"Achieving Outcomes by Building Capability"

The AgriBusiness Group™

Farm Scale Economic Impact Analysis of One Plan Intensive Land Use Provisions

Prepared for: Horizons
Prepared by: The AgriBusiness Group
October 2017

Contents

Farm Scale Economic Impact Analysis of One Plan Intensive Land Use Provisions

Executive Summary

The purpose of this work is:

To calculate the economic impact of mitigations to reduce nitrogen leaching as a result of recommended changes to the consenting process, including the costs associated with consent applications for intensive horticultural land use activities following the Environment Court declaration.

Our methodology was to link the requirements of this work with some previous work which we carried out for HortNZ which is titled “Nutrient Performance and Financial Analysis of Horticultural Systems in the Horizons Region” which was completed in June 2014. In this way the economic impacts of the nutrient management framework and the costs of consenting will be calculated for each of the three of the horticultural land use types which we identified in 2014:

- **Rotation 1 – Cash Cropping**
- **Rotation 2 – Intensive Vegetable Production**
- **Rotation 3 – Market Garden**

These rotations represent different scale and intensity of horticultural operations and will therefore represent a reasonable range of costs both for the consenting costs and the mitigation costs.

The modelling of the nutrient performance of the three farm systems was carried out using the OVERSEER 6.2.3 model. The use of OVERSEER as a means of accurately depicting the performance of Horticultural systems has some challenges.

The financial models were adapted from some whole farm financial models which were created for a recent project for MFE. The data from the Horizons region was entered into this model.

The mitigation options that were modelled were:

- Mitigation 1 – Limiting N application. This mitigation technique limited any one application of N to 80 kg N / ha per month.
- Mitigation 2 – Altering the amount of N and the yield**.** This mitigation option altered the amount of N applied to the crop in 10% deductions from 0 to a 30% reduction in the amount of N applied.
- Mitigation 3 – The use of cover crops.

Overall the results of the overseer analysis indicate that there is very little that can be done in terms of the use of the currently available mitigation techniques that will lower the amount of N leaching in the three models used. As can be seen from Table 1 the N leaching results for the Cash Cropping rotation are lower then the initial target of 30 kg N / ha / year whilst the results for the Intensive Vegetable and Market Garden rotations are close to twice the initial target leaching rate.

Table 1: N leaching results (kg N / ha / annum)

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Rotation 1	23	22	23	21	21	22
Rotation 2	69	66	67	66	63	66
Rotation 3	61	64	59	57	52	58

The result of the financial modelling indicate that the major impacts are a considerable deterioration of the financial performance of each of the rotations as a result of the restrictions on the amount of N used.

The most effective means of mitigation that is possible to ensure that a vegetable grower can continue to grow vegetables whilst meeting the requirements of the existing planning regime would be to buy additional land that they could farm less intensively which would balance the whole farm N leaching result to meet the 30 kg N / ha limit.

In order to meet the requirements of Table 14.2 Rotations 2 Intensive Vegetable and 3 Market Garden experience a significant deterioration in their ROI.
While the results for both remain technically viable from a Nett Cash Position perspective the Return on Investment which they receive is unsatisfactory. Therefore I believe that the vegetable growers in the Horizons area would find it more attractive to move their operations to an area where they were not required to meet such targets than to go to the additional cost of the mitigations modelled here.

This will mean that by far the majority of vegetable growers will be required to apply for a restricted discretionary consent outside Table 14.2. The costs to do this will be considerable and the outcomes of their application are uncertain.

1 Introduction

In the introduction to this work we detail the background behind the requirement to provide it and the methodology which we used to complete the report.

1.1 Background

This report is written in response to a project brief document provided by Horizons and a telephone conversation to clarify the objectives.

As stated in the project brief document:

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

And:

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

The purpose of this work is:

To calculate the economic impact of mitigations to reduce nitrogen leaching as a result of recommended changes to the consenting process, including the costs associated with consent applications for intensive horticultural land use activities following the Environment Court declaration.

The scope provided is as follows:

"*The research will address the economic effects of the One Plan consenting and policy framework on activities qualifying as restricted discretionary consent applications. It will deliver a report which quantifies the cost impost on applicants to compile, have processed and to implement a land use consent for intensive horticulture in target catchments including:*

- *consultant fees;*
- *Council processing, rural advice and compliance/monitoring fees;*
- *data and information costs;*
- *annual nutrient budgeting costs;*
- *costs to implement on-farm mitigations;*
- *fees for any other specialist consultants involved in the consenting and implementation of a granted intensive land use activity.*

The report will additionally need to consider the costs associated with notification of a land use consent."

1.2 Methodology

Our methodology was to link the requirements of this work with some previous work which we carried out for HortNZ which is titled "Nutrient Performance and Financial Analysis of Horticultural Systems in the Horizons Region" which was completed in June 2014. In this way the economic impacts of the nutrient management framework and the costs of consenting will be calculated for each of the three of the horticultural land use types which we identified in 2014:

- **Rotation 1 – Cash Cropping**
  Horticultural cropping is secondary to the primary purpose which is grazing of the land. Cropping is a relatively short term operation and is often for specialist crops like seed potatoes.

