support, carrying 0.6 Friesian cross heifers/ha from weaning (110kg live weight) through to 1 May the following year (398kg live weight). The farm also grazes carry-over cows at a rate of 1/ha. In addition, a further 0.4 cows/ha are wintered on the property for a period of eight weeks (1 June to 31 July).

3.6.1.7 *Standardised economic performance*

While the run-off is essentially operated as part of the larger dairy unit, on the basis of arm's length transactions between the two properties, Farm E is generating a status quo operating profit of $488/ha, or $57/SU. Farm working expenses are 50% of gross farm income and the business has operating profit margin of 43%. This equates to a return on capital of 4%. This is summarised in *Appendix 2* below.

3.6.1.8 *Constraints*

From a conventional viewpoint, the low underlying levels of available soil phosphate coupled with no significant phosphate fertiliser applications suggests that underlying productivity will be compromised at some stage into the future.

[17] This product also contains 19% Ca, 4% Si, 3% Mg, 3% Na plus other trace elements and components (gibberellic, fulvic, and humic acids). The actual nutrient composition of the fertiliser was able to be input into Overseer for nutrient loss modelling.

3.6.1.9 Status quo nutrient loss

Modelling of the status quo farm system in Overseer 6 estimated annual N losses of 12kg N/ha/year and annual P run-off of 1kg P/ha/year. These nutrient losses included the impact of retired bush areas equivalent to 11% of the effective area. Excluding these retired areas, nutrient losses from the effective pastoral area are 13.6kg N/ha/year and 1.2kg P/ha/year

3.6.2. Mitigations

The following mitigation scenarios were considered for Farm E:

3.6.2.1 Elimination of N fertiliser to pasture and usage of DCD on all winter crops (E1)

The use of nitrogenous fertiliser, even when applied in line with best management practices has a contributory impact on increasing nitrogen losses from the farm system. This occurs through both increasing the quantity of N cycling through the farm system and typically allowing higher stock intensities to be farmed, normally through the higher risk, winter leaching period. The elimination of N in dairy systems might be managed through the importing of additional feed. In dry stock systems where the returns per kg DM eaten are typically lower than the cost per kg DM of imported feed, it is typically more profitable to lower feed demand (i.e. reduce stock numbers) than increase feed supply (i.e. purchase more feed). However, in the case of Farm E, the integrated nature of the property within a wider dairy system make replacing the reduced pasture production with imported still a profitable action[18]. Accordingly, we have assumed the import of maize silage ($0.37/kg DM delivered to Farm E location) to buffer the reduced pasture growth in the absence of fertiliser N.

While the use of DCD across a whole farm system has a low level of efficacy, particularly when used on a system with low pre-existing levels of nitrogen leaching, its use on N loss "hot spots", such as winter crops, is likely to be more efficient. Shepherd *et al.* (2012) reported that the use of DCD applied within two days of grazing and then again six weeks after grazing at a rate of 12kg DCD/ha resulted in reduction of

[18] Removal of young stock from the milking platform effectively allows surplus feed to be converted into milk – a marginal return of $0.50/kg DM cf. the $0.19/kg DM cost of external contract grazing.

measured nitrate loss in drainage of 20-27%. Assuming the lowest reported reduction of 20%, using DCD on crops at Farm E in this manner might reduce N leaching from these areas an average of 52kg N/ha to 42kg N/ha[19]. The estimated costs of the application are $97/ha, based on application by farm staff ahead of the grazing animals and a contracted application after grazing has been completed. Note that the use of DCD specifically to crop areas is not currently available mitigation in Overseer 6, so a manual adjustment to the Overseer N loss estimates is required.

The implementation of these mitigations on Farm E resulted in a reduction in whole farm average annual N losses of 0.8kg N/ha/year, and a reduction in whole farm EBIT of 3.9% to $469/ha.

3.6.2.2 Elimination of crop for cow wintering (E2)

The use of a forage crop for wintering grazing dairy cows is utilised by Farm E both as a development tool for breaking up the old browntop thatch and to combat the low annual pasture growth potential of the property in its current stage of development.

The elimination of winter crop specifically for the dairy cow grazing would likely alter the stocking rates of the existing cattle policies and potentially result in a reduction in feed conversion efficiency of the operation. This would arise through reduced feed demand in the spring and summer periods resulting in the accumulation of surplus pasture which will rapidly decline in quality. It would also require a more expensive pasture renewal program ($1,200/ha cf. $610/ha) due to the cultivation and additional chemical applications required to eliminate the browntop in the absence of a cropping regime.

Removing the winter crop as a means of grazing the contracted dairy cows is forecast to result in some additional feed coming into the farm system – in this scenario the use of pasture silage has been assumed due to the lower utilisation expected from maize silage during winter.

Overall, this mitigation is expected to result in a reduction in EBIT of 25% to $367/ha, with accompanying reductions in annual N & P losses of 1.1 and 0.1kg/ha/year respectively when compared to the existing status quo situation.

[19] On the basis that the majority of N leaching occurs during and after crop defoliation.

3.6.2.3 *Creation of a wintering facility (E3)*

It is well established that the wintering of mature cows has a significant impact on the annual N losses from a property. Given the importance of ensuring that at least some dairy cattle are kept off the milking platform during winter, the wintering of adult dairy cattle on purpose-built facility where urine deposits can be captured and applied to the pasture at optimal times is a recognised mitigation tool.

Given that any such wintering facility at Farm E is only to be used for a short period of the year (whereas similar infrastructure on a dairy platform often has additional utility) the construction of an uncovered stand-off pad with adjoining feed lanes has been modelled. This will allow the continuous "housing" of cows for up to 24 hours per day for extended periods. Effluent is captured via a lined base filled with drainage metal over nova-flo, on top of which an absorbent material high in carbon content, such as bark, sits. The bark in the stand-off absorbs much of the effluent but any leaching is contained and drained out into an effluent pond that will require construction. The top 300mm of bark is replaced annually and can be spread over paddocks that are to be cultivated. Feeding is facilitated through the use of adjacent concrete feed lanes, where feed can be deposited for consumption by the cows whilst they remain on the pad. The price estimate for an uncovered covered bark stand-off pad, feed lanes and associated effluent system is estimated at $850/cow for Farm E. The basic specifications of this are presented in *Appendix 3*. We recognise that it may be possible that such a facility could be constructed cheaper than this depending on the availability of materials and exact design specifications.

Annual maintenance costs for the facility come to $72/ha[20] associated with the need for annual renewal of the top bark layer, removal and application of effluent in the effluent pond.

The development of such a facility on Farm E would be associated with the cessation of the winter feed crop, but require the importation of additional feed to complement the grass silage harvested from the farm. Grass silage has again been assumed as the imported feed source. It has been assumed that the mixed aged cows wintered on the facility will require up to half their diet from pasture grazed in situ, sourced from grazing up to 8 hours per day during the 8 week wintering period.

The implementation of these mitigations on Farm E resulted in a reduction in whole farm average annual N losses of 2.3kg N/ha, and a reduction in whole farm EBIT to

[20] Based on Farm E's effective area.

$375/ha. No further reductions in P loss are forecast over and above those resulting from the elimination of the winter crop.

