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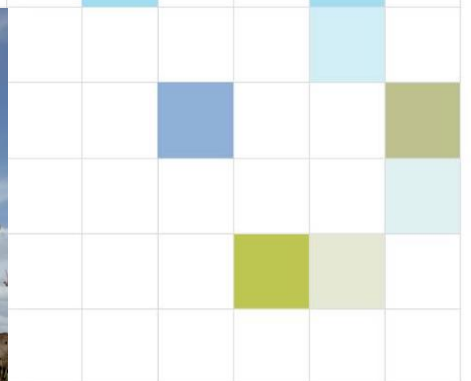
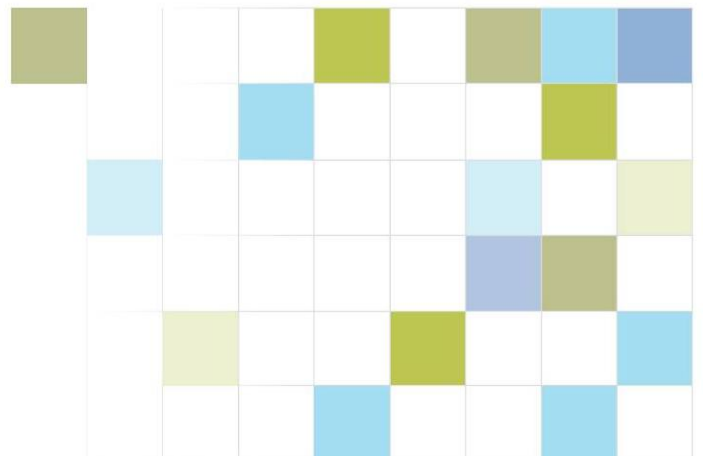
Upper Waitaki Farm Systems and Nutrient Assessment

Stage 4: Irrigated nutrient assessments

July 2009



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Upper Waitaki Farm Systems and Nutrient Assessment Stage 4: Irrigated nutrient assessments

Report prepared for GHD

July 2009

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Executive Summary

- This report describes the results of nutrient loss assessments carried out for a range of typical likely dryland and irrigated farming systems in the Upper Waitaki region. The purpose of these assessments is to provide typical nutrient loss rates for farms that will then be scaled up to calculate likely nutrient losses at the sub-catchment scale.
- The modelling approach taken here was to obtain long-term average pasture and forage crop growth rates appropriate for the region to create feasible farming systems in the Farmax (sheep and beef) and UDDER (dairy) farm system models. Information from these models was then supplied to OVERSEER[®] to calculate whole-farm long-term average loads of nitrogen and phosphorous loss.
- Nine dryland farm systems were modelled. The farms varied in the percentage of beef stock units on the farm (1, 10, and 21% of the total stock units) and the area of winter forage crop on the farm (0, 3, and 6% of the whole farm area). Typical nitrogen applications were made to the forage crop area but no other nitrogen fertiliser was used on the farm. These scenarios are labelled Farm01 to Farm09 below.
- The series of irrigated sheep and beef systems modelled had 25, 35, or 100% of the farm area irrigated and included a range of beef stock units or dairy support stock units. Scenarios with and without nitrogen fertiliser used on the irrigated blocks were modelled. Five irrigated dairy farms were modelled that included crossbreed and Friesian cows with various wintering options. One system including a feed pad was modelled.
- Nitrogen losses from the sheep and beef farms were low, generally less than 5 kg N /ha, for farm systems with 0, 25, or 35% of the area irrigated. Although irrigating 25 or 35% of the area resulted in substantially higher stocking rates, the losses from the irrigated farms were generally about the same as the losses from the dryland farms with the higher area of forage cropping.
- Phosphorous losses from the 20 and 35% irrigated sheep and beef systems were only marginally higher than the dryland farm systems with the larger areas of forage cropping. Once the area of irrigation was increased to 100% of the farm the N and P losses were greater than the dryland scenarios with losses of 7 – 10 kg N /ha and 0.1 kg P /ha.
- Nutrient losses from dairy farms were higher than the other scenarios, ranging from 15 to 27 kg N /ha and 0.13 to 0.2 kg P /ha. There are however, several options to mitigate these losses as demonstrated by the inclusion of a feed pad.

