Supplement to the Farm-scale Modelling Report

Ruamāhanga Whaitua Collaborative Modelling Project

December 2016

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Contents

Glossary of the Terms Used in this Report

Farm models. The technical descriptions of the farms in this project follow a cascade from the general to the specific and from the beginning to the conclusion of the modelling process. The cascade flows as follows:

- Farm types. Established initially by the Ministry for Primary Industries and the Ruamāhanga Whaitua Committee to guide the selection of example farms to be surveyed for this project.
- Example farms. Real farming businesses operating within the Ruamāhanga catchment. The example farms were highly dynamic and needed to be adjusted to create representative farms for further modelling.
- Representative farm. These are farm scale businesses in a long-term equilibrium, that could include more than one enterprise with each enterprise producing a unique output for their own specialist markets. The representative farms were developed by making adjustments to the "real" example farms.
- Farm enterprises. These provide viable and sustainable farming within the catchment by building on farming systems that manage resources productively and efficiently (especially natural resource use).
- Farm Systems. A purposeful integration of farming inputs producing outputs.

  For example, sheep and beef farms operate as integrated farming businesses. A sheep and beef farm has at least two enterprises that are integrated - a sheep enterprise and a beef enterprise. The sheep enterprise may have a breeding system and a lamb finishing system. Each system could have its own inputs to help produce its outputs.

- Virtual farms. Created by modelling farm enterprises to represent potential farms within the Ruamāhanga catchment. Whereas the representative farms are models of whole farms including such things as farm buildings and infrastructure, the virtual farms are based on outputs per unit area.

Farm types. A range of twelve farm types were specified to be modelled in this study. The farm types were characterised based on their farming enterprise (eg dairying, livestock or cropping); their climate (eg high, moderate or low rainfall) their area (ha) and their typography (eg flat).

Example farms. These are the farms that were surveyed by Baker and Associates. The farming systems and operational budgets have the actual information provided to Baker and Associates by farmers operating within the catchment.

Representative farms. These are the farms that were developed by modifying the example farms to run in the long-term version of Farmax and in Overseer. Both the underlying farming systems and the operational budgets have been modified beyond the information originally provided by Baker and Associates.

Farm enterprises. A farming business may include a number of enterprises that generate their own operational profit and loss (eg livestock, forestry and fishing).

Farm systems. A farming system is a dynamic representation of inputs and outputs interlinking to support a farming business. They create estimates of profitability, animal production, nutrient uses and losses of nutrients, sediment and pathogens.

Virtual farms. These are farms created when the representative farms are used in Overseer with different soil, topography and climate conditions. The farming systems developed for the representative farms remain unchanged, however the operational budgets might change with changes in maintenance fertiliser policy.

Whaitua. In resource management within the Wellington Region this māori term means a designated space or catchment. .

1. Purpose

This report has been prepared as a supplement to 'Farm-scale Modelling Report' prepared by the Ministry for Primary Industries for the Ruamāhanga Whaitua Collaborative Modelling Project. The supplementary report has been provided as a response to some of the questions raised following the presentation of 'Farm-scale Modelling Report' in May, July and August workshops with stakeholders.

This report is not a stand-alone report. It should be read in conjunction with the original 'Farm-scale Modelling Report'.

2. Readers Guide

This report has been prepared for two groups of people:

a) The main group are the stakeholders in the Ruamāhanga Whaitua . These readers should turn to the headings that most closely address the areas that after reading the main report still interest them.
b) The other group are the Whaitua Committee. This report may provide them with additional detail about topics they need greater insight into.

3. Farm Modelling Approach

The farm modelling used in this part of the project provided the Ruamāhanga Whaitua Committee with a description of farming systems in the Wairarapa. It provides information about each farm's base-line environmental impact on water allocation, water quality, sediment contamination and pathogen contamination. Developing this information required two farm system models for each farm. An enterprise model (Farmax®) to describe how the farming inputs and outputs supported the farming businesses and a nutrient model (Overseer®) that described how nutrients from the farms reached catchment waterways. The nutrient modelling provided estimates for nitrogen, phosphorus and potassium losses in surface runoff and leaching into groundwater. This report expands the information provided about nutrient cycling.

4. Representative Farms and their Nutrient Cycling Information

Tables 1-3 list the representative farms described in the full report and adds the nutrient cycling information attached as separate tables as an addendum to that report. In addition, the block sizes (ha) have been included.

In the tables, each block has its own line describing its contribution to the farm totals shown on the top line. Each farm total consists of the accumulated results from the blocks that are listed in the following rows. Fodder crops that are not sown in the same paddock each year, but rather are shifted from paddock to paddock, are moved through some of these blocks and in the table are listed separately at the end of the entries for each farm. Therefore, the contribution of fodder crops is in addition to the pasture contributions already described for each block.

As well as the specific blocks and fodder crops, there is an additional source for nitrogen and phosphorus losses, labelled "other". The other is always placed above any fodder crop terms. "Other" is an estimate of the non-block losses to water from farm infrastructure such as raceways, yards, and effluent storage systems.

On dairy farms, any area not grazed as part of the milking platform has been included in the "run-off" block. On sheep and beef farms, any area not grazed has been included in an "unproductive" block.

5. A Comparison between Overseer Model Results

The initial Overseer results were modelled in March and April 2016. The March and April results provided the figures that have been used by the biophysical modellers to model contaminant loads in the catchment. After April, there have been changes in the representative farm information and in Overseer versions. These changes were needed to have greater alignment between the Farmax and Overseer models and to ensure that the files were all consistently prepared.