Table 9: Summary of Case Study E mitigations

	Case Study E	SQ		E1		E2		E3	
		per SU	per ha	per SU	per ha	per SU	per ha	per SU	per ha
Profit	Total asset value	$1,440	$12,238	$1,440	$12,238	$1,440	$12,238	$1,586	$13,484
	Gross Farm Income (GFI)	$132	$1,125	$132	$1,125	$132	$1,125	$132	$1,125
	Farm Working Expenses (FWE)	$66	$564	$69	$583	$81	$685	$80	$676
	Total Operating Expenses (TOE)	$75	$638	$77	$657	$89	$759	$88	$750
	Total Operating Profit (EBIT)	$57	$488	**$55**	**$469**	**$43**	**$367**	**$44**	**$375**
	Change from SQ	-		**-3.9%**		**-25%**		**-23%**	
	Change in EBIT/change in kg N loss			**-$25.03**		**-$113.59**		**-$48.18**	
	ROA %	**4.0%**		**3.8%**		**3.0%**		**2.8%**	
Efficiency	Stocking rate (SU/ha)	8.5		8.5		8.5		8.5	
	Tonnes net pasture grown	4.6		4.6		4.7		4.7	
	kg net product per ha	111		111		111		111	
	kg LW wintered	752		752		752		752	
	kg DM/kg product	41		41.4		42.1		42.3	
Risk	Operating profit margin	43%		42%		33%		33%	
	FWE/ %GFI	50%		52%		61%		60%	
Solvency	Capital released (required)	-		$0		$0		-$1,246	
	Debt able to be serviced	$3,110		$2,989		$2,339		$2,391	
	Minimum equity %	75%		76%		81%		82%	
	Can system change be funded?	n/a		Yes		Yes		Yes	
Environmental	kg N leached/ha								
	efffective ha	13.6		12.8		12.5		11.3	
	change from SQ		-	-0.8		-1.1		-2.3	
	kg P runoff/ha								
	efffective ha	1.2		1.2		1.1		1.1	
	change from SQ			0.0		-0.1		-0.1	

ROA % - return on assets EBIT – earnings before interest & tax LW – live weight DM – dry matter SU – stock unit

3.7. **Case study F**

3.7.1. Description of operation

Farm F is a small, intensive sheep, beef and arable property located in the Little Waipa sub-catchment. The property has a high stocking rate of 18.4 SU/ha on area of the farm in permanent pasture, with an overall stocking rate of 12.4 SU/ha when the 33% of the farm in maize silage production is included.

Annual Report Demand for Case Study F

Status quo

	Area		
	Grazing	Effective	Whole
Total Feed Eaten (tDM/ha)	10.06	6.79	6.79
Demand from Supplements (%)	23.7	23.7	23.7
Standardised Stocking Rate (SU/ha)	18.3	12.4	12.4
Live wt. Wintered (kg/ha)	1386	935	935
Net Product (kg/ha)	387	261	261
Feed Conversion Efficiency	26.0	26.0	26.0
Sheep:Beef:Deer Ratio	33:67:0	33:67:0	33:67:0

Figure 14: Annual demand summary for Case study F

3.7.1.1 Contour

The effective area on the property comprises 100% rolling contour, with 33% of the farm mowable.

3.7.1.2 Soil

The soils on the property are predominantly formed out of Tirau ash. These allophanic soils have exceptionally high phosphate retention (cf. >80%), are well drained and have moderately levels of natural fertility, especially compared with more recent pumice soils.

Recent soil tests for the farm indicate existing soil fertility ranges between Olsen P levels of 16-25mg/L. Soil pH tends to range between 5.6 and 6.

3.7.1.3 *Climate*

The nominal annual rainfall on the property is in the vicinity of 1,500-1,600mm.

The property is prone to facial eczema over the summer period.

3.7.1.4 *Pasture and crops*

While the area used for maize silage is now fixed in one location, previous crop rotations resulted in larger areas of the farm developed into improved ryegrass white clover pasture. Brown-top is only found on those limited areas of the farm that aren't traversable by tractor.

Approximately 33% of the available effective area is conventionally cultivated each year and sown into maize for harvest as whole crop silage. Annual ryegrass is sown down post-harvest and used for cattle and lamb finishing over the winter period.

While annual pasture production potential on the rolling pastoral area been estimated at 9.8t DM/ha, if the better areas used for maize silage production were converted back to permanent pasture, the whole farm pasture growth potential is estimated at 10.5t DM/ha.

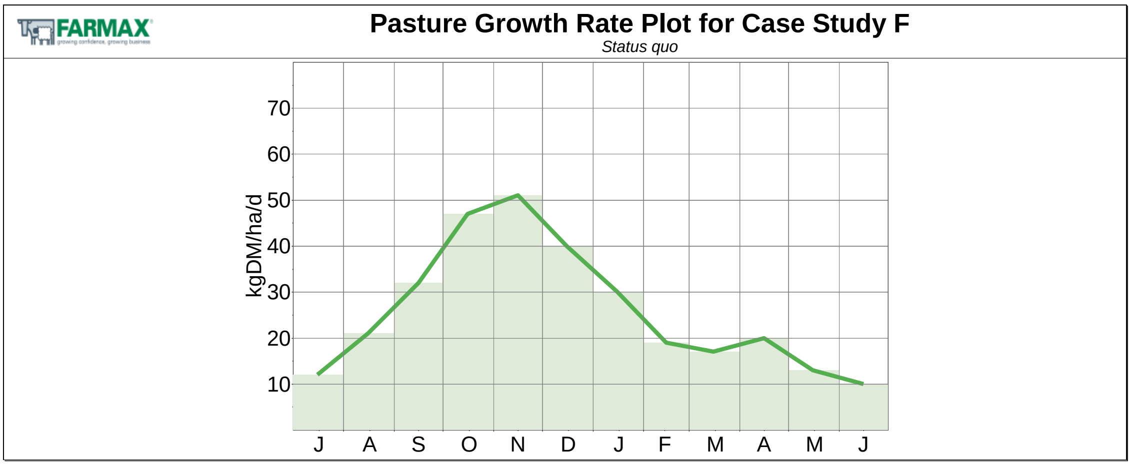

Figure 15: Pasture growth profile for Farm F

3.7.1.5 *Fertiliser*

The farm typically receives an annual dressing of 375k/ha of 30% potash sulphur super, delivering 21kg P/ha in a single aerial dressing in March. Nitrogen fertiliser use is restricted to the areas used to harvest silage.

3.7.1.6 *Stock and production*

(i) Sheep

Farm F operates a terminal ewe policy, with all ewes put to a facial eczema tolerant ram on March 18. The ewes are close to 70kg live weight at tupping. The farm operates with a single December main shear, with cull ewes sold at weaning and replacements purchased in January. The flock has a lambing percentage of 135%.

All home born lambs are finished progressively by the end of January at carcass weights of between 15-16kg. Additional lambs are then purchased in April, once the main risk of facial eczema has passed, and finished in the winter.

(ii) Cattle

Farm F exclusively operates a trading policy for the cattle. Rising two-year old steers are purchased at approximately 400kg live weight in the autumn and grown through until slaughter in December – February at an average 315kg cwt.

3.7.1.7 *Standardised economic performance*

Farm F is generating a status quo operating profit of $865/ha, or $70SU –in large part due to the profitability of the contract maize silage growing. However, this is equivalent to a 2.9% return on assets, due to the high market value of the land given its potential alternative land uses, primarily dairying. Farm working expenses are 58% of gross farm income and the business has operating profit margin of 39%. This is summarised in *Appendix 2* below.

3.7.1.8 Constraints

The risk of facial eczema has led to the adoption of a terminal ewe policy and restricts the business to significant lamb purchases in the autumn only.

3.7.1.9 Status quo nutrient loss

Modelling of the status quo farm system in Overseer 6 estimated annual N losses of 20kg N/ha/year – the highest of all the case study farms. Estimated annual P run-off is low at 0.4kg P/ha/year is high, largely because of the predominantly flat to rolling contour of the farm.

