ORC mitigation framework model

Final report

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Executive Summary

This report describes the mitigation model framework developed to assess the impacts of a range of mitigation options, within the Otago region.

The model utilises catchment data (provided by ORC) to evaluate the effectiveness of 20 different mitigation options, with respect to potential reductions in nitrogen leaching, phosphorous and sediment loss, and E. coli contamination. Key inputs into the model include:

- Estimates of the total area of land used for each of the FMU/Rohe according to 10 different land use options' (dairy, dairy support, sheep and beef, sheep and beef including deer, specialist beef, specialist sheep, specialist deer, cropping, fruit and nut trees, plantation forestry).
- A description of each land use type, according to the proportion of land irrigated, terrain type (flat, rolling, steep) and soil type (drained, free draining and undrained).
- An estimate of land usage by activity for each terrain type (grazing, cropping, forested)
- The estimated impacts of each of the different mitigation options according to land use, terrain type, soil type and activity.
- The estimated costs of implementation and ongoing maintenance of each of the mitigation options.
- Estimated reductions in Nitrogen leaching and phosphorous loss (kg/ha) relative to cost ($/kg).

A series of preliminary results for the Catlin's FMU and Upper Lakes Rohe were developed and presented to the ORC in October, with the model then further refined according to feedback from Ross Monaghan (AgResearch) and ORC. For ease of use, a series of linked spreadsheets has been developed to enable easy viewing of model outputs, and the report updated to include commentary on potential enhancements/developments for consideration.

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Contents

EXECUTIVE SUMMARY 2

BACKGROUND 6

MODEL OVERVIEW 6

Mitigation options 8

Land use options modelled 9

Catchment data 10

Impact assessments 13

RESULTS 14

FMU comparisons 14

Impact assessments 15

NEXT STEPS 19

APPENDIX 1: MITIGATION OPTIONS 20

Mitigation 1: Crop Buffer strips 20

Mitigation 2: Crop Choice 21

Mitigation 3: Minimal tillage 21

Mitigation 4: Crop Grazing (Best Management Practice - BMP) 21

Mitigation 5: Catch crops 22

Mitigation 6: Stand-off facilities 22

Mitigation 7: Critical Source Area Management 23

Mitigation 8: Soil moisture monitoring and scheduling irrigations 23

Mitigation 9: Convert flood to spray 23

Mitigation 10: Irrigation infrastructure 24

Mitigation 11: Match stock class to Land use capability 24

Mitigation 12: Phosphate – Form and rate applied 25

Mitigation 13: Timing of Nitrogen applications 25

Mitigation 14: Reduce farm nitrogen surplus 25

Mitigation 15: Effluent storage and application 26

Mitigation 16: Riparian planting 26

Mitigation 17: Sediment traps 26

Mitigation 18: Stock crossings 27

Mitigation 19: Stock exclusion (fencing) 27

Mitigation 20: Wetlands 28

APPENDIX 2: LAND USE DATA 29

Catchment data 29

1: Catlin's FMU 32

2: Clutha FMU 33

3: Dunedin and coast FMU 35

4. North Otago FMU 36

5. Taieri FMU 38

6. Dunstan Rohe 39

7. Lower Clutha Rohe 41

8. Manuherekia Rohe 42

9. Roxburgh Rohe 44

10. Upper Lakes Rohe 45

APPENDIX 3: IMPACT ASSESSMENTS 47

Step 1: Check/update the FMU input data 47

Scaling factors 49

Step 2: Estimates the percentage of land affected 50

Steps 3 & 4: Apply the scaling factors and account for reductions in the potential area of land impacted. 51

Step 5: Impact calculations 54

Step 6: Cost calculations **55**

Step 7: Outputs: impact versus cost **56**

Background

The Otago Regional Council (ORC) wishes to develop information around options for improving water quality within the Otago region. As part of this, AbacusBio Ltd, have been contracted to develop a provisional list of mitigation options that could be used to reduce the impacts of Nitrogen(N) leaching, soil loss (Phosphorous (P) and sediment), and Escherichia coli (E. coli) contamination within the Otago region.

This report outlines development of a mitigation model framework to assess the impacts of a range of potential mitigation options.

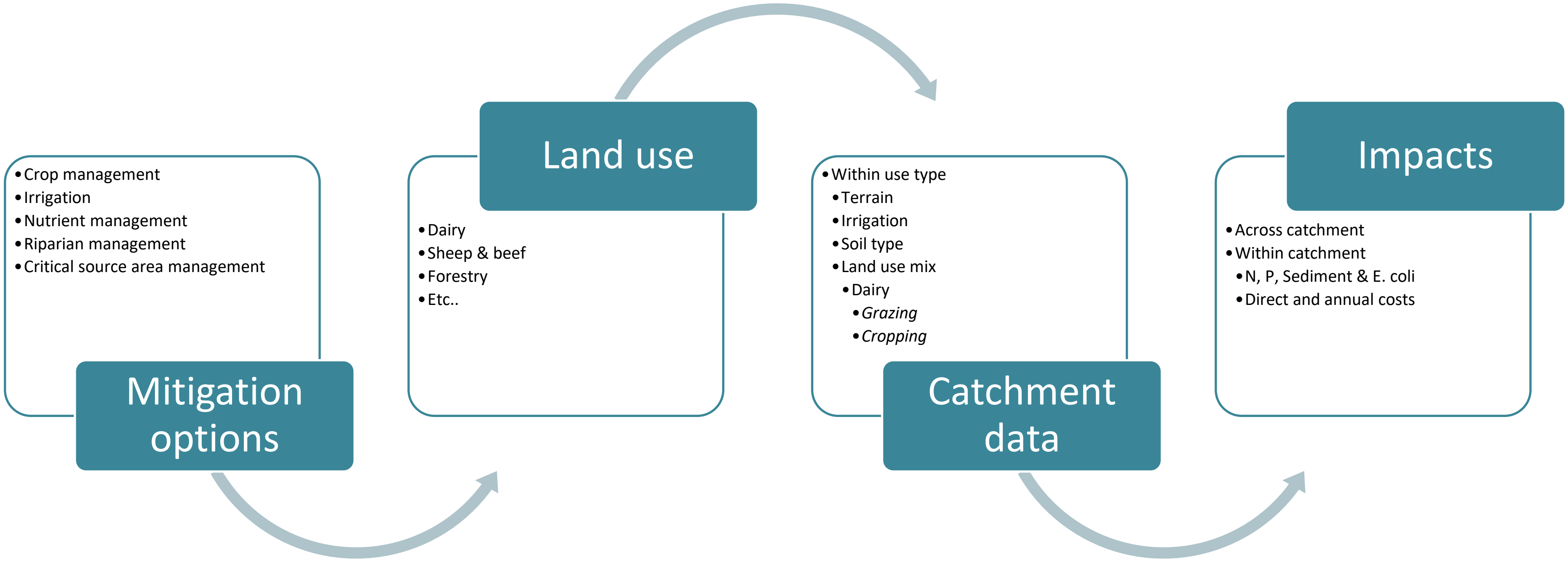
Note that the mitigation model framework has been developed as a hands-on tool to assess the likely impacts of each of the mitigation options within catchment, with detailed farm level models (Overseer, Farmax) required to provide a more accurate impact assessment for individual farms.

Model overview

Figure 1 shows a high-level overview of the ORC mitigation model framework, which is effectively broken up into 4 parts with further information on each of the components provided in the following sections.

1. **Mitigation options:** includes a provisional list of 20 different mitigation options, grouped according to mitigation type.
2. **Land use options**: used to compartmentalise the Freshwater management unit (FMU)/Rohe data into 10 different land use types.
3. **Catchment data:** used to create FMU specific data for each of the 10 land types, according to the average proportion of flat, rolling & steep terrain, drainage (Free draining, drained, poorly drained), area of land irrigated and activity (grazing, cropping, trees).
4. **Impacts:** estimated according to the expected reduction in N, P and sediment loss, and *E.coli* contamination, relative to direct and annual costs of implementation.

Figure 1. High level overview of the ORC mitigation model framework.



Mitigation options

A comprehensive literature review was undertaken to assess a range of mitigation options for use within the framework. Table 1 shows a high-level summary of the 20 mitigation options assessed, grouped according to mitigation type with the key management areas including crop management; critical source area management; irrigation; nutrient and riparian management.

Table 1. Potential mitigation options assessed within the ORC mitigation model framework.

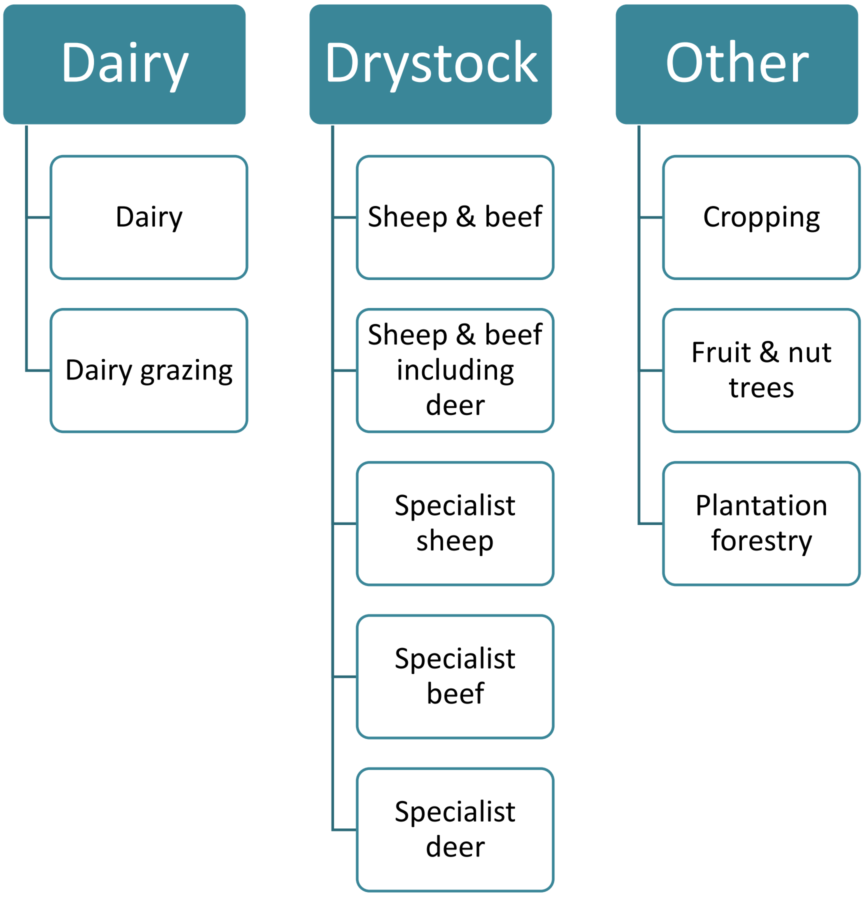
	Management area	Description
M1	Crop management	Crop buffer strips
M2		Crop choice
M3		Minimal tillage
M4		Strategic crop grazing
M5		Catch crops
M6	CSA's	Stand-off facilities
M7		Critical source area management
M8	Irrigation	Soil moisture monitoring / scheduling
M9		Upgrade from flood to efficient irrigation
M10		Irrigation infrastructure
M11	Nutrient management	Match stock class to land use capability
M12		P form and application rate
M13		N surplus reduction
M14		Low-rate N applications
M15		Effluent management
M16	Riparian management	Riparian planting
M17		Sediment traps to filter overland water flows
M18		Suitable stock crossings
M19		Stock exclusion (fencing)
M20		Constructed wetlands

The impacts of each of these options were then assessed according to land use information, with the impacts grouped according to expected reductions in N leaching, soil loss (P and sediment) and E Coli contamination, with these reductions initially assessed using a 1,2,3 system equating to 5%,17% and 25% reductions. These assumptions were then reviewed and refined by Ross Monaghan (AgResearch), with a recommendation from Ross to focus on N leaching and P loss, with further enhancement required to the underlying models used for sediment loss and E Coli contamination. As a result of this, the sediment and E coli models have been retained for use in the high-level outputs only and are not included in the final impact outputs. Further information on mitigation use, reference data and cost for each of the mitigation options provided within Appendix 1.

Land use options modelled

Figure 2 shows a high-level summary of the farming enterprises included within the model, with these options used to describe the primary purpose of the farm, and allowance made for inclusion of grazing, cropping and forestry within each of these farm types. For example, a 'typical' sheep & beef farm in the Catlin's FMU is likely to include a portion of land used for cropping (and supply of winter feed), and potentially a forestry block (that could be exotics or native plantings).

Figure 2. Land use options modelled



With many of the mitigation options impacting on only 1 activity type (for example strategic crop grazing impact on cropping activities but not grazing or forestry), each of the mitigations has been assessed according to likely impacts on farm type, terrain, soil type and activity, where for simplicity soil type has simply been classified as Free draining (e.g. Ngapara), Drained (e.g. Timaru (Pallic), or Poorly drained (e.g. Pallic soils) without artificial drainage.

An example of this is shown in Table 2, where for mitigation 1 (introduction of crop buffers) is likely to result in a small reduction (5%) in P loss on flat Free draining land used for cropping on a dairy farm, whilst the same mitigation is expected to have a much larger impact (25%) on rolling or steep terrain due to a reduction in the amount of soil loss from cropping areas when it rains.

Similar assessment criteria have been assembled for each of the other farm types, with a total of 27 different assessment criteria used over each of the 10 farm types and 20 mitigation options included within the preliminary model (Appendix 2).

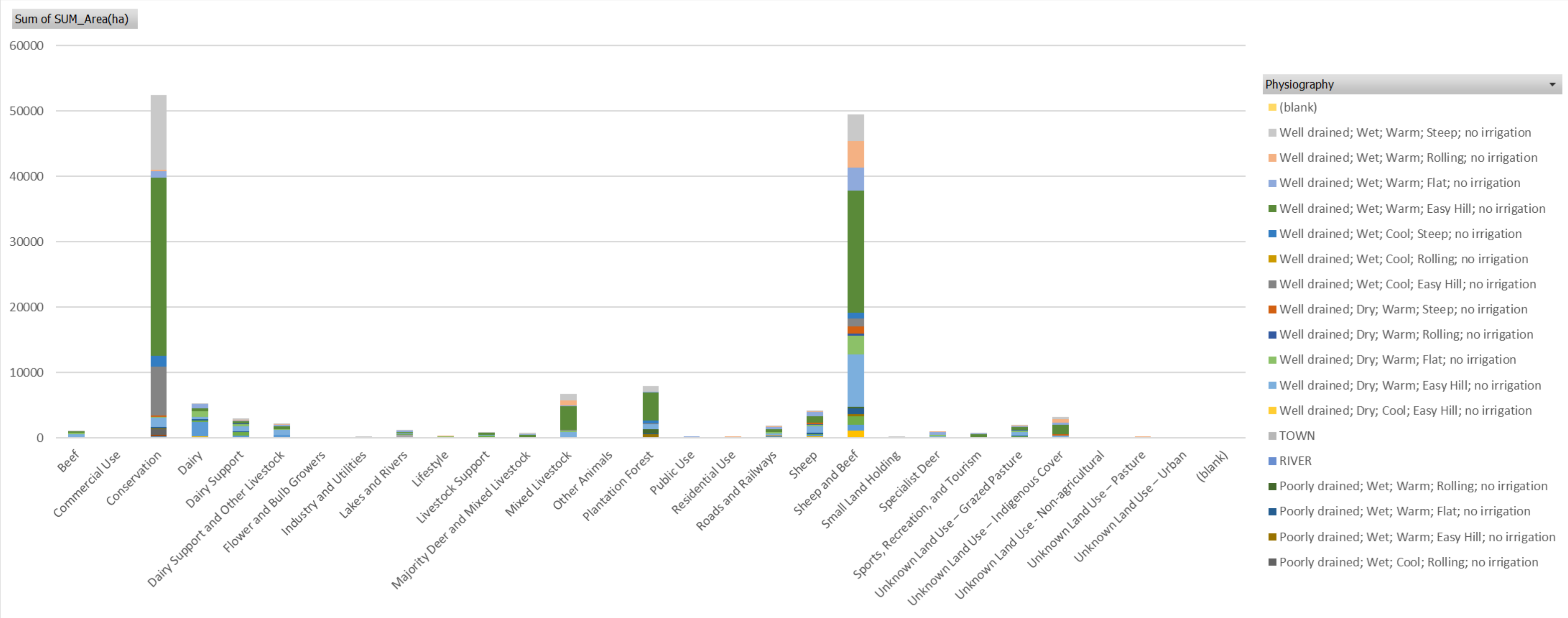
Table 2. Impact assessment criteria for Mitigation 1 (crop buffers), with the highlighting showing expected differences in P loss due to terrain.

