The Impact of Management Changes on Discharges to Water and Emissions to Air

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Paper presented at the 2011 NZARES Conference

Tahuna Conference Centre – Nelson, New Zealand. August 25-26, 2011

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Summary

This is a summary of two projects that were designed to investigate the cost effectiveness associated with adoption of farm management practices designed to reduce discharges to water and greenhouse gas emissions. The first report had the purpose of expressing the results as the financial cost to the case study farm per kg of nutrient discharge reduction achieved, or per mm of water use saved (per year) i.e., the cost-effectiveness of the measures. This second extension of that work had the objectives to both; further scope the research context and parameters and refine and expand the modeling capability. The full range of 11 mitigation options were modeled over the 5 Dairy, 13 Sheep and Beef and 2 Deer Monitoring Models. The results in terms of Nitrogen discharges (kg N) were then incorporated into farm financial models to determine the impact of adoption of the management changes on farm financial performance. The results are reported as mitigation cost effectiveness of each option on each farm and as a reduction in the carbon cost to the farm.

Key Conclusions

- Many of the practices that have been reported as providing both positive financial returns and significant reductions in nitrogen discharges in the past are practices that are now considered as "standard practice" rather than "best practice" (advanced effluent treatment and disposal, nutrient budgeting, winter nitrogen application, split nitrogen application etc). Therefore their potential as a means to improve farm discharge performance is limited as they are incorporated into the base farm model as standard practice. The range of new mitigation or "easy" options available to farmers is reducing.

- Intensive farming systems have a wide range of potential options available to them whereas the more extensive systems have a much more limited choice. This reflects the fact that the low level of inputs in extensive systems (nitrogen, feed etc) are not able to be manipulated to any great effect. Therefore they are limited to farm system intensity change options.

- Although there is a wide level of performance across and between models it can generally be concluded that the most effective options are reducing N inputs, reducing system intensity (which includes reduced N application) and altering application or substitution for nitrogen.

- Where applicable, the use of nitrification inhibitors is moderately effective.

- Very few options gave positive financial returns with the majority of effective options having moderate to significant negative impacts on the farms financial performance.

- Some of the options financial performance depends on the relative cost of nitrogen and supplementary feeds.

- Variability of farm revenues can change the cost effectiveness of mitigation options considerably.

- The majority of greenhouse gas mitigation options entail the reduction of stocking rate and / or nitrogen use. These two items are the major contributor to greenhouse gas emissions. Therefore there is a dual impact of reduction of both discharges and emissions. The potential for a carbon charge would therefore result in a cost saving.

- However in most cases that cost saving is not sufficient to ameliorate the significance of the impacts on farm financial performance.

Key Words:
discharges, emissions. cost effectiveness.

Background

Project Goal

This is a MAF funded operational research project that contributes to development of policy decision making.

The program goal was to:

"Increase the usefulness for policy purposes of the existing research into the cost effectiveness associated with adoption of farm management practices designed to reduce discharges and include greenhouse gas emissions."

In 2006 MAF commissioned a report[1] to estimate the costs associated with adoption of farm management practices designed to reduce nutrient discharges to water and reduce water use; and the benefits in terms of reduced discharges or reduced water use. The

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[1] Ford et al, 2007. *Impact of Management Changes on Farm Profitability and Environmental Outcomes*. Unpublished report to MAF Policy.

results were expressed as the financial cost to the case study farm per kg of nutrient discharge reduction achieved, or per mm of water use saved (per year) i.e., the cost-effectiveness of the measures. This extension of that work had the objectives to both; further scoping research context and parameters and refine and expand the modelling capability.

The mitigation (or management) practices modelled are those that are able to be modelled in the (then) latest version (V 5.4.1) of OVERSEER. These include mitigation in the form of;

- effluent management system choice and operation,
- changing farming system intensity,
- manipulating farm inputs in the form of feed and fertiliser,
- reducing winter pasture loading of animals by grazing off farm or utilising wintering or feed pads,
- establishment of wetlands.

The modelling involved incorporating the 5 Dairy, 13 Sheep and Beef and 2 Deer MAF Farm Monitoring models into OVERSEER testing a group of 11 mitigation options that are able to be modelled in OVERSEER.

The results in terms of Nitrogen discharges (kg N) were then incorporated into farm financial models to determine the impact of adoption on farm financial performance. This is reported as:

- Gross Farm Revenue.
- Cash Farm Expenditure.
- Cash Farm Surplus
- Discretionary Cash Flow

The Canterbury Arable farm model methodology was different to the pastoral models. Crop and Food Research were able to run existing crop and soil models for a 10 year crop rotation over a series of 20 years climate data taken from Lincoln weather data. The results reported are the averages of crop yield information and discharges for the period modelled.

Horticultural models of a Kiwifruit Orchard and a Marlborough Vineyard were also tested with little reported in the way of discharges to be mitigated. This is mainly due to the fact that there is no animal transfer or concentration of urine and no methane emissions. The majority of discharges are as a result of fertiliser practice and the majority of emissions are from the use of machinery. It should be noted that vegetable growing operations have higher discharges as a result of higher fertiliser applications and higher emissions as a result of greater machinery use. The total of discharges and emissions are much lower than those modelled here and can be managed to a degree by good practice.

The results are reported here in detail for two individual case study farms to demonstrate the reporting capability of the model. The full report carries much more detailed analysis of the outcomes of the work.

First Stage Findings

The following bullet points are the key messages that came out of the first stage of this project.

- A method for assessing the economic and environmental implications of adoption of mitigation technologies and practices to reduce nutrient loss to water has been successfully developed and tested on case study farms from a cross-section of agricultural sectors. The same method was also applied to water efficiency enhancing technologies.
- Use of the method has the potential to allow more informed decision making by farmers and regulators when identifying practical and priority actions to take to address loss of nutrients to water from farm systems.
- All management interventions assessed have the potential to reduce nutrient losses off-farm.
- Results of the modelling carried out to date show that there is 'no one size fits all' solution. Solutions need to be tailored to the farming system and enterprise type.
- Few options are both effective at reducing nutrient losses and maintaining or improving farm profitability. This would indicate that Research needs to investigate and deliver solutions that are both cost effective and operationally efficient.
- The most effective options for reducing nutrient losses often involve significant capital investment. Opportunities to remove or reduce this barrier could change the attractiveness to the farm business significantly.
- Adoption of management practices or new technologies will depend on factors that are influencing farm profitability and therefore affordability at the time, such as commodity prices, as well as operational factors such as ease of implementation.
- Some of the management practices modelled have already been widely taken up by farmers and are being targeted by their industries for increased adoption.

The method provides an estimate of the cost to the farmer of the mitigation technologies. Use of the methodology to carry out a full cost-*benefit* analysis of an individual management practice would also require an evaluation of the off-farm costs and benefits of undertaking differing mitigation practices.

Methodology

The Farm Models

All of the MAFPolicy Farm Monitoring pastoral models have been incorporated into the modelling capability. They are listed in **Table 1**.