3.7.2. Mitigation scenarios

The following mitigation scenarios were considered for Farm F:

3.7.2.1 Reduce age class of cattle and increase sheep:cattle ratio (F1)

As an alternative to Farm F’s practice of purchasing yearling steers and finishing them for slaughter as two-year olds, the purchase of weaner steers in the autumn with subsequent store sale the following summer was evaluated. Given the lower N signature of sheep compared to cattle, the sheep policy was also increased in size due to (a) their greater assumed profitability and (b) to offset the accompanying reduction in profitability of the cattle policy associated with moving to younger animals and store sale.

These changes are forecast to reduce overall farm EBIT by 5.7% to $816/ha, primarily due to the increase in the sheep:cattle ratio to 66:34 from 35:65. The reduction in profitability could be eliminated by further increases in the numbers of sheep relative to bulls, but the facial eczema issue, risks associated with parasite burden in the sheep flock and greater labour requirements of sheep probably make further increases in sheep numbers prohibitive.

Annual N losses are expected to decline to 17.8kg N/ha/year – a reduction of 2.2kg N/ha. No change in P losses is forecast.

3.7.2.2 Reduce maize area and sell silage (F2)

With 33% of the farm area used for maize silage production with a higher nitrogen signature than the rest of the farm, partially reducing the area in this highly profitable activity and replacing it with the production of grass silage for harvest might reduce whole farm nutrient losses.

Reducing the maize silage area by 50% will require grass silage production and an increase in sheep numbers to manage the additional grass and offset the loss of maize income. Increasing the sheep to cattle ratio to 43:57 (retaining the older cattle) and exporting grass silage is expected to lower annual N losses by 0.8kg N/ha, but with a reduction in whole farm EBIT of 4%, down to $831/ha.

P losses were unchanged at 0.4kg P/ha/year.

3.7.2.3 Eliminate maize cropping (F3)

In a continuation from scenario F2 above, the complete elimination of maize silage production and replacing it with grass silage export and a low N signature livestock production finishing system (such as winter lamb finishing) was explored for Farm F.

This resulted in a more significant reduction in EBIT of 63% to $324/ha (not dissimilar to other non-cash cropping dry stock systems) but a larger reduction in N losses of 3.1kg N/ha/year to 16.9kg N/ha/year – a reduction of 16%.

P losses were unchanged at 0.4kg P/ha/year.

Table 10: Summary of Case Study F mitigations

	Case Study F	SQ		F1		F2		F3	
		per SU	per ha	per SU	per ha	per SU	per ha	per SU	per ha
Profit	Total asset value	$2,380	$29,515	$2,591	$29,273	$2,074	$29,870	$2,347.99	$29,585
	Gross Farm Income (GFI)	$206	$2,555	$236	$2,671	$152	$2,192	$115	$1,452
	Farm Working Expenses (FWE)	$130	$1,616	$144	$1,782	$104	$1,287	$85	$1,053
	Total Operating Expenses (TOE)	$136	$1,690	$150	$1,856	$110	$1,361	$91	$1,127
	Total Operating Profit (EBIT)	**$70**	**$865**	**$66**	**$816**	**$67**	**$831**	**$26**	**$324**
	Change from SQ	-		**-5.7%**		**-4%**		**-63%**	
	Change in EBIT/change in kg N loss			**-$22.56**		**-$43.41**		**-$176.39**	
	ROA %	**2.9%**		**2.8%**		**2.8%**		**1.1%**	
Efficiency	Stocking rate (SU/ha)	12.4		11.3		14.4		12.9	
	Tonnes net pasture grown	7.8		7.4		8.5		8.4	
	kg net product per ha	261		267		321		279	
	kg LW wintered	935		803		1089		953	
	kg DM/kg product	29.9		27.8		26.6		30.0	
Risk	Operating profit margin	34%		28%		44%		23%	
	FWE/ %GFI	63%		61%		68%		74%	
Solvency	Capital released (required)	-		$211		-$299		-$64	
	Debt able to be serviced	$5,514		$5,200		$5,301		$2,067	
	Minimum equity %	81%		82%		82%		93%	
	Can system change be funded?	n/a		Yes		Yes		Yes	
Environmental	kg N leached/ha								
	efffective ha	20		17.8		19.2		16.9	
	change from SQ		-	-2.2		-0.8		-3.1	
	kg P runoff/ha								
	efffective ha	0.4		0.4		0.4		0.4	
	change from SQ			0		0		0	

ROA % - return on assets EBIT – earnings before interest & tax LW – live weight DM – dry matter SU – stock unit

4. DISCUSSION

4.1. Case study analysis

4.1.1. When arithmetically averaged across all six case studies, there appears to be a broad trend in both the extent of N savings achieved and "farm-gate" impact on EBIT from implementation as the mitigations analysed for the case study farms increase in difficulty from easy through hard.

4.1.2. As can be seen in *Table 11: Summary of efficacy of mitigation scenarios* below, on average the "easy" mitigations achieved a 7% reduction in annual N loss at a cost of $9/kg N loss reduction. The moderate mitigations delivered 9% savings in N losses at a greater cost of $31/kg N, while the hard mitigations resulted in average reductions in annual loss of 11% at a cost of $33/kg N.

4.1.3. If we capitalise these annual impacts on farm EBIT (at 5%) we get a range of N cost from $181-$660/kg N)

Table 11: Summary of efficacy of mitigation scenarios

KPI	Easy	Moderate	Hard
Reduction in kg N leached/ha from SQ	7%	9%	11%
Change in EBIT/change in kg N loss	-$9.06	-$31.43	-$33.01
Reduction in kg P runoff/ha from SQ	0%	-7%	-1%

4.1.4. However, when all of the mitigations are considered for their efficacy as a whole, there is no correlation between the cost of a given mitigation scenario and the extent of the reduction in nitrogen loss that is achieved (see *Figure 16: Comparison of change in annual farm profit and extent of N loss reduction achieved across UWDNS case study farms* below).

4.1.5. When considered in their (albeit small) farm size groups, the range in variation between the efficacy of the mitigations modelled becomes more apparent.

4.1.6. *Table 12: Efficacy of mitigations when considered against farm size* below presents a breakdown of the mitigation scenarios for each of the farm size case studies.

4.1.7. The small farms (E & F), with the highest levels of operating profit of all the case studies, exhibited the overall (and perhaps expected) trend, with the impact of nutrient mitigations increasing with the nominal difficulty of implementation. The high gross margins achieved in these businesses, largely through their association with the dairy industry to some extent (heifer grazing, maize silage production) resulted in most changes having a negative impact on operating performance.