- **Rotation 2 – Intensive Vegetable Production**
  These properties are generally of a greater scale than Market Garden. They generally have several years of a break crop such as pasture in the rotation. They use advanced farming systems to achieve the scale of production. They have a broad mix of crops.

- **Rotation 3 – Market Garden**
  These farms represent the intensive market garden systems which have many crops in the same field with up to three crops a year in a continuous rotation.

These rotations represent different scale and intensity of horticultural operations and will therefore represent a reasonable range of costs both for the consenting costs and the mitigation costs.

1.2.1 Cost to implement on farm mitigations.

This is based on the on farm mitigation work that was carried out in our earlier report for each of the case study farms. This was expanded to encompass the mitigations that are required to achieve good management practice status and then to achieve the level of mitigations required of them to achieve the standards set in the Horizons plan in Table 14.2.

Commentary has been provided on analysis of the impact of the costs of the potential mitigations on the business as a whole. These include commentary on both the viability of the business of the changes and on the sustainability of the business in the long term. This was examined across a range of property sizes and the range of potential prices that can be received for the produce.

1.2.2 Analysis of the potential for the grower to remain viable while still meeting the targets set in Table 14.2.

In this section we set out the financial performance of the two different example rotations of the grower continuing to meet each 5 year target in Table 14.2.

2 Cost to implement on farm mitigations

In the following section we first explain the methodology used in analysing the mitigations, we have a brief discussion on the issues related to the use of Overseer as a modelling tool in the horticultural sector, we then discuss the background to N leaching in horticulture, we then detail the range of mitigations analysed and then discuss the results. At the end of this section of the report we report the only viable mitigation technique that would be necessary to keep the N leaching figure for the whole farm below the figure in Table 14.2 which is 30 kg N / ha for this class of land.

2.1 Methodology

2.1.1 OVERSEER Modelling

The modelling of the nutrient performance of the three farm systems was carried out using the OVERSEER 6.2.3 model. The use of OVERSEER as a means of accurately depicting the performance of Horticultural systems has some challenges that are noted in Appendix 1.

As highlighted by the FAR (2013) review, the accuracy of the OVERSEER 6.2.3 model has not been tested against actual N leaching results for Horticultural properties. So the results presented here should be regarded as appropriate for use at this point of time but could change as further research information becomes available and is able to better inform the model.

An alternative model (APSIM) is available and it may be able to better model the performance of N leaching and P output in Horticulture. APSIM is primarily a research tool that is used in New Zealand by Plant and Food in New Zealand but it is increasingly being used in projects in the commercial sector in New Zealand. Horticulture NZ were one of the project partners in a research project which compared the performance of Overseer to APSIM in a vegetable growing context. That research identified several further problems with the way that crops are modelled in Overseer.

The definitions and scopes of the three core models were developed in a workshop with Horizons growers. Each model was set up with the parameters set to be standard with all of the key parameters like Soil Type (Manawatu Silt Loam) and the climatic variables being a reflection of those experienced in the growing area.

The makeup of the actual rotation of the crops was taken from the data collected in the survey.

Rotation 1 – Cash Cropping

Horticultural cropping is secondary to the primary purpose which is grazing of the land. Cropping is a relatively short term operation and is often for specialist crops like seed potatoes. Once the land is worked up for the crop it is then taken for a cereal crop and regrassed back into pasture. The rotation used is as follows:

Pasture (8 years) > Potatoes > Barley > Pasture

Rotation 2 – Intensive Vegetable

These properties are generally of a greater scale than Market Garden. They generally have several years of a break crop such as pasture in the rotation. They use advanced farming systems to achieve the scale of production. They have a broad mix of crops including brassicas, curcurbits, potatoes, onions, melons which are often rotated over many blocks of leased land. They are generally intensively managed through cover crops like oats / mustard / perennial grasses.

Pasture (2 years) > Cabbage > Lettuce > Spinach > Squash > Onions > Pasture

Rotation 3 – Market Garden

These farms represent the historic Pearl River (Guangdong) intensive market garden systems which have many crops in the same field with up to three crops a year in a continuous rotation.

Broccoli > Spinach > Lettuce > Cabbage > Cauliflower > Cabbage

2.1.2 Choice of Area Cropped

The choice of the area that is cropped has a significant influence on the amount of N leaching which OVERSEER calculates over the total area of the farm. For each crop choice there are three choices of what can be done with the land In OVERSEER. The “cultivated area” is the area of land on which the calculation of the impact of the farming activity is calculated. “Headlands and Tracks” are areas that are cultivated but there is no crop grown on them and “Other areas” are defined as areas where the land is not cultivated.

The issue with horticultural land use is that there are often significant areas within a paddock where the crop is not grown. This is mainly taken up with the beds that are formed to grow the crops in which have a significant area taken up with the areas where tractors, sprayers and harvesters run over the paddock. The headlands and track area are also quite significant areas because of the need to turn quite large machinery. The adoption of technology to spread fertiliser which utilises banding and side application also means that a significant portion of the area also doesn’t have fertiliser applied to it.