1. Introduction

This report describes the results of nutrient loss assessments carried out for a range of typical likely irrigated farming systems in the Upper Waitaki region. A small range of assessments for typical dryland farming systems are also presented to complement the assessments done for existing farming systems reported in Snow *et al.* (2008). The purpose of these assessments is to provide typical nutrient loss rates for farms that will then be scaled up to calculate likely nutrient losses at the sub-catchment scale.

2. Methods

2.1 Approach taken

The modelling approach taken here was the same general approach as described in Snow *et al.* (2008), except that the farm systems modelled were generic or typical farm systems rather than replicates of existing farm systems. Long-term average pasture and forage crop growth rates appropriate for the region were obtained from a combination of review (Trolove 2008; King 2008), pasture growth modelling (Snow and King 2008) with some modifications based on modelling of existing partially irrigated farm systems in the area (Snow *et al.* 2008). That information was then combined input into Farmax (Webby *et al.* 1995; Marshall *et al.* 1991) for sheep and beef farms or UDDER (Larcombe 1999) for dairy farms to calculate likely farm production and stocking rate information. That information was then supplied to OVERSEER[®] (Wheeler *et al.* 2006; Ledgard *et al.* 1999; Wheeler *et al.* 2003) to calculate whole-farm long-term average nitrogen and phosphorous loss rates. See Snow *et al.* (2008) for more detailed information on the methodology and assumptions used in the modelling.

As with some of the farm systems modelled in Snow *et al.* (2008), analysis of the OVERSEER[®] outputs for some irrigated blocks showed very large accumulations of nitrogen in the soil organic matter. While it is usual for there to be substantial increases in soil organic nitrogen after a dryland is irrigated (e.g. Gillabel *et al.* 2007), such a rate of immobilisation cannot be sustained indefinitely so we consider these to result in underestimates of N leaching in the long term. To obtain the upper bound of leaching under irrigated conditions the OVERSEER[®] simulations were run again with the development status of the irrigated blocks set to "Highly Developed". This option in the model prevents any immobilisation and so gives an upper bound on the leaching from the irrigated blocks providing a highly conservative estimate of N leaching from these blocks.

2.2 Dryland and irrigated sheep and beef farm systems modelled

Nine 3300-ha dryland farm systems were modelled. The farms varied in the percentage of beef stock units on the farm (1, 10, and 21% of the total stock units) and the area of winter forage crop on the farm (0, 3, and 6% of the whole farm area). Typical nitrogen applications were made to the forage crop area but no other nitrogen fertiliser was used on the farm. These scenarios are labelled Farm01 to Farm09 below.

The series of irrigated sheep and beef systems modelled had 25, 35, or 100% of the farm area irrigated and included a range of beef stock units or dairy support stock units. Scenarios with and without nitrogen fertiliser used on the irrigated blocks were modelled. These, and all other

irrigated farm systems, did not include any winter forage crop area because sufficient summer-grown forage was conserved to fill the winter feed gaps. These scenarios are labelled Farm10 to Farm24 and are +N or –N (30 scenarios in total).

Further farm system description information is given in Table A1.

2.3 Irrigated dairy systems modelled

Five 300-ha irrigated dairy farms were modelled. It was assumed that the whole farm was irrigated and that all replacement stock were grazed off. Farm25 had 4 crossbreed cows /ha with the animals wintered away from the milking platform. Farm26 was a higher intensity system with 5.3 crossbreed cows /ha. Farm27 used heavier, Friesian, cows at 3.7 cows /ha with the cows wintered away. Farm28 and Farm29 reduced the Friesian stocking rate to 3.3 cows /ha and kept the cows on the platform over winter and was either without or with a feeding pad with appropriate effluent collection. All farm systems were assumed to have an effluent reuse area of at least 8 ha /100 cows. The area was made larger, if necessary, to ensure that a maximum N loading on the effluent area of 150 kg N /ha /yr. More detail regarding the dairy farm scenarios is given in Table A2.