One of the dairy farms (4.5) still had a 1.0ha block of pine trees. These were removed and the area that was in pine trees included as part of the dairy farm "runoff block". Farmax calculations were made using the effective grazing area on sheep and beef farms. However, in Overseer the total farm area needed to be used for all farms and this correction was also made to any farms not entered with the total farm area.

These changes make the between farm comparisons more reliable. In Table 4 the changes are shown for nitrogen losses. Mostly the results have stayed within 10% of the initial results. However, farms 4.2, 4.5, 4.7, 4.11, 4.13, 4.14 and 4.15 all changed by more than 10% between Overseer versions, and farm 4.9 changed with new information.

Table 1. A summary of nutrient cycling information for dairy farms

Reference number	Name	Farm/block area (ha)	Total N lost (kg N/yr)	N lost to water (kg N/ha/yr)	N in drainage (ppm)	N surplus (kg N/ha/yr)	Added N (kg N/ha/yr)	Clover N (kg N/ha/yr	Fertiliser N (kg N/ha/yr)	Other N (kgN/ha/yr)	Total P (kg P/yr)	P lost (kg P/ha/yr)	Soil P loss	Fertiliser P loss	Effluent P loss
4.1	Dry flat dairy (low rainfall and high production)	367	15423	42				122	94	22	354	1			
	Effluent (nonirrigated)	24	2585	108	29.1	494	427				35	1.5	Medium	n/a	Extreme
	Gley (nonirrigated)	47	1321	28	8.5	199	94				21	0.4	Low	Low	n/a
	Brown (irrigated)	27	2944	109	11.8	253	126				15	0.5	Low	Low	n/a
	Pallic (irrigated)	73	5183	71	7.7	261	126				100	1.4	Medium	Medium	n/a
	Runoff	196	3037	15	4.3	146	78				55	0.3	Low	Low	n/a
	Other		352								128				
4.2	Dry flat dairy (low rainfall and moderate production)	171	5738	34				109	105	36	251	1.5			
	Irrigated block	28	805	34	2.4	311	182				48	2	High	High	n/a
	Effluent	16	844	62	7.3	488	375				43	3.2	Medium	Low	Extreme
	Non-irrigated	127	2006	19	3.0	205	113				69	0.6	Low	Low	n/a
	Other		322								58				
	Turnips	15	431	29	4.4	242	20				17	1.1			
	Kale	11	1330	121	18.7	235	34				16	1.5			
4.3	Dry flat dairy (moderate rainfall)	301	7372	24				110	87	15	361	1.2			
	MP effluent	80	1913	26	5.6	200	122				70	1	Medium	Low	Medium
	MP non-irrigated	45	604	15	3.4	175	105				20	0.5	Low	Low	n/a
	MP irrigated gun	50	1866	41	4.7	228	158				122	2.7	High	High	Medium
	MP irrigated pods	10	385	42	4.7	248	190				25	2.7	High	High	Medium
	Runoff	116	1581	14	5.5	205	83				20	0.2	Low	Low	n/a
	Other		417								82				
	Turnips	15	607	40	9.0	214	35				22	1.5			
4.4	Dry flat dairy (high rainfall	204	9556	47							338	1.7			
	Milking platform	105	4658	48	6.2	202	117	100	102	18	128	1.3	Medium	Medium	n/a
	MP effluent	20	1514	81	10.3	427	358				40	2.1	High	Medium	Extreme
	Runoff rolling	5653	720	15	1.8	118	117				65	1.3	Medium	High	n/a
	Runoff gullies	26	386	15		41	36				28	1.1	Medium	n/a	n/a
	Other		360								70				
	Turnips	7	936	134	14.0	289	44				4	0.6			
	Kale	5	981	196	20.6	299	44				3	0.6			
4.5	Irrigated flat dairy	427	10263	24				97	77	41	378	0.9			
	Effluent unirrigated	30	947	35	10.3	328	204				14	0.5	Low	Low	Medium
	Effluent irrigated	30	1923	71	7.8	339	204				46	1.7	Medium	Medium	Medium
	MP irrigated	105	1821	19	2.1	238	110				110	1.2	Medium	Medium	n/a
	MP unirrigated	105	1732	18	6.0	222	110				27	0.3	Low	Low	n/a
	Runoff	157	1350	10	2.9	99	46				42	0.3	Low	Low	n/a
	Other		278												
	Turnips	21	365	17	5.6	216	41				13	0.6			
	Kale	10	857	86	27.4	228	44				11	1.1			
	Oats	10	991	99	30.6	230	44				7	0.7			
4.6	Organic dairy	355	12302	35				138	0	12	275	0.8			
	Effluent block	26.5	2135	85	11.6	281	185				28	1.1	Medium	Low	Medium
	Irrigated pallic	40	1355	36	4.9	140	0				44	1.2	Medium	Medium	n/a
	Irrigated recent	119	6345	57	7.8	134	0				100	0.9	Medium	low	n/a
	Non-irrigated recent	24.5	403	17	7.3	105	0				2	0.1	Low	Low	n/a
	Runoff	145	1757	12	5.0	44	0				14	0.1	Low	Low	n/a
	Other		143								85				
	Turnips	12.0	164	14	6.0	165	0				2	0.2			

Table 2. A summary of nutrient cycling information for sheep & beef finishing farms