Therefore in this modelling exercise we have adopted a policy that for all cropping land uses there is 80% of the total area taken up with the cultivated area, 10% is taken up by headlands and tracks and 10% is taken up by other areas. The exception to this is for Rotation 3 Market Garden which in order to demonstrate the impact of unused area on the total impact of the property we have adopted 70% of the area taken as cultivated area , 20% is taken up by headlands and tracks and 10% is taken up by other areas.

This is why we see that the results expressed for the whole farm N leaching figure is less than any of the individual cropping figures.

2.1.3 Financial Models

The financial models were adapted from some whole farm financial models which were created for a recent project for MFE.[1] The data from the Horizons region was entered into this model.

---

[1] Aqualinc (unpublished at date of writing): Water Allocation Economic Analysis: Land Water Use Modelling. Report completed for MFE.

Gross revenue is created with the total yield for the crop multiplied by the price received. Farm working expenses were made up from the data received in the survey of growers and by adopting the performance of the data used in the Ministry for Primary Industries Farm Monitoring model Western Lower North Island Intensive Sheep and Beef.

Examples of the three core rotations financial models are found in Appendix two.

2.2 Background on N leaching in Horticulture

It is recognised that there are a number of issues related to horticulture production which result in high N leaching and relative inefficiency of N use compared to other pastoral land uses. However, many horticulture growers have continued to refine their use of N inputs, which has resulted in reduced use of N and therefore the total amount of N leaching over time.

The following quote on the nature and impact of horticultural land use on the rate of N leaching is taken from a report prepared for Environment Bay of Plenty[2] and explains the relative inefficiency of the use of N in horticultural systems. It is concluded that the major source of N leaching is derived from fertiliser and crop residue and that fertiliser N management strategies are key when devising mitigation strategies. The analysis of mitigation techniques in this report concentrates on the two strategies of timing and volume of N application.

The main factors responsible for nitrate leaching in these systems are: high N use (fertiliser and manure), frequent cultivation, relatively short periods of plant growth, low nutrient use efficiency by many vegetable crops, and crop residues remaining after harvest (Di and Cameron, 2002a).

Compared to other agricultural systems, market gardens are the most intensively fertilised and cultivated production systems - hence their propensity to leach N. N application rates used in vegetable crops can be as high as 600 kg N ha-1 yr-1 (Wood, 1997). Large application rates are used to ensure maximum growth because vegetable crops have sparse root systems that are inefficient at recovering applied fertiliser. Also, vegetables typically have short growing periods and are also grown over winter when plant growth and N uptake is slow (Haynes and Francis, 1996; Haynes, 1997). Therefore, the recovery of applied N by vegetable crops is often less than 50%, and can be as low as 20% (Di and Cameron, 2002a). Consequently, a large quantity of fertiliser N remains in the soil surface layers and is susceptible to leaching during rainfall or irrigation. Additionally, following crop harvest large amounts of plant residues are usually incorporated into the soil which, following decomposition, release mineral N into soil. The amount of mineral N derived from fertiliser and crop residue that is present in the soil after harvest can be as high as 200-300 kg N ha-1, and is the major source of leached N, indicating that fertiliser N management strategies are the key to nitrate leaching intervention in these systems.

The issues which cause N leaching in vegetable growing operations therefore are:

- High use of applied N as a result of sparse root systems for the crops (particularly when they are immature).
- Poor N use efficiency.

---

[2] Meneer J C, Ledgard S F, Gillingham A G: Land use impacts on nitrogen and phosphorous loss and management options for intervention.

- Short growth periods and therefore (in some cases) multiple crops in one year.
- Grown over winter when leaching rates are high due to high rainfall and saturated soils.
- Large amounts of crop residue left in the paddock after harvest which is worked into the soil.

2.3 Mitigation Techniques Modelled

Background research suggests that the mitigation options available to vegetable growers are based around improving nutrient use efficiency. These include:

- Nutrient management planning,
- Proper fertiliser material selection,
- Better application timing and placement,
- Improved irrigation scheduling.

The use of slow release fertilisers and the use of DDE's which act as a retardant to N leaching are both potential mitigation techniques that should be considered. The issue with slow release fertilisers is that there are certain times when vegetable crops have very high demand on N and therefore slow release fertilisers would not be able to adequately meet the crops requirement. Also, it is not possible to model the types of slow release fertilisers that are available at present in OVERSEER.

Our analysis of the current mitigation practices of growers in the Horizons Region was that they are carrying out nutrient management planning, fertiliser material selection and better timing and placement of N application. However, they are limited by the type of system which they could use in terms of improved irrigation scheduling.

Having modelled the Status Quo option which modelled what they were doing now, it became obvious that the major impacts on N Leaching was related to the amount and timing of application of N. Therefore, the following mitigation techniques were trialled:

Mitigation 1 – Limiting N application.