Table 1: Farm Models

Dairy Models	Northland
	Waikato / Bay of Plenty
	Taranaki
	Canterbury
	Southland
Sheep and Beef Models	Northland
	Waikato / Bay of Plenty Intensive
	Central North Island Hill
	Gisborne Hill
	Hawkes Bay Wairarapa Hill
	Lower North Island - East
	Lower North Island - West
	Canterbury Marlborough Breeding Finishing.
	Canterbury Marlborough Hill
	Otago Dry Hill
	Southland South Otago Hill
	Southland South Otago Intensive
	South Island High Country
Deer Models	North Island Deer
	South Island Deer
Arable	South Island Arable

All of the pastoral farm models were entered into OVERSEER using the descriptions in the 2007/08 farm monitoring report. These models were later aligned with OVERSEER models used by MAF to report nitrate leaching and green house gas emissions in the 2008 Pastoral Monitoring Report[2].

[2] MAF Policy 2008; Pastoral Monitoring Report 2008

Each of the farm models was run through OVERSEER to establish the base performance for the model. The mitigation options were each run as scenarios and the leaching and mitigation results compared with the base farm performance in order to determine their effectiveness. OVERSEER results that were collected included discharge and emissions result as well as variable parameters for stocking rate, production (milksolids), fertiliser application, supplementary feed made and purchased.

The Arable model data was created by Crop and Food Research.

Farm financial models were created based on the models used in the 2007/08 farm monitoring report so that the financial performance of the base model can be compared with that under the mitigation options.

The financial model is Excel based (described separately in the operating instructions for the financial model) has the capability to vary the key farm parameters (size, cow numbers and stocking rate),revenue and expenditure parameters as well as the key parameters around the costs and expenditure that will be involved in adopting and operating the mitigation options.

At the time of the modelling the three models (Crop and Food, financial and OVERSEER) were not able to be linked for data transfer. Therefore the results and parameter changes had to be transferred between the two models manually. A proposed new version of OVERSEER will have the capability to export results electronically to other programmes.

Nitrogen Mitigation Practices Modelled

The mitigation (or management) practices modelled in this report are those that are able to be modelled in the latest version (V 5.4.1) of OVERSEER. These include mitigation in the form of;

- effluent management system choice and operation,
- changing farming system intensity,
- manipulating farm inputs in the form of feed and fertiliser,
- reducing winter pasture loading of animals by grazing off farm or utilising wintering or feed pads,
- establishment of wetlands.

Effluent Management

The previous work indicated the potential for significant reduction in discharges as a result of effluent system choice and operation with a move towards best practice systems. A review of current practice across the models indicates that there is a high level of adoption of best practice and that the significant gains indicated by earlier modelling of moving from a poor quality system to best practice are one off and, in most cases, have been achieved.

Farming system intensity changes

Two scenarios changing the intensity of farming operations by reducing stocking rate have been modelled to test the impact on discharges and financial performance. These are described as ;

- **10% Stocking Rate Reduction (10SRR)** and
- **20% Stocking Rate Reduction (20SRR).**

On the dairy farms 10SRR change represents a reduction in farm intensity with external feed inputs and the use of nitrogen being reduced at a level indicated by the reduction in cow numbers.

The second level intensity change, 20SRR, represents a change in farming system to a system with no external feed provision (supplementary feed purchase or off farm grazing) and nil nitrogen use. This means that this system is completely self-supporting. The reduction in stocking rate is in the form of reduced cow numbers which are to some degree replaced by the return of the young stock that were previously grazed off the farm.

For the sheep and beef farm systems the system change was dependent on the intensity of the existing system. For the intensive finishing systems the 10SRR option involved reduction in nitrogen use and supplementary feed with the 20SRR involving a significant reduction or elimination of external inputs and supplementary feed along with a reduction in variable inputs in line with the stocking rate reduction. For the extensive and hill country models the 10SRR option eliminates all external and supplementary feed use and nitrogen use. The 20SRR option reduces variable inputs in relation to the reduction in stocking rate.

For the Dairy farm models the peak cows milked were reduced by 10% and 20% respectively while in the sheep and beef and deer livestock farms total stocking rate was reduced by 10 and 20 % across all livestock classes.

Alter Nitrogen Inputs

A range of mitigation practices are available that involve manipulation or substitution of nitrogen application. For each option, productivity changes are calculated by OVERSEER based on the average yearly response to applied N. This approach can tend to underestimate the impact or contribution of nitrogen to overall system productivity on farms where nitrogen use is strategic and is used to accelerate pasture growth to improve the seasonal feed profile. This strategic use can have a much greater impact on whole farm system by supporting productivity and stocking rates in a greater proportion to that achieved by average response rates. Therefore the productivity changes reported in the form of milksolids production and stocking rate may under represent the actual impact of nitrogen use.

- **No Nitrogen Fertiliser (NNF)**
  Models the farming system with no application of nitrogen fertiliser.

- **Replace Nitrogen with Supplements (RNS)**

  This option sets N fertiliser rates to zero and bring in a selected supplement onto the farm. The rate of supplement is calculated so that the metabolisable energy (ME) in the pasture grown due to N fertiliser (rate of N * average response to N * average ME in pasture) is equal to the amount of ME in the supplement brought in, assuming that 90% of the supplement brought on to the farm is actually utilised. Because ME in pasture and supplements is the same, it is assumed that there is no associated change in production. However, the annual yearly response to N when substituting supplements does effect the amount of supplements.

- **No Winter Nitrogen Application (NWN)**

  Winter Nitrogen rates are set to zero and total N applied is reduced by the amount applied in winter. If different types of N are applied then this is apportioned across the types. Analysis of model practice indicates that winter nitrogen application is not very wide spread and only seems to be a practice in the intensive northern faming systems where winter ground temperatures are conducive to economic responses from nitrogen application in the winter.

Alter Fertiliser Inputs

- **Apply Maintenance Fertiliser (AMF)**

  Applying Maintenance Fertiliser involves matching application of nutrients to the calculated property demand using Overseer to calculate demand. It is interesting to note that although over application of fertiliser on Dairy farms was relatively common until recently, on the other hand for some sheep and beef models maintenance fertiliser rates were greater than current practice. There has been a significant change in fertiliser application behaviour more recently[3]. This is as a result of the widespread use of OVERSEER nutrient budgeting to calculate the appropriate level and match application of maintenance fertiliser with the farms requirements. This has been aided by the use of a wider range of fertiliser types and mixes which are better able to match requirements with available product.

  The other trend is the increasing economic and financial imperative of managing input costs to reflect financial returns. As the cost of fertiliser has steadily increased and farming returns have remained relatively static the marginal return from each additional unit of fertiliser application has decreased to the point where over application comes at a cost to farm profitability.

- **Nitrification inhibitors (DCD)**

  DCD reduces the amount of nitrous oxide emissions and the amount of N leached. Extra pasture productivity or substitution of fertiliser N is estimated from the amount of N added as DCD and N saved from leaching and atmospheric loss. DCD is applied two times a year to limit the loss of N through leaching. One proprietary product can be incorporated into existing fertiliser applications while

[3] Jeff Moreton Balance Pers Comm

the other must be sprayed onto pasture in a liquid emulsion. Therefore application of the latter is limited to easily accessible country.

Recent developments in our knowledge of the efficacy and use of nitrification inhibitors has altered our use of them. They are now considered as more appropriate for use in areas with low autumn soil temperatures and where stocking rate is intensive enough for them to be used on paddocks where nitrogen deposition from urine is high[4]. This means that they are considered to be more appropriate for use south of the Waikato on dairy farms and intensive beef finishing systems only. Their efficacy and impact on increased pasture production improves the further South you go and the more intensive the farming system.