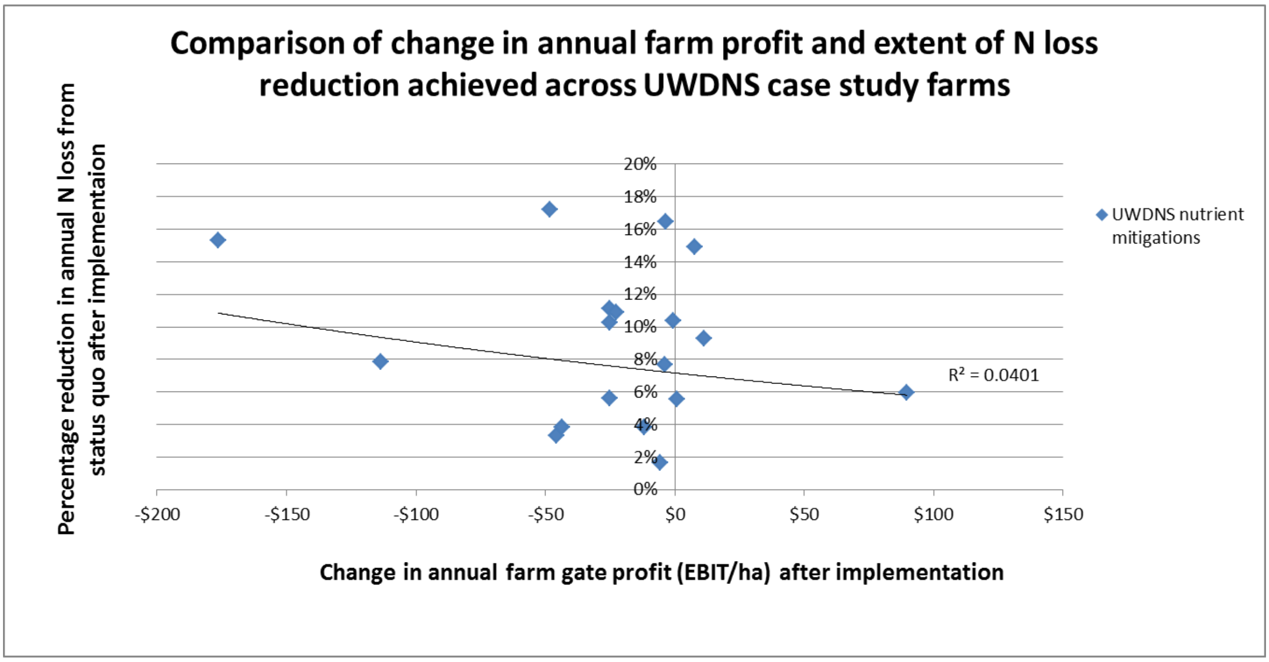

Figure 16: Comparison of change in annual farm profit and extent of N loss reduction achieved across UWDNS case study farms

Table 12: Efficacy of mitigations when considered against farm size

Farm size	Average SQ N loss (kg N/ha/year)	% reduction in N loss and associated change in annual farm-gate EBIT		
		Easy	Moderate	Hard
Small	16.8	8% -$24	6% -$79	16% -$112
Medium	15.9	10% $5	14% -$14	10% $49
Large	8.0	3% -$9	7% -$1	7% -$35

PERRIN AG CONSULTANTS

4.1.8. The medium sized farms were forecast to actually improve profitability through implementing the "easy" mitigation scenarios (largely through the removal of inefficient nitrogen usage), while moderately difficult mitigations were forecast to further reduce N losses, but with a negative impact on profitability – largely through the reduction in profitable operating policies associated with higher N loss signatures. The implementation of "hard" mitigations for both these farms involved system change with capital or management constraints to be dealt with. While on average no more N loss savings were achieved, significant increases profitability was forecast. Both were due to the expansion or adoption of highly profitable stock policies relative to their existing operations.

4.1.9. The large farms (B+D) had the lowest assessed levels of profitability, typically due to the fact that both were exclusively breeding properties, low levels of pasture growth and relatively high levels of cost associated with all livestock being capital in nature. Easy mitigations invariably resulted in low levels of N loss reduction due to the nature of the mitigations considered impacting a very low proportion of the business's total nutrient signature. Such mitigations had a negative impact on EBIT due to the imposition of cost on the operations with no improvement operating margins. The moderate mitigations considered for both large case studies was the afforestation of the steeper, poorer producing areas of the farm. This resulted in reductions in N losses more or less proportional to the associated reduction in stocking rate, while a reduction in P losses was closer to 20%, due to the fact that higher risk areas for P losses were removed. While the average economic impact of the afforestation (as modelled in this study) was close to zero, Farm B was assessed as likely to experience an increase in profitability, while Farm D was to experience a reduction in farm gate EBIT.

The hard mitigations assessed involved system change which resulted in the partial exchange of the existing livestock policy (breeding cows) for one with a lower profitability (low growth two-year old trading steers), with an accompanying reduction in annual EBIT. The difference in the efficacy of this mitigation across both farms is not easily explained, with Farm B experiencing very little change in N loss (net 2%), while Farm D modelling indicated a potential 7% reduction in assessed N losses.

4.1.10. Other than afforestation or the cessation of large scale winter cropping practice, none of the mitigations resulted in reductions in assessed levels of phosphate from the farm systems.

4.2. General findings

4.2.1. Depending on individual farm system, it would appear that the elimination of N fertiliser, the targeted use of DCD, altering livestock policies and afforestation provide the most efficacious suite of mitigations across the sample group.

Table 13: Summary of modelled UWDNS mitigations by type

Mitigation	Average[21] reduction in N loss	AverageError! ookmark not defined. impact on EBIT ($/kg N reduced)	*n*
Reduction in cash cropping	-4%	-$43.40	1
Elimination of N and/or targeted use of DCD	-6%	-$6.30	5
Afforestation (8% farm area)	-7%	-$1.40	2
Change to lower N livestock policies	-9%	-$3.50	6
Elimination of winter forage cropping for cows	-12%	-$58.60	2
Elimination of cash cropping	-15%	-$176.40	1
Wintering infrastructure	-17%	-$48.20	1

4.2.2. However, it is critical to recognise that the relative profitability of the sheep, cattle and deer enterprises have a significant impact on the likely profitability of using livestock system change to reduce nutrient losses. While increasing the sheep to cattle ratio tends to lower nitrogen losses, depending on their positions within their respective commodity cycles implementing such a change might not lead to an increase in profitability if the lamb price is low in comparison to the beef price. Changes in livestock policies, particularly where breeding stock are involved, often have significant lag periods before increases in profitability are achieved and are not easily reversed once implemented.

4.2.3. The cessation of fertiliser nitrogen usage, typically accompanied by a reduction in stocking rate, generally led to a reduction in system N losses with no reduction in EBIT.

[21] This is an arithmetic average i.e. not weighted for farm size

This was typically due to the marginal cost of the N fertiliser exceeding the return from the feed reduced – not uncommon in dry stock farming systems.

4.2.4. The use of DCD on crop (as assumed based on Shepherd *et al* 2012) did assist in delivering an overall reduction in whole farm N losses, but the extent of its efficacy largely relied on the extent of the winter cropping program. It did introduce a cost to the farm system that wasn't able to be recouped.

4.2.5. The increases in EBIT modelled on some of the farms associated with system change indicates that many of the case study farms could be optimised further in terms of policy mix, with an accompanying decrease in N loss.

4.2.6. While all of the mitigation scenarios selected resulted in a reduction in N losses, many had differing results from those anticipated. Of particular interest was the observation that introducing deer onto pumice farm land did not appear to result in an elevated risk of increasing P loss, nor was the assessed levels of N loss from maize silage cropping as significant as in earlier version of Overseer.

4.2.7. The observation that little P loss reduction accompanied the modelled system changes is not unexpected. Given that the differing mechanisms by which nitrogen and phosphorus enter the wider environment from farm systems, changes to farm systems that target N loss reduction are unlikely to impact on P losses unless a reduction in soil disturbance is an outcome.

4.2.8. While the cost-benefit of the mitigations had no clear relationships, the modelling clearly demonstrated the relationship between reducing stocking rate and lowering N losses beyond the farm gate. There was also an underlying trend that, for the most part, reduction in N losses will result in some negative impacts on underlying farm profitability.

4.3. Wider catchment considerations

4.3.1. While the mitigations modelled on the individual case studies can be implemented at an individual level, the reality is that expanding the mitigations into a catchment scale may have issues. These include:

(i) The complete replacement of heifers for meat production with steers would likely result in a significant change in the supply/demand relationship for male versus female cattle, with a significant negative impact on profitability. The option to source increased numbers of male progeny from the dairy industry may also not result in cattle suitable for existing farm production systems, particularly on harder hill country properties.