This mitigation technique limited any one application of N to 80 kg N / ha per month. This mainly entailed the splitting of the first application of N by either moving some of it forward into the pre planting cultivation phase and incorporating it into the soil or by evening out the amount of N in subsequent fertiliser applications up to the maximum of 80 kg N / ha. No impact on yield was modelled from this mitigation technique it was assumed that the evening out of the N applications did not have a negative impact on the yield of the crop. This was partly driven by the relatively regular N applications that are made in horticultural crops and the fact that in OVERSEER the smallest window of applications are on a monthly basis. Current best practice is for the application of N to be more regular than once per month, particularly in the early growing stages when the plants are relatively small and growing rapidly and have a high requirement for N.
An example of the impact of limiting the amount of N applied in each application for each of the rotation types is shown in Table 2.

.

Table 2: Examples of the mitigation of limiting the amount of N in each application month to 80 in Overseer. (kg N / ha / year).

Rotation 1 Cash Cropping	Aug	Potato Sept	Oct	Nov	
Status Quo		204		72	
Mitigation 1	82	82	41	72	
Rotation 2 Intensive Vegetable	**Apr**	**Cabbage May**	**Jun**	**Jul**	**Aug**
Status Quo		197		184	
Mitigation 1	80	80	37	80	80
Rotation 3 Market Garden	**Feb**	**Spinach Mar**	**April**	**May**	
Status Quo		180	60	80	
Mitigation 1	81	81	80	80	

There is also the requirement to get the application of N on relatively early in the growth phase of many of the crops because experience shows that later application of N can lead to reduced yield and a deterioration of quality of many of the crops as a result of being pushed along later in their maturity.

Mitigation 2 – Altering the amount of N and the yield.

This mitigation option altered the amount of N applied to the crop in 10% deductions from 0 to a 30% reduction in the amount of N applied. The amounts of yield reductions modelled were created by reference to some research reports[3] on the impact of N on yield and informed by the experienced opinion of some of the growers in the Pukekohe District. The assumptions as to average yield reduction by individual crop are attached in Appendix 3. Many of the research reports referenced refer to trials which occurred from the mid 1960's to the late 1980's. In that time period the amount of N used was much higher than what is used now. Although very little research has been carried out recently into N use on horticultural crops, many of the growers have continued to develop their knowledge on the timing and volume of N application to be able to maximise crop growth and to try and improve N use efficiency and at the same time reduce costs. This has resulted in much lower rates of N usage than those quoted in the old research reports.

Mitigation 3 – The use of cover crops

The use of cover crops is a good mitigation technique to reduce the amount of Nitrogen which leaks through the soil profile, particularly during the winter months when there is high rainfall and the soil is generally saturated, therefore there is a lot of movement through the soil profile. For this exercise when the gap between crops was more than two months then a cover crop was put in. At the end of the cover crop it was worked into the soil profile.

[3] Pearson, Renquist, Reid (1999): MAF vegetable fertiliser trails – A re appraisal using a new model.
Wood (1998): Effect on crop yields from reduced N inputs to selected winter vegetable crops.
Wood (1997): Reduced N inputs to winter vegetable crops – Pukekohe district 1997.
Thomas, Obreza, Sartain : Improving N and P fertiliser use efficiency for Floridas horticultural crops.
MAF (1979): Celery production in Hutt Horowhenua.
Sher (1997): Nutrient uptake of vegetable crops. Summary of results 1993 – 1996.

2.4 Results

2.4.1 Overseer modelling

The results of the OVERSEER modelling of each rotation are displayed across the columns the results are shown for the status quo option first and then for each of the mitigation options.

Table 3: N leaching results (kg N / ha / annum)

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Rotation 1	23	22	23	21	21	22
Rotation 2	69	66	67	66	63	66
Rotation 3	61	64	59	57	52	58

Rotation 1 – Cash Cropping

The results of rotation 1 show that because of the relatively large area of non-horticultural land within the model that the whole farm N leaching results are not sensitive to the mitigation options trialled.

Rotation 2 – Intensive Vegetable

In rotation 2 the results indicate that although there is a potential 9% drop in the total leaching result in M2 30% there is nothing showing which would give any encouragement that there could be significant lowering of the leaching of the crop with the use of the mitigation practices used.

Rotation 3 – Market Garden

In rotation 3 the results indicate that although there is a potential 15% drop in the total leaching result in M2 30% there is nothing showing which would give any encouragement that there could be significant lowering of the leaching of the crop with the use of the mitigation practices used.

Overall the results of the overseer analysis indicate that there is very little that can be done in terms of the use of the currently available mitigation techniques that will lower the amount of N leaching in the three models used.

This will mean that by far the majority of vegetable growers will be required to apply for a restricted discretionary consent outside Table 14.2. The costs to do this will be considerable and the outcomes of their application are uncertain.

2.4.2 Financial results.

The core models were adjusted by the following techniques to alter the results for each mitigation option.

Mitigation 1 – Limit N

For each additional application of N an amount of $50 / ha was added to the fertiliser costs. The $50 / ha was the amount shown for each fertiliser application in the Lincoln Budget Manual[4].