The other more recent development is related to cost in that it is recommended that for effective use nitrification inhibitors should be applied in two applications per year closely following animal grazing. At a cost of $100 / application[5] this means that they are relatively expensive at an annual cost of $200 /ha relative to no application at all. At a relatively low dairy payout it is unlikely that there will be sufficient positive impact on pasture production for this level of cost to be justified on pure financial grounds.

The use of DCD's on the intensive sheep and beef farming systems have been incorporated in this report although it is not recommended practice to apply them over the whole farm.

Alter winter management

The removal of animals from the paddocks, particularly in the high risk months May, June and July, can reduce the amount of N leached. Two options have been modeled:

- **Winter feed pad (WFP)**

  For the Dairy farms the full wintering pad option has been modeled which means that additional supplements are required to maintain the animals on the pad along with limited pasture grazing. This will result in an increase in production on the farm. This increase in production has the effect of increasing green house gas production. Effluent is collected and applied through the farm effluent system under optimum management and solids are spread across the farm.

  For the sheep, beef and deer models only the beef cattle and deer have been wintered on the feed pad in the at risk months but have been fully fed on pasture while on the pad therefore not requiring additional supplementary feed and there being no corresponding increase in productivity. This is effectively modeling a stand off pad operation.

  It should be noted that OVERSEER calculates an increased level of leaching of Nitrogen on the wintering pad options unless the pad is constructed and managed

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[4] Jeff Moreton Balance Pers Comm

[5] Ravensdown Fertiliser Price Guide (Feb 2009).

in such a way that the effluent and solids are collected and applied over the farm under optimum soil conditions. Therefore the modeling reported here is of a wintering pad that has such a collection, storage and application system therefore the construction and ongoing costs are relatively high.

- **Graze Off (GOF)**

  This option has been modeled in all the Dairy Models. The modeling assumes that there will be a small increase in production due to the extra feed not consumed over winter. This increase will be higher if the paddocks are hard grazed prior to the animals leaving. It should be noted that an increasing number of the models already have all or a large proportion of their livestock grazing off the farm in the winter as standard practice. This is particularly so for the southern models.

  It should be noted that grazing off as a mitigation option does not reduce total discharges or emissions that could be attributed to the farm; it effectively exports or transfers them to another location. Therefore the success of the technique is to reduce the total discharges or emissions that can be attributed to the land area of the farm it does not reduce the “footprint” of the farming operation. The practice would be considered effective in reducing the total footprint if the discharges or emissions at the grazing off location were lower than those that would occur at the source farm. This may eventuate if the grazing off was carried out in conditions that were sufficiently different to the source farm in order for to result in lower levels of discharges or emissions.

  The discharges reported here are for the model farms only and do not include the discharges from stock that are grazed off.

Wetlands (WET); are artificially constructed as a means of intercepting and removing nutrients and faecal bacteria from runoff before it enters surface water. The use of wetlands to reduce Nitrogen discharge was modelled for all models under the parameters of wetlands being established on 1% of the land area which intercepted between 30% and 50% of runoff from the total farm catchment according to the scale of the farm model.

Arable Model

The Arable model had two basic options tested.

Improved Arable Rotation; is the adoption of an arable farm crop rotation designed to reduce the loss of nutrients through the soil profile. This is primarily achieved through the establishment of feed crops during the traditional fallow periods between cereal crops in order to capture soil nitrogen in those crops.

Low / No Nitrogen input farming; has been modelled as farming systems without the introduction of any artificial Nitrogen in the form of fertiliser.

Green House Gas Mitigation Practices Modelled

OVERSEER offers three greenhouse gas mitigation options as follows:

- **Changing lime rates**

  Lime produces CO_2 as it dissolves. Reducing lime rates can reduce the amount of CO_2 emission. However this needs to be balanced against the need to change soil pH (capital lime applications) or to maintain soil acidity levels. In OVERSEER it is assumed that there is no change in production due to lime applications. Reducing N leaching losses or increased effluent disposal from a winter feed pad can reduce maintenance lime rates. Therefore maintenance lime is calculated to take account of these changes.

  As there is no evidence of excess lime application (see discussion on apply maintenance fertiliser). In fact the opposite is true as the application rates of lime in the MAF Farm models are below the recommended rates for Lime application. As the modeled impacts on GGH levels are minimal we have not reported this mitigation technique in this report.

- **Reduce energy use**

  Fuel and electricity contribute to CO_2 emissions, and are a significant energy cost on some farms. This mitigation option requires an estimate of reductions in energy use that can be achieved on a farm. Methods for doing this include measures such as insulation of milk vats, using heat pumps or solar power, good electric fence maintenance, good machinery maintenance, using energy efficiency irrigation procedures, etc. In the absence of firm information on the degree of impact available from these options to reduce the energy use on farm and the apparent minimal impact on the modeling results we have not reported these results here.

- **Change animal efficiency**

  One alternative for the future is to achieve a change in animal performance by changing the efficiency of animals.

  One method of reducing methane emissions from animals is to increase animal efficiency, i.e. to produce the same amount of product per ha from fewer animals. The reasoning behind this is that less metabolic energy is spent on maintenance of the animals. Therefore relative productivity can be increased.

  The modeling approach used in OVERSEER is to decrease animal numbers up to a maximum of 20% while not reducing productivity at all. The program assumes that the decrease in animal numbers is achievable, and that pasture quality and utilisation can be maintained with the reduced animal numbers. It also assumes that there are no changes in animal product output. OVERSEER will sometimes show a reduction in N leaching and N fixation due to a decrease in pasture production. This may suggest that decreasing animal numbers may have the potential to increase animal production. However the relationship between feed levels and animal performance is complex, and is beyond the scope of this version of the program.

We have reported this mitigation option as an option to reducing both leaching and emissions as a means of reporting a possible future option rather than suggesting that it is currently available to farmers.

The majority of emissions on New Zealand farms are from animals therefore any change in the intensity of farming operations that changes livestock numbers will have an impact on emissions. All the mitigation options reported in the nitrogen leaching modelling have some impact on stock numbers and therefore are also reported as mitigation techniques for Greenhouse Gas emissions. This means that the range of options that have an impact on N usage have also had an effect on emissions.

Results

The results as reported here are for two farms one dairy and one sheep and beef. Full results of all farm types across all relevant options are reported in the full report.

Northland Dairy Farm

Nitrogen Discharges

Table 2 : Summary of Northland Dairy Farm Mitigation Performance.