	Land use	Terrain type	Soil type	Activity type	Impact rating			
					N	P	S	E. coli
1	Dairy	*Flat*	*Free draining*	*Grazing*	0%	0%	0%	0%
2				*Cropping*	5%	5%	5%	5%
3				*Forested*	0%	0%	0%	0%
4			*Drained*	*Grazing*	0%	0%	0%	0%
5				*Cropping*	5%	5%	5%	5%
6				*Forested*	0%	0%	0%	0%
7			*Poorly drained*	*Grazing*	0%	0%	0%	0%
8				*Cropping*	5%	5%	5%	5%
9				*Forested*	0%	0%	0%	0%
10		*Rolling*	*Free draining*	*Grazing*	0%	0%	0%	0%
11				*Cropping*	5%	25%	25%	25%
12				*Forested*	0%	0%	0%	0%
13			*Drained*	*Grazing*	0%	0%	0%	0%
14				*Cropping*	5%	25%	25%	25%
15				*Forested*	0%	0%	0%	0%
16			*Poorly drained*	*Grazing*	0%	0%	0%	0%
17				*Cropping*	5%	25%	25%	25%
18				*Forested*	0%	0%	0%	0%
19		*Hill*	*Free draining*	*Grazing*	0%	0%	0%	0%
20				*Cropping*	5%	25%	25%	25%
21				*Forested*	0%	0%	0%	0%
22			*Drained*	*Grazing*	0%	0%	0%	0%
23				*Cropping*	5%	25%	25%	25%
24				*Forested*	0%	0%	0%	0%
25			*Poorly drained*	*Grazing*	0%	0%	0%	0%
26				*Cropping*	5%	25%	25%	25%
27				*Forested*	0%	0%	0%	0%

Catchment data

Catchment data has been used to characterise each of the FMUs according to the area of land attributed to each of the 10 land use options included within the model. Summary statistics based on land usage maps created by ORC were used to evaluate land area according to land type and physiography. Figure 3 shows an example of the land-use data provided for the Catlin's FMU, where 39% of land was defined as used for sheep and beef farming, and 36% for conservation. There are also small pockets of land identified as used as dairy, dairy support etc, with a total of 30 land use classifications included within the ORC summary statistics.

Figure 3. Example of the land usage data and physiography for the Catlin's FMU.



To enable this data to be fitted to the model, data was combined to represent the land classes evaluated within the model, with Table 3 showing a summary of data included within the preliminary framework for the Catlin's FMU. With significant variation in the average size and number of properties within each of the land use/physiography groupings, no attempt has been made to classify results on a per farm basis. A full description of the methods used to estimate terrain, irrigation and drainage data provided within Appendix 2.

Table 3. Example of the land use data derived from the ORC summary statistics for the Catlin's FMU.

	Area (ha)	% Irrigated	% Flat	% Rolling	% Steep
Terrain					
Dairy	5,252	0%	77%	22%	2%
Dairy Grazing	5,938	0%	27%	64%	9%
Dry stock (Sheep & Beef)	56,168	0%	15%	73%	12%
Dry stock (including Deer)	-		-	-	-
Specialist sheep	4,174	0%	31%	61%	9%
Specialist Beef	1,092	0%	24%	72%	4%
Specialist Deer	1,685	0%	43%	44%	13%
Cropping	-		-	-	-
Fruit & tree Nuts	-		-	-	-
Plantation Forestry	7,949	0%	3%	81%	17%
Total	82,258	0	20%	68%	12%
Drainage					
Well drained	70,641		66%	71%	13%
Poorly drained	11,564		34%	29%	87%

With no definitive information on activity within each of the different farm types, allowance was then made for expected differences in land use within farm type. Table 4 shows the preliminary assumptions made around activity type (grazing, cropping, forestry) for each of the different farm types where for example, 96% of dairy flat land is assumed to be used for grazing, as opposed to 91% of rolling or easy hill land, with 6% of this land assumed to be used for cropping and 3% for forestry.

Table 4. Preliminary assumptions made around activity with respect to terrain type for each of the different farm type modelled.

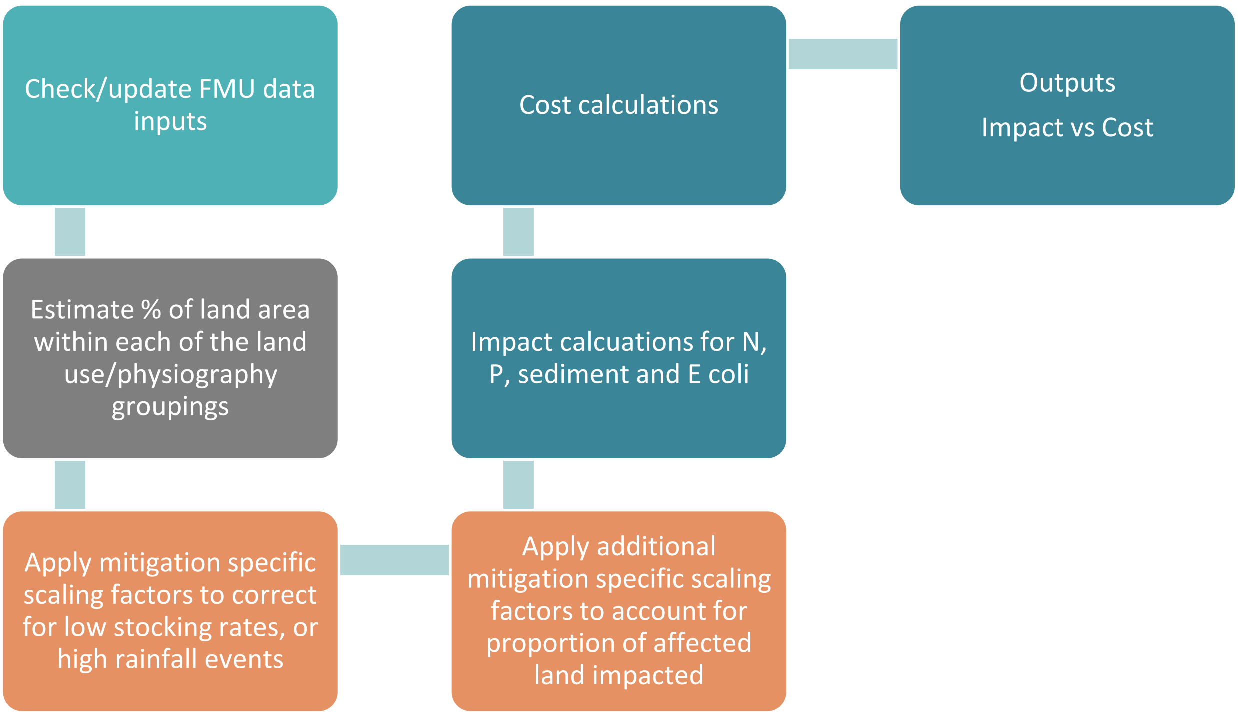
	Flat			Rolling			Hill		
	Grazing	Cropping	Forestry	Grazing	Cropping	Forestry	Grazing	Cropping	Forestry
Dairy	96%	4%	0%	91%	6%	3%	85%	6%	9%
Dairy Grazing	95%	5%	0%	88%	8%	4%	83%	8%	9%
Dry stock (Sheep & Beef)	96%	4%	0%	88%	8%	3%	83%	8%	9%
Dry stock (inc Deer)	96%	4%	0%	88%	8%	3%	83%	8%	9%
Specialist sheep	96%	4%	0%	88%	8%	3%	83%	8%	9%
Specialist Beef	96%	4%	0%	88%	8%	3%	83%	8%	9%
Specialist Deer	96%	4%	0%	88%	8%	3%	83%	8%	9%
Cropping	0%	100%	0%	0%	100%	0%	0%	100%	0%
Fruit & tree Nuts	100%	0%	0%	100%	0%	0%	100%	0%	0%
Plantation Forestry	0%	0%	100%	0%	0%	100%	0%	0%	100%

Impact assessments

Impact assessments for each of the mitigation options were undertaken based on the proportion of land affected within each of the land/use typography categories. Figure 4 shows a high-level overview of the impact assessment process, with a summary of each of the key steps outlined below, and further information (including example calculations) provided within Appendix 3.

1. Ensuring that the land use data for each of the FMU input parameters provides a fair representation of farm types that may benefit from use of one or more of the mitigation options modelled.
2. Estimating the percentage of land within each of the 27 physiography options (terrain, soil type and activity) for each land use type.
3. Evaluate the mitigation specific scaling factors that need to be applied within each evaluation. These scaling factors can be used to account for external factors such as low stock rate or extreme rainfall events that may impact expected mitigation outcomes. It also allows us to customise according to the estimated proportion of area within each FMU/Rohe impacted.
4. Impact calculations for each FMU based on reductions in N leaching, soil loss (P and sediment) and E coli contamination, and cost.

Figure 4. High level overview of the impact assessment process.



Results

FMU comparisons

Figure 5 shows a comparison of land area modelled within each of the FMU/Rohe, with the Clutha / Mat-Au FMU covering all of land included within the Dunstan, Lower Clutha, Manuherekia, Roxburgh and Upper Lakes Rohe, with a full summary (including terrain data) provided within Appendix 2. Figure 6 provides a comparison of land usage, with sheep and beef accounting for 70-90% across the Catlin's, Clutha, North Otago and Taieri FMU, whilst on a proportional basis, Dunedin has significantly more land classified as plantation forestry.

Figure 5. Comparison of land area modelled (hectares) for the Otago FMU/Rohe.

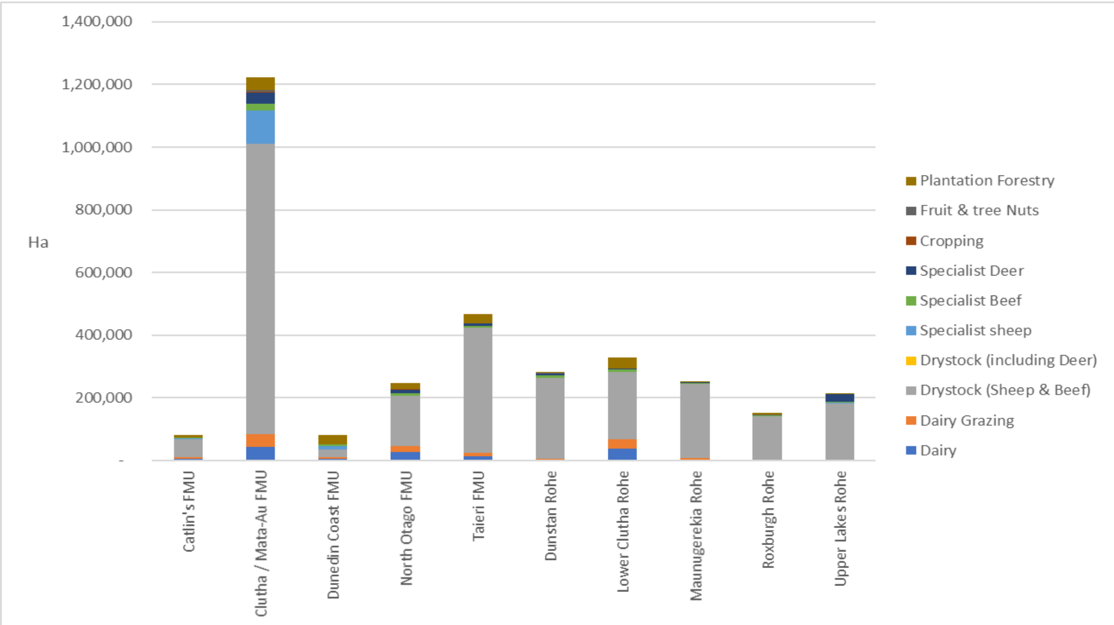
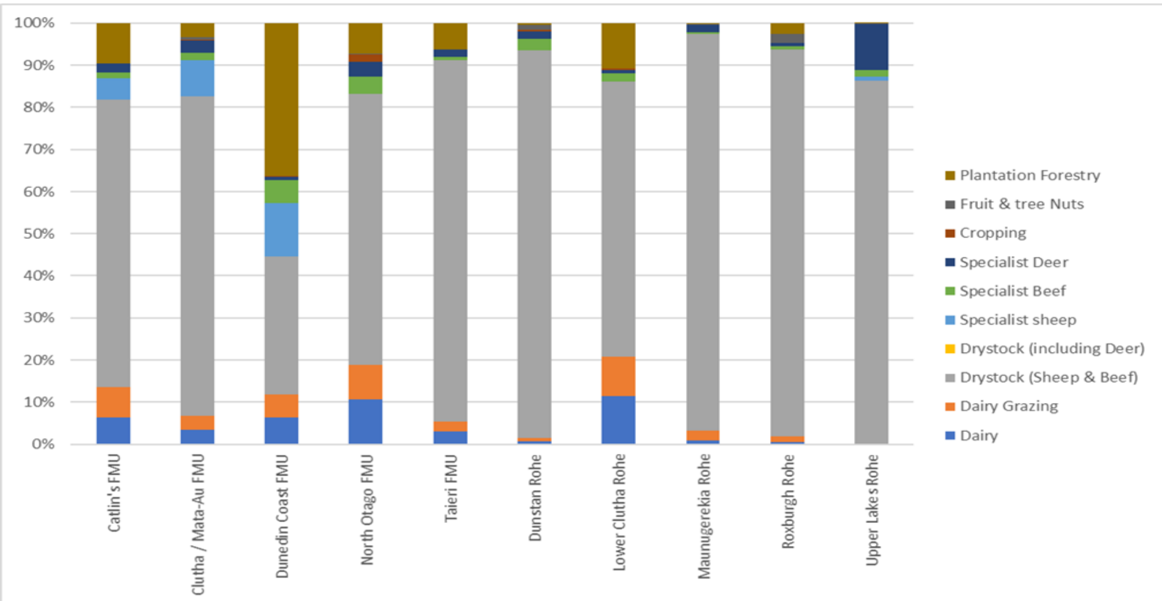


Figure 6. comparison of variability in the total proportion of land included within each of the 10 land use types modelled.