[4] Lincoln University: Financial Budget Manual

Mitigation 2 – Alter N and Yield

The yield of the crop grown was adjusted by the percentages shown in appendix one. This then flowed through to a reduction in expenditure for those expenditure items which are influenced by the yield of the crop including fertiliser expenditure.

Mitigation 3 – Cover Crop

For each time that a cover crop was added into the rotation an additional cost of $550 / ha was added to the financial model. This amount is taken from the Lincoln University Financial Budget Manual and incorporates items for the seed drilled and the costs of drilling the seed.

Table 4: Financial results for Rotation 1

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Gross Farm Revenue	523,860	523,860	491,985	443,235	416,985	512,610
Farm Operating Expenses	203,268	203,768	199,826	194,734	189,918	208,268
Cash Operating Surplus	320,592	320,092	292,159	248,501	227,067	304,342
Net Cash Position	156,716	156,316	133,969	99,043	81,896	143,716
ROI	4.9%	4.9%	4.2%	3.1%	2.6%	4.5%

As can be seen from Table 4 there is very little change in the financial performance of rotation 1 from mitigation. Mitigation 2 very rapidly causes a deterioration in the financial results as measured by the Net Cash Position and ROI. Mitigation 3 has a relatively minor negative impact on the financial result.

Table 5: Financial results for Rotation 2

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Gross Farm Revenue	2,557,680	2,557,680	2,206,420	1,853,020	1,639,440	2,557,680
Farm Operating Expenses	1,927,017	1,930,617	1,742,746	1,550,469	1,475,619	1,931,337
Cash Operating Surplus	630,663	627,063	463,674	302,551	163,821	626,343
Net Cash Position	404,773	401,893	271,181	142,283	31,299	401,317
ROI	12.7%	12.6%	8.5%	4.5%	1.0%	12.6%

As can be seen from Table 5 both Mitigations 1 and 3 have a very minor impact on the financial result. Mitigation 2 however has quite severe negative impact on the financial result which increases markedly as the proportion of N applied decreases.

Table 6: Financial results for Rotation 3

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Gross Farm Revenue	960,980	953,720	817,922	687,420	579,492	960,980
Farm Operating Expenses	580,568	585,068	521,562	467,143	422,448	588,818
Cash Operating Surplus	380,412	368,652	296,360	220,277	157,044	372,162
Net Cash Position	196,572	195,164	129,330	68,463	17,877	189,972
ROI	13.1%	13.0%	8.6%	4.6%	1.2%	12.7%

As can be seen from Table 6 both Mitigations 1 and 3 have a very minor impact on the financial result. Mitigation 2 however has quite severe negative impact on the financial result which increases markedly as the proportion of N applied decreases.

The results of the financial modelling indicate that the major impacts are a considerable deterioration of the financial performance of each of the rotations as a result of the restrictions on the amount of N used.

2.5 Achieving the 30 kg N / ha target

The most effective means of mitigation that is possible to ensure that a vegetable grower can continue to grow vegetables whilst meeting the requirements of the existing planning regime would be to buy additional land that they could farm less intensively which would balance the whole farm N leaching result to meet the 30 kg N / ha limit.

For the sake of demonstration of the impact of such a mitigation technique being adopted in each of the core rotations the example uses the addition of sufficient land which is farmed in a "cut and carry" operation which has all of the pasture grown removed from the site as silage. This option is the highest financial returning land use per kg N leached whilst adopting a no animals policy.. This means that it is the most attractive option for a vegetable grower to try and mitigate the total N leaching figure from the additional land required at the greatest possible financial return. It is predicated on their being sufficient demand from the Dairy sector for the purchase of additional silage which is made off farm.

The additional land is assumed that it would be purchased entirely from borrowed money so the value and the amount of debt both go up by the same amount but the debt servicing increases by the amount of the additional purchase.

In the case of rotation 1 which has a total N leaching figure of 23 this would mean that this rotation was within the target so no mitigation would be neccesary. For rotation 2 it would require the addition of 210 ha and for rotation 3 it would require the addition of 35 ha. These areas of pasture are calculated by changing the area under pasture (N leaching 8 kg N / ha / year) until the N leaching for the total area of land farmed achieves the average target of 30 kg N / ha / year.

The results of adopting this mitigation technique are shown in Table 7.

Table 7: Financial results for achieving the 30 kg N / ha requirement.

	Rotation 2 SQ	Rotation kg N / ha	Rotation 3 SQ	Rotation kg N / ha
Gross Farm Revenue	2,557,680	2,804,520	960,980	1,004,540
Farm Operating Expenses	1,927,017	1,908,337	580,568	619,749
Cash Operating Surplus	630,663	896,183	380,412	384,791
Net Cash Position	404,773	357,189	196,572	113,333
ROI	13%	4.4%	13%	3.5%

For rotation 2 there is a significant reduction in the ROI but not as significant reduction in the Net Cash Position. For rotation 3 there is a significant reduction in both the Net Cash Position and the ROI as a result of moving from the status quo position to meeting the initial target of 30 kg N / ha / year.