Reference number	Name	Farm/block area (ha)	Total N lost (kg N/yr)	N lost to water (kg N/ha/yr)	N in drainage (ppm)	N surplus (kg N/ha/yr)	Added N (kg N/ha/yr)	Clover N (kg N/ha/yr	Fertiliser N (kg N/ha/yr)	Other N (kgN/ha/yr)	Total P (kg P/yr)	P lost (kg P/ha/yr)	Soil P loss	Fertiliser P loss	Effluent P loss
4.7	Sheep and beef finishing, summer dry	620	6095	10				80	3	2	117				
	Flat	160	1192	9	3.3	75	0				3	0	Low	Low	n/a
	Easy hills	245	1806	7	-	74	0				42	0.2	Low	Low	n/a
	Steep hills	180	1327	7	-	73	0				23	0.1	Low	Low	n/a
	Unproductive	35	105	3	-		0				4	0.1			
	Other		65								43				
	Rape	10	907	91	35.9	329	81				1	0.1			
	Kale	10	693	69	27.5	282	81				1	0.1			
4.9	Sheep and beef finishing, summer wet	540	9403	17				54	18	2	2465	4.6			
	Rolling	388	4884	13	1.7	78	23				1961	5.1	Extreme	Extreme	
	Steep	50	583	12	-	62	0				427	8.5	Extreme	Extreme	
	Kale & turnips	12	3522	294	33.0	329	39				36	3	n/a	n/a	
	Unproductive	90	270	3	-						9	0.1	n/a	n/a	
	Other		144								33				
4.10	Sheep and bull finishing	1110	8757	8				56	9	3	812	0.7			
	Flats	528	4170	8	2.7	74	15				153	0.3	Low	Low	
	Flats irrigated	40	345	9	2.8	100	55				19	0.5	Low	Low	
	Rolling	227	1849	8	3.0	64	0				314	1.4	Medium	High	
	Steep hill	100	728	7	-	65	0				226	2.3	High	Extreme	
	Kale & rape	32	1003	31	10.8	270	0				16	0.5	n/a	n/a	
	Unproductive	183	549	3	-						18	0.1	n/a	n/a	
	Other		113								66				
4.11	Irrigated sheep and beef farm	370	5679	15				66	44	6	308	0.8			
	Irrigated flats	84	877	12	1.8	141	68				142	2	High	Medium	
	Flats	168	1247	9	4.3	130	68				26	0.2	Low	Low	
	Rolling	72	693	11	5.3	109	31				50	0.8	Low	High	
	Easy hill	36	336	11	-	91	0				38	1.2	Medium	High	
	Unproductive	10	30	3	-	-	-				1	0.1	n/a	n/a	
	Other		35								34				
	Kale	25	1173	47	23.1	192	0				8	0.3	n/a	n/a	
	Rape	30	1288	43	20	268	0				9	0.3	n/a	n/a	

Table 3. A summary of nutrient cycling information for sheep & beef breeding farms, arable farms and dairy-support farms

Reference number	Name	Farm/block area (ha)	Total N lost (kg N/yr)	N lost to water (kg N/ha/yr)	N in drainage (ppm)	N surplus (kg N/ha/yr)	Added N (kg N/ha/yr)	Clover N (kg N/ha/yr	Fertiliser N (kg N/ha/yr)	Other N (kgN/ha/yr)	Total P (kg P/yr)	P lost (kg P/ha/yr)	Soil P loss	Fertiliser P loss	Effluent P loss
4.8	Sheep and beef breeding, summer wet	380	8646	23				59	36	2	984	2.6			
	Rolling	170	2640	17	-	98	49				158	1	Medium	Medium	
	Steep	190	2376	13	-	87	30				787	4.1	Extreme	High	
	Unproductive	20	60	3	-	-	-				2	0.1	n/a		
	Other		110								30				
	Rape	10	2586	259	35.2	257	36				5	0.5	n/a	n/a	
	Plantain	9	874	97	12.6	266	28				3	0.3	n/a	n/a	
4.13	Sheep and beef breeding, summer dry	680	5248	8				68	8	2	123	0.2			
	Flat	55	487	9	2.8	87	33				3	0	Low	Low	
	Rolling	430	3325	8	2.7	74	8				52	0.1	Low	Low	
	Steep	135	937	7		70	0				25	0.2	low	n/a	
	Unproductive	60	180	3							6	0.1	n/a	n/a	
	Other		89								36				
	Turnips	15	230	15	5.0	259	11				2	0.1			
4.12	Arable, lamb and bull trading	93	1877	20				56	154	2	52	0.6			
	Flats	74	1212	17	5.6	203	173				32	0.5	Low	low	
	Barley	19	577	30	9.5	250	106				10	0.5	n/a		
	Other		14								8				
	Hunter (leafy turnips)	4	74	21	7.0	288	35				2	0.5	n/a	n/a	
4.14	Arable, finishing beef	380	7981	21				36	77	2	173	0.5			
	Pasture	173	2325	13	4.1	104	89				37	0.2	Low	Low	
	Poc Choy	10	674	66	17.0	322	162				14	1.3	n/a	n/a	
	Barley	55	545	10	3.2	201	51				27	0.5	n/a	n/a	
	Peas	31	2381	78	18.6	175	56				20	0.6	n/a	n/a	
	Oats	27	1123	42	12.7	269	155				25	0.9	n/a	n/a	
	Plaintain	47	544	12	3.7	233	44				21	0.5	n/a	n/a	
	Feed barley	18	291	16	4.9	272	97				9	0.5	n/a	n/a	
	Unproductive	20	60	3	n/a						2	0.1	n/a	n/a	
	Other		38								17				
4.15	Dairy support, summer dry	284	4502	16				66	0	2	77	0.3			
	Maramau	150	1117	8	2.3	72	0				23	0.2	Low	Low	
	Woodside stones	91	1093	13	3.6	95	0				18	0.2	Low	Low	
	Barley woodside	10	493	52	11.9	136	0				4	0.4	n/a	n/a	
	Barley maramau	14	187	13	3.5	146	0				6	0.4	n/a	n/a	
	Wheat maramau	10	174	17	4.1	-28	0				4	0.4	n/a	n/a	
	Maize silage maramau	10	179	18	4.8	230	0				5	0.5	n/a	n/a	
	Other		38								12				
	Rape	10	1221	128	37.9	257	0				6	0.6			
4.16	Dairy support, summer wet	300	29410	98				31	69	2	304	1			
	Flat	15	968	6	1.1	125	40				73	0.5	Low	Medium	
	Kale year1	50	10037	201	32.2	303	122				75	1.5	n/a	n/a	
	Barley	50	6698	134	18	182	30				46	0.9	n/a	n/a	
	Kale year2	50	11642	233	37.3	327	143				99	2	n/a	n/a	
	Other		65								11				