3. Results

Table 1 gives the nutrient loss estimates for the farm systems described above. Nitrogen losses were low, generally less than 5 kg N /ha, for farm systems with 0, 25, or 35% of the area irrigated. Although irrigating 25 or 35% of the area resulted in substantially higher stocking rates, about 500% of the dryland case, the losses from the irrigated farms were generally about the same as the losses from the dryland farms with the higher area of forage cropping. Phosphorous losses from the 20 and 35% irrigated systems increased but again were only marginally higher than the dryland farm systems with the larger areas of forage cropping. Once the area of irrigation was increased to 100% of the farm, the N and P losses were greater than the dryland scenarios with losses of 7 – 10 kg N /ha and 0.1 kg P /ha. There was no effect on nutrient losses when the beef stock units were replaced with dairy support stock units.

As expected, the losses from dairy farms were higher than the other scenarios, ranging from 15 to 27 kg N /ha and 0.13 to 0.2 kg P /ha. There are however several options to mitigate these losses as demonstrated by the inclusion of a feed pad (Farm29 compared to Farm28).

Table 1. Estimated nutrient loss from the modelled farm scenarios. N losses are given with both “Developed” (or default) and “Highly developed” (no immobilisation) options for the irrigated blocks.

Scenario	Description	N loss (kg N /ha)		P Loss (kg P /ha)
		Developed	Highly dev.	
Farm01	0% irrig - 0% forage, ~0% beef SU	2.1	n/a	<0.01
Farm02	0% irrig - 3% forage, ~0% beef SU	3.3	n/a	0.02
Farm03	0% irrig - 6% forage, ~0% beef SU	4.5	n/a	0.03
Farm04	0% irrig - 0% forage, ~10% beef SU	2.4	n/a	<0.01
Farm05	0% irrig - 3% forage, ~10% beef SU	3.3	n/a	0.02
Farm06	0% irrig - 6% forage, ~10% beef SU	4.5	n/a	0.03
Farm07	0% irrig - 0% forage, ~20% beef SU	2.4	n/a	<0.01
Farm08	0% irrig - 3% forage, ~20% beef SU	3.4	n/a	0.02