In order to meet the requirements of Table 14.2 Rotations 2 Intensive Vegetable and 3 Market Garden experience a significant deterioration in their ROI.

Analysis of the potential for the grower to remain viable while still meeting the targets set in Table 14.2. The targets set for N leaching on class 1 soils (as classified by the LUC classification system) are set to drop in five yearly intervals until 20 years from the original date as shown in Table 8.

Table 8: Targets of kg N / ha / year that have been set into the future.

Period	LUC
Year 1	30
Year 5	27
Year 10	26
Year 20	25

The impact of the cost of servicing the additional land required to meet the various targets which are set over time are somewhat offset by the additional income received from the land. The results of the ongoing impact of meeting the targets are shown in Table 9.

Table 9: The financial impact of achieving the N leaching targets over time.

	Status Quo	30	27	26	25
Rotation 2					
Net Cash Position	404,773	569,641	607,199	606,902	623,453
ROI	13%	7.0%	5.5%	5.2%	5.1%
Rotation 3					
Net Cash Position	196,572	136,375	131,108	129,133	126,499
ROI	13.1%	5.0%	4.4%	4.2%	3.9%

As can be seen from Table 9 for rotation 2 Intensive Vegetable production there is a slight lift in the nett cash position from the status quo to the 30 kg N / ha / year but a significant drop in the Return on Investment figure. After that the results of the impact are showing a small but steady rise in the Nett Cash Position but a further deterioration in the Return on Investment. This is brought about by the returns from the additional alnd being greater than the cost of the debt servicing but the cost of the additional land causing the Return on Investment to deteriorate.

For Rotation 3 there is a substantial drop from the Status Quo to the 30 kg N / ha / year in both the Nett Cash Position and the Return on Investment and then a continual slide as the targets drop further in both measures.

While the results for both remain technically viable from a Nett Cash Position perspective the Return on Investment which they receive is unsatisfactory. Therefore I believe that the vegetable growers in the Horizons area would find it more attractive to move their operations to an area where they were not required to meet such targets than to go to the additional cost of the mitigations modelled here.

Appendix One: Caution on the Use of Overseer

We believe that considerable caution should be used in the use of nutrient benchmarking results produced in Overseer for the Horticultural industry. The following commentary sets out our reasons for this warning.

It is HortNZ's policy to work with Overseer to try and improve the accuracy of the N leaching figures produced by the tool. However when Councils seek to use Overseer as a tool to aid their legislative intentions in the vegetable sector HortNZ has some serious doubts about Overseers ability to accurately predict the performance of the sector.

In the report written by The AgriBusiness Group "Nutrient Performance and Financial Analysis of Lower Waikato Horticulture Growers" the authors identified a number of challenges related to modelling vegetable crops in Overseer which had a potential negative effect on our ability to accurately model the N leaching performance of the vegetable growing sector. In that report it commented on a review carried out by FAR of the use of Overseer in the Arable and Horticultural sector as follows:

The Foundation for Arable Research[5] *carried out an independent review of the use of OVERSEER in the arable sector, which incorporated consideration of the horticultural sector. It came up with the following conclusion:*

OVERSEER® is the best tool currently available for estimating N leaching losses from the root zone across the diversity and complexity of farming systems in New Zealand. This review sets out a pathway for improving its fitness for this purpose in the arable sector (see recommendations). It also highlights that the new challenges facing OVERSEER® place demands on the development team and model owners that need to be acknowledged and resourced appropriately.

The review came up with the following recommendations which are relevant to the horticultural sector:

OVERSEER® crop model estimates of N leaching should be evaluated against measurements of N leaching to identify whether there are any systematic errors in predictions.

We note that this has been the subject of new projects facilitated and led by HortNZ and the Foundation of Arable Research through the "Rootzone Reality" Programme establishing a national network of lysimeters. Of direct relevance is the extension of this project in partnership with Auckland Council and Waikato Regional Council. The extension has led to a series of additional trial sites where groups of fluxmeters have been installed under cropping land in Pukekohe, Pukekawa and Matamata to directly measure nitrogen discharges below the rootzone. The work was commenced in 2014 with installation of sites. It will take at least 3-4 years to establish measurements that are useful. It will take additional time for the OVERSEER® owners to incorporate the new information into modelling predictions.

OVERSEER® crop model estimates of N leaching should be evaluated against predictions of longterm leaching produced by established, detailed research models e.g. APSIM.

---

[5] FAR (2013) : A peer review of OVERSEER in relation to modelling nutrient flows in arable crops.

Horticulture New Zealand, Foundation for Arable Research and the Fertiliser Association of New Zealand has a contract with Plant and Food Research to test Overseer results in comparison with APSIM. It will take additional time for the OVERSEER® owners to incorporate the new information into modelling predictions.

The testing outlined in recommendations (1) and (2) is likely to identify and justify areas for further development of OVERSEER® to improve N leaching predictions.

As far as we are aware none of the three recommendations made in that report have been completed. This is at least partially due to the development of Overseer being limited by the expenditure of capital and partially due to the low priority put on the development of vegetable production capability by Overseer.