Table 4. Representative farm changes in overseer results for nitrogen losses in 2016. The Overseer version is in brackets.

Representative Farm Number	April (6.2.1) Nitrogen losses (kgN/ha)	August (6.2.1) Nitrogen losses (kgN/ha)	August (6.2.2) Nitrogen losses (kgN/ha)	November (6.2.3) Nitrogen losses (kgN/ha)
4.1	42	42	43	43
4.2	34	34	41	41
4.3	24	24	27	27
4.4	47	47	48	48
4.5	24	24	28	28
4.6	35	35	37	37
4.7	10	10	12	12
4.8	23	23	24	24
4.9	20	17	19	19
4.10	9	8	10	10
4.11	15	15	18	18
4.12	20	20	22	22
4.13	8	8	10	10
4.14	21	21	27	21
4.15	15	16	20	21
4.16	93	93	95	100

To compare the effect that the introduction of new versions of Overseer can have on measures of nutrient losses, consider the results in the last two columns showing results for versions 6.2.2 and 6.2.3 respectively. The version of Overseer used in this report (6.2.1) is no-longer publically available.

6. A Description of the Intensity-System Figure Applied to each of the Farms and how Typical the Overall Distribution might be for the Catchment.

The full base-line report included a table of differing livestock intensities (Table 4 in that report). In Table 5 below, these have been reproduced along with the stocking rates on the same farms. The table shows two different types of stocking rates and a system intensity measure. The table is only possible because the authors had access to Farmax data as well as Overseer results. In the table the first stocking rate figure is based on the numbers of animals being farmed in winter compared to the area of the milking platform and the effective area on dairy and drystock farms respectively. Winter is the time when pasture grows slowest and the time when animal numbers are generally at their lowest. As might be expected dairy farms had about twice the stocking rate as other livestock and arable farms.

The next stocking rate figure (RSU) is from Overseer and is calculated by dividing the available annual pasture by a fixed figure for the annual pasture production consumed by one stock unit.

The last figure is a farming system description based on papers produced by DairyNZ and discussions with NZ Beef & Lamb. Guidance by DairyNZ was that the average farm system in 2013/14 was a System 3, similar guidance was not available from NZ Beef and Lamb.

Table 5. Stocking rates and system intensity results for each of the representative farms

Representative Farm	**Farm area (ha)**	**Winter stocking rates (su/ha)**	**Annual stocking rates (RSU/ha)**	**Farming system intensity**				
				1	**2**	**3**	**4**	**5**
4.1	367	26 (MP)	22				●	
4.2	171	18 (MP)	23			●		
4.3	301	24 (MP)	21				●	
4.4	204	20 (MP)	20			●		
4.5	426	22 (MP)	20			●		
4.6	355	19 (MP)	20		●			
4.7	620	11	12			●		
4.8	380	9	11		●			
4.9	540	8	10			●		
4.10	1110	11	9			●		
4.11	370	11	13				●	
4.12	93	11	14				●	
4.13	680	9	10		●			
4.14	380	9	9			●		
4.15	284	11	9				●	
4.16	300	11	10				●	

In Table 5 (MP) stands for Milking Platform

A large difference between the winter stocking rate and the annual stocking rate indicates the potential for a highly efficient all grass grazing system. If the farm also has a low level of system intensity it indicates that it does mainly depend upon pasture availability to generate its production. If a similar farm has a high level of intensity then the system is dependent on imported supplements to achieve production.

Amongst the dairy farms number 4.2 has a low winter stocking rate (18su/ha) and a higher annual relative stocking rate (23su/ha). It also uses a relatively low proportion of imported supplement (17%) and so appears to be a very feed-efficient farm. Amongst the sheep and beef farms 4.9 and 4.12 both have the potential for high levels of grazing efficiency. Farm 4.9 is a finishing farm on summer wet country it appears to finish a lot of lambs over summer in a moderately intensive system. Farm 4.12 is an arable farm that finishes all the animals grazed on it, and has no breeding stock. It has a more intensive feeding system.

7. A description of the Approach taken with Pasture Utilisation

Pasture utilisation by grazing animals was treated differently between Overseer modelling of nutrient cycling and Farmax calculations of farm operational profit. However, both models use pasture utilisation calculations based on the areas actually grazed by livestock (the effective areas). In the report by the Ministry for Primary Industries, the pasture utilisation figure shown for each of the farms was calculated using results from Farmax (Table 6).