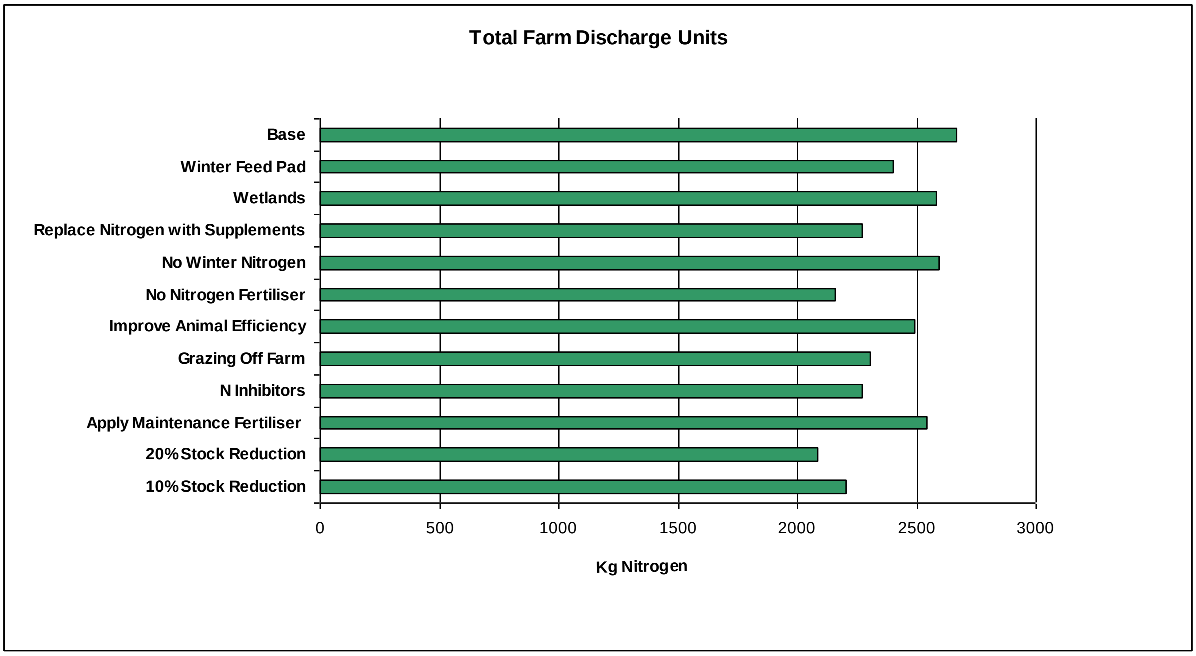
Mitigation Option	Total Units	Reduction from Base	Change in Cash Farm Surplus	Cost / Unit of Reduction Average	Cost / Unit of Reduction High	Cost / Unit of Reduction Low
10% Stock Reduction	2206	458	(28,634)	(63)	(75)	(50)
20% Stock Reduction	2082	582	(57,858)	(99)	(119)	(80)
Apply Maintenance Fertiliser	2542	122	(5,868)	(48)	(58)	(38)
N Inhibitors	2269	395	(24,200)	(61)	(74)	(49)
Grazing Off Farm	2303	361	(64,050)	(177)	(213)	(142)
Improve Animal Efficiency	2491	173	8,688	50	60	40
No Nitrogen Fertiliser	2161	503	(20,297)	(40)	(48)	(32)
No Winter Nitrogen	2594	70	-	-	-	-
Replace Nitrogen with Supplements	2273	391	4,034	10	12	8
Wetlands	2583	81	(8,019)	(99)	(119)	(79)
Winter Feed Pad	2403	261	(40,073)	(154)	(184)	(123)
Base	2664					

Cost / unit of reduction are expressed as High, Average and Low to reflect the sensitivity testing around financial performance. High is 20% higher than the average and low is 20% lower.

These results are presented in more detail in the following figures.

Discharge Reduction Effectiveness

Figure 1: Northland Dairy farm total discharges (kg N /yr)



The most effective mitigation options are the options that reduce stocking rate and or nitrogen use. Both of the two stocking rate options reduce and eliminate nitrogen use respectively. The next most effective group are those that mitigate Nitrogen's impact by the use of nitrification inhibitors and substituting other inputs for nitrogen. A number of the options have minimal effectiveness as the reduction levels are within the potential margins for error in the modelling technique.

This is demonstrated in the next table with the three options of stock reductions and no N fertiliser showing the greatest farm wide reduction in discharges. The next group entails the use of N inhibitors and replacement of nitrogen with supplements.

Figure 2: Northland Dairy farm total farm discharge reduction (kg N /yr)

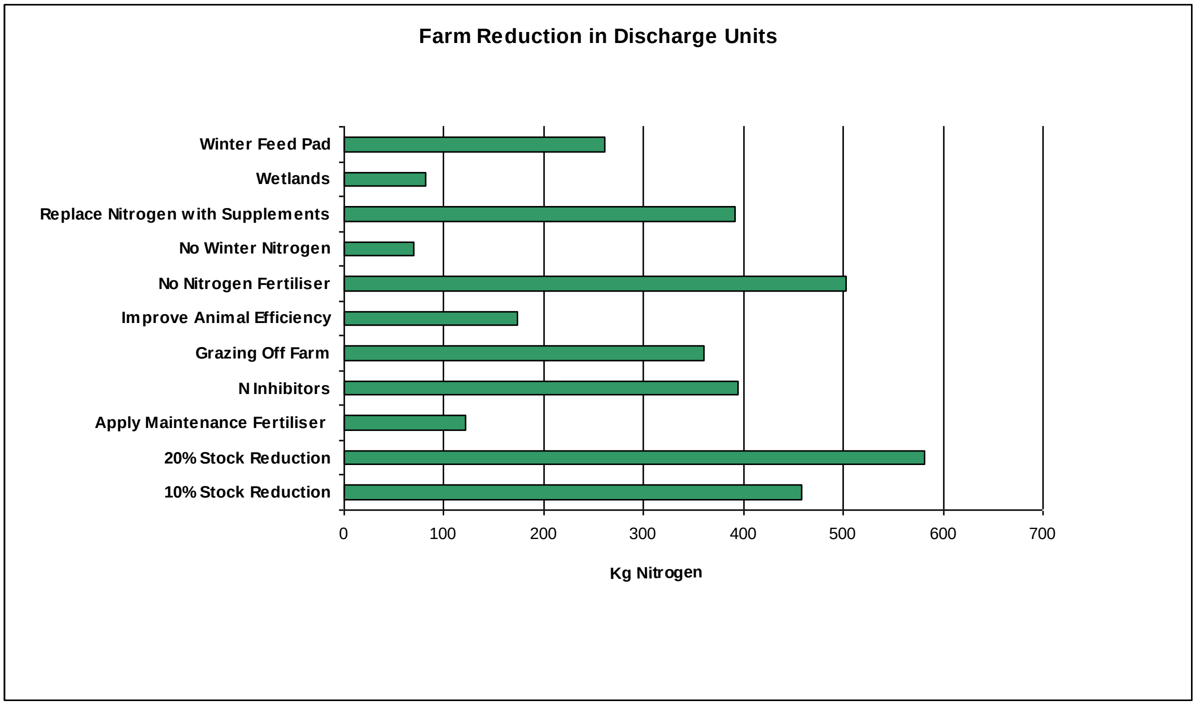
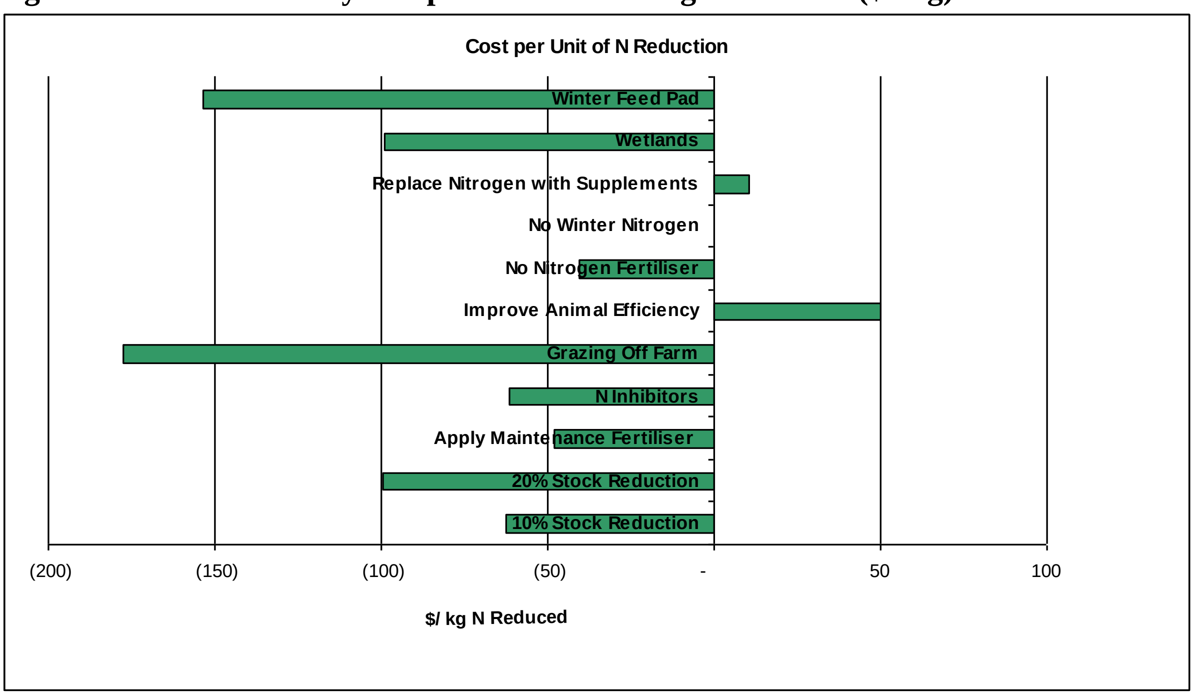