Scenario	Description	N loss (kg N /ha)		P Loss (kg P /ha)
		Developed	Highly dev.	
Farm09	0% irrig - 6% forage, ~20% beef SU	4.5	n/a	0.03
Farm10-N	25% irrig - ~0% beef SU	3.9	6.4	0.03
Farm10+N	25% irrig - ~0% beef SU	4.4	7.6	0.03
Farm11-N	25% irrig - ~10% beef SU	3.9	6.4	0.03
Farm11+N	25% irrig - ~10% beef SU	4.4	7.6	0.03
Farm12-N	25% irrig - ~20% beef SU	4.1	6.4	0.03
Farm12+N	25% irrig - ~20% beef SU	4.6	9.1	0.03
Farm13-N	35% irrig - ~0% beef SU	4.1	7.0	0.04
Farm13+N	35% irrig - ~0% beef SU	4.8	8.3	0.04
Farm14-N	35% irrig - ~10% beef SU	4.1	7.3	0.04
Farm14+N	35% irrig - ~10% beef SU	5.2	10.1	0.04
Farm15-N	35% irrig - ~20% beef SU	4.5	7.3	0.04
Farm15+N	35% irrig - ~20% beef SU	5.2	10.4	0.04
Farm16-N	100% irrig - ~0% beef SU	7.0	11.0	0.10
Farm16+N	100% irrig - ~0% beef SU	9.0	26.0	0.10
Farm17-N	100% irrig - ~10% beef SU	7.0	14.0	0.10
Farm17+N	100% irrig - ~10% beef SU	9.0	27.0	0.10
Farm18-N	100% irrig - ~20% beef SU	7.0	14.0	0.10
Farm18+N	100% irrig - ~20% beef SU	10.0	28.0	0.10
Farm19-N	25% irrig - ~10% dairy support SU	3.9	6.4	0.03
Farm19+N	25% irrig - ~10% dairy support SU	4.6	7.6	0.03
Farm20-N	25% irrig - ~20% dairy support SU	4.1	6.4	0.03
Farm20+N	25% irrig - ~20% dairy support SU	4.4	8.1	0.03
Farm21-N	35% irrig - ~10% dairy support SU	4.5	7.3	0.04
Farm21+N	35% irrig - ~10% dairy support SU	5.2	10.1	0.04
Farm22-N	35% irrig - ~20% dairy support SU	4.5	7.3	0.04
Farm22+N	35% irrig - ~20% dairy support SU	5.2	10.4	0.04
Farm23-N	100% irrig - ~10% dairy support SU	7.0	14.0	0.10
Farm23+N	100% irrig - ~10% dairy support SU	9.0	27.0	0.10
Farm24-N	100% irrig - ~20% dairy support SU	7.0	14.0	0.10
Farm24+N	100% irrig - ~20% dairy support SU	9.0	28.0	0.10
Farm25	Dairy 4.0 /ha Crossbreed WinterOff	15.0	19.7	0.13
Farm26	Dairy 5.3 /ha Crossbreed WinterOff	18.6	25.2	0.14
Farm27	Dairy 3.7 /ha Friesian WinterOff	15.0	20.0	0.13
Farm28	Dairy 3.3 /ha Friesian WinterOn	27.2	34.9	0.13
Farm29	Dairy 3.3 /ha Friesian WinterOn+Pad	19.2	24.8	0.20

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Appendix 1: Sheep and beef farm descriptions

Table A1. Description of the sheep and beef farm scenarios.

Scenario	%Area Irrigated	%Area Easy Dry Pasture	%Area Easy Dry Forage Crop	%Area Steep	N irrig block (kgN /ha)	# Trading Lambs	% Sheep SU	% Cattle SU	% Dairy Support SU	Farm SU /ha
Farm01	0%	39%	0%	61%	0	0	99%	1%	0%	1.3
Farm02	0%	36%	3%	61%	0	0	99%	1%	0%	1.3
Farm03	0%	33%	6%	61%	0	0	99%	1%	0%	1.3
Farm04	0%	39%	0%	61%	0	0	90%	10%	0%	1.3
Farm05	0%	36%	3%	61%	0	0	89%	10%	0%	1.3
Farm06	0%	33%	6%	61%	0	0	89%	10%	0%	1.2
Farm07	0%	39%	0%	61%	0	0	79%	21%	0%	1.3
Farm08	0%	36%	3%	61%	0	0	79%	21%	0%	1.3
Farm09	0%	33%	6%	61%	0	0	79%	21%	0%	1.2
Farm10-N	25%	14%	0%	61%	0	0	100%	0%	0%	5.3
Farm10+N	25%	14%	0%	61%	70	0	100%	0%	0%	5.6
Farm11-N	25%	14%	0%	61%	0	0	90%	10%	0%	5.3
Farm11+N	25%	14%	0%	61%	70	0	90%	10%	0%	5.6
Farm12-N	25%	14%	0%	61%	0	0	79%	21%	0%	5.2
Farm12+N	25%	14%	0%	61%	70	0	79%	21%	0%	5.6
Farm13-N	35%	4%	0%	61%	0	0	100%	0%	0%	6.2
Farm13+N	35%	4%	0%	61%	70	0	100%	0%	0%	6.6
Farm14-N	35%	4%	0%	61%	0	0	90%	10%	0%	6.1
Farm14+N	35%	4%	0%	61%	70	0	90%	10%	0%	6.6
Farm15-N	35%	4%	0%	61%	0	0	79%	21%	0%	6.1
Farm15+N	35%	4%	0%	61%	70	0	79%	21%	0%	6.5
Farm16-N	100%	0%	0%	0%	0	10193	100%	0%	0%	12.1
Farm16+N	100%	0%	0%	0%	70	11540	100%	0%	0%	13.7
Farm17-N	100%	0%	0%	0%	0	9245	90%	9%	0%	12.1
Farm17+N	100%	0%	0%	0%	70	10373	90%	9%	0%	13.6
Farm18-N	100%	0%	0%	0%	0	17993	82%	18%	0%	12.2
Farm18+N	100%	0%	0%	0%	70	20242	82%	18%	0%	13.7
Farm19-N	25%	14%	0%	61%	0	0	89%	0%	10%	5.3
Farm19+N	25%	14%	0%	61%	70	0	89%	0%	11%	5.6
Farm20-N	25%	14%	0%	61%	0	0	78%	0%	21%	5.3