In the table the pasture production figures represent the potential pasture production that each farm system could potentially achieve. It includes responses from applied nitrogen fertiliser, but it does not include potential losses from such things as "under-grazed pasture". It represents the potential ceiling to the amount of pasture available on a farm. Any imported supplementary feed is additional to this figure.

The pasture intake figures represent the amount of pasture consumed by animals to achieve their expected level of production.

There is an interaction modelled within Farmax between animal pasture consumption and the amount of pasture actually grown, along with its feed quality. The pasture utilisation figures in the last column of the table represent the amount of feed actually eaten by animals as a percentage of the amount of pasture that could potentially be grown. For each farm the pasture utilisation results, amongst other things, provide an indicator of the capability of the farmer or grazing manager in feed management.

In this project, the pasture utilisation results have been kept constant before and after any mitigations have been introduced into the farming systems. This constraint has been included as a proxy for assuming that the level of farmer capability has been constant throughout the development of the project.

Through the Farmax calculations, each representative farm system has its own unique pasture utilisation associated with the expected costs and returns.

Overseer calculations do not follow the same modelling steps as Farmax. In Overseer, animal requirements are calculated as an expected intake of pasture (including the use of feed supplements). Pasture utilisation is then entered by the operator so that Overseer can calculate the amount of pasture grown.

Table 6. Pasture utilisation figures calculated for each representative farm

Landuse	Representative farm title	Potential pasture production (kgDM/ha)	Animal intake (kgDM/ha)	Pasture utilisation (%)
Dairy	4.1. Dry flat dairy (low rainfall and high production)	15,794	13,692	87
	4.2. Dry flat dairy (low rainfall and moderate production)	15,089	12,875	85
	4.3. Dry flat dairy (moderate rainfall)	13,623	11,670	86
	4.4. Dry flat dairy (high rainfall)	15,141	13,388	88
	4.5. Irrigated flat dairy	14,081	11,375	81
	4.6. Organic dairy	11,082	9,607	87
Sheep&Beef finishing	4.7. Sheep and beef finishing, summer dry	7,887	6,821	86
	4.9. Sheep and beef finishing, summer wet	7,231	5,943	82
	4.10. Sheep and bull finishing	7,800	5,035	65
	4.11. Irrigated sheep and beef farm	10,844	8,197	76
Sheep&Beef breeding	4.8. Sheep and beef breeding, summer wet	7,516	5,581	74
	4.13. Sheep and beef breeding, summer dry	6,830	5834	85
Arable	4.12. Arable, lamb and bull trading	11,967	9872	82
	4.14. Arable, finishing beef	10,427	8272	79
Dairy support	4.15. Dairy support, summer dry	6,226	4875	78
	4.16. Dairy support, summer wet	9,093	6519	72

In this project, in order to determine a nutrient budget for each landuse within the catchment, the default pasture utilisation figures within Overseer were used. Having consistent pasture utilisation figures will enable the results to be applied across the catchment without introducing further variables to complicate the process.

If Table 6 is examined further, it shows that a high pasture utilisation of 88% was achieved on a summer-wet dairy farm (4.4). A low pasture utilisation of 65% was achieved on a sheep & beef breeding farm with a summer-dry system (4.10).

As an example of the effects of pasture utilisation on estimated nitrogen losses, dairy farm number 4.5 in the main report is an irrigated farming system. The farm has a pasture utilisation level calculated in Farmax of 81%. In Overseer this was assumed to be 85%. It should be possible on this farm to achieve a pasture utilisation of 89%. Each of these different pasture utilisations is associated with different farm nitrogen losses in Overseer of 10204kgN, 10263kgN and 10315kgN. However, the changes are still relatively small and the nitrogen loss rate per unit area remains 24kgN/ha for all of them.

8. A Description of the Approach taken with Excluding Mitigations on Farms

For this project, the Ministry for Primary Industries has been particularly interested in comparing landuses before and after nutrient management mitigations have been introduced. To focus the landuses, the representative farms have included livestock enterprises and arable enterprises but excluded other landuses such as forestry.

To provide a baseline of representative farms before significant mitigations have been introduced, any areas of wetlands and riparian strips on farms have been removed. Similarly, the farming systems have all been adjusted to apply maintenance fertiliser annually and they have all used conventional tillage for forage cropping. When a crop rotation has been modelled, the first cultivation has been assumed to be conventional and the subsequent cultivations are minimum tillage. Direct drilling has been considered a mitigation practice in this project and therefore has not been included.

9. A Description of the Approach used to Model: Effluent systems Irrigation and Cropping.

The information about each of the example dairy farms included a description of their effluent systems. The effluent system on the representative farms used the same information without adjustment, and that information is the basis of the description provided in Section 9 of this report.

Seven of the example farms had irrigation systems in place. The irrigation systems on the representative farms used the information that the example farms provided and that information is the basis of Sections 10 and 11.

A similar situation applied with the forage crops and cash cropping used on the representative farms. These were all based on the cropping carried out on the example farms used. The results are described in Section 12.

10. A Description of the Effluent Systems being used on the Representative Dairy Farms

All the representative dairy farms in this study except one collect the farm dairy effluent in a sump and apply it directly to land for soil-based treatment. Approximately 50% of the dairy farms in the Wairarapa do this currently (GWRC pers. comm.). Farm 4.6 (organic) is the exception in this project. That farm collects the effluent in a holding pond where the effluent is regularly stirred and applied to land. Holding the effluent in the pond on Farm 4.6 volatilises some nitrogen and allows it to be retained in storage on wet days. All the effluent for Farm 4.6 in Overseer is assumed to be applied within 2 weeks of storage.