Figure 3: Northland Dairy cost per unit of discharge reduction ($ / kg)



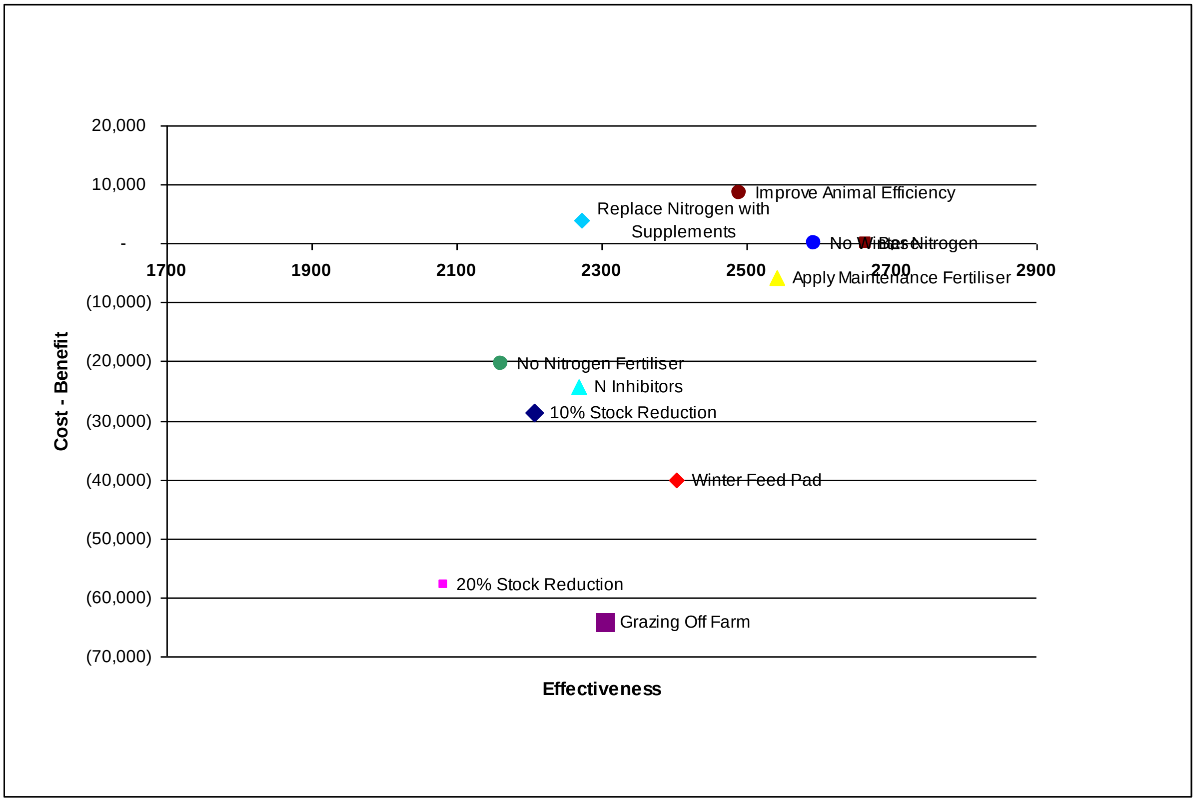
Two options show positive cost effectiveness. Improving animal efficiency is a theoretical option that is available through OVERSEER that is designed to offer improvements in productivity of animals with no increase in feed required. It is not practically available to farmers as a response mechanism. However the results suggest that this could be a positive option in the future and that there should be a concentration of research effort in this area.

The positive cost benefit from the replacement of nitrogen with supplements is driven by the relative cost of nitrogen fertiliser and purchased feed. At the time of modelling the cost of nitrogen fertiliser was at a historically high level and the economics of nitrogen use at average seasonal response rates as modelled by OVERSEER would mean that its use would compare unfavourably with supplementary feed. The relative position of this option would change as the cost of nitrogen fertiliser changed.

Options that require major capital expenditure (feed pads and wetlands) have very high costs per unit of reduction.

The following figure shows the two positive options above the zero impact line with a grouping of options with little impact on or below the line. Reduction of nitrogen fertiliser use, nitrification inhibitors and a 10% stock reduction all have similar cost effectiveness while winter feed pads, 20% stock reduction and grazing off farm all had very poor cost effectiveness.

Figure 4: Northland Dairy mitigation cost effectiveness.



In **Figure 4** the two axes are Cost – Benefit and effectiveness. The cost – benefit is expressed as the total cost or benefit to the farming system expressed as change in Cash

Farm Surplus from the base scenario. While the effectiveness measure is the total level of discharges from the farm expressed as the total Kilograms of Nitrogen.