So we still do not know whether there is any justification for the crop model estimates being used by Overseer and we have not had them verified by comparison to other means of modelling (APSIM).

Apart from the basic uncertainty around the accuracy of the crop model estimates used in Overseer there are also concerns about:

- The gross nature of the inputs used in entering data into Overseer (monthly data is the finest input timeframe) which are unable to accurately reflect the complexities of relatively fine scale vegetable production systems and

- The fact that Overseer is not currently capable of modelling all possible crop types. In a recent paper written for ECan (Hume)[6], Plant and Food identified that approximately half of the crops sown were not named as options in Overseer in an exercise in crop modelling in Canterbury. We would assume that this figure would be even more extreme in the high producing vegetable growing sector.

- The fact the Overseer is a long term averaging tool which has a fixed, and somewhat limited, array of long term climatic data which it uses to spread the climatic data entered over, which represents an average of thirty years data.

In the Hume paper it identified that there were a total of 21 complexities that they encountered when modelling horticultural properties in Overseer. For each one they had to develop "work arounds" to try and accurately come up with an N leaching figure which was best able to report the estimates made by Overseer.

In summary they said:

Councils using OVERSEER® for regulatory purposes should consider the listed issues and, along with industry bodies (e.g. HortNZ and FAR), inform growers with guidelines and expectations for the modelling of their farms to ensure consistency of outputs across the industry.

[6] Hume et al 2015. MGM Technical Report Arable and Horticultural crop modelling. Report written by Plant and Food for ECan.

Appendix Two: the core financial models

Rotation 1	SQ				
Physical Characteristics					
	Hectares	**t/ha**	**Total yield (tDM)**	**$/t**	**Total $**
Effective area (ha)	210				
Potatoes (summer	10	50	500	450	225,000
Onions			-	500	-
Carrots			-	450	-
Squash			-		-
Oats and rye			-		-
Barley (grain)	10	10	100	375	37,500
Oats and rye			-		-
Total/ average	**20**	**30**	**600**		**262,500**
	4				
Dairy grazing			**Total yield (kgDM)**	**$/kgDM**	**Total $**
Sheep and beef	180	0	-	0.30	-
Total	**180**		**0**		**0**
Financial Data					
			Unit	**$ Total**	**$/ha (eff)**
Revenue					
Cereals				37,500	179
Process/ fresh vege				225,000	1,071
Other Crops					0
Crop Residues		0	/ha	-	-
Total Crop				262,500	1,250
Sheep and Beef		1,452		261,360	1,245
Other Farm Income			/ha	-	0
Gross Farm Revenue				**523,860**	**2,495**
Farm Working Expenses		**$/ha**		**$ Total**	**$/ha (eff)**
Wages		500	35.36	11,365	54
			45.76	8,237	39
Breeding			4.16	749	4
Electricity			16.64	2,995	14
Grading		625		6,250	30
Packing		600		6,000	29
Freight		325		3,250	15
Fertiliser		1392	231.92	55,666	265
Lime			8.32	1,498	7
Freight			18.72	3,370	16
Seed dressing				-	-
Seeds		1385	18.72	17,220	82
Shearing			39.52	7,114	34
Weed & Pest		1168	13.52	14,114	67
Fuel		671		6,710	32
Vehicle Costs		671	29.12	11,952	57
Repairs & Maintenance		136	59.28	12,030	57
Communications			16	3,360	16
Accountancy			21	4,410	21
Legal & Consultancy			16	3,360	16
Admin.			17	3,570	17
Water Charges				-	-
Rates			50	10,500	50
Insurance			25	5,250	25
ACC.			12.48	2,621	12
Other			8	1,680	8
Total Farm Operating Expenses				**203,268**	**968**
Cash Operating Surplus				**320,592**	**1,527**
Interest		6.50%		37,822	180
Tax		0.2		56,554	269
Drawings				57,000	271
Capital Purchases				12,500	60
Development					-
Principal Repayment				25,239	120
Net Cash Position				**156,716**	**746**
Total Farm Assets				3,180,601	15,146
Total Liabilities				581,880	2,771
Total Equity				2,598,721	12,375
				ROI	4.9%