In Table 7 the effluent field information is reported from Overseer calculations. The effluent field area is the actual area being used on the example and representative farms. The actual area varied from being 8% to 70% of the total milking platform area. The result of the different sizes for the effluent fields are differing equivalent amounts of nitrogen being applied annually. These varied from 333kgN/ha/yr to 4kgN/ha/yr respectively. Farmers were usually also applying nitrogen fertiliser to their effluent areas and the combined totals varied between 427kgN/ha to 94kgN/ha.

Overseer uses the standard industry "good practice" guideline to calculate that the effluent field areas should be large enough so that farmers are applying no more than 150kgN/ha/yr in total when no additional fertiliser is used. In the table some farms require the effluent field to be doubled to reach industry good-practice and other farms already had the field large enough.

Effluent is high in potassium and high levels of potassium in feed are associated with animal health problems such as milk fever[1]. If the representative farms had owners concerned about potassium then most of them would need their effluent areas to be increased to at least the size of their milking platform.

When farmers are irrigating effluent straight from the sump at the farm dairy, on some days they are likely to apply effluent to soils that are already saturated[2]. Under such conditions annual nitrogen losses for a whole farm may be increased by 4%. One farm was also checked to examine the benefits of changing effluent practice from good practice to best practice by applying "active management" to their effluent. In that case the improvement in reduced nitrogen loss was less than 1%.

[1] http://www.dairynz.co.nz/media/2528008/TS-issue-26-transition-cow.pdf
[2] To model this in Overseer one farm was checked by adding mole and tile drains to the effluent block.

Table 7. Description of effluent field for dairy farms

Farm number	Milking platform area (ha)	Effluent field area (ha)	Equivalent nitrogen application (kgN/ha)	Additional nitrogen fertiliser (kgN/ha)	Target effluent area for 150kgN/ha	Target effluent area for maintenance potassium
4.1	171	24	333	94	53	68
4.2	171	14	313	62	28	480
4.3	185	129	4	90	43	224
4.4	125	19	241	117	30	164
4.5	270	54	65	74	47	0
4.6	210	25	185	0	31	0

11. A Description of the Irrigation Systems being used on the Representative Farms

There are seven representative farms that are applying irrigation. Two of them are sheep and beef farms, and the rest of them are dairy farms. Most of the farms apply very typical amounts of water annually (600-900mm) although farm 4.10 applies only a low amount of water each return period (Table 8).

Table 8.

Farm number	Area irrigated (ha)	Block rainfall (average mm/yr)	Irrigation type	Irrigation supplied (average mm/yr)	Fixed depth (mm)	Return period (days)
4.1	100	967	Centre pivot and sprayline	819	30	6
4.2	100	1356	Centre pivot and sprayline	887	65	14
4.3	60	1100	Travelling irrigator and spraylines	580	50	14
4.5	135	915	Spraylines	819	30	6
4.6	159	801	Centre pivot and spraylines	819	30	6
4.10	40	870	Sprayline	116	10	14
4.11	84	778	Centre pivot	814	25	5

One farm was used to calculate the difference made by implementing a water budget using moisture measurement and irrigating between 60%PAW and 90%PAW. For farm number 4.5 the annual requirement for irrigation water dropped from 819mm to 320mm.

12. Arable Farming and Irrigation in the Catchment.

Neither of the two arable representative farms apply irrigation. According to industry people, about one third to half of the arable farms in the Wairarapa do use irrigation, but none of them were in the original sample.

13. A Description of the Cropping Systems being used on the Representative Farms

On livestock farms cropping was sometimes added to provide additional feed for animals in winter, in summer, or both. On sheep and beef farms numbers 4.9 and 4.10 the forage crops were grown in the same paddocks each year. All the other farms that had forage crops, annually rotated them through specific sets of paddocks. In Overseer typical yields were assumed for each crop based on industry knowledge.

In the information reported in Tables 2, 3 and 4 the nutrient losses from forage cropping are kept separate from the information about each of the blocks and must be included to obtain an overall figure for each farm. For farms 4.9 and 4.10 the area in forage crop is already treated as a separate farm block and so their effects have already been included in the farm totals for each nutrient.

If a crop type is not available in Overseer, a possible analogue is provided in their Good Practice guide. The crops used in the representative farm systems and the analogues that were used in Overseer are shown in Tables 9 & 10.

Table 9. Forage crops and their Overseer analogues

Crop managed	Crop modelled	Farm numbers
Kale	Kale	4.4, 4.5, 4.7, 4.9, 4.10, 4.11, 4.16
Leafy turnips (summer crop)	Turnips - leafy	4.3, 4.4, 4.5, 4.6, 4.9, 4.13
Rape	Rape	4.7, 4.8, 4.10, 4.11, 4.12, 4.15
Plantain	Annual ryegrass	4.8, 4.11, 4.14
Oats (green)	Forage oats	4.5, 4.14

Table 10 Arable crops and their Overseer analogues

Crop managed	Crop modelled	Farm numbers
Barley	Barley	4.12, 4.14, 4.15
Wheat	Wheat	4.15
Poc Choy	Cabbage	4.14
Peas	Peas	4.14
Oats	Oats	4.14
Maize-silage	Maize-silage	4.15
Clover seed	Pasture	4.14

In table 8 only plantain required an Overseer analogue. In table 9 Poc Choy and Clover seed both required analogues.