Impact assessments

A range of outputs have been developed to enable comparisons of the impacts of each of the mitigations across land use type and FMUs, including:

Output 1: 'Star ranking' system: for the weighted average impact of each of the mitigation options with the FMU/Rohe, which provides a 'high level' overview of which mitigation options are more effective than others with respect to N, P, Sediment and E coli. Results for the current model set-up are shown in Figure 7 where 1 star reflects a small (<5%) reduction over the entire FMU/Rohe, and 2 stars a moderate reduction (5-17%).

Figure 7. Star rankings as to the average impact of each of the different mitigation options within Otago FMU/Rohe.

Mitigation option		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Crop buffers	Crop choice	Minimal tillage	Crop grazing	Catch crops	Stand off facilities	CSA management	Soil moisture	Irrigation (flood to efficient)	Irrigation (effic)	Managed SR	P form & rate	N surplus reduction	N rate	Effluent management	Riparian planting	Sediment traps	Stock crossings	Fencing	Wetlands
Nitrogen																					
FMU1	Catlin's FMU	•	•	•		•	•					••		•	•	•	•	•	•	•	••
FMU2	Clutha / Mata-Au FM	•	•	•		•	•		•	•	•	••		•	•	•	•	•	•	•	••
FMU3	Dunedin Coast FMU	•	•	•		•	•					••		•	•	•	•	•	•	•	••
FMU4	North Otago FMU	•	•	•		•	•		••	•	•	•		•	•	•	•	•	•	•	••
FMU5	Taieri FMU	•	•	•		•	•		•	•	•	•		•	•	•	•	•	•	•	••
FMU6	Dunstan Rohe	•	•	•		•	•		••	•	•	•		•	•	•	•	•	•	•	••
FMU7	Lower Clutha Rohe	•	•	•		•	•		•	•	•	•		•	•	•	•	•	•	•	••
FMU8	Manuherikia Rohe	•	•	•		•	•		••	•	•	•		•	•	•	•	•	•	•	••
FMU9	Roxburgh Rohe	•	•	•		•	•		•	•	•	••		•	•	•	•	•	•	•	••
FMU10	Upper Lakes Rohe	•	•	•		•	•		•	•	•	••		•	•	•	•	•	•	•	••
Phosphorous																					
FMU1	Catlin's FMU	•		•	•	•	•	••				•	•			•	•	••	•	•	•
FMU2	Clutha / Mata-Au FM	••		•	•	•	•	••	•	•	•	•	•			•	•	••	•	•	•
FMU3	Dunedin Coast FMU	••		•	•	•	•	••				•	•			•	•	••	•	•	•
FMU4	North Otago FMU	••		•	•	•	•	••	••	•	•	•	•			•	•	••	•	•	•
FMU5	Taieri FMU	••		•	•	•	•	••	•	•	•	•	•			•	•	••	•	•	•
FMU6	Dunstan Rohe	••		•	•	•	•	••	••	•	•	•	•			•	•	••	•	•	•
FMU7	Lower Clutha Rohe	••		•	•	•	•	••	•	•	•	•	•			•	•	••	•	•	•
FMU8	Manuherikia Rohe	••		•	•	•	•	••	••	•	•	•	•			•	•	••	•	•	•
FMU9	Roxburgh Rohe	••		•	•	•	•	••	•	•	•	•	•			•	•	••	•	•	•
FMU10	Upper Lakes Rohe	••		•	•	•	•	••	•	•	•	•	•			•	•	••	•	•	•
Sediment																					
FMU1	Catlin's FMU	•		•	•	•	•	••				•						•	•	•	•
FMU2	Clutha / Mata-Au FM	••		•	•	•	•	••	•	••	•	•						•	•	•	••
FMU3	Dunedin Coast FMU	••		•	•	•	•	••				•						•	•	•	••
FMU4	North Otago FMU	••		•	•	•	•	••	••	••	•	•						•	•	•	•
FMU5	Taieri FMU	••		•	•	•	•	••	•	••	•	•						•	•	•	•
FMU6	Dunstan Rohe	••		•	•	•	•	••	••	••	•	•						•	•	•	•
FMU7	Lower Clutha Rohe	••		•	•	•	•	••	•	•	•	•						•	•	•	•
FMU8	Manuherikia Rohe	••		•	•	•	•	••	••	••	•	•						•	•	•	•
FMU9	Roxburgh Rohe	••		•	•	•	•	••	•	••	•	•						•	•	•	••
FMU10	Upper Lakes Rohe	••		•	•	•	•	••	•	•	•	•						•	•	•	••
E Coli																					
FMU1	Catlin's FMU	•		•	•	•	•	••										•	•	•	•
FMU2	Clutha / Mata-Au FM	•		•	•	•	•	••			•							•	•	•	•
FMU3	Dunedin Coast FMU	•		•	•	•	•	••										•	•	•	•
FMU4	North Otago FMU	•		•	•	•	•	••			•							•	•	•	•
FMU5	Taieri FMU	•		•	•	•	•	••			•							•	•	•	•
FMU6	Dunstan Rohe	•		•	•	•	•	••			•							•	•	•	•
FMU7	Lower Clutha Rohe	•		•	•	•	•	••			•							•	•	•	•
FMU8	Manuherikia Rohe	•		•	•	•	•	••			•							•	•	•	•
FMU9	Roxburgh Rohe	•		•	•	•	•	••			•							•	•	•	•
FMU10	Upper Lakes Rohe	•		•	•		•	••			•							•	•	•	•

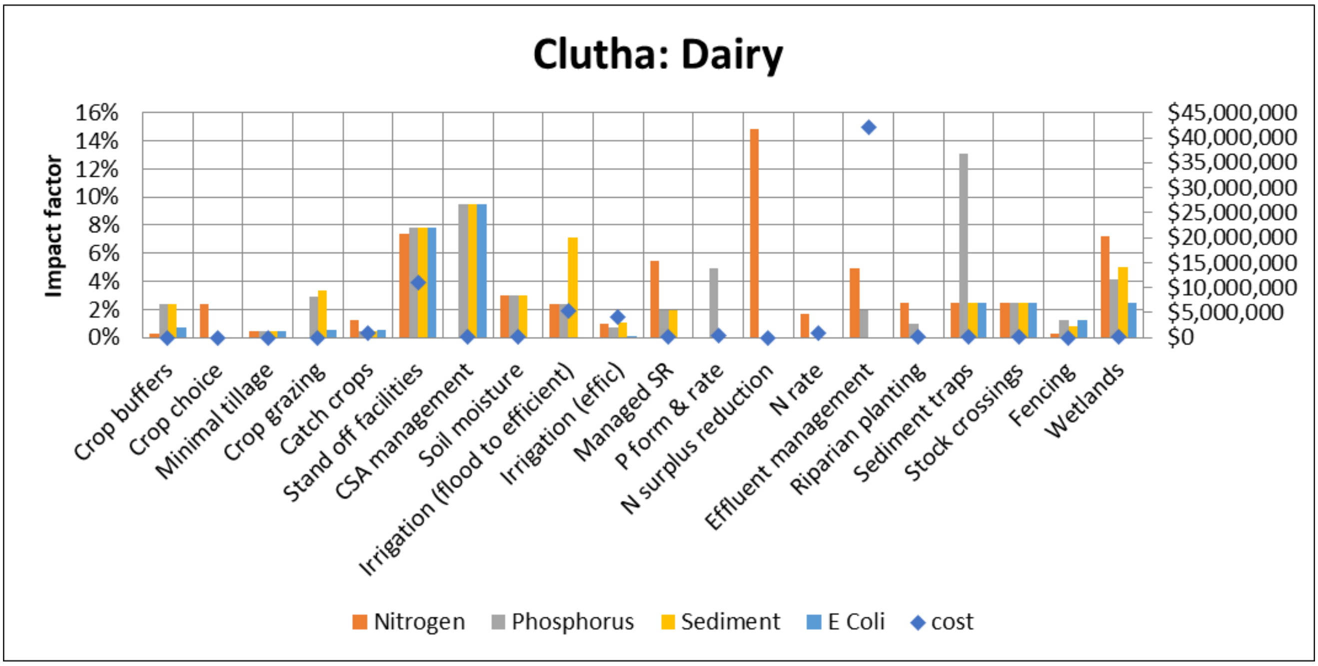
Output 2: Top ranked mitigation by region and enterprise; Similar to output 1, this output has been developed to identify the 'top' mitigation option for any given situation, with the star system adapted to show impact rankings of low (<5% reduction), moderate (5-17% reduction), and high (<17% reduction).

	Catlin's FMU	Clutha / Mata-Au FMI	Dunedin Coast FMU	North Otago FMU	Taieri FMU	Dunstan Rohe	Lower Clutha Rohe	Manuherikia Rohe	Roxburgh Rohe	Upper Lakes Rohe
Dairy						Dairy				
Nitrogen	N surplus reduction: Mod	N surplus reduction: Mod	N surplus reduction: Mod	Soil moisture: High	N surplus reduction: Mod	Soil moisture: High	N surplus reduction: Mod	Soil moisture: High	N surplus reduction: Mod	0: 0
Phosphorous	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Soil moisture: High	Sediment traps: Mod	Soil moisture: High	Sediment traps: Mod	Soil moisture: High	Sediment traps: Mod	0: 0
Sediment	CSA management: Mod	CSA management: Mod	CSA management: Mod	Irrigation (flood to efficie	Irrigation (flood to efficien	Irrigation (flood to efficie	CSA management: Mod	Irrigation (flood to efficie	Irrigation (flood to efficien	0: 0
E coli	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	0: 0
Dairy Grazing										
Nitrogen	Managed SR: Mod	Managed SR: Mod	Wetlands: Mod	Managed SR: Mod	Stand off facilities: Mod	Soil moisture: Mod	Wetlands: Mod	Soil moisture: Mod	Stand off facilities: Mod	Managed SR: Mod
Phosphorous	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Soil moisture: Mod	Sediment traps: Mod	Soil moisture: Mod	Sediment traps: Mod	Sediment traps: Mod
Sediment	CSA management: Mod	Irrigation (flood to efficien	CSA management: Mod	Irrigation (flood to efficie	CSA management: Mod	Irrigation (flood to efficie	CSA management: Mod	Irrigation (flood to efficie	CSA management: Mod	Stand off facilities: Mod
E coli	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	Stand off facilities: Mod
Drystock (Sheep & Beef)										
Nitrogen	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod
Phosphorous	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod
Sediment	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod
E coli	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod
Drystock (including Deer)										
Nitrogen	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0
Phosphorous	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0
Sediment	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0
E coli	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0
Specialist sheep										
Nitrogen	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	Managed SR: Mod
Phosphorous	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	Sediment traps: Mod
Sediment	CSA management: Mod	CSA management: Mod	CSA management: Mod	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	CSA management: Mod
E coli	CSA management: Mod	CSA management: Mod	CSA management: Mod	0: 0	0: 0	0: 0	0: 0	0: 0	0: 0	CSA management: Mod
Specialist Beef										
Nitrogen	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Wetlands: Mod	Wetlands: Mod	Managed SR: Mod	Wetlands: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod
Phosphorous	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod	Sediment traps: Mod
Sediment	CSA management: Mod	CSA management: Mod	CSA management: Mod	Irrigation (flood to efficie	CSA management: Mod	CSA management: Mod	CSA management: Mod	Irrigation (flood to efficie	CSA management: Mod	CSA management: Mod
E coli	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod	CSA management: Mod
Specialist Deer										
Nitrogen	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod	Managed SR: Mod
Phosphorous	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High
Sediment	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High
E coli	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High	CSA management: High
Cropping										
Nitrogen	0: 0	Catch crops: High	Catch crops: High	Catch crops: High	Catch crops: High	Catch crops: High	Catch crops: High	Catch crops: High	Catch crops: High	Catch crops: High
Phosphorous	0: 0	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High
Sediment	0: 0	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High	Crop buffers: High
E coli	0: 0	Crop buffers: Mod	Crop buffers: Mod	Crop buffers: Mod	Crop buffers: Mod	Crop buffers: Mod	Crop buffers: Mod	Crop buffers: Mod	Crop buffers: Mod	Crop buffers: Mod
Fruit & tree Nuts										
Nitrogen	0: 0	Soil moisture: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Soil moisture: Mod	Soil moisture: Mod	Wetlands: Mod
Phosphorous	0: 0	Soil moisture: Mod	Wetlands: Mod	Soil moisture: Mod	Wetlands: Low	Soil moisture: Mod	Wetlands: Low	Soil moisture: Mod	Soil moisture: Mod	Wetlands: Low
Sediment	0: 0	Irrigation (flood to efficien	Wetlands: Mod	Irrigation (flood to efficie	Irrigation (flood to efficien	Irrigation (flood to efficie	Wetlands: Low	Irrigation (flood to efficie	Irrigation (flood to efficien	Wetlands: Low
E coli	0: 0	Wetlands: Low	CSA management: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low
Plantation Forestry										
Nitrogen	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod
Phosphorous	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low
Sediment	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Mod	Wetlands: Low	Wetlands: Mod	Wetlands: Low	Wetlands: Mod	Wetlands: Mod
E coli	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low	Wetlands: Low

Output 3: Comparison of impact versus cost within each of the FMU/Rohe; where impact is assessed as the estimated % reduction in N, P, Sediment or E coli (assuming 100% adoption), and cost as the total annualised regional cost of implementation and management (over 10 years).

Figure 8 shows an example of this, where the total annualised costs of developing effluent management systems for dairy cows in the Clutha FMU has been estimated at $42m and expected to result in a 5% reduction in N leaching, and 2% reduction in P loss. In contrast, improvements in Nitrogen surplus reduction, could result in substantive improvements in nitrogen leaching at very little or no costs to farmers, but additional mitigation procedures would be required to reduce the impacts of P and sediment loss, and E Coli contamination.

Figure 8. Comparison of impact versus cost for each of the 20 different mitigation options on dairy farms within the Clutha FMU.