Rotation 1	**SQ**				
Physical Characteristics					
	Hectares	**t/ha**	**Total yield (tDM)**	**$/t**	**Total $**
Effective area (ha)	105				
Cabbage	20	70	1,400	368	515,200
Lettuce	20	10	200	3,022	604,400
Spinach	20	40	800	850	680,000
Squash	20	25	500	500	250,000
Onions	20	50	1,000	450	450,000
			-		-
			-		-
Total/ average	**60**	**39**	**3,900**		**2,499,600**
Dairy grazing			**Total yield (kgDM)**	**$/kgDM**	**Total $**
Livestock	40	0	-	0.30	-
Total	**40**		**0**		**0**
Financial Data					
			Unit	**$ Total**	**$/ha (eff)**
Revenue					
Cereals					-
Process/ fresh vege				2,499,600	23,806
Other Crops					0
Crop Residues		0	/ha	-	-
Total Crop				2,499,600	23,806
Sheep and Beef		1,452		58,080	553
Other Farm Income			/ha	-	0
Gross Farm Revenue				**2,557,680**	**24,359**
Farm Working Expenses		**$/ha**		**$ Total**	**$/ha (eff)**
Wages		8592	35.36	516,914	4,923
			45.76	1,830	17
Breeding			4.16	166	2
Electricity		100	16.64	2,666	25
Grading		3625		217,500	2,071
Packing		3512		210,700	2,007
Freight		4842		290,500	2,767
Fertiliser		1670	231.92	109,477	1,043
Lime			8.32	333	3
Commision		2990	18.72	180,149	1,716
Seed dressing				-	-
Seeds		1444	18.72	87,389	832
Shearing		150	39.52	10,581	101
Weed & Pest		1168	13.52	70,621	673
Fuel		1000		60,000	571
Vehicle Costs		1011	29.12	61,825	589
Repairs & Maintenance		1000	59.28	62,371	594
Communications			25	2,625	25
Accountancy			42	4,410	42
Legal & Consultancy			32	3,360	32
Admin.			35	3,675	35
Water Charges				-	-
Rates			105	11,025	105
Insurance			100	10,500	100
ACC.			55	5,775	55
Other			25	2,625	25
Total Farm Operating Expenses				**1,927,017**	**18,353**
Cash Operating Surplus				**630,663**	**6,006**
Interest		6.50%		37,822	360
Tax		0.2		118,568	1,129
Drawings				57,000	543
Capital Purchases				12,500	119
Development					-
Principal Repayment				25,239	240
Net Cash Position				**404,773**	**3,855**
Total Farm Assets				3,180,601	30,291
Total Liabilities				581,880	5,542
Total Equity				2,598,721	24,750
				ROI	13%

Rotation 3	**SQ**				
Physical Characteristics					
	Hectares	**t/ha**	**Total yield (tDM)**	**$/t**	**Total $**
Effective area (ha)	20				
Broccoli	5	12	60	1,667	100,020
Spinach	5	30	150	2,200	330,000
Lettuce	5	10	50	3,022	151,100
Cabbage	5	70	350	368	128,800
Cauliflower	5	20	100	1,150	115,000
Cabbage	5	70	350	368	128,800
			-		-
Total/ average	**15**	**35**	**1,060**		**953,720**
Dairy grazing			**Total yield (kgDM)**	**$/kgDM**	**Total $**
Livestock	5	0	-	0.30	-
Total	**5**		**0**		**0**
Financial Data					
			Unit	**$ Total**	**$/ha (eff)**
Revenue					
Cereals					-
Process/ fresh vege				953,720	47,686
Other Crops					0
Crop Residues		0	/ha	-	-
Total Crop				953,720	47,686
Sheep and Beef		1,452		7,260	363
Other Farm Income			/ha	-	0
Gross Farm Revenue				**960,980**	**48,049**
Farm Working Expenses		**$/ha**		**$ Total**	**$/ha (eff)**
Wages		9433	35.36	141,677	7,083.84
			45.76	229	11.44
Breeding			4.16	21	1.04
Electricity		100	16.64	1,583	79.16
Grading		3488		52,313	2,615.63
Packing		5089		76,338	3,816.88
Freight		7188		107,813	5,390.63
Fertiliser		1541	231.92	24,275	1,213.73
Lime			8.32	42	2.08
Commision		3775	18.72	56,719	2,835.93
Seed dressing				-	-
Seeds		1493	18.72	22,489	1,124.43
Shearing			39.52	198	9.88
Weed & Pest		1037	13.52	15,623	781.13
Fuel		1094		16,410	820.50
Vehicle Costs		1000	29.12	15,146	757.28
Repairs & Maintenance		1200	59.28	18,296	914.82
Communications			125	2,500	125.00
Accountancy			160	3,200	160.00
Legal & Consultancy			150	3,000	150.00
Admin.			165	3,300	165.00
Water Charges				-	-
Rates			450	9,000	450.00
Insurance			250	5,000	250.00
ACC.			150	3,000	150.00
Other			120	2,400	120.00
Total Farm Operating Expenses				**580,568**	**29,028**
Cash Operating Surplus				**380,412**	**19,021**
Interest		6.50%		37,822	1,891.11
Tax		0.2		68,518	3,425.90
Drawings				57,000	2,850.00
Capital Purchases				20,500	1,025.00
Development					-
Principal Repayment				25,239	1,261.95
Net Cash Position				**196,572**	**9,829**
Total Farm Assets				1,500,000	75,000
Total Liabilities				581,880	29,094
Total Equity				918,120	45,906
				ROI	13.1%

Appendix Three: Average Estimated Reduction in yield with reduction in applied N

Reduction in N	Potato (Summer), Onions, Carrots,	Squash, Broccoli, Lettuce,	Cabbage, Spinach, Cauliflower	Potato (Winter)	Barley
10%	10%	15%	15%	25%	25%
20%	20%	25%	30%	35%	35%
30%	30%	40%	40%	50%	45%