14. A Description of how Overseer was Calibrated.

Decision support models can provide decision makers with ways to reduce the burden of making complex decision, They provide insights into dynamic interactions between system variables and they can enable the outcomes of different scenarios to be compared. To be useful to decision makers, decision support models need to be constructed to encompass the full range of options available and to provide results using variables important to decision makers. The models need to be tested and validated to provide decision makers with confidence in their results.

The following information was taken from the Overseer website and is based on the work of David Wheeler and Andrew Shepherd of AgResearch.

Accuracy: The accuracy of a measurement system is the degree of closeness of measurements of a quantity to that quantity's actual (true) or accepted (where actual measurement is difficult) value. The accuracy of Overseer at the whole farm level is not something that can be observed in scientific experiments and so other measures must be used.

Precision: The precision of a model is the degree to which repeated measurements under unchanged conditions show the same results. Overseer has been shown to have high levels of precision.

Uncertainty: Uncertainty, in the context of a model such as Overseer, can be defined as a potential limitation in some part of the modelling process that is a result of incomplete knowledge. The concept of uncertainty is the most applicable concept to be applied to the use of Overseer, as given the number of assumptions and errors involved in the model, there will be a level of uncertainty about the estimate of nutrient losses.

The owners of Overseer have identified a number of uncertainties in Overseer that they would like to address. These uncertainties include: sensitivity tests, using the model in annual mode, and including more mitigation strategies[3].

Overseer is a model that represents most primary industry enterprises across a wide range of environments in New Zealand. At the moment most of the data used for calibrating Overseer has been provided from the Waikato, Manawatu, Canterbury and Southland. When small scale farmlet data from these areas is plotted against Overseer results a close fit has been shown (Figure 1[4]).

An estimated error of 25-30% is usually assumed with individual Overseer whole-farm results. This can be compared with the expected error of around 20% with individual soil test results[5]. Similar errors are associated with dairy cow condition scoring. In each of these cases, observer experience, consistency of approach and using multiple measures to identify trends can assist decision makers make the best use of applying these management tools.

The owners of Overseer have identified a need for more calibration for: cropping farms, beef & sheep farms, all farm-types with rainfall greater than 1200 mm per year, clay soils, and shallow soils. Over time the results of these new calibrations are expected to influence further changes in the Overseer model.

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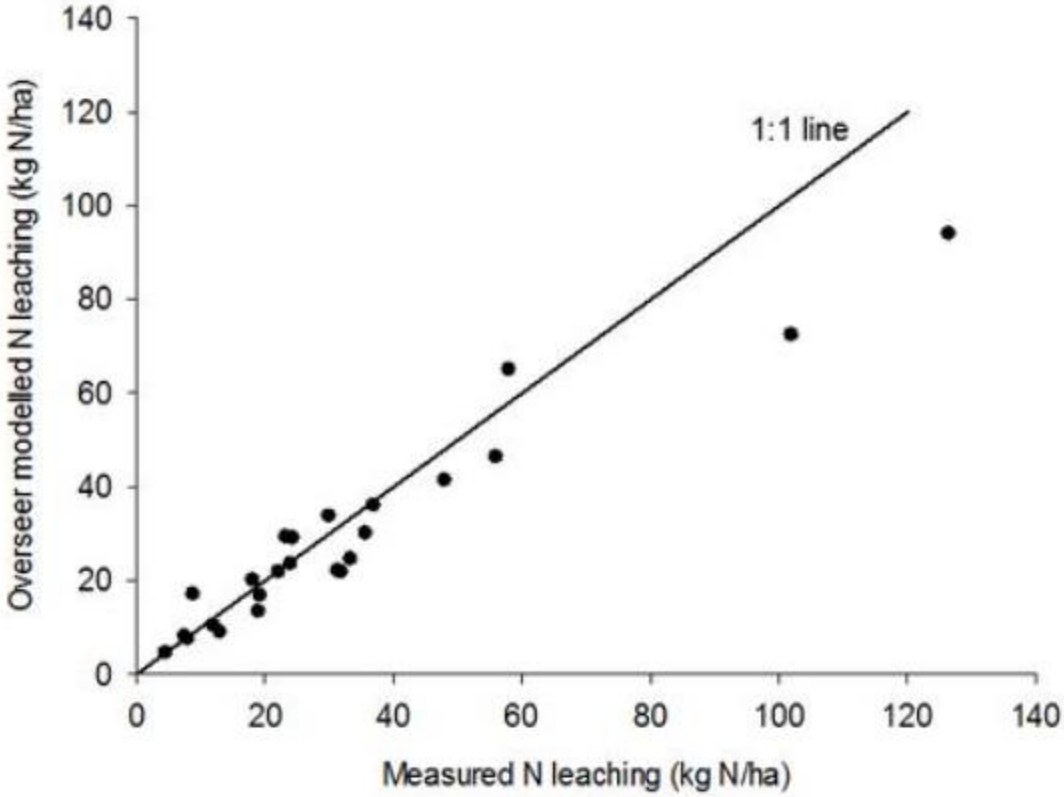
[3] These were included in a list of suggestions provided by Liz McGruddy – Federated Farmers

[4] file:///C:/Users/PACT/Downloads/OVERSEER%20Summary%20for%20Agriculture%20Committee%202013.pdf

[5] Massey University 2013. Sustainable Nutrient Management in New Zealand Agriculture, p4-28.