(ii) A change away from the grazing of dairy cows on crop over winter to either all pasture wintering or confinement would lead to an increase in the cost to the dairy industry of such wintering activity. Based on the three case study models where dairy cows were wintered, the modelled scenarios would require an increase in the assumed winter grazing rate of $22/cow/week to between $23 and $32/cow/week to offset the profitability impact on the farm systems[22]. Specialist dairy support properties are likely to incur a higher cost as a result of eliminating winter feed crops than mixed policy systems where less profitable livestock enterprises can be reduced in scale to offset the reduction in available winter feed.

(iii) While the elimination of maize silage production might result in a significant reduction in system N losses, the removal of maize silage production from the catchment would have significant impacts on the related dairy industry, which relies on this externally produced feed source to increase on farm productivity and profitability. The inclusion of low protein maize silage in the diets of dairy cows has also been shown to have a positive impact on reducing N losses from pastoral dairying activities, so reducing the availability of this feedstuff might have wider implications for whole-of-catchment nitrogen losses.

(iv) The apparent economic cost of partially converting farms from pastoral activity to forestry was relatively low. This is consistent with the apparent higher relative profitability of forestry on an EBIT/kg N leached basis under the assumptions used ($50/kg N loss) compared all of the case studies (although it was considered as a mitigation in only two case studies). In fact, if the NPV analysis was used to estimate the annualised per hectare value of forestry, rather than the forestry right approach taken, then under our assumptions conversion would have actually increased profit in a meaningful way. Given that afforestation was the only mitigation that resulted in meaningful reduction in phosphate losses as well and it has a likely positive economic impact on some areas of most properties, catchment nutrient mitigation strategy targeting afforestation warrants further investigation, but significant farmer education and land

[22] The implication of capital movements through reduction in stock numbers or investment in infrastructure has been excluded.

management planning would be needed to overcome expected farmer aversion and address the issues identified in 2.23.7 above.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. While it is impossible to capture all of the considerable combination of the suite of mitigations available to dry stock farmers to reduce their nutrient footprints, the UWDNS analysis has highlighted a number of key conclusions.

5.1.1. As with the earlier UWNES work, there is no singular "recipe" to both reduce N & P losses that at the same time optimises farm performance and profitability.

5.1.2. While a small sample size again makes definitive conclusions difficult to state, there appears to be clear opportunity for dry stock farms, on average, to achieve reductions in N losses of the order of 5-10% through changes in operating policies with limited reductions in farm gate profitability.

5.1.3. The system changes considered, while varying depending on the individual nature of the case studies, delivered reductions up to 17% of current (status quo) losses within the constraint of reasonable system variation. While greater reductions might have been possible, it would have required significant system or land use change to achieve this.

5.1.4. Approximately half of the livestock policy changes considered were achievable with a net improvement in farm-gate EBIT, suggesting that a degree of farm system optimisation, even before productivity improvements are considered, might be possible to offset the negative economic impact of other mitigation options, such as targeted DCD usage. However this will be to some extent dependent on the relative medium term price outlooks between various livestock enterprises.

5.1.5. Afforestation was the only mitigation to have a meaningful impact on both N & P losses. Combined with a higher average profitability per hectare than many parts of the case-study farms based on our forestry rental methodology, partial afforestation could be a powerful mitigation tool, assuming it is explained and managed correctly.

5.2. To appreciate the impact that whole catchment implementation might have, further work needs to be undertaken to both identify the range and distribution of farm system and land uses across the Upper Waikato catchment and then ensure that sufficient representative case studies are analysed. This could be followed up with GIS analysis to develop an appropriate methodology for extrapolating likely combination of mitigations across farm location and system types. The proposed combination of the existing UWNES data set with this one would certainly provide access to additional properties at little cost.

5.3. While the timing of this report made obtaining and reporting on participant farmer feedback to this analysis impractical, it will be important that the WRC and B+LNZ 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 easily such scenarios might be implemented in a real-world situation. This could be facilitated through a participant workshop.

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

(d) That the WRC and B+LNZ undertake a participant workshop following the submission of the final report.

(e) Utilising existing information and the feedback from farmer participants in both the UWNES and UWDNS projects, identify an appropriate suite of mitigations for extrapolation across the wider Upper Waikato catchment to assess the range of potential realistic results of wider scale adoption of nutrient loss mitigations in the target catchment.

(f) Given the apparent efficacy of afforestation as mitigation, particularly for both N & P, a separate piece of work is commissioned to more thoroughly investigate the implementation of this as a mitigation option. This would need to take into account the likely farmer push-back 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. Consideration on the social and wider environmental impacts of forestry should also be considered.

REFERENCES

AgFirst Waikato 2009. Upper Waikato Nutrient Efficiency Study. Final report to Environment Waikato. 104p.

Edmeades, D. *ed*. 2008: Fertiliser Costs: For Sheep & Beef Farmers pp 1-2 *In* The Fertiliser Review: Issue 21. Hamilton, AgKnowledge. 6p.

Gburek, W.J.; Sharpely, A.N.. 1998. Hyrdologhic controls on phosphorus loss from upland agricultural watersheds. Journal of Environmental Quality 27, 267-277.

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

McDowell, R.W.; Srinivasan, M.S. 2009. Identifying critical source areas for water quality: 2. Validating the approach for phosphorus and sediment losses in grazed headwater catchments. Journal of Hydrology 379, 68-80.

Morton, J.D.; Roberts, A.H.C. *ed*. 1999. Fertiliser Use on New Zealand Seep & Beef Farms. Auckland, New Zealand Fertiliser Manufacturers' Association. 36p.

Shepherd, M. Stafford, A. Smeaton, D. 2012. The use of a nitrification inhibitor (DCn™) to reduce nitrate leaching under a winter-grazed forage crop in the Central Plateau. Proceedings of the New Zealand Grasslands Association 74, 103-107.

APPENDICES

Appendix 1: Base economic assumptions

Appendix 2: Status quo operating performance of the six UWDNS case studies

Appendix 3: Wintering pad cost assumptions

Animal Health Costs for UWDNS

Status quo

Animal Health Costs (excl. Velveting)

Sheep	$ / hd / yr	Beef	$ / hd / yr	Deer	$ / hd / yr
Ewe Lamb	2.40	Heifer Calf	12.00	Hind Fawn	5.00
Ewe Hogget	2.40	1-Year Heifer	8.00	1-Year Hind	7.00
Ewe	3.65	2-Year Heifer	7.00	2-Year Hind	5.00
Ram Lamb	2.40	Cow	12.00	Hind	4.00
Ram Hogget	2.40	Bull Calf	18.00	Stag Fawn	5.00
Ram	5.00	1-Year Bull	8.00	1-Year Stag	7.00
Wether Lamb	2.40	2-Year Bull	7.00	2-Year Stag	5.00
Wether Hogget	2.40	Bull	20.00	3-Year Stag	5.00
Wether	2.00	Steer Calf	7.00	Stag	5.00
		1-Year Steer	8.00		
		2-Year Steer	7.00		
		Steer	7.00		