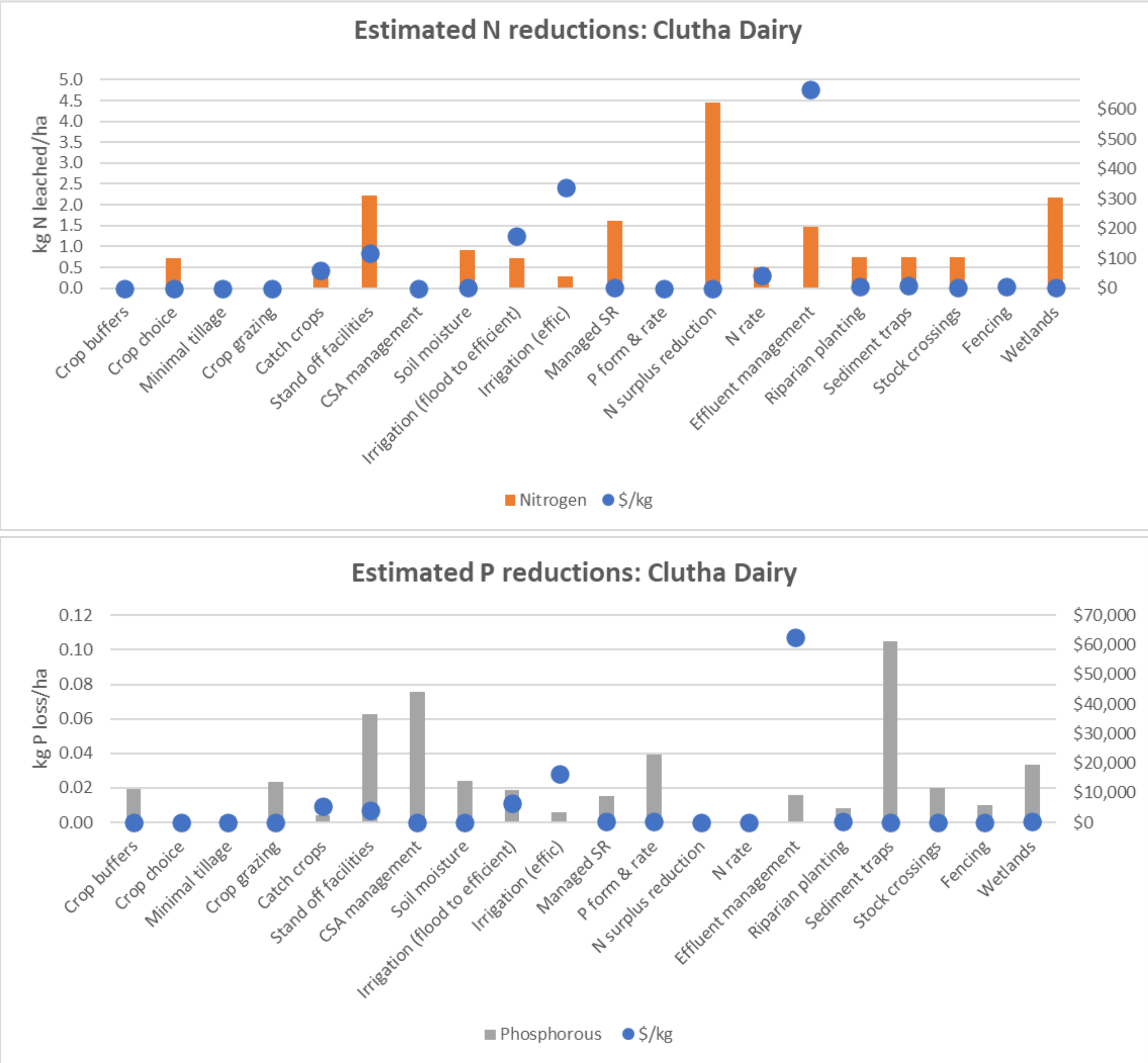


Output 4: Comparison of reductions in N leaching, & phosphorous loss (kg/ha) relative to the costs of implementation; where base levels of N and P loss for each of the farm enterprises are used to model expected losses per ha and used to estimate costs per kg of N or P loss mitigated.

Figure 9 shows an example of these outputs for dairy farms within the Clutha FMU, where the base level of Nitrogen leached is assumed to be 30 kg/ha, compared to P loss at 0.8 kg/ha (see Appendix 3). This results in a 38-fold difference in impact versus cost, where using standoff facilities as an example, estimated impact versus cost can be calculated as:

- Estimated reduction N leaching = 7% reduction * 30 kg/ha = 2.1 kg/ha
  - Estimated cost = $525 /2.1 * 21,098 /42,735 ha = $116/kg
- Estimated reduction P loss = 8% reduction * 0.8 kg/ha = 0.06 kg/ha
  - Estimated cost = $525 /0.06 * 21,098 /42,735 ha = $4,141/kg

Figure 9. Comparison of the estimated impact relative cost per kg mitigated.



For ease of use, a series of linked spreadsheets has been developed to enable easy viewing of model inputs and outputs:

1. ORC mitigation model inputs.xls contains 3 separate worksheets including:
    a. **Mitigation Matrix** used to drive the impact assumptions with respect to land use, terrain, soil type and activity.
    b. **FMU inputs** used to characterise the catchment data with respect to land use, terrain, soil type and activity.
    c. **Scaling factors** used to account for variations in the percentage of farm area that may be affected. For example, whilst the mitigation options could apply to any of the livestock or crop system modelled, irrigation data has been used to limit the impacts of irrigation related mitigation options (M8, M9 & M10). Mitigations such as stock exclusion which have a large impact but are 95% implemented already (Dairy, dairy support) will have very little impact overall.

2. **FMU outputs.xls** – contains results for each of the 10 FMU/Rohe, including the FMU impact cost outputs (as shown in Figure 8 above), and the costs of mitigation for N/P per kg reduction (Figure 9).
3. **Enterprise comparisons.xls** – shows comparisons of the the N/P per kg reduction outputs for each of the FMU/Rohe by enterprise.
    a. Note that results have been sorted by irrigation status (irrigated/not irrigated) and results scaled to enable direct comparisons.

Next steps

As this project has developed, the model framework has become significantly more complex than originally intended, and a degree of skill required to ensure that the model inputs provide an accurate characterisation of both the FMU inputs and expected impacts within any given farm system and FMU/Rohe. There is also a degree of uncertainty around the accuracy of values included within the 'mitigation matrix' with these based on a mixture of published reference information, and 'feet on the ground' knowledge.

Whilst every effort has been made to ensure that the initial outputs (developed for industry consultation) are a good reflection of the likely impacts of adoption with each of the farm systems & FMU/Rohe modelled, care is required in interpretation. AbacusBio is happy to provide additional technical support, if necessary (including participation in industry meetings), and have also developed a brief list of potential enhancements for consideration:

1. Further development of the Sediment and E coli models (including additional input data) to provide a more accurate reflection of potential mitigation outcomes.
2. Development of a 'stacking model' to assess the likely impacts of adoption of multiple mitigation options at once
3. Development of an adoption framework, to evaluate the potential scale of reductions over time
4. Development of a user-friendly R-shiny model application which can be used by wider industry, with the existing excel framework used for development and testing purposes only.

Appendix 1: Mitigation options

A summary of assumptions made around each of the mitigation options and impact factors (IF) include within the provisional model is provided below, along with reference information and cost assumptions.

Note that:

1. Results are filtered to remove data for mitigation options that have no impact on any given land use/slope/soil type/activity option.
2. No attempt has been made to estimate indirect 'lost opportunity' costs of any of the mitigation options. For example, inclusion of crop buffer strips may reduce the amount of land available for crop production, but costs on based on use of the buffer strips only, with no allowance made for lost production

Mitigation 1: Crop Buffer strips

Typical usage	Typically requires temporary fencing for duration of crop grazing, then re-grassed back into permanent pasture after crop. Most benefit for plantation forestry at harvest and during establishment – 5ys
Reference	Report 040600 – Land use impacts, Nitrogen, Phosphorous Loss management options intervention + Mitigating nutrient loss – Horizons Waikato regional council – farm menu
Setup Costs	Minimal cost, normally temporary fencing for duration of crop, then re-grassed back into permanent pasture after crop - plantation forestry during establishment
Annual costs	Depending on the paddock, buffer strip costs will be incurred each year of cropping. Dairy, dairy grazing, beef, cropping, forestry – No cost S&B, sheep rolling/steep country - We have assumed that a 100m buffer strip will influence 20Ha of area and will cost $1000/Ha to complete resulting in $50/Ha
Scale factor	Scale factor = 1: all qualifying land expected to be benefit from the mitigation

Mitigation 2: Crop Choice

Typical usage	Fodder beet instead of Kale to lower N urinary deposition, (lower N content of feed eaten)
Reference	Waikato District Council farm menu
Setup Costs	Negligible – more expensive to sow but FB higher yielding per hectare than Kale.
Annual costs	assumed to be $0
Scale factor	Scale factor = 1: all qualifying land expected to be benefit from the mitigation

Mitigation 3: Minimal tillage

Typical usage	Refers to cultivation techniques that do not involve ploughing. Minimises soil disturbance and reduces risk of phosphate and sediment loss during re-grassing and cropping. Where conventional cultivation is replaced by direct drilling results in less soil disturbance reducing erosion risk.
Reference	Report 040600 - Land use impacts Nitrogen Phosphorous Loss Management Options Intervention Waikato regional council – farm menu
Setup Costs	Normally results in reduced cultivation costs. Usually reduces cultivation costs but can result in more variable yields
Annual costs	Assumed to be Nil
Scale factor	Scale factor = 1: all qualifying land expected to be benefit from the mitigation

Mitigation 4: Crop Grazing (Best Management Practice - BMP)

Typical usage	When BMP is followed with grazing stock on winter/summer crop paddocks. Stock grazed downhill and away from critical source areas. Back fencing is used to minimise soil disturbance and buffer strips are left un-grazed near water ways etc.
Reference	Mitigating Nutrient Loss - Horizons Waikato regional council – farm menu
Setup Costs	Greater requirement for labour and temporary water supply. For this we have allowed a small upfront cost of $20 per ha of cropped area to purchase fencing and portable troughs.
Annual costs	Additional time to fence and back fence as well as shift the water supply and trough is estimated at $20 per hectare of grazed crop each year for all land use types.
Scale factor	Scale factor = 1: all qualifying land expected to be benefit from the mitigation

Mitigation 5: Catch crops

Typical usage	Grass or cereal sown after winter grazing to reduce nitrogen loss to ground and surface water. Also reduces sediment and P loss to open waterways.
Reference	Erosion & Sediment Control Guidelines for Vegetable Production; Report 040600 - Land use impacts Nitrogen Phosphorous Loss Management Options Intervention Waikato regional council – farm menu
Setup Costs	Extra cultivation / seed required annually
Annual costs	Incurred each year as a mitigation and will vary depending on the area cropped. We have allowed a cost of $450/Ha being the cost to cultivate and sow the impacted area for all land use types. Might not be practical for all situations eg, poorly drained soils
Scale factor	Scale factor = 1: all qualifying land expected to be benefit from the mitigation

Mitigation 6: Stand-off facilities

Typical usage	Constructed stand-off facilities for cattle to use when paddocks are water-logged. We have assumed that these facilities are used by dairy farmers only.
Reference	Mitigating Nutrient Loss - Horizons Waikato regional council – farm menu
Setup Costs	Cost will depend on the type of structure, but predominately used for dairy farms. The set-up costs are $500 -$2500 per cow. For this exercise we have used $1,500/ha based on 3 cows per ha, total setup cost of $4,500/Ha.
Annual costs	Some cleaning, nutrient spreading, and maintenance cost will be incurred annually, estimated at $75/ha/yr
Scale factor	Scale factor: dairy = 0.5 for dairy and 0.1 for all other stock types (very low use of stand-off pads in the dry stock sector)

Mitigation 7: Critical Source Area Management

Typical usage	Minimising stock access to CSA's through high-risk periods when soils are water-logged.
Reference	Mitigating Nutrient Loss - Horizons; Dairy New Zealand - Mitigations and options; Nutrient Limits - making money when the rules change Waikato regional council – farm menu
Setup Costs	Minimal labour and temporary fencing costs.
Annual costs	Generally, minimal labour costs to shift animals when weather conditions are poor. Labour costs are recurring unless areas are permanently fenced which we have included in fencing – stock exclusion.
Scale factor	Scale factor = 1: all qualifying land expected to be benefit from the mitigation

Mitigation 8: Soil moisture monitoring and scheduling irrigations

Typical usage	Adjust irrigation applications based on soil moisture levels. Avoids saturation of soil to minimise risk of erosion and leaching
Reference	Reducing nutrient losses through improving irrigation efficiency -Aqualinc
Setup Costs	Main cost associated with soil monitoring technology to aid irrigation scheduling. The ability to measure soil moisture requires investment in monitoring devices which often have annual subscription charges. We have estimated $45/Ha to monitor soil moisture. We have not accounted for upgrading irrigation infrastructure.
Annual costs	Minimal – assume $8/Ha for annual subscriptions for all land use under irrigation.
Scale factor	Scale factor = 1: all qualifying land expected to be benefit from the mitigation

Mitigation 9: Convert flood to spray

Typical usage	Install spray irrigation to replace flood or border dyke to improve water use efficiency and minimise overland flow and nitrogen leaching
Reference	Reducing Nutrient losses through improving irrigation efficiency -Aqualinc
Setup Costs	$8000/ha - cost to convert from Duke to spray irrigation on flat land
Annual costs	$250/ha power and maintenance
Scale factor	Scale factor = the proportion of land irrigated within each of the land use models (based on the ORC summary statistics)

Mitigation 10: Irrigation infrastructure

Typical usage	A broad category relating to investing in irrigation upgrades allowing for more efficient application of water resulting in less drainage and run off
Reference	REDUCING NUTRIENT LOSSES THROUGH IMPROVING IRRIGATION EFFICIENCY - Aqualinc
Setup Costs	Changes to irrigation infrastructure are often considerable and are undertaken with an expectation of growing additional feed per unit of water applied. upgrading to pivot or solid set irrigation on Rolling Hills can be $8,000/ha and $14,000/ha respectively. We have used $10,000/Ha as a mid-range cost
Annual costs	We have not considered that the ongoing cost would be any different from existing irrigation infrastructure
Scale factor	Scale factor = the proportion of land irrigated within each of the land use models (based on the ORC summary statistics)

Mitigation 11: Match stock class to Land use capability

Typical usage	Particularly in mixed livestock enterprises where some grazing areas will not be suitable for some stock classes, particularly where known behaviour issues exist – eg wallowing deer. We have assumed that one stock class is replaced with an alternative class that will have a lower impact. Some land classes are excluded as the land class is assumed as suitable for any stock class I.e. flat land. Changing land use for an entire farm has not been considered with this mitigation.
Reference	Dairy New Zealand - Mitigations and options
Setup Costs	Will be situation dependent but usually low cost. In some situations this will require a system re-think. We are assuming most mixed livestock enterprises will reassess suitable stock grazing areas for each stock class, therefore there would be minimal cost to implement.
Annual costs	We have assumed that overall there is no ongoing financial impact
Scale factor	Scale factor = 1: all qualifying land expected to be benefit from the mitigation

Mitigation 12: Phosphate – Form and rate applied

Typical usage	Monitor and adjust applications according to requirement including consideration of fertiliser solubility (RPR). Significant dairy land has phosphate levels exceeding requirement for optimal growth which increases risk to water quality.
Reference	Dairy New Zealand - Mitigations and options Waikato regional council – farm menu
Setup Costs	Unknown – depends on fertiliser history. For this mitigation we assume that Olsen P is near optimal overall and the cost incurred is additional testing which we have allowed an additional $2000/200Ha (dairy/dairy grazing) or $10/Ha and $2000/500Ha or $4/Ha other land use.
Annual costs	Additional testing but can save fertiliser costs.
Scale factor	Scale factor = 1 for dairy where P levels are high and 0.3 for all dry stock land expected to be benefit from the mitigation

Mitigation 13: Timing of Nitrogen applications

Typical usage	Applying nitrogen when the soil and plant environment is best suited to promote pasture growth. Minimise in cold/wet or hot/dry conditions. Reducing or eliminating applications when temperature limits growth, lowering leaching risk. Also relates to hot dry conditions where volatilisation risk is high.
Reference	Mitigating Nutrient Loss - Horizons Waikato regional council – farm menu
Setup Costs	No cost but feed shortfalls will need to be managed in other ways
Annual costs	No cost
Scale factor	Scale factor = 1 for dairy, and 0.3 for all other livestock models