Scenario	%Area Irrigated	%Area Easy Dry Pasture	%Area Easy Dry Forage Crop	%Area Steep	N irrig block (kgN /ha)	# Trading Lambs	% Sheep SU	% Cattle SU	% Dairy Support SU	Farm SU /ha
Farm20+N	25%	14%	0%	61%	70	0	74%	0%	21%	5.6
Farm21-N	35%	4%	0%	61%	0	0	89%	0%	11%	6.2
Farm21+N	35%	4%	0%	61%	70	0	89%	0%	11%	6.6
Farm22-N	35%	4%	0%	61%	0	0	79%	0%	21%	6.2
Farm22+N	35%	4%	0%	61%	70	0	79%	0%	21%	6.6
Farm23-N	100%	0%	0%	0%	0	9245	91%	0%	9%	12.1
Farm23+N	100%	0%	0%	0%	70	10373	90%	0%	10%	13.6
Farm24-N	100%	0%	0%	0%	0	17993	82%	0%	18%	12.1
Farm24+N	100%	0%	0%	0%	70	20242	82%	0%	18%	13.7

Appendix 2: Dairy farm descriptions

Table A2 Description of the dairy farm scenarios.

Scenario	Farm25	Farm26	Farm27	Farm28	Farm29
Description	Dairy 4/ha Crossbreed WinterOff	Dairy 5.3 /ha Crossbreed WinterOff	Dairy 3.7 /ha Friesian WinterOff	Dairy 3.3 /ha Friesian WinterOn	Dairy 3.3 /ha Friesian WinterOn+Pad
Farm area (ha)	300	300	300	300	300
Winter herd (cows /ha)	4	5.3	3.7	3.3	3.3
November herd (cows /ha)	3.9	5.2	3.6	3.3	3.3
Replacement Stock	Off	Off	Off	Off	Off
Stocking rate (SU /ha) ⁽¹⁾	29.5	34.7	30.9	33.1	33.1
Sep fertiliser N (kg N /ha)	40	40	40	60	60
Oct fertiliser N (kg N /ha)	40	40	40	40	40
Nov fertiliser N (kg N /ha)	40	40	40	40	40
Total fert. N used (kg N /ha)	120	120	120	140	140
Cows wintered off (%)	100	100	100	0	0
Feedpad	No	No	No	No	Yes
Pasture eaten (t DM /ha)	11.4	14.3	11.3	11.5	11.5
Silage fed (t DM /ha)	4.1	2.7	4.6	5.4	5.4
Imported feed (t DM /ha)	0.7	2.1	1.1	1.3	1.3
Production (kg MS /ha)	1409	1617	1379	1279	1279
Effluent area (ha)	96	125	88	80	177

1 – calculated based on 550 kg DM consumption per SU