Wool Prices for UWDNS

Status quo

Wool Prices		
Crossbred Lamb	3.10	$ / kg Greasy
Crossbred Hogget	2.90	$ / kg Greasy
Crossbred Adult	2.70	$ / kg Greasy
Superfine Lamb	9.40	$ / kg Greasy
Superfine Hogget	9.40	$ / kg Greasy
Superfine Adult	8.45	$ / kg Greasy
Ultrafine Lamb	11.16	$ / kg Greasy
Ultrafine Hogget	11.16	$ / kg Greasy
Ultrafine Adult	9.55	$ / kg Greasy
Shearing Costs		
Lambs	3.00	$ / head
Hoggets	3.10	$ / head
Adults	3.30	$ / head
Crutching Costs		
Lambs	0.50	$ / head
Hoggets	0.50	$ / head
Adults	0.50	$ / head

Miscellaneous Prices for UWDNS

Status quo

Velvet Prices		
Spiker	40.00	$ / kg
2-year	60.00	$ / kg
Adult	80.00	$ / kg
Velveting Cost		
Velveting	15.00	$ / head
General Costs		
Nitrogen Fertiliser	2.17	$ / kg N
	1000	$ / t Urea
Regrassing	610	$ / ha
Interest Rate	8.8	%

Sheep Prices Prices / kg for UWDNS

Status quo

Prices / kg												
Works ($/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
15 kg PM Lamb	6.16	6.00	5.50	5.12	5.01	4.95	5.01	5.22	5.45	5.61	5.89	6.11
24 kg Sheep	2.96	2.76	2.53	2.35	2.25	2.33	2.50	2.46	2.72	2.80	2.94	3.11
Store ($/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
Ewe Lamb	2.59	2.52	2.25	2.15	2.15	2.13	2.15	2.25	2.29	2.41	2.59	2.75
Ewe Hogget	2.83	2.82	2.64	2.46	2.20	1.98	1.90	1.83	1.96	2.24	2.71	2.81
MA Ewe	2.22	2.22	2.04	1.43	1.40	1.39	1.40	1.46	1.58	1.68	2.06	2.14
Ram Lamb	2.77	2.64	2.37	2.30	2.25	2.23	2.25	2.35	2.40	2.52	2.77	2.87
Ram Hogget	4.25	4.38	4.29	2.51	2.50	2.57	2.85	3.03	3.21	3.37	3.65	3.85
MA Ram	7.45	7.25	7.59	8.34	8.51	8.61	8.91	8.36	8.17	7.80	7.77	7.57
Wether Lamb	2.71	2.58	2.37	2.25	2.20	2.18	2.20	2.30	2.34	2.47	2.71	2.81
Wether Hogget	2.34	2.22	2.04	1.94	2.05	2.03	2.00	2.19	2.34	2.52	2.59	2.44
MA Wether	1.97	2.04	1.76	1.59	1.80	1.83	1.85	1.67	1.74	1.80	1.82	1.71

Bull Beef Prices Prices / kg for UWDNS

Status quo

Prices / kg												
Works ($/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
295 kg M Bull	4.05	3.90	3.71	3.60	3.53	3.53	3.53	3.60	3.71	3.82	3.97	4.05
Store ($/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
R1 Bull	4.29	3.86	3.49	3.35	3.17	2.61	2.29	2.20	2.19	2.33	2.46	2.39
R2 Bull	2.27	2.11	2.04	1.91	1.83	1.80	1.80	1.76	1.78	1.99	2.19	2.19
MA Bull	2.27	2.14	2.04	1.91	1.83	1.80	1.80	1.76	1.78	1.99	2.23	2.19

Grazing costs (cows per month) for UWDNS

Status quo

Month	Grazing Fee ($/hd/week)	Month	Grazing Fee ($/hd/week)
Jan	8.00	Jul	22.00
Feb	8.00	Aug	22.00
Mar	8.00	Sep	22.00
Apr	8.00	Oct	8.00
May	22.00	Nov	8.00
Jun	22.00	Dec	8.00

Grazing costs (heifers) for UWDNS

Status quo

Age (months)	Grazing Fee ($/hd/week)	Age (months)	Grazing Fee ($/hd/week)
0 - 4	6.00	15	8.00
5	6.00	16	8.00
6	6.00	17	8.00
7	6.00	18	8.00
8	6.00	19	8.00
9	6.00	20	8.00
10	8.00	21	8.00
11	8.00	22	22.00
12	8.00	23	22.00
13	8.00	24 +	22.00
14	8.00		

Prime Beef Prices Prices / kg for UWDNS

Status quo

Prices / kg												
Works ($/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
295 kg M Steer	4.25	4.06	3.90	3.74	3.71	3.67	3.63	3.71	3.82	3.94	4.13	4.25
220 kg LT Heifer	4.21	3.97	3.78	3.71	3.63	3.59	3.55	3.67	3.67	3.82	4.18	4.25
230 kg M Cow	3.32	3.20	3.04	2.92	2.89	2.86	2.79	2.82	3.02	3.15	3.35	3.36
Store ($/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
R1 Heifer	2.47	2.35	2.26	2.17	2.15	2.16	2.03	2.00	2.03	2.13	2.27	2.30
R2 Heifer	2.30	2.27	2.22	2.10	2.00	1.91	1.81	1.78	1.83	1.93	2.03	2.08
MA Cow	1.70	1.74	1.64	1.50	1.59	1.50	1.67	1.63	1.68	1.69	1.65	1.66
R1 Steer	2.98	2.84	2.73	2.62	2.59	2.57	2.43	2.37	2.37	2.48	2.65	2.64
R2 Steer	2.51	2.31	2.26	2.13	2.11	2.05	1.99	1.93	1.95	2.05	2.23	2.30
MA Steer	2.42	2.23	2.14	2.06	2.04	2.02	1.96	1.93	1.95	2.05	2.23	2.30

Deer Prices Prices / kg for UWDNS

Status quo

Prices / kg												
Works ($/kg Cwt)	O	N	D	J	F	M	A	M	J	J	A	S
60 kg AP Stag	8.55	8.03	7.43	7.05	6.90	6.90	6.83	6.97	7.13	7.43	8.10	8.70
60 kg Hind	8.29	7.78	7.20	6.84	6.69	6.69	6.62	6.77	6.91	7.20	7.86	8.44
Store ($/kg Lwt)	O	N	D	J	F	M	A	M	J	J	A	S
R1 Hind	3.59	3.53	3.19	2.89	2.97	3.31	3.62	3.70	3.78	3.79	3.81	3.91
R2 Hind	5.90	5.54	4.08	3.74	3.52	3.45	3.62	3.70	3.78	4.08	4.86	5.65
MA Hind	5.90	5.54	3.86	3.67	2.90	2.97	3.41	4.19	4.42	4.75	5.26	5.74
R1 Stag	4.28	3.85	3.49	3.31	2.97	3.59	4.30	4.53	4.49	4.53	4.46	4.61
R2 Stag	5.13	4.82	4.46	4.23	4.14	4.14	3.96	4.05	4.13	4.16	4.62	5.05
MA Stag	6.58	5.86	5.79	4.72	4.28	4.35	4.91	5.58	5.84	6.01	5.75	7.22