Mitigation 14: Reduce farm nitrogen surplus

Typical usage	Reduce total amount of nitrogen applied. We are assuming a 20% reduction in N applied over a season
Reference	Mitigating Nutrient Loss - Horizons; Dairy New Zealand - Mitigations and options
Setup Costs	For this mitigation we are assuming a lower total amount of nitrogen is used through a season for the average farm. Dry stock operations tend to use little and often no nitrogen fertiliser, therefore, this mitigation only applies to dairy and dairy support.
Annual costs	Likely to result in an increase in feed cost (570KgDM/ha at 30c) $171/ha
Scale factor	Scale factor = 1 for dairy/dairy support

Mitigation 15: Effluent storage and application

Typical usage	Increasing storage (90 days) and decreasing application rates provide more flexibility with effluent management. It will significantly reduce risk of ponding and effluent runoff to water ways during wet weather or busy periods on farm. Provides more "safe days" for effluent application.
Reference	Waikato regional council – farm menu
Setup Costs	Increasing effluent storage can be a large cost ($200K or $1000/ha)
Annual costs	No ongoing costs other than general R & M
Scale factor	Scale factor = 1: all qualifying land expected to be benefit from the mitigation

Mitigation 16: Riparian planting

Typical usage	Stabilise and support stream banks – reducing erosion risk.
Reference	Report 040600 - Land use impacts Nitrogen Phosphorous Loss Management Options Intervention; Mitigating Nutrient Loss - Horizons Waikato regional council – farm menu
Setup Costs	$6000 per Ha based on typical native plant cost. Assume that 100m x 3m of riparian planting (300m2) influences 50Ha of catchment, with an effective cost of $36/ha. This will vary by site as will the need to include exclusion fencing (excluded from cost)
Annual costs	We allow for a small annual cost ($4/ha) to maintain the planted area and keep weed free.
Scale factor	Scale factor = 0.5: 50% of qualifying land expected to be benefit from the mitigation

Mitigation 17: Sediment traps

Typical usage	Constructed sediment trap to catch sediment/nutrients prior to entering a receiving waterway.
Reference	Mitigating Nutrient Loss - Horizons; Stocktake of diffuse pollution attenuation tools for New Zealand pastoral farming systems, NIWA Waikato regional council – farm menu
Setup Costs	We are assuming that each sediment trap will influence 10ha for dairy/dairy support and 30ha for other with the main cost being digger time to excavate trap - 4hrs at $200/hr
Annual costs	Need to be excavated to remain effective. We have anticipated 1hr of cleaning every 4 years ($5/ha dairy, $2/ha other)
Scale factor	Scale factor = 0.5 with 50% of qualifying land expected to be benefit from the mitigation

Mitigation 18: Stock crossings

Typical usage	Includes provision of infrastructure to allow stock and vehicles to cross waterways without entering the water. Relates to point source issues primarily, and as a result has a weak overall impact.
Reference	Riparian characteristics of pastoral waterways in the Waikato Region, 2002-2017;
Setup Costs	High – structures need to meet H&S requirements. Also note that smaller waterways tend to have lower cost crossings per m of length. With simple culvert crossings we have assumed $5,000 to construct and assumed these to be the most prevalent form of stock crossing on farms. Given the stage of development we also assume that most basic stock and vehicle crossings are already in place for dairy farms. We have assumed that one stock crossing is constructed for every 100ha of farmed land at $5000/crossing ($50/ha) for all land use.
Annual costs	Nil – low maintenance only
Scale factor	Scale factor = 0.5: 50% of qualifying land expected to be benefit from the mitigation

Mitigation 19: Stock exclusion (fencing)

Typical usage	Fencing water ways (ditches, drains, creeks, rivers, CSA's ponds and lakes) to prevent access from farm animals. Stock cause significant erosion of soil (sediment) when entering water ways and contribute to direct e-coli contamination. Fencing to exclude stock access to waterways. We have not included the additional cost to reticulate water to livestock, but this is an important consideration.
Reference	Waikato Regional Council farm menu
Setup Costs	Cost of fencing were estimated according to the average costs of non- electric wire fencing for sheep & cattle, and netting boundary fences for deer[1]. The stock exclusion scaling factor is then used to account for the proportion of land impacted (i.e. already fenced), and the per metre fencing costs then converted to per hectare equivalents assuming 100 m of fencing is required per 50 ha(Table 5). With each of the FMUs, fencing costs are calculated according to the average proportions of flat Rolling and steep land within each of the land use models, with the average costs of fencing (across all land types) estimated at $28.76/ha.
Annual costs	Annual maintenance costs have been estimated at $8/ha (all stock types)
Scale factor	Scale factor = 0.05 for dairy, 0.2 for sheep and beef, and 0.4 for deer, with 95%, 80% & 60% of qualifying land respectively expected to have existing fencing

[1] Ministry for Primary Industries, Stock Exclusion Costs Report: MPI Technical Paper No: 2017/11

Table 5. Average fencing costs used within the model.

Terrain	Dairy		Sheep & cattle		Deer	
	$/m	$/ha	$/m	$/ha	$/m	$/ha
Flat	$4.67	$9.34	$13.02	$26.04	$18.90	$37.80
Rolling	-		$13.66	$27.32	$19.68	$39.36
Steep	-		$16.64	$33.28	$22.71	$45.42

Mitigation 20: Wetlands

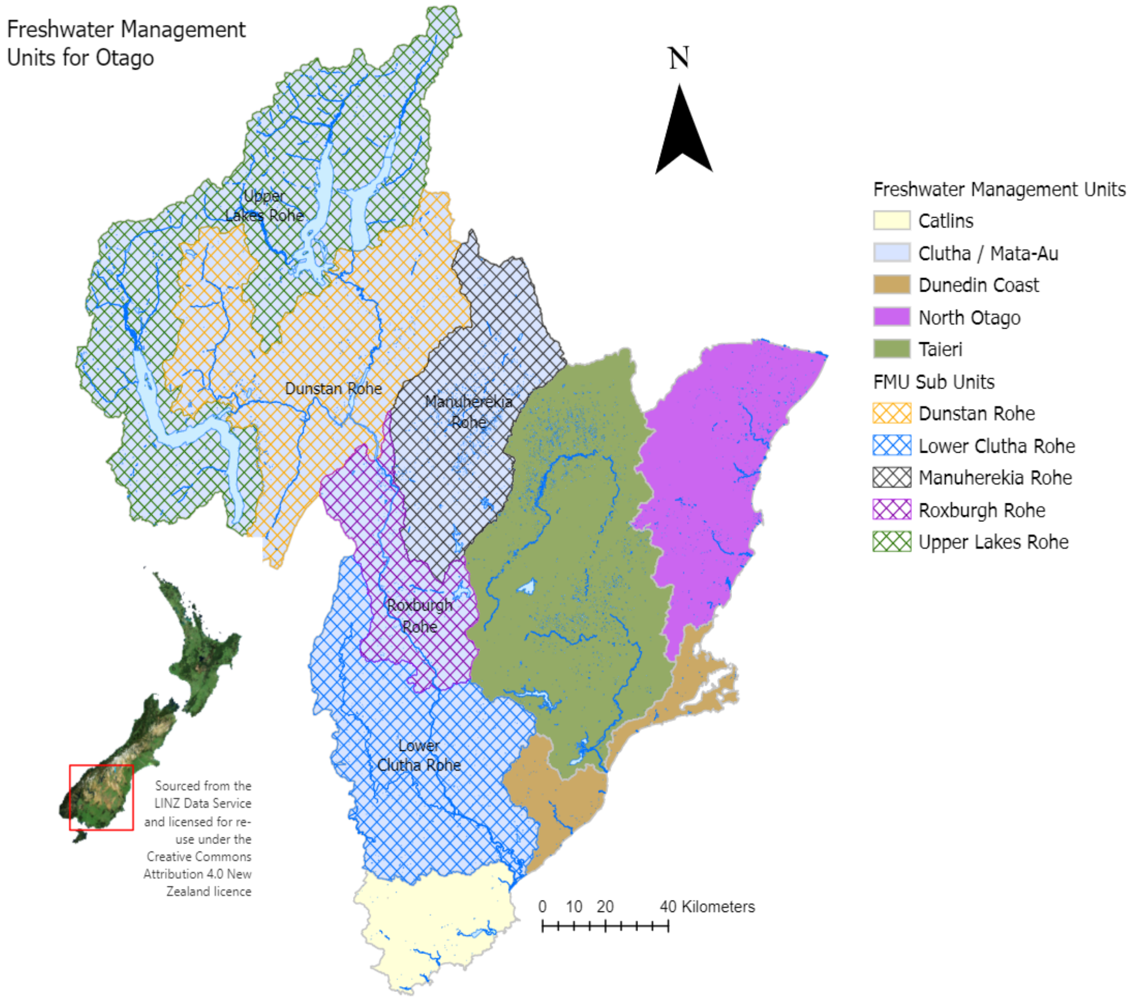
Typical usage	Fencing off natural low land wet areas which act to filter a large catchment area. Removes sediment and nutrients prior to entering sensitive water ways. All situations where wetlands are constructed to allow a reduction in nutrient and sediment passage to a receiving waterway. Includes the option to take tile and mole drain flows and reduce Nitrate concentration through reduction processes
Reference	Mitigating Nutrient Loss - Horizons; Waikato Regional Council – farm menu
Setup Costs	Fencing and planting of wetland area to provide effective filtering capability for water flowing through the catchment Planning and excavation to achieve the desired mitigation – estimated at $4000 of excavation time (25hrs) and $1000 of planning per wetland which will influence 50Ha. Fencing and planting will be required in most cases so we have allowed a further $2000 per wetland, resulting in an estimates implementation costs of $140/ha
Annual costs	We have not allocated any additional costs
Scale factor	Scale factor = 0.5 with 50% of qualifying land expected to be benefit from the mitigation

Appendix 2: Land use data

Catchment data

Catchment data has been used to characterise each of the FMUs according to the area of land attributed to each of the 10 land use options included within the model. Figure 10 outlines the geographic locations of each of the freshwater management units included within the model, with summary statistics based on land use maps created by ORC used to evaluate land area according to land type and physiography.[2]

Figure 10. Freshwater Management Units/Rohe for Otago.



A brief data summary for each FMU is outlined below, where data from relevant land classes has been 'fitted' to the 10 farm use types included within the model. Table 6 shows a summary of the mapping process used with 18 of the 30 land classes included within the ORC data sets excluded from the model. The remaining 12 land classes have then been combined into 8 of the 10 land use types, with a full summary of the catchment data for each of the FMUs provided in the following section.

[2] Otago Regional Technical Methodology Document: Prepared by Tapuwa Marapara, 3 May 2021

Table 6. Conversion table used to map ORC summary data into the land use types included within the model

ORC land use statistics	Cropping	Dairy	Dairy Grazing	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Specialist sheep	Fruit and nut trees	Other
Arable	X									
Beef						X				
Commercial Use										X
Conservation										X
Dairy		X								
Dairy Support			X							
Dairy Support & Other Livestock			X							
Flower and Bulb Growers										X
Horticulture										X
Industry and Utilities										X
Lakes and Rivers										X
Lifestyle										X
Livestock Support			X							
Majority Deer and Mixed Livestock							X			
Mixed Livestock				X						
Nurseries, Orchards, and Vineyards									X	
Other Animals										X
Plantation Forest					X					
Public Use										X
Residential Use										X
Roads and Railways										X
Sheep								X		
Sheep and Beef				X						
Small Land Holding										X
Specialist Deer							X			
Sports, Recreation, and Tourism										X
Unknown– Grazing Pasture										X
Unknown– Indigenous Cover										X
Unknown - Non-agricultural										X
Unknown– Pasture										X
Unknown– Urban										X

Physiography data was then used to estimate the proportion of land within each of the different farm types, classified as flat, Rolling, or steep Hill land, and soil type with respect to drainage. Table 7 shows a summary of how the ORC physiography data was mapped to classifications used within the model, where the proportion of flat, Rolling and steep Hill land was calculated within land use groups (dairy sheep & beef etc), whilst drainage was assessed for the catchment as a whole (excluding land used for conservation and 'other' non-farming activities). Irrigation status was also used to determine the proportion of land that is irrigated, versus not irrigated and could benefit from the irrigation interventions.

Table 7. Apportioning of the ORC physiography categories, to categories used within the provisional mitigation model

ORC classification	Model classification		
terrain (by land usage)	**Flat**	**Rolling**	**Hill**
Flat	100%		
Easy Hill		100%	
Rolling		100%	
Steep			100%
Soil type (all land use types[1])	**Free draining**	**Drained**	**Poorly Drained**
Poorly Drained			100%
Well Drained	50%	50%	

[1] for land use types included within the model (excluding conservation and 'other' non farming activities))

Catchment data for each of the 10 FMU/Rohe are provided below, with summary data used within the FMU input included within the **ORC mitigation model inputs.xls** file. Note that there are some discrepancies, with terrain data used to estimate the proportion of stock on flat, rolling and hill land, and areas with no terrain data excluded from the analysis.

1: Catlin's FMU

ORC land usage statistics: Catlin's FMU	Dairy	Dairy Grazing	Dry-stock (S&B)	Other	Plantation Forest	Specialist Beef	Specialist Deer	Specialist sheep	Grand Total
Beef				1		1,092			1,093
Commercial Use				10					10
Conservation				52,446					52,446
Dairy	5,252			5					5,257
Dairy Support		2,961		1					2,962
Dairy Support and Other Livestock		2,169							2,169
Flower and Bulb Growers				3					3
Industry and Utilities				100					100
Lakes and Rivers				1,136					1,136
Lifestyle				231					231
Livestock Support		808							808
Majority Deer and Mixed Livestock							740		740
Mixed Livestock			6,682						6,682
Other Animals				12					12
Plantation Forest				2	7,949				7,951
Public Use				80					80
Residential Use				153					153
Roads and Railways				1,874					1,874
Sheep				5				4,174	4,179
Sheep and Beef			49,486	7					49,493
Small Land Holding				176					176
Specialist Deer							945		945
Sports, Recreation, and Tourism				688					688

ORC land usage statistics: Catlin's FMU	Dairy	Dairy Grazing	Dry-stock (S&B)	Other	Plantation Forest	Specialist Beef	Specialist Deer	Specialist sheep	Grand Total
Unknown Land Use – Grazed Pasture				1,934					1,934
Unknown Land Use – Indigenous Cover				3,189					3,189
Unknown Land Use - Non-agricultural				11					11
Unknown Land Use – Pasture				119					119
Unknown Land Use – Urban				6					6
Grand Total	**5,252**	**5,938**	**56,168**	**62,188**	**7,949**	**1,092**	**1,685**	**4,174**	**144,446**

2: Clutha FMU

ORC land usage statistics: Clutha FMU	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Specialist sheep	Grand Total
Arable					2,463						2,463
Beef			19,835								19,835
Commercial Use									257		257
Conservation									614,439		614,439
Dairy						42,871					42,871
Dairy Support							22,480				22,480
Dairy Support and Other Livestock							9,694				9,694
Flower and Bulb Growers									81		81
Horticulture									1,658		1,658
Industry and Utilities									1,546		1,546
Lakes and Rivers									89,790		89,790
Lifestyle									11,144		11,144