Figure 1. Calibration of Overseer data with farmlet experimental data.



15. A Description of the Expert Panel Decision Making on the Assignment of Representative Farms to Catchment Polygons.

15.1 Background to polygon assignment

Each of the sixteen farms prepared in this part of the study represents a particular farming system with its own set of inputs, outputs, and levels of profitability. This farm information has then been incorporated in further modelling at a catchment scale.

(1). Biophysical modelling. The biophysical modelling of the catchment has accumulated nutrient loss information from each landuse and applied them to the combinations of soil types and rainfall ranges identified across the catchment. Sixteen landuses were described by the representative farms and ten other landuses (40% of the area) were also modelled[6]. These were not enough to describe all the combinations of soil types and landuses within the Ruamāhanga catchment. So for catchment modelling purposes, the information about the representative farms was expressed per unit area and assigned to the most aligned polygons of soil X climate X landuse. The assignment process is described below.

(2). Economic modelling. The economic modelling of the catchment used the same polygon information that was used in the biophysical modelling. That means that the economic modelling has not used the whole-of-farm information from the Ministry for Primary Industries report. A polygon unit of analysis was used so that the biophysical modelling and the economical modelling had the same units and changes in one could be related to changes in the other.

15.2 Assignment method

The task of assigning representative farms to each catchment polygon was undertaken by Ministry for Primary Industries staff with the assistance of the three farm consultants working in the project. At a meeting on the 9th December 2015 the biophysical modellers and Greater Wellington described the combination of land uses, soil groups, and rainfall ranges that needed representative farms assigned to them. Table 11 shows all the combinations of these elements to be addressed. Each column shown in the table was independent of the other two, so overall there were ninety possible different assignments to make, although not all of the combinations can be found within the Ruamāhanga Catchment.

Table 11. Polygon descriptors used to assign representative farm information

Soil groups	Rainfall ranges	Landuse types
Brown	750-850mm	Dairy farming
Gley	850-1050mm	Dairy support
Mallenic	1050-1250mm	Sheep & beef farming
Pallic	1250-1650mm	
Recent	1650-2050mm	
	2050-2450mm	

[6] Daigeanult pers. comm. 2016.

There were six different dairy farming systems, two different dairy support systems, and eight different arable and sheep & beef systems to be allocated. Using the local knowledge of the three farm consultants each of the sixteen farms was assigned to polygons in the catchment. This process was based on the soils and climate details in the Overseer files and each farm's locality on the catchment map in the Ministry for Primary Industries 'Farm-scale Modelling Report' [7]. In some cases one representative farm was assigned to a polygon, in other cases several farms were combined on a proportional basis, and in other cases several farms were assigned depending upon their spatial distribution in the catchment, e.g. from north to south.

The information from the representative farms was then applied by the modellers to the appropriate polygons for further analyses.

16. Calculations of Landuse Land Area

In order to check the authenticity of the estimated areas and numbers of farm types in Table 3, Ministry for Primary Industries compared these with results from StatisticsNZ. The Wairarapa is just under 600,000ha and about 350,000ha is in pastoral production, the rest is in scrub, bush and urban areas (Table 6). In this project, the estimated area for each landuse can be calculated from the number of each farm type and the farm areas, both specified in Table 3 of the Ministry for Primary Industries report. Table 7 shows the results for these calculations. Although the total figure in production in Table 7 is almost the same as the total area in grassland from Statistics NZ it is still likely to be an over-estimate. That is because the number of dairy farms in Table 7 is above the industry figure (164 compared with 157), and the area in grassland is likely to be similar to the concept of farm effective area rather than total area. Never-the-less, the comparison does suggest that the specifications for the example farms to be selected has approximated landuse in the Wairarapa.

Table 6. Land use statistics for the Wairarapa (2011-2012; Source: Statistics NZ)

Territorial Authority	Grassland (ha)	Other Grazing Land (ha)	Crops (ha)	Horticulture (ha)	Exotic Forestry (ha)
Masterton District Council	131,430[8]	-	2,100	-	33,950
Carterton District Council	57,430	230	2,300	220	10,680
South Wairarapa District Council	97,420	-	3,740	-	7,640
Total	**286,280**	**230**	**8,140**	**220**	**52,270**

[7] Parminter and Grinter, 2016. Farm-scale Modelling Report, Ruamahanga Whaitua Collaborative Modelling Project. August. Ministry for Primary Industries, p15, table 4.
[8] Note that this figure was incorrect in the original version of the report published by MPI.

Table 7. Land use within the Ruamāhanga catchment estimated from this study's results

Land Use	**Estimated numbers of farms**	**Catchment area represented by farms types (ha)**	
		(% of subtotal)	**(ha)**
Dairy	164	11	31,400
Dairy support	100	7	20,000
Sheep & Beef	315	77	222,000
Beef	30	5	9,000
Cropping	20	-	6,000
Other agriculture		-	
Total of agricultural landuses	**629**	**100**	**288400**

Statistics NZ have calculated that about 50% of the 1450 farms in the Wairarapa are less than 60ha in size. Properties below that size will mostly be uneconomic as primary production units. It has also been calculated by Statistics NZ that a little over 5% of the grassland in the Wairarapa has been set-up for irrigation (15,245ha). The estimate based on the numbers in the MPI report is also about 5% (13,716ha).

The Ruamāhanga Whaitua administers an area that is approximately 60% of the Wairarapa area (355,685ha). There are no landuse statistics available from Statistics NZ, DairyNZ or Beef and Lamb NZ, specific to the Whaitua.