Status quo operating budget

Case study A

Stocking rate (SU/ha)			11.7
Sheep: cattle : deer ratio			48:27:25
Labour efficiency (SU/FTE)			2,636
Total farm assets ($/effective ha)			$14,790
INCOME		/SU[1]	/ha
Net sheep revenue	$5.50 /kg lamb	$73.74	$414
Net cattle revenue (incl. lease fees)	$3.75 /kg prime bull	$70.63	$223
Net deer revenue	$7.50 /kg venison	$95.49	$279
Wool	$2.70 /kg greasy	$12.80	$72
Velvet	$40 /kg spiker velvet	$3.70	$11
Grazing revenue	$22 /cow/week	$31.47	$99
Other (cash crop lease etc)			
TOTAL INCOME (GFI)		**$93.91**	**$1,098**
EXPENSES		/SU[1]	/ha
Labour expenses			
Permanent wages (incl. superanuation)		$19.65	$230
Casual wages		$1.48	$17
ACC		$1.06	$12
Animal health			
Breeding		$0.45	$5
Cash crop expenses			
DCD usage		$0.00	$0
Electricity		$0.60	$7
Grazing expenses			
Feed expenses			
Grass silage/hay (incl. fert)	$599 /ha cut	$3.01	$35
Feed crops (incl fert)	$830 /ha cropped	$4.62	$54
Imported feed		$0.00	$0
Farm stores		$0.00	$0
Fertiliser & lime		$8.68	$101
Freight		$0.00	$0
Pasture urea	$1,000 /t applied	$1.27	$15
Regrassing (incl. fert)	$610 /ha	$2.72	$32
Repairs & Maintenance		$2.65	$31
Shearing		$6.12	$34
Velveting costs		$1.40	$4
Vehicle expenses		$2.57	$30
Weed & pest control		$0.94	$11
TOTAL FARM WORKING EXPENSES (FWE)		$55.86	$653
Overheads			
Accounting/secretarial charge		$0.51	$6
Communications		$0.26	$3
Direct consultancy/supervision		$0.26	$3
General administration		$0.77	$9
Insurance		$0.86	$10
Rates		$1.37	$16
TOTAL CASH OPERATING EXPENSES		**$59.88**	**$700**
TOTAL CASH OPERATING SURPLUS		**$34.03**	**$398**
less Depreciation based on IRD rates		$3.24	$38
OPERATING PROFIT (EBIT)		**$30.79**	**$360**
		/kg N loss	$33
Return on assets (ROA)			**2.4%**

Status quo operating budget

Case study B

Stocking rate (SU/ha)			7.2
Sheep: cattle : deer ratio			59:41:0
Labour efficiency (SU/FTE)			3,532
Total farm assets ($/effective ha)			$10,267
INCOME		/SU[1]	/ha
Net sheep revenue	$5.50 /kg lamb	$51.22	$218
Net cattle revenue	$4.00 /kg prime steer	$49.62	$146
Net deer revenue		$0.00	$0
Wool	$2.70 /kg greasy	$15.64	$66
Velvet		$0.00	$0
Grazing revenue		$0.00	$0
Other (cash crop lease etc)			
TOTAL INCOME		**$59.79**	**$430**
EXPENSES		/SU[1]	/ha
Labour expenses			
Permanent wages (incl. superanuation)		$13.32	$96
Casual wages		$1.48	$11
ACC		$1.06	$8
Animal health			
Breeding		$0.45	$3
Cash crop expenses			
DCD usage			
Electricity		$0.97	$7
Grazing expenses			
Feed expenses			
Grass silage/hay (incl. fert)	$599 /ha cut	$2.84	$20
Feed crops (incl fert)	$830 /ha cropped	$1.00	$7
Imported feed		$0.00	$0
Farm stores		$0.00	$0
Fertiliser & lime		$9.14	$66
Freight		$0.00	$0
Pasture urea	$1,000 /t applied	$0.00	$0
Regrassing (incl. fert)	$610 /ha	$0.73	$5
Repairs & Maintenance		$4.31	$31
Shearing		$7.09	$30
Velveting costs		$0.00	$0
Vehicle expenses		$4.17	$30
Weed & pest control		$1.53	$11
TOTAL FARM WORKING EXPENSES (FWE)		**$48.02**	**$346**
Overheads			
Accounting/secretarial charge		$0.83	$6
Communications		$0.42	$3
Direct consultancy/supervision		$0.42	$3
General administration		$1.25	$9
Insurance		$1.39	$10
Rates		$2.22	$16
TOTAL CASH OPERATING EXPENSES		**$54.55**	**$393**
TOTAL CASH OPERATING SURPLUS		**$5.24**	**$38**
less	Depreciation based on IRD rates	$3.75	$27
OPERATING PROFIT (EBIT)		**$1.49**	**$11**
		/kg N loss	$1
Return on assets (ROA)			**0.1%**

[1] Shearing, velveting and direct livestock revenues reported on a per relevant SU basis i.e. shearing expressed per sheep SU

Status quo operating budget

Case study C

Stocking rate (SU/ha)			14.1
Sheep: cattle : deer ratio			53:47:0
Labour efficiency (SU/FTE)			3,512
Total farm assets ($/effective ha)			$11,237
INCOME		/SU[1]	/ha
Net sheep revenue	$5.50 /kg lamb	$74.15	$554
Net cattle revenue	$3.75 /kg prime bull	$68.83	$456
Net deer revenue		$0.00	$0
Wool	$3.40 /kg greasy	$11.81	$88
Velvet		$0.00	$0
Grazing revenue		$0.00	$0
Other (cash crop lease etc)			
TOTAL INCOME		**$77.91**	**$1,098**
EXPENSES		/SU[1]	/ha
Labour expenses			
Permanent wages (incl. superanuation)		$14.32	$202
Casual wages		$1.48	$21
ACC		$1.06	$15
Animal health			
Breeding		$0.45	$6
Cash crop expenses			
DCD usage		$0.00	$0
Electricity		$0.50	$7
Grazing expenses			
Feed expenses			
Grass silage/hay (incl. fert)	$599 /ha cut	$0.91	$13
Feed crops (incl fert)	$830 /ha cropped	$3.15	$44
Imported feed		$0.00	$0
Farm stores		$0.00	$0
Fertiliser & lime		$7.29	$103
Freight		$0.00	$0
Pasture urea	$1,000 /t applied	$2.04	$29
Regrassing (incl. fert)	$610 /ha	$2.32	$33
Repairs & Maintenance		$2.20	$31
Shearing		$4.66	$35
Velveting costs		$0.00	$0
Vehicle expenses		$2.13	$30
Weed & pest control		$0.78	$11
TOTAL FARM WORKING EXPENSES (FWE)		**$43.22**	**$609**
Overheads			
Accounting/secretarial charge		$0.43	$6
Communications		$0.21	$3
Direct consultancy/supervision		$0.21	$3
General administration		$0.64	$9
Insurance		$0.71	$10
Rates		$1.13	$16
TOTAL CASH OPERATING EXPENSES		**$46.55**	**$656**
TOTAL CASH OPERATING SURPLUS		**$31.35**	**$442**
less Depreciation based on IRD rates	$27 /ha	$1.91	$27
OPERATING PROFIT (EBIT)		**$29.44**	**$415**
		/kg N loss	$24
Return on assets (ROA)			**3.7%**

[1] Shearing, velveting and direct livestock revenues reported on a per relevant SU basis i.e. shearing expressed per sheep SU