ORC land usage statistics: Clutha FMU	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Specialist sheep	Grand Total
Livestock Support							8,844				8,844
Majority Deer and Mixed Livestock				32,460							32,460
Mixed Livestock	205,294										205,294
Nurseries, Orchards, and Vineyards								7,278			7,278
Other Animals									619		619
Plantation Forest		40,866									40,866
Public Use									205		205
Residential Use									6,468		6,468
Roads and Railways									14,005		14,005
Sheep										107,486	107,486
Sheep and Beef	731,418										731,418
Small Land Holding									5,426		5,426
Specialist Deer				4,649							4,649
Sports, Recreation, and Tourism									25,718		25,718
Unknown Land Use – Grazed Pasture									57,421		57,421
Unknown Land Use – Indigenous Cover									1,503		1,503
Unknown Land Use - Non-agricultural									71		71
Unknown Land Use – Pasture									9,859		9,859
Unknown Land Use – Urban									636		636
(blank)											
Grand Total	936,713	40,866	19,835	37,109	2,463	42,871	41,018	7,278	840,849	107,486	2,076,486

3: Dunedin and coast FMU

ORC land usage statistics: Dunedin and coast FMU	Dry-stock (S & B)	Other	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Specialist sheep	Grand Total
Arable						227						227
Beef				4,499								4,499
Commercial Use		145										145
Conservation		6,059										6,059
Dairy							5,306					5,306
Dairy Support								2,408				2,408
Dairy Support and Other Livestock								1,345				1,345
Flower and Bulb Growers		13										13
Horticulture		17										17
Industry and Utilities		1,170										1,170
Lakes and Rivers		396										396
Lifestyle										3,614		3,614
Livestock Support								649				649
Majority Deer and Mixed Livestock					328							328
Mixed Livestock	5,958											5,958
Nurseries, Orchards, and Vineyards									23			23
Otago Harbour												1
Other Animals		393										393
Plantation Forest			29,453									29,453
Public Use		397										397
Residential Use		3,379										3,379
Roads and Railways		3,077										3,077
Sheep											10,426	10,426
Sheep and Beef	20,958											20,958

ORC land usage statistics: Dunedin and coast FMU	Dry-stock (S & B)	Other	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Specialist sheep	Grand Total
Small Land Holding		2,017										2,017
Specialist Deer					209							209
Sports, Recreation, and Tourism		1,266										1,266
Unknown Land Use – Grazed Pasture		3,678										3,678
Unknown Land Use – Indigenous Cover		1,851										1,851
Unknown Land Use - Non-agricultural		26										26
Unknown Land Use – Pasture		603										603
Unknown Land Use – Urban		379										379
Grand Total	**26,916**	**24,866**	**29,453**	**4,499**	**537**	**227**	**5,306**	**4,402**	**23**	**3,614**	**10,426**	**110,271**

4. North Otago FMU

ORC land usage statistics: Dunedin and coast FMU	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Arable					4,735					4,735
Beef			10,038							10,038
Commercial Use									46	46
Conservation									18,062	18,062
Dairy						27,106				27,106
Dairy Support							6,216			6,216
Dairy Support and Other Livestock							9,213			9,213
Flower and Bulb Growers									4	4
Horticulture									459	459

ORC land usage statistics: Dunedin and coast FMU	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Industry and Utilities									850	850
Lakes and Rivers									1,602	1,602
Lifestyle									2,350	2,350
Livestock Support							4,842			4,842
Majority Deer and Mixed Livestock				7,342						7,342
Mixed Livestock	19,768									19,768
Nurseries, Orchards, and Vineyards								59		59
Other Animals									1,242	1,242
Plantation Forest		18,169								18,169
Public Use									96	96
Residential Use									1,159	1,159
Roads and Railways									4,145	4,145
Sheep	8,535									8,535
Sheep and Beef	130,941									130,941
Small Land Holding									1,728	1,728
Specialist Deer				1,397						1,397
Sports, Recreation, and Tourism									384	384
Unknown Land Use – Grazed Pasture									14,299	14,299
Unknown Land Use – Indigenous Cover									224	224
Unknown Land Use - Non-agricultural									926	926
Unknown Land Use – Pasture									766	766
Unknown Land Use – Urban									65	65
Grand Total	**159,244**	**18,169**	**10,038**	**8,739**	**4,735**	**27,106**	**20,271**	**59**	**48,407**	**296,768**

5. Taieri FMU

ORC land usage statistics: Taieri FMU	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Arable					176					176
Beef			4,329							4,329
Commercial Use									43	43
Conservation									56,959	56,959
Dairy						14,324				14,324
Dairy Support							4,436			4,436
Dairy Support and Other Livestock							3,987			3,987
Flower and Bulb Growers									46	46
Horticulture									41	41
Industry and Utilities									2,546	2,546
Lakes and Rivers									8,445	8,445
Lifestyle									1,941	1,941
Livestock Support							2,692			2,692
Majority Deer and Mixed Livestock				7,151						7,151
Mixed Livestock	37,818									37,818
Nurseries, Orchards, and Vineyards								74		74
Other Animals									458	458
Plantation Forest		29,423								29,423
Public Use									152	152
Residential Use									925	925
Roads and Railways									6,955	6,955
Sheep	35,732									35,732
Sheep and Beef	326,853									326,853
Small Land Holding									1,500	1,500

ORC land usage statistics: Taieri FMU	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Specialist Deer				435						435
Sports, Recreation, and Tourism									1,262	1,262
Unknown Land Use – Grazed Pasture									16,775	16,775
Unknown Land Use – Indigenous Cover									1,452	1,452
Unknown Land Use - Non-agricultural									1	1
Unknown Land Use – Pasture									4,170	4,170
Unknown Land Use – Urban									219	219
Grand Total	**400,403**	**29,423**	**4,329**	**7,586**	**176**	**14,324**	**11,114**	**74**	**103,889**	**571,320**

6. Dunstan Rohe

ORC land usage statistics: Dunstan Rohe	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Arable					902					902
Beef			7,774							7,774
Commercial Use									125	125
Conservation									152,827	152,827
Dairy						1,904				1,904
Dairy Support							1,481			1,481
Flower and Bulb Growers									25	25
Horticulture									962	962
Industry and Utilities									624	624
Lakes and Rivers									7,147	7,147

ORC land usage statistics: Dunstan Rohe	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Lifestyle									6,525	6,525
Livestock Support							990			990
Majority Deer and Mixed Livestock				3,208						3,208
Mixed Livestock	55,921									55,921
Nurseries, Orchards, and Vineyards								3,485		3,485
Other Animals									256	256
Plantation Forest		1,216								1,216
Public Use									53	53
Residential Use									3,288	3,288
Roads and Railways									3,088	3,088
Sheep	32,110									32,110
Sheep and Beef	175,625									175,625
Small Land Holding									1,968	1,968
Specialist Deer				1,859						1,859
Sports, Recreation, and Tourism									10,878	10,878
Unknown Land Use – Grazed Pasture									33,910	33,910
Unknown Land Use – Indigenous Cover									19	19
Unknown Land Use - Non-agricultural									5	5
Unknown Land Use – Pasture									748	748
Unknown Land Use – Urban									363	363
Grand Total	**263,656**	**1,216**	**7,774**	**5,067**	**902**	**1,904**	**2,472**	**3,485**	**222,811**	**509,288**

7. Lower Clutha Rohe

ORC land usage statistics: Lower Clutha Rohe	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Arable					1,334					1,334
Beef			6,383							6,383
Commercial Use									31	31
Conservation									25,621	25,621
Dairy						37,789				37,789
Dairy Support							17,993			17,993
Dairy Support and Other Livestock							7,425			7,425
Flower and Bulb Growers									25	25
Horticulture									339	339
Industry and Utilities									268	268
Lakes and Rivers									3,916	3,916
Lifestyle									820	820
Livestock Support							5,515			5,515
Majority Deer and Mixed Livestock				1,298						1,298
Mixed Livestock	26,053									26,053
Nurseries, Orchards, and Vineyards								48		48
Other Animals									48	48
Plantation Forest		35,118								35,118
Public Use									74	74
Residential Use									580	580
Roads and Railways									5,659	5,659
Sheep	34,058									34,058
Sheep and Beef	155,202									155,202
Small Land Holding									617	617

ORC land usage statistics: Lower Clutha Rohe	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Specialist Deer				1,415						1,415
Sports, Recreation, and Tourism									551	551
Unknown Land Use – Grazed Pasture									8,554	8,554
Unknown Land Use – Indigenous Cover									1,067	1,067
Unknown Land Use - Non-agricultural									1	1
Unknown Land Use – Pasture									2,522	2,522
Unknown Land Use – Urban									138	138
Grand Total	**215,313**	**35,118**	**6,383**	**2,713**	**1,334**	**37,789**	**30,933**	**48**	**50,831**	**380,461**

8. Manuherekia Rohe

ORC land usage statistics: Manuherekia Rohe	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Arable					123					123
Beef			1,147							1,147
Commercial Use									19	19
Conservation									37,525	37,525
Dairy						2,426				2,426
Dairy Support							1,854			1,854
Dairy Support and Other Livestock							1,620			1,620
Flower and Bulb Growers									8	8
Horticulture									164	164
Industry and Utilities									58	58
Lakes and Rivers									2,968	2,968

Lifestyle									1,602	1,602
Livestock Support							2,108			2,108
Majority Deer and Mixed Livestock				3,554						3,554
Mixed Livestock	50,671									50,671
Nurseries, Orchards, and Vineyards								341		341
Other Animals									151	151
Plantation Forest		562								562
Public Use									16	16
Residential Use									577	577
Roads and Railways									2,139	2,139
Sheep	26,609									26,609
Sheep and Beef	160,627									160,627
Small Land Holding									860	860
Specialist Deer				848						848
Sports, Recreation, and Tourism									526	526
Unknown Land Use – Grazed Pasture									4,231	4,231
Unknown Land Use – Indigenous Cover									76	76
Unknown Land Use – Pasture									105	105
Unknown Land Use – Urban									22	22
Grand Total	**237,908**	**562**	**1,147**	**4,401**	**123**	**2,426**	**5,582**	**341**	**51,046**	**303,537**

9. Roxburgh Rohe

ORC land usage statistics: Roxburgh Rohe	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Arable					103					103
Beef			1,189							1,189
Commercial Use									13	13
Conservation									17,555	17,555
Dairy						752				752
Dairy Support							1,158			1,158
Dairy Support and Other Livestock							649			649
Flower and Bulb Growers									23	23
Horticulture									194	194
Industry and Utilities									562	562
Lakes and Rivers									3,157	3,157
Lifestyle									1,341	1,341
Livestock Support							156			156
Majority Deer and Mixed Livestock				595						595
Mixed Livestock	11,836									11,836
Nurseries, Orchards, and Vineyards								3,322		3,322
Other Animals									94	94
Plantation Forest		3,771								3,771
Public Use									20	20
Residential Use									540	540
Roads and Railways									1,750	1,750
Sheep	12,485									12,485
Sheep and Beef	114,851									114,851
Small Land Holding									1,699	1,699

ORC land usage statistics: Roxburgh Rohe	Dry-stock (S & B)	Plantation Forest	Specialist Beef	Specialist Deer	Cropping	Dairy	Dairy grazing	Fruit and nut trees	Other	Grand Total
Specialist Deer				449						449
Sports, Recreation, and Tourism									558	558
Unknown Land Use – Grazed Pasture									2,963	2,963
Unknown Land Use – Indigenous Cover									38	38
Unknown Land Use - Non-agricultural									54	54
Unknown Land Use – Pasture									201	201
Unknown Land Use – Urban									11	11
Grand Total	**139,172**	**3,771**	**1,189**	**1,044**	**103**	**752**	**1,963**	**3,322**	**30,773**	**182,089**

10. Upper Lakes Rohe

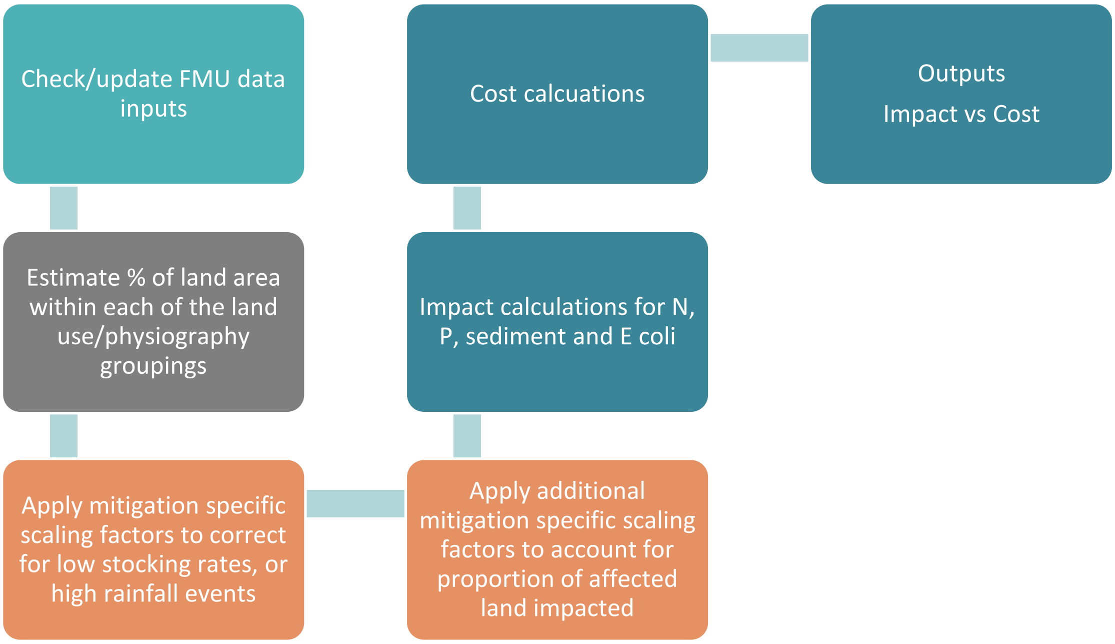
ORC land usage statistics: Upper Lakes Rohe	Cropping	Dairy Grazing	Dry stock (Sheep & Beef)	Fruit & tree Nuts	Other	Plantation Forestry	Specialist Beef	Specialist Deer	Specialist sheep	(blank)	Grand Total
Arable	0										0
Beef							3,341				3,341
Commercial Use					70						70
Conservation					380,971						380,971
Industry and Utilities					33						33
Lakes and Rivers					72,607						72,607
Lifestyle					857						857
Livestock Support		75									75
Majority Deer and Mixed Livestock					681			23,125			23,805
Mixed Livestock			60,325		487						60,813

ORC land usage statistics: Upper Lakes Rohe	Cropping	Dairy Grazing	Dry stock (Sheep & Beef)	Fruit & tree Nuts	Other	Plantation Forestry	Specialist Beef	Specialist Deer	Specialist sheep	(blank)	Grand Total
Nurseries, Orchards, and Vineyards				83							83
Other Animals					70						70
Plantation Forest					2	197					199
Public Use					43						43
Residential Use					1,483						1,483
Roads and Railways					1,371						1,371
Sheep					0				2,223		2,223
Sheep and Beef			122,293		2,819						125,113
Small Land Holding					281						281
Specialist Deer								78			78
Sports, Recreation, and Tourism					13,204						13,204
Unknown Land Use – Grazed Pasture					7,769						7,769
Unknown Land Use – Indigenous Cover					303						303
Unknown Land Use - Non-agricultural					11						11
Unknown Land Use – Pasture					6,282						6,282
Unknown Land Use – Urban					101						101
Grand Total	**0**	**75**	**182,619**	**83**	**489,444**	**197**	**3,341**	**23,203**	**2,223**	**701,184**	**1,402,368**

Appendix 3: Impact assessments

Figure 4 shows a high-level overview of the impact assessment process, with further information on each step provided below.