Greenhouse Gas Emissions

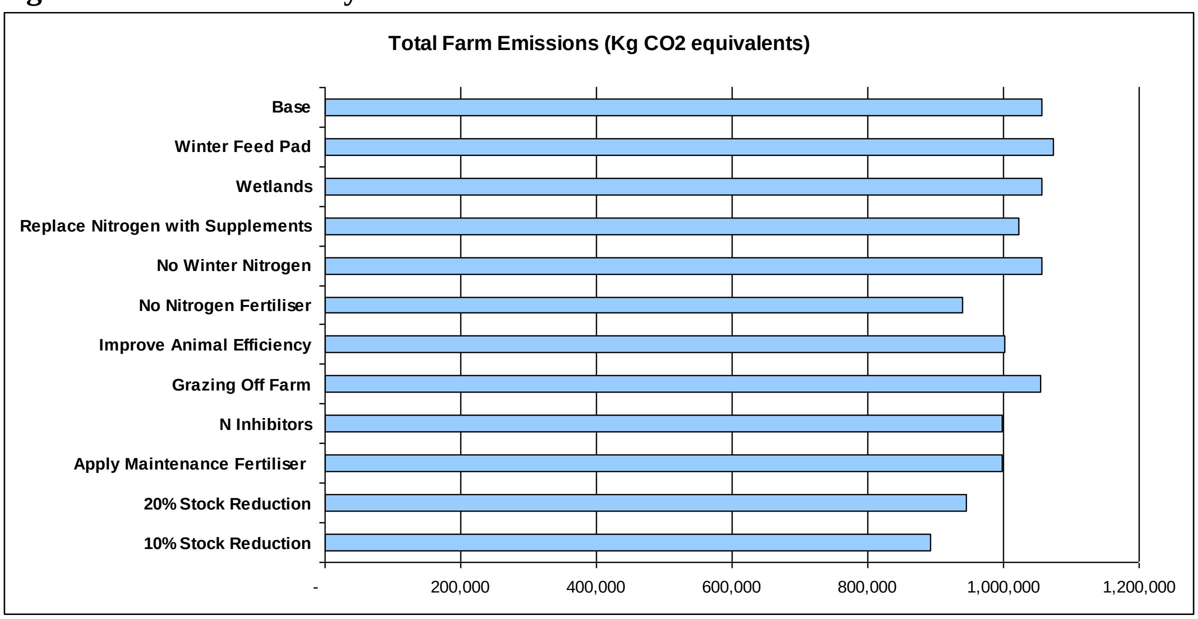
The majority of effective nitrogen discharge mitigation options also have impacts on greenhouse gas production. This is natural as the two major contributors are through animal emissions and the use of nitrogen. Therefore anything that reduces livestock numbers and or the use or leaching of nitrogen will also reduce green house gas emissions.

Winter feed pads increase green house gas emissions due to the increase in animal activity on the farm and the storage and distribution of waste.

Table 3 : Summary of Northland Dairy Farm Mitigation Performance.

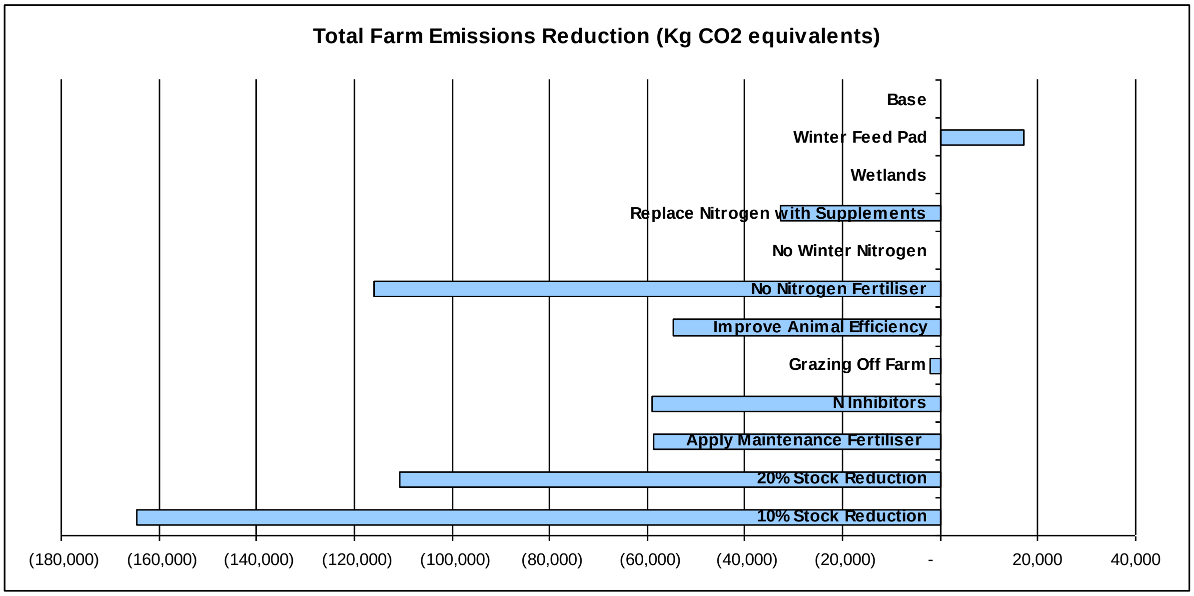
Mitigation Option	Total Units	Reduction from Base	Carbon Charge	Reduction in Carbon cost
10% Stock Reduction	891,770	(164,439)	22,294	(4,111)
20% Stock Reduction	945,615	(110,594)	23,640	(2,765)
Apply Maintenance Fertiliser	997,645	(58,564)	24,941	(1,464)
N Inhibitors	997,282	(58,927)	24,932	(1,473)
Grazing Off Farm	1,054,031	(2,178)	26,351	(54)
Improve Animal Efficiency	1,001,638	(54,571)	25,041	(1,364)
No Nitrogen Fertiliser	940,170	(116,039)	23,504	(2,901)
No Winter Nitrogen	1,056,209	-	26,405	-
Replace Nitrogen with Supplements	1,023,539	(32,670)	25,588	(817)
Wetlands	1,056,209	-	26,405	-
Winter Feed Pad	1,073,391	17,182	429.55	(25,976)
Base	1,056,209		26,405	

Figure 5: Northland Dairy total farm emissions.



As can be seen from **Figure 5** and **Figure 6** similar results are found with the greenhouse gas emissions with livestock reductions and N reduction causing the greatest reduction in emissions.

Figure 6: Northland Dairy total farm emissions reduction.



The use of a feed pad is the only option that returns a positive result. The remainder can incur very high costs on the farm.

Waikato / Bay of Plenty Sheep and Beef Farm

Nitrogen Discharges

Table 4 : Summary of Waikato / Bay of Plenty Sheep and Beef Farm Mitigation Performance.

Mitigation Option	Total Units	Reduction from Base	Change in Cash Farm Surplus	Cost / Unit of Reduction Average	Cost / Unit of Reduction High	Cost / Unit of Reduction Low
10% Stock Reduction	2,699	(91)	(9,314)	(102)	(123)	(82)
20% Stock Reduction	2,335	(455)	(32,891)	(72)	(87)	(58)
No Nitrogen Fertiliser	2,753	(37)	3,434	93	111	74
Replace Nitrogen with Supplements	2,767	(23)	1,349	59	70	47
Winter Feed Pad	2,631	(159)	(27,900)	(175)	(211)	(140)
N Inhibitors	2,534	(256)	(25,609)	(100)	(120)	(80)
Apply Maintenance Fertiliser	2,713	(77)	(6,586)	(86)	(103)	(68)
Wetlands	2,743	(47)	(1,440)	(31)	(37)	(25)
Base	2,790					

These results are presented in more detail in the following figures.