Status quo operating budget
Case study D

Stocking rate (SU/ha)			8.2
Sheep: cattle : deer ratio			64:36:0
Labour efficiency (SU/FTE)			3,333
Total farm assets ($/effective ha)			$20,504
INCOME		/SU[1]	/ha
Net sheep revenue	$5.50 /kg lamb	$52.18	$274
Net cattle revenue	$3.75 /kg prime bull	$53.15	$157
Net deer revenue		$0.00	$0
Wool	$3.40 /kg greasy	$15.62	$82
Velvet		$0.00	$0
Grazing revenue		$0.00	$0
Other (cash crop lease etc)			
TOTAL INCOME		**$64.44**	**$528**
EXPENSES		/SU[1]	/ha
Labour expenses			
Permanent wages (incl. superanuation)		$15.68	$129
Casual wages		$1.48	$12
ACC		$1.06	$9
Animal health			
Breeding		$0.45	$4
Cash crop expenses			
DCD usage			
Electricity		$0.85	$7
Grazing expenses			
Feed expenses			
Grass silage/hay (incl. fert)	$599 /ha cut	$5.59	$46
Feed crops (incl fert)	$830 /ha cropped	$3.32	$27
Imported feed		$0.00	$0
Farm stores		$0.00	$0
Fertiliser & lime		$9.08	$74
Freight		$0.00	$0
Pasture urea	$1,000 /t applied	$1.28	$10
Regrassing (incl. fert)	$610 /ha	$3.90	$32
Repairs & Maintenance		$3.78	$31
Shearing		$7.01	$37
Velveting costs		$0.00	$0
Vehicle expenses		$3.66	$30
Weed & pest control		$1.34	$11
TOTAL FARM WORKING EXPENSES (FWE)		**$58.74**	**$482**
Overheads			
Accounting/secretarial charge		$0.73	$6
Communications		$0.37	$3
Direct consultancy/supervision		$0.37	$3
General administration		$1.10	$9
Insurance		$1.22	$10
Rates		$1.95	$16
TOTAL CASH OPERATING EXPENSES		**$64.47**	**$529**
TOTAL CASH OPERATING SURPLUS		**-$0.03**	**$0**
less Depreciation based on IRD rates	$27 /ha	$3.29	$27
OPERATING PROFIT (EBIT)		**-$3.32**	**-$27**
		/kg N loss	-$4
Return on assets (ROA)			-0.1%

[1] Shearing, velveting and direct livestock revenues reported on a per relevant SU basis i.e. shearing expressed per sheep SU

Status quo operating budget
Case study E

Stocking rate (SU/ha)			8.5
Sheep: cattle : deer ratio			0:100:0
Labour efficiency (SU/FTE)			1,972
Total farm assets ($/effective ha)			$12,238
INCOME		/SU[1]	/ha
Net sheep revenue	$5.50 /kg lamb	$0.00	$0
Net cattle revenue	$3.75 /kg prime bull	$0.00	$0
Net deer revenue		$0.00	$0
Wool	$3.40 /kg greasy	$0.00	$0
Velvet		$0.00	$0
Grazing revenue		$132.40	$1,125
Other (cash crop lease etc)			
TOTAL INCOME		**$132.40**	**$1,125**
EXPENSES		/SU[1]	/ha
Labour expenses			
Permanent wages (incl. superanuation)		$18.56	$158
Casual wages		$1.48	$13
ACC		$1.06	$9
Animal health			
Breeding		$0.00	$0
Cash crop expenses		$0.00	$0
DCD usage			
Electricity		$0.82	$7
Grazing expenses		$0.00	$0
Feed expenses			
Grass silage/hay (incl. fert)	$599 /ha cut	$7.90	$67
Feed crops (incl fert)	$830 /ha cropped	$4.21	$36
Imported feed		$0.00	$0
Feed pad expenses		$0.00	$0
Fertiliser & lime		$16.83	$143
Freight		$0.00	$0
Pasture urea equivalent	$1,000 /t applied	$3.88	$33
Regrassing (incl. fert)	$610 /ha	$3.09	$26
Repairs & Maintenance		$3.65	$31
Shearing		$0.00	$0
Velveting costs		$0.00	$0
Vehicle expenses		$3.53	$30
Weed & pest control		$1.29	$11
TOTAL FARM WORKING EXPENSES (FWE)		**$66.30**	**$564**
Overheads			
Accounting/secretarial charge		$0.71	$6
Communications		$0.35	$3
Direct consultancy/supervision		$0.35	$3
General administration		$1.06	$9
Insurance		$1.18	$10
Rates		$1.88	$16
TOTAL CASH OPERATING EXPENSES		**$71.83**	**$611**
TOTAL CASH OPERATING SURPLUS		**$60.57**	**$515**
less Depreciation based on IRD rates	$27 /ha	$3.18	$27
OPERATING PROFIT (EBIT)		**$57.39**	**$488**
		/kg N loss	$36
Return on assets (ROA)			**4.0%**

[1] Shearing, velveting and direct livestock revenues reported on a per relevant SU basis i.e. shearing expressed per sheep SU

Status quo operating budget

Case study F

Stocking rate (SU/ha)				12.4
Sheep: cattle : deer ratio				33:67:0
Labour efficiency (SU/FTE)				1,984
Total farm assets ($/effective ha)				$29,515
INCOME			/SU[1]	/ha
Net sheep revenue	$5.50	/kg lamb	$116.79	$478
Net cattle revenue	$3.75	/kg prime bull	$61.14	$508
Net deer revenue			$0.00	$0
Wool	$2.70	/kg greasy	$10.24	$42
Velvet			$0.00	$0
Grazing revenue			$0.00	$0
Other (cash crop lease etc)				$1,528
TOTAL INCOME			**$206.07**	**$2,555**
EXPENSES			/SU[1]	/ha
Labour expenses				
Permanent wages (incl. superanuation)			$25.06	$311
Casual wages			$1.48	$18
ACC			$1.06	$13
Animal health				
Breeding			$0.45	$6
Cash crop expenses				
Electricity			$0.56	$7
Grazing expenses				
Feed expenses				
Grass silage/hay (incl. fert)	$599	/ha cut	$6.04	$75
Feed crops (incl fert)	$440	/ha cropped	$11.53	$143
Imported feed			$0.00	$0
Farm stores			$0.00	$0
Fertiliser & lime			$0.00	$0
Freight			$0.00	$0
Pasture urea	$1,000	/t applied	$1.45	$18
Regrassing (incl. fert)	$610	/ha	$0.00	$0
Repairs & Maintenance			$2.50	$31
Shearing			$1.97	$8
Velveting costs			$0.00	$0
Vehicle expenses			$2.42	$30
Weed & pest control			$0.89	$11
TOTAL FARM WORKING EXPENSES (FWE)			**$130.36**	**$1,616**
Overheads				
Accounting/secretarial charge			$0.48	$6
Communications			$0.24	$3
Direct consultancy/supervision			$0.24	$3
General administration			$0.73	$9
Insurance			$0.81	$10
Rates			$1.29	$16
TOTAL CASH OPERATING EXPENSES			**$134.15**	**$1,663**
TOTAL CASH OPERATING SURPLUS			**$71.92**	**$892**
less Depreciation based on IRD rates	$27	/ha	$2.18	$27
OPERATING PROFIT (EBIT)			**$69.74**	**$865**
			/kg N loss	$43
Return on assets (ROA)				**2.9%**

[1] Shearing, velveting and direct livestock revenues reported on a per relevant SU basis i.e. shearing expressed per sheep SU

Appendix 3: Example cost breakdown of uncovered 1,8720m^2 stand-off pad (incl. feed lanes)

Component									Cost
Lengths of block wall	345.9	m		@	$	22	/m constructed	$	7,637
Post & wire "railing"	345.9	m		@	$	38		$	13,241
Troughs	4	per pad		@	$	450	/trough installed	$	1,800
Effluent drainage culvert and sand trap								$	10,000
Lengths of novaflow	43.2	at	40	m @	$	399	/100m	$	6,902
Impermeable membrane (silage wrap)	6.5	sheets with	1	per width @	$	838	ea	$	5,475
Drainage metal (300mm deep)	561	cubic meters		@	$	54	/cubic m delivered	$	30,294
Post peelings (500mm deep)	935	cubic meters		@	$	17	/cubic m delivered	$	15,895
Concrete feed lanes (1200mm wide)	62	cubic meters		@	$	213	/cubic m laid	$	13,264
Sub-total								$	104,507
plus effuent pond								$	40,000
Total cost								$	144,507