Figure 11. High level overview of the impact assessment process.



Step 1: Check/update the FMU input data

Figure 12 shows an example of the FMU input data input screen, to effectively describe the land usage and terrain parameters required for each of the individual FMU's.

- The model has been developed to allow evaluation of the impacts on either individual farms or total land area. The **average area inputs shown in cells C4:C13** have been derived directly from the ORC catchment data and represent the total amount of area classified within each of the land use types. Note that ORC summary data also provided information on the number of properties within each land use/physiographic group. This could be used to estimate average farm area, but with much variation in the average number of properties and land area, this information has not been used within the model.
    - There is also a factor to account for the percentage of land deemed as 'effective area', with the current model set up to assume 100%v effective area.
- The **terrain inputs included in cells E4:G13** has also been derived directly from the ORC data summaries, with the activity assumptions shown in cells I4:T4 based on expected activity and able to be updated on an FMU basis if required.
- The soil data **inputs included in cells B17:D19** has derived directly from the ORC data summaries, as described in Appendix 2

Figure 12. Example of the FMU input data screen for the Catlin's region.

FMU1: Catlin's FMU	Land use (ha)				Terrain			
	n farms	average area	% effective	total area	Flat	Rolling	Hill	check
Dairy	1	5,252	100%	5,252	77%	22%	2%	100%
Dairy Grazing	1	5,938	100%	5,938	27%	64%	9%	100%
Drystock (Sheep & Beef)	1	56,168	100%	56,168	15%	73%	12%	100%
Drystock (including Deer)	0	1,000	100%	–	100%	0%	0%	100%
Specialist sheep	1	4,174	100%	4,174	31%	61%	9%	100%
Specialist Beef	1	1,092	100%	1,092	24%	72%	4%	100%
Specialist Deer	1	1,685	100%	1,685	43%	44%	13%	100%
Cropping	0	1,000	100%	–	100%	0%	0%	100%
Fruit & tree Nuts	0	1,000	100%	–	100%	0%	0%	100%
Plantation Forestry	1	7,949	100%	7,949	3%	81%	17%	100%
Total				82,258				

FMU1: Catlin's FMU	Activity (by land type)											
	Flat				Rolling				Hill			
	Grazing	Cropping	Forestry		Grazing	Cropping	Forestry		Grazing	Cropping	Forestry	
Dairy	96%	4%	0%	100%	91%	6%	3%	100%	85%	6%	9%	100%
Dairy Grazing	95%	5%	0%	100%	88%	8%	4%	100%	83%	8%	9%	100%
Drystock (Sheep & Beef)	96%	4%	0%	100%	89%	8%	3%	100%	83%	8%	9%	100%
Drystock (including Deer)	96%	4%	0%	100%	89%	8%	3%	100%	83%	8%	9%	100%
Specialist sheep	96%	4%	0%	100%	89%	8%	3%	100%	83%	8%	9%	100%
Specialist Beef	96%	4%	0%	100%	89%	8%	3%	100%	83%	8%	9%	100%
Specialist Deer	96%	4%	0%	100%	89%	8%	3%	100%	83%	8%	9%	100%
Cropping	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%	100%
Fruit & tree Nuts	100%	0%	0%	100%	100%	0%	0%	100%	100%	0%	0%	100%
Plantation Forestry	0%	0%	100%	100%	0%	0%	100%	100%	0%	0%	100%	100%

Soil types	Flat	Rolling	Hill
Free draining	33%	45%	50%
Drained	33%	45%	50%
Poorly drained	34%	11%	0%
check	100%	100%	100%
scaling factors	Flat	Rolling	Hill
% impacted by low SR	100%	50%	10%
% impacted by high rainfall events	100%	100%	100%

Scaling factors

A range of scaling factors can then be entered for each of the FMUs to account for external factors.

The first set of scaling factors (cells B21:D23) are linked to stocking rate and high rainfall events and need to be considered in conjunction with mitigation type. Table 8 shows a summary of the initial mitigation options evaluated, with the external scaling factors for low stocking rate, and high rainfall events set to 0.5 (50%) and 1.3 (130%) for the fencing, stock crossing and wetlands mitigation options respectively.

Note that there is an option to include or exclude the scaling factors applied to high rainfall events, with all results presented in this report calculated with the high rainfall scaling factors excluded.

Table 8. Mitigation options included within the preliminary model including scaling factors to account for low stocking rate and high rainfall events.

Mitigation type		External scaling factors	
		Low SR	High Rainfall
M1	Crop buffer strips	100%	100%
M2	Cultivate across contour	100%	100%
M3	Minimal tillage	100%	100%
M4	Strategic crop Grazing	100%	100%
M5	Catch crops	100%	100%
M6	Stand-off facilities	100%	100%
M7	Critical source area management	100%	100%
M8	Soil moisture monitoring / scheduling	100%	100%
M9	Maintenance of irrigation equipment	100%	100%
M10	Irrigation infrastructure	100%	100%
M11	Match stock class to land use capability	100%	100%
M12	Keep Olsen P at optimal	100%	100%
M13	Timing of N applications	100%	100%
M14	Low-rate N applications	100%	100%
M15	Placement of fertiliser	100%	100%
M16	Riparian planting	100%	100%
M17	Sediment traps to filter overland water flows	100%	100%
M18	Suitable stock crossings	50%	100%
M19	Stock exclusion (fencing)	50%	100%
M20	Constructed wetlands	100%	130%

A **2nd set of scaling factors** is then used to account for differences in the expected proportion of qualifying land that could be impacted by mitigation. Figure 13 shows the FMU specific scaling factors applied to the Catlin's model where for example, we have assumed that stand off facilities would be made accessible to 50% of qualifying land within the dairy model, whilst they are unlikely to applicable within any of the other livestock systems modelled.

Figure 13. Example of the mitigation specific scaling factors applied to the Catlin's model.

		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20
		Crop buffers	X contour cult	Minimal tillage	Crop grazing	Catch crops	Stand off facilities	CSA managemnt	Soil moisture	Irrigation (main)	Irrigation (effic)	Managed SR	Olsen P opt	N timing	N rate	Fert placment	Riparian planting	Sediment traps	Stock crossings	Fencing	Wetlands
FMU1: Ctalins	Dairy	1	1	1	1	1	0.5	1	0	0	0	1	1	1	1	1	0.5	0.5	0.5	0.05	0.5
	Dairy Grazing	1	1	1	1	1	0	1	0	0	0	1	1	0.3	0.1	1	0.5	0.5	0.5	0.2	0.5
	Drystock (Sheep & Beef)	1	1	1	1	1	0	1	0	0	0	1	1	0.3	0.1	1	0.5	0.5	0.5	0.2	0.5
	Drystock (including Deer)	1	1	1	1	1	0	1	0	0	0	1	1	0.3	0.1	1	0.5	0.5	0.5	0.4	0.5
	Specialist sheep	1	1	1	1	1	0	1	0	0	0	1	1	0.3	0.1	1	0.5	0.5	0.5	0.2	0.5
	Specialist Beef	1	1	1	1	1	0	1	0	0	0	1	1	0.3	0.1	1	0.5	0.5	0.5	0.2	0.5
	Specialist Deer	1	1	1	1	1	0	1	0	0	0	1	1	0.3	0.1	1	0.5	0.5	0.5	0.4	0.5
	Cropping	1	1	1	1	1	0	1	0	0	0	1	1	1	1	1	0.5	0.5	0.5	0.2	0.5
	Fruit & tree Nuts	1	1	1	1	1	0	1	0	0	0	1	1	1	1	1	0.5	0.5	0.5	0.2	0.5
	Plantation Forestry	1	1	1	1	1	0	1	0	0	0	1	1	1	1	1	0.5	0.5	0.5	0.2	0.5

Note that within the preliminary model, the same set of scaling factors have been applied to each of the FMU/Rohe models, except for mitigations for soil moisture (M8), maintenance of irrigation equipment (M9), and irrigation efficiency (M10). These have been adjusted according to the proportion of land irrigated, and summarised within Appendix 2, catchment data.

Step 2: Estimates the percentage of land affected

Once the input parameters have been checked, the next key step in the model process is to assess the percentage of land affected. This is simply a combination of the total area multiplied by the percentage of land within each terrain, soil, and activity type, with an example of the land usage data for FMU 1 (Catlin's) shown in Table 9, where using data from Figure 12, the total area of flat free draining land used for grazing within the dairy model can be calculated as

- Total effective land area modelled = 5252 ha
- Proportion flat = 76.5%
- Proportion fee draining = 34%
- Proportion used for grazing = 96%
    - 5252ha * 77% * 34% * 96% =1,310 ha

Table 9: Example of the land usage matric for the Catlin's FMU.

Land use	Terrain		Activity	FMU 1: area (ha)	%
Dairy	Flat	Free draining	Grazing	1,310	25%
Dairy	Flat	Free draining	Cropped	55	1%
Dairy	Flat	Free draining	Forested	0	0%
Dairy	Flat	Drained	Grazing	1,310	25%
Dairy	Flat	Drained	Cropped	55	1%
Dairy	Flat	Drained	Forested	0	0%
Dairy	Flat	Poorly Drained	Grazing	1,238	24%
Dairy	Flat	Poorly Drained	Cropped	52	1%
Dairy	Flat	Poorly Drained	Forested	0	0%

Land use	Terrain		Activity	FMU 1: area (ha)	%
Dairy	Rolling	Free draining	Grazing	370	7%
Dairy	Rolling	Free draining	Cropped	24	0%
Dairy	Rolling	Free draining	Forested	12	0%
Dairy	Rolling	Drained	Grazing	370	7%
Dairy	Rolling	Drained	Cropped	24	0%
Dairy	Rolling	Drained	Forested	12	0%
Dairy	Rolling	Poorly Drained	Grazing	304	6%
Dairy	Rolling	Poorly Drained	Cropped	20	0%
Dairy	Rolling	Poorly Drained	Forested	10	0%
Dairy	Hill	Free draining	Grazing	7	0%
Dairy	Hill	Free draining	Cropped	0	0%
Dairy	Hill	Free draining	Forested	1	0%
Dairy	Hill	Drained	Grazing	7	0%
Dairy	Hill	Drained	Cropped	0	0%
Dairy	Hill	Drained	Forested	1	0%
Dairy	Hill	Poorly Drained	Grazing	61	1%
Dairy	Hill	Poorly Drained	Cropped	4	0%
Dairy	Hill	Poorly Drained	Forested	6	0%
Total				5,252	100%

Steps 3 & 4: Apply the scaling factors and account for reductions in the potential area of land impacted.

The impact assessment table is then used to calculate the expected impact of each of the 20 mitigation options across each of the land use/physiography options. The same principles are then used is assessing the impacts of crop buffers, and other mitigation options on P, sediment loss and E. coli contamination, across the 10 land use models, and result summarised for reporting.

Figure 14 shows an example of the impact calculations for N leaching for dairy farms in the Catlin's region, where:

- The mitigation matrix impact factor for Crop buffers =0 for 1 flat Free draining land used for Grazing and 1 if the same land were to be used for cropping (see **ORC mitigation model inputs.xls)**.
- Flat Free draining land used for Grazing (1310 ha) and cropping (55 ha) account for 25% and 1% of total Dairy land area (Table 9).
- Crop buffers are not adversely affected by low stock rates or high rainfall effects and are not currently included within the FMU specific scaling parameters, so the scaling factors (SF_1) applied to stocking flat, Rolling and Hill terrain remain set to 1 (100%)
- The mitigation specific factor for crop buffers is assumed to be 1, where all land that could benefit from crop buffers is included within the calculation.

The impact assessments (I) are then calculated as a proportion of the total land within the FMU/land use/ physiography category where:

- Flat Free draining Grazing land: I = impact factor 0 * 25% * SF_1 1 * SF_2 1 = 0.00 (cell E7)
- Flat Free draining Cropped land: I = impact factor 1 * 1% * SF_1 1 * SF_2 1 = 0.01 (cell E8)

The impact of crop buffers for N leaching within dairy farms can then be calculated as the sum of the individual impact assessment, with the total impact of crop buffers being assessed as 0.04.

The same principles are then used is assessing the impacts of crop buffers, and other mitigation options on P, sediment loss and E. coli contamination, across the 10 land use models, and result summarised for reporting.

Figure 14. an example of the impact assessment matrix for N leaching for the Catlin's FMU.

				Nitrogen																			
		Flat		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	50%	100%
		Rolling		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	75%	75%	100%
Scaling factors for strocking rate and rainfall vents (realtive to terrain)		Hill		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	95%	95%	100%
Land use	code		d area	Crop buffers	X contour cult	Minimal tillage	Crop grazing	Catch crops	Stand off facilities	CSA managemnt	Soil moisture	Irrigation (main)	0: Irrigation (effic)	1: Managed SR	2: Olsen P opt	3: N timing	4: N rate	5: Fert placment	6: Riparian planting	7: Sediment traps	8: Stock crossings	9: Fencing	0: Wetlands
Dairy	Dairy:Flat:free draining:grazed	1310	25%	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.25	0.00	0.50	0.00	0.00	0.50	0.25	0.25	0.00	0.00	0.12	0.01	0.25
Dairy	Dairy:Flat:free draining:cropped	55	1%	0.01	0.00	0.00	0.01	0.03	0.03	0.00	0.02	0.00	0.02	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.01	0.01	0.01
Dairy	Dairy:Flat:free draining:Forested	0	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:Flat:drained:grazed	1310	25%	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.50	0.25	0.25	0.00	0.00	0.12	0.12	0.25
Dairy	Dairy:Flat:drained:cropped	55	1%	0.01	0.00	0.00	0.01	0.03	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.01	0.01	0.01
Dairy	Dairy:Flat:drained:Forested	0	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:Flat:Undrained:grazed	1238	24%	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.24	0.00	0.24	0.00	0.00	0.47	0.24	0.24	0.00	0.00	0.12	0.12	0.24
Dairy	Dairy:Flat:Undrained:cropped	52	1%	0.01	0.00	0.00	0.01	0.03	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.01
Dairy	Dairy:Flat:Undrained:Forested	0	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:rolling:free draining:grazed	370	7%	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.14	0.00	0.14	0.14	0.00	0.14	0.07	0.07	0.00	0.07	0.05	0.05	0.07
Dairy	Dairy:rolling:free draining:cropped	24	0%	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:rolling:free draining:Forested	12	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:rolling:drained:grazed	370	7%	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.07	0.00	0.07	0.14	0.00	0.14	0.07	0.07	0.00	0.07	0.05	0.05	0.07
Dairy	Dairy:rolling:drained:cropped	24	0%	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:rolling:drained:Forested	12	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:rolling:Undrained:grazed	304	6%	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.06	0.00	0.06	0.06	0.00	0.12	0.06	0.06	0.00	0.06	0.04	0.04	0.06
Dairy	Dairy:rolling:Undrained:cropped	20	0%	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:rolling:Undrained:Forested	10	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:hill:free draining:grazed	7	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:hill:free draining:cropped	0	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:hill:free draining:Forested	1	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:hill:drained:grazed	7	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:hill:drained:cropped	0	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:hill:drained:Forested	1	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:hill:Undrained:grazed	61	1%	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.01
Dairy	Dairy:hill:Undrained:cropped	4	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy	Dairy:hill:Undrained:Forested	6	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Step 5: Impact calculations

Pivot tables are then used to aggregate the data for reporting purposes. Figure 15 shows an example of the pivot table outputs for the Clutha regions, with the impact assessment for M1: Crop buffers ranging from 0 to 0.05 for N leaching, and 0 to 0.5 for P loss.