Discharge Reduction Effectiveness

Figure 7: Waikato / Bay of Plenty Sheep and Beef farm total discharges (kg N /yr)

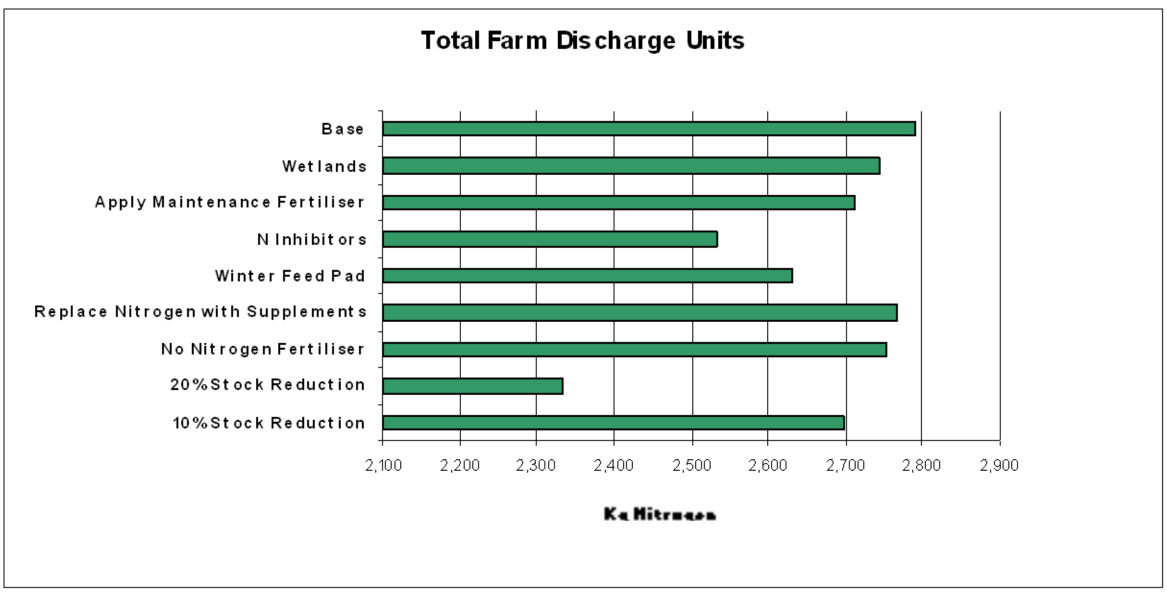


Figure 7 shows that the greatest discharge reduction options are 20% livestock reduction, the use of N inhibitors and a winter feed pad. The other options are all fairly similar in their effectiveness in reducing discharges. It should be noted that they all have a minimal effect on the total farm discharge.

Figure 8: Waikato / Bay of Plenty Sheep and Beef farm total farm discharge reduction (kg N /yr)

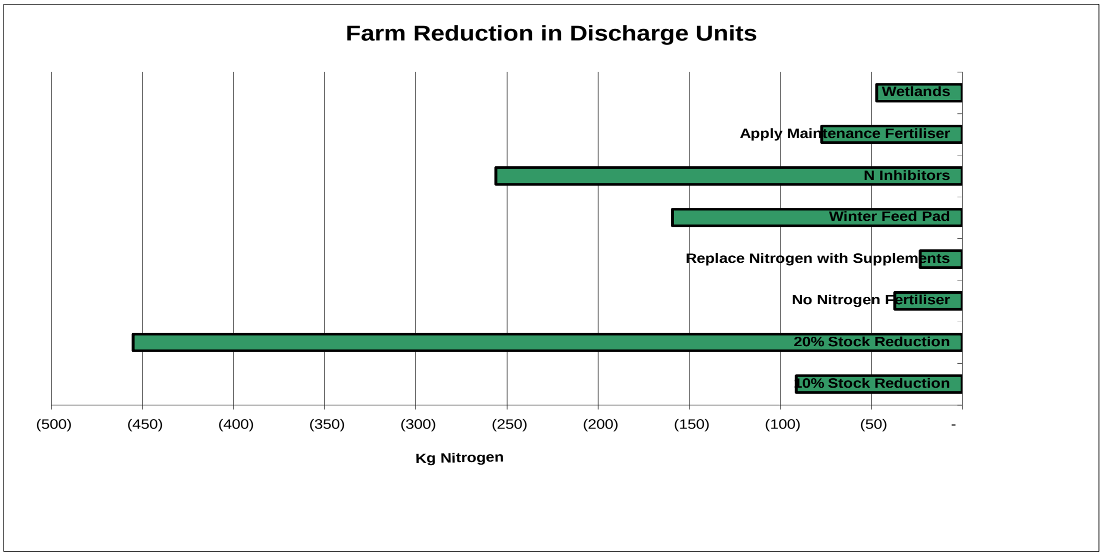
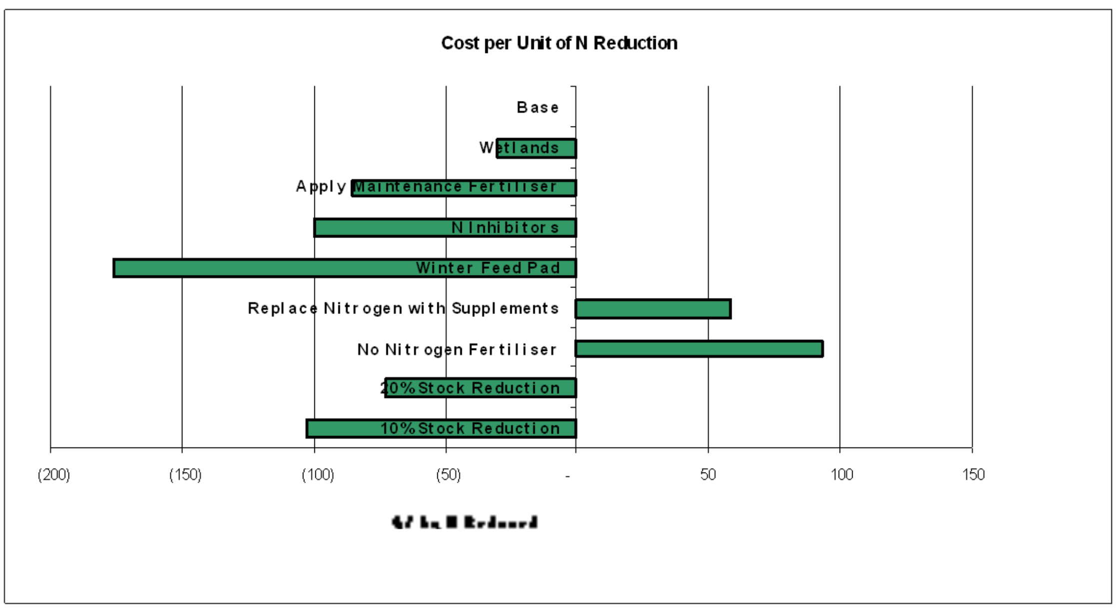
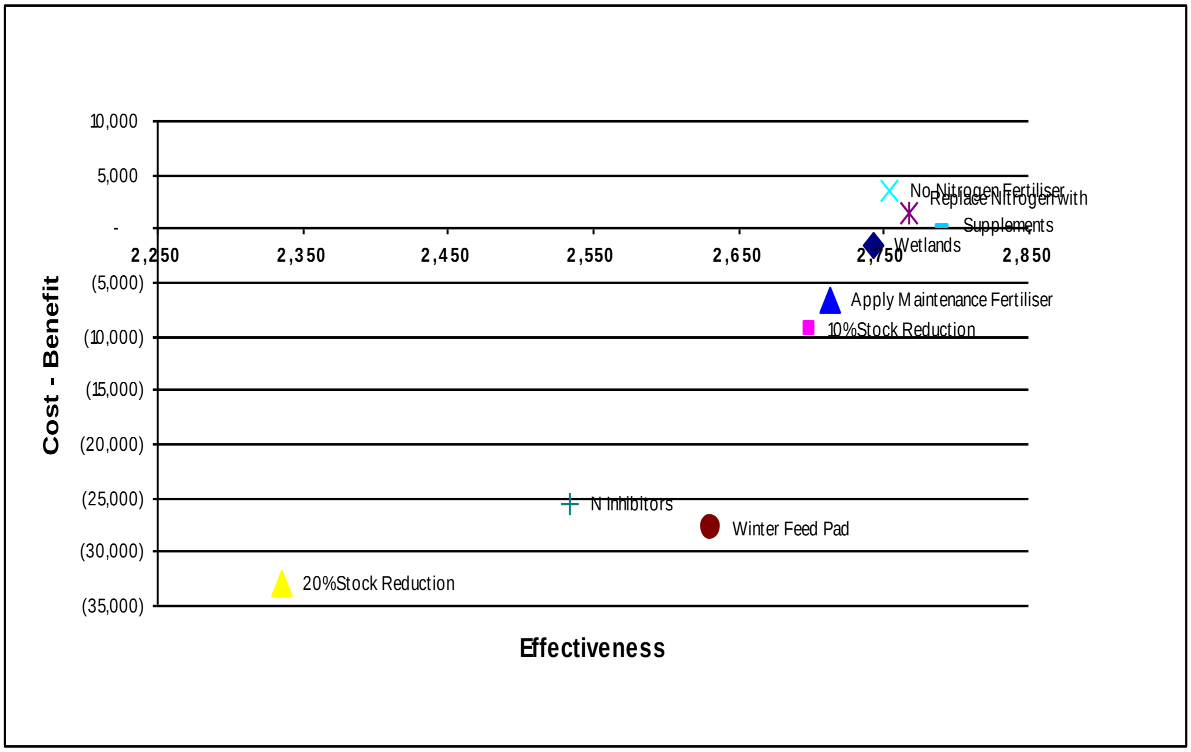