Figure 15. Example of the Pivot table used to estimate the impacts of each of the mitigation options for N, P, Sediment and E. coli across the Clutha FMU.

Nitrogen

	Sum of M1: (	Sum of M2:	Sum of M3:	Sum of M4:	Sum of M5:	Sum of M6:	Sum of M7:	Sum of M8:	Sum of M9:	Sum of M10:	Sum of M11:	Sum of M12:
Cropping	0.05	0	0.1	0	0.241649804	0	0	0.02	0.016	0.004313829	0	0
Dairy	0.00242	0.0242	0.00484	0	0.012210851	0.073967745	0	0.03	0.0236976	0.0095529	0.054185644	0
Dairy Grazing	0.003445	0.03445	0.00689	0	0.017814948	0.075922163	0	0.0775	0.0603756	0.026020626	0.078918456	0
Drystock (including Deer)	0	0	0	0	0	0	0	0	0	0	0	0
Drystock (Sheep & Beef)	0.0037	0.037	0.0074	0	0.020350455	0	0	0.0075	0.0057282	0.002754526	0.112055192	0
Fruit & tree Nuts	0	0	0	0	0	0	0	0.1525	0.122	0.05133413	0	0
Plantation Forestry	0	0	0	0	0	0	0	0	0	0	0	0
Specialist Beef	0.00346	0.0346	0.00692	0	0.018232909	0	0	0.0275	0.0214258	0.009597849	0.093128935	0
Specialist Deer	0.00364	0.0364	0.00728	0	0.020501864	0	0	0.0025	0.0018896	0.000923645	0.110890169	0
Specialist sheep	0.00354	0.0354	0.00708	0	0.019086958	0	0	0	0	0	0.100214077	0
Grand Total	**0.070205**	**0.20205**	**0.14041**	**0**	**0.3498478**	**0.1498899**	**0**	**0.3175**	**0.2511168**	**0.1044975**	**0.5493925**	**0**

Phosphorous

Row Labels	Sum of M1: (	Sum of M2:	Sum of M3:	Sum of M4:	Sum of M5:	Sum of M6:	Sum of M7:	Sum of M8:	Sum of M9:	Sum of M10:	Sum of M11:	Sum of M12:
Cropping	0.5	0	0.0143	0	0.1	0	0.001626993	0.02	0.016	0.00066169	0	0.05
Dairy	0.0242	0	0.004284	0.02904	0.00484	0.078233469	0.094907704	0.03	0.0236976	0.00743086	0.01911	0.04937
Dairy Grazing	0.03445	0	0.008696	0.04134	0.00689	0.082650885	0.092442891	0.0775	0.0603756	0.025376062	0.02767	0.04869
Drystock (including Deer)	0	0	0	0	0	0	0	0	0	0	0	0
Drystock (Sheep & Beef)	0.037	0	0.013672	0.0444	0.0074	0	0.089757679	0.0075	0.0057282	0.002959193	0.036835	0
Fruit & tree Nuts	0	0	0	0	0	0	0.012603331	0.1525	0.122	0.038840696	0	0
Plantation Forestry	0	0	0	0	0	0	0	0	0	0	0	0
Specialist Beef	0.0346	0	0.010376	0.04152	0.00692	0	0.092586506	0.0275	0.0214258	0.01009434	0.032275	0
Specialist Deer	0.0364	0	0.014416	0.04368	0.00728	0	0.436331542	0.0025	0.0018896	0.000919994	0.03496	0
Specialist sheep	0.0354	0	0.011816	0.04248	0.00708	0	0.091156853	0	0	0	0.033635	0
Grand Total	**0.70205**	**0**	**0.07756**	**0.24246**	**0.14041**	**0.1608844**	**0.9114135**	**0.3175**	**0.2511168**	**0.0862828**	**0.184485**	**0.14806**

Sediment

Row Labels	Sum of M1: (	Sum of M2:	Sum of M3:	Sum of M4:	Sum of M5:	Sum of M6:	Sum of M7:	Sum of M8:	Sum of M9:	Sum of M10:	Sum of M11:	Sum of M12:
Cropping	0.5	0	0.0143	0	0.1	0	0.001626993	0.02	0.048	0.00066169	0	0
Dairy	0.0242	0	0.004284	0.03388	0.00484	0.078233469	0.094907704	0.03	0.0710928	0.010702537	0.01911	0
Dairy Grazing	0.03445	0	0.008696	0.04823	0.00689	0.082650885	0.092442891	0.0775	0.1811268	0.030711585	0.02767	0
Drystock (including Deer)	0	0	0	0	0	0	0	0	0	0	0	0
Drystock (Sheep & Beef)	0.037	0	0.013672	0.0518	0.0074	0	0.089757679	0.0075	0.0171846	0.003170723	0.036835	0
Fruit & tree Nuts	0	0	0	0	0	0	0.012603331	0.1525	0.366	0.055567304	0	0
Plantation Forestry	0	0	0	0	0	0	0	0	0	0	0	0
Specialist Beef	0.0346	0	0.010376	0.04844	0.00692	0	0.092586506	0.0275	0.0642774	0.011490444	0.032275	0
Specialist Deer	0.0364	0	0.014416	0.05096	0.00728	0	0.436331542	0.0025	0.0056688	0.001004606	0.03496	0
Specialist sheep	0.0354	0	0.011816	0.04956	0.00708	0	0.091156853	0	0	0	0.033635	0
Grand Total	**0.70205**	**0**	**0.07756**	**0.28287**	**0.14041**	**0.1608844**	**0.9114135**	**0.3175**	**0.7533504**	**0.1133089**	**0.184485**	**0**

E coli

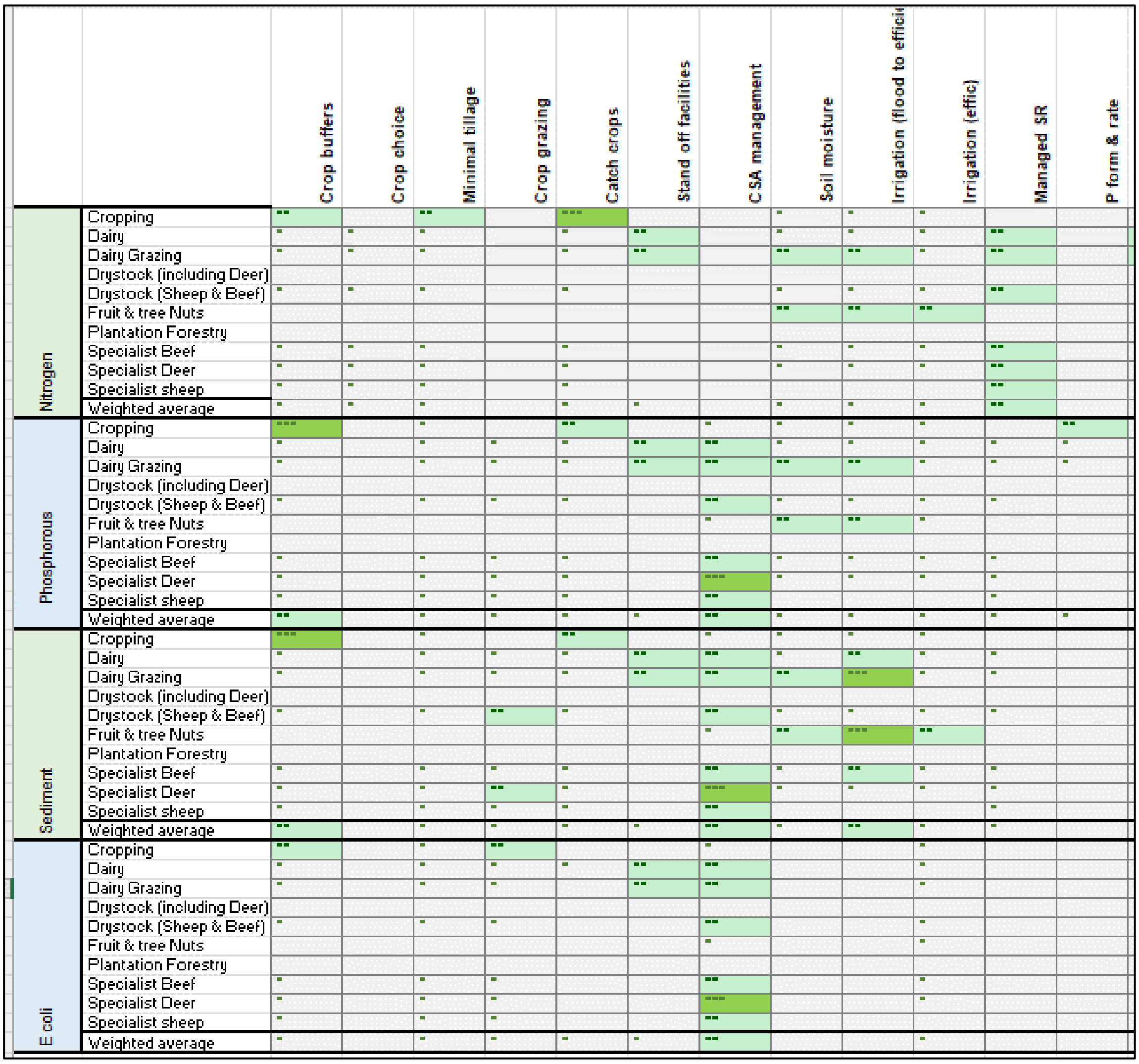
Row Labels	Sum of M1: (	Sum of M2:	Sum of M3:	Sum of M4:	Sum of M5:	Sum of M6:	Sum of M7:	Sum of M8:	Sum of M9:	Sum of M10:	Sum of M11:	Sum of M12:
Cropping	0.064	0	0.0143	0.0608	0	0	0.001626993	0	0	0.000159038	0	0
Dairy	0.00746	0	0.004284	0.005444	0.005444	0.078233469	0.094907704	0	0	0.001509692	0	0
Dairy Grazing	0.013525	0	0.008696	0.009621	0	0.082650885	0.092442891	0	0	0.005747511	0	0
Drystock (including Deer)	0	0	0	0	0	0	0	0	0	0	0	0
Drystock (Sheep & Beef)	0.0173	0	0.013672	0.013972	0	0	0.089757679	0	0	0.000693335	0	0
Fruit & tree Nuts	0	0	0	0	0	0	0.012603331	0	0	0.007688032	0	0
Plantation Forestry	0	0	0	0	0	0	0	0	0	0	0	0
Specialist Beef	0.01514	0	0.010376	0.010916	0	0	0.092586506	0	0	0.002350492	0	0
Specialist Deer	0.01676	0	0.014416	0.014776	0	0	0.436331542	0	0	0.000209308	0	0
Specialist sheep	0.01586	0	0.011816	0.012276	0	0	0.091156853	0	0	0	0	0
Grand Total	**0.150045**	**0**	**0.07756**	**0.127805**	**0.005444**	**0.1608844**	**0.9114135**	**0**	**0**	**0.0183574**	**0**	**0**

Results are then converted to a 'star' ranking system for reporting. The star ranking system is based on the impact assessment criteria (Table 10) used to evaluate each of the mitigation options, with an example of the report outcomes for the Catlin's FMU shown in Figure 16. Note that this includes an assessment of the effectiveness of each of the mitigations for the FMU as a whole – which is based on a weighted average of impacts versus land area.

Table 10. Impact assessment criteria used to classify each of the mitigation options.

	Nitrogen
0	*no reduction*
*	*<5% reduction*
**	*5-17% reduction*
***	*>17% reduction*

Figure 16. Reporting outputs for the Clutha FMU, where the weighted average reflects the overall impact of each of the mitigation options within the FMU.



Step 6: Cost calculations

The cost of each mitigation is then calculated according to an annualised cost of setup and maintenance over 10 years. To ensure that differences between setup and maintenance costs are fully captured within each of the different farm types, individual costs matrices have been developed for each. Table 11 shows a summary of the per hectare costs where:

- annualised cost = (set-up cost + annual cost*10)/10

Table 11. Estimated setup and annual costs for each of the mitigation options

	Crop buffers	Crop choice	Minimal tillage	Crop grazing	Catch crops	Stand-off facilities	CSA management	Soil moisture	Irrigation (flood to efficient)	Irrigation (efficiency)	Managed SR	P form & rate	N surplus reduction	N rate	Effluent management	Riparian planting	Sediment traps	Stock crossings	Fencing	Wetlands
Diary & Dairy grazing																				
Set-up	$0	$0	$0	$20	$0	$4,500	$5	$45	$8,000	$10,000	$0	$0	$0	$0	$0	$36	$80	$50	$9	$140
Annual	$0	$0	$0	$20	$450	$75	$5	$8	$250	$0	$10	$10	$0	$25	$1,000	$4	$5	$0	$8	$0
Annualised	$0	$0	$0	$22	$450	$525	$6	$13	$1,050	$1,000	$10	$10	$0	$25	$1,000	$8	$13	$5	$9	$14
Dry-stock and other land use types																				
Set-up	$0	$0	$0	$20	$0	$4,500	$5	$45	$8,000	$10,000	$0	$0	$0	$0	$0	$36	$27	$50	$29	$140
Annual	$50	$0	$0	$20	$450	$75	$5	$8	$250	$0	$10	$4	$0	$0	$1,000	$4	$2	$0	$8	$0
Annualised	$50	$0	$0	$22	$450	$525	$6	$13	$1,050	$1,000	$10	$4	$0	$0	$1,000	$8	$5	$5	$11	$14

Step 7: Outputs: impact versus cost

Base levels of N and P loss are then used to estimate total change per ha, with the base levels of N and P loss used for each of the farm enterprises within the model shown in **Error! Reference source not found.**, where:

- kg N loss = % reduction * base load
- $/kg = annualised cost/kg loss * affected area/total area

Table 12. Base levels of Nitrogen leaching, and Phosphorous loss used to calculate estimate reductions relative to cost for each of the farm systems modelled.

	Dairy	Dairy Grazing	Dry stock (Sheep & Beef)	Dry stock (including Deer)	Specialist sheep	Specialist Beef	Specialist Deer	Cropping	Fruit & tree Nuts	Plantation Forestry
N loss (kg/ha/year)	30	30	15	15	15	15	15	30	30	5
P loss (kg/ha/year)	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Note that the N And P reduction estimates are based around N & P values reported by Monaghan et.al[3], and it is important to note that there is likely to be significant variations within both individual farms and FMU/Rohe and these estimates are for indicative purposes only.

[3] Monaghan et.al 2021: Quantifying contaminant losses to water from pastoral land uses in New Zealand I. Development of a spatial framework for assessing losses at a farm scale. New Zealand Journal of Agricultural Research, 64:3, : https://doi.org/10.1080/00288233.2021.1936572