Figure 9: Waikato / Bay of Plenty Sheep and Beef cost per unit of discharge reduction ($ / kg)



The two options that have a financial net benefit are no N fertiliser and replacing N fertiliser with supplements. This is because of the relative cost of N fertiliser compared with the alternatives. It should also be remembered that the response to N fertiliser is calculated by Overseer as the average. If the response to N fertiliser was above the average then the relative returns would change. Apart from the wetland and winter feed pad option all the other options are relatively similar in cost.

Figure 10: Waikato / Bay of Plenty Sheep and Beef mitigation cost effectiveness.



In **Figure 10** the two axes are Cost – Benefit and effectiveness. The cost – benefit is expressed as the total cost or benefit to the farming system expressed as change in Cash Farm Surplus from the base scenario. While the effectiveness measure is the Total level of discharges from the farm expressed as the total Kilograms of Nitrogen.

Figure 10 shows the relative effectiveness of the options. This shows the relatively tight grouping of the majority of options around the break even line. Winter feed pad and N inhibitors show an unattractive cost. This is mainly due to the relative effectiveness of N inhibitors in the Waikato. The final option of 20% Livestock Reduction has the highest cost.

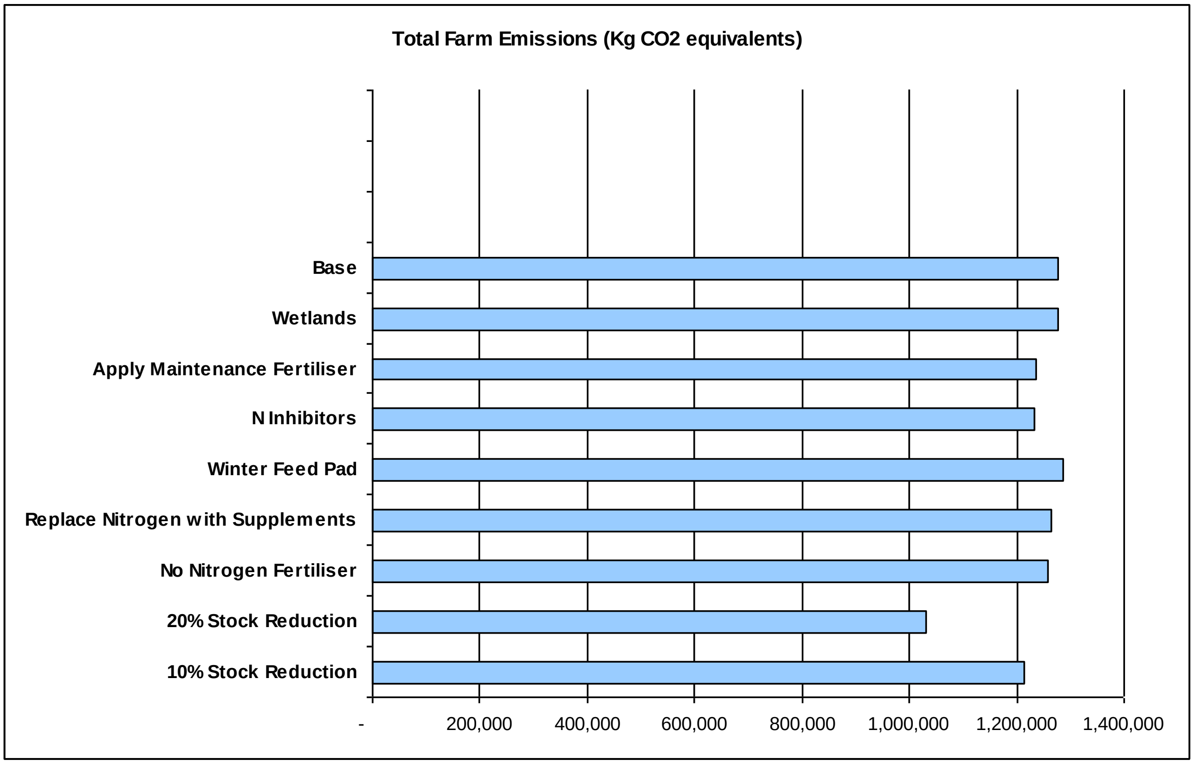
Greenhouse Gas Emissions

Table 5 : Summary of Waikato / Bay of Plenty Sheep and Beef Farm Mitigation Performance.

Mitigation Option	Total Units	Reduction from Base	Change in Cash Farm Surplus	Cost / Unit of Reduction Average
10% Stock Reduction	1,215,300	(61,500)	30,383	(1,538)
20% Stock Reduction	1,030,200	(246,600)	25,755	(6,165)
No Nitrogen Fertiliser	1,256,700	(20,100)	31,418	(503)
Replace Nitrogen with Supplements	1,264,800	(12,000)	31,620	(300)
Winter Feed Pad	1,287,600	10,800	32,190	270
N Inhibitors	1,233,300	(43,500)	30,833	(1,088)
Apply Maintenance Fertiliser	1,234,500	(42,300)	30,863	(1,058)
Wetlands	1,276,800	-	31,920	-
Base	1,276,800		31,920	

These results are presented in more detail in the following figures.

Figure 11: Waikato / Bay of Plenty Sheep and Beef total farm emissions.



This shows a relatively tight grouping around the base rates of greenhouse gas emissions with the largest drop occurring for the decrease in livestock units, as would be expected.

Figure 12: Waikato / Bay of Plenty Sheep and Beef total farm emissions reduction