ASSESSING THE IMPACT OF INPUT CHOICES WITHIN OVERSEER® (V6) ON THE MODELLED N LOSSES TO WATER FOR LINCOLN UNIVERSITY DAIRY FARM (LUDF)

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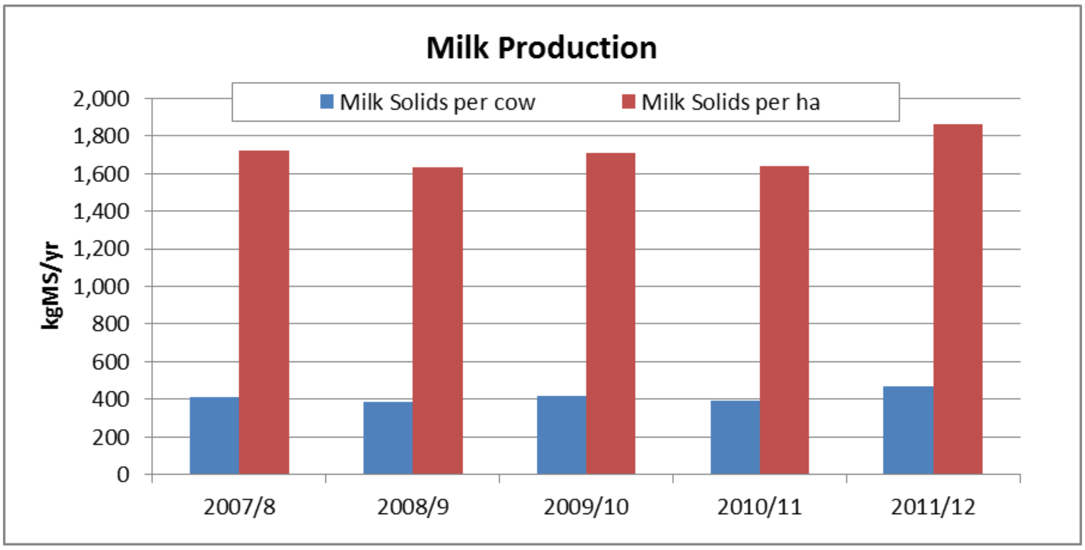
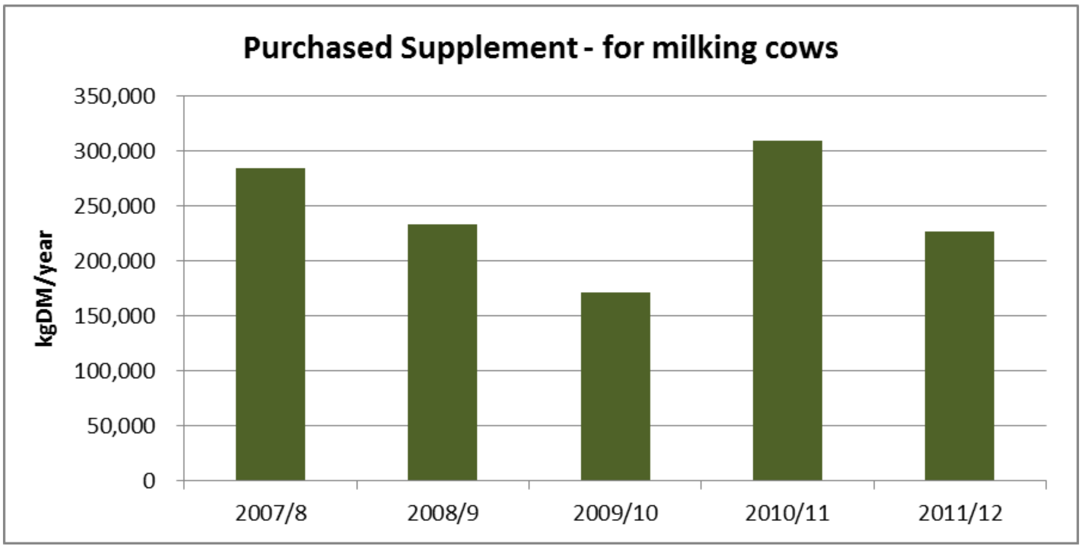
Introduction:

Lincoln University Dairy Farm (LUDF) is a 160 hectare (effective) dairy farm milking approximately 4 cows/ha on predominantly centre pivot irrigated pasture. The farm is focussed on pasture based milk production, typically supplemented with small amounts of bought in grass silage and the majority of the cows wintered off.

The farm system was 'primarily the same' from 2004 through till 2010/11 when a system change was implemented to increase profitability through increasing productivity without increasing the farms total environmental footprint.

Production typically ranged from 1630 – 1720 kgMS/ha and around 400kgMS/cow up till and including 2010/11. Benchmarking of the farms profitability (operating surplus per ha) positioned the farm within the top 2-5% of Canterbury and NZ dairy farms. The system change in 2011/12 increased production 12.5% and profitability on a like for like basis (same payout) by 15%. Production rose to 470kg/cow and 1860kgMS/ha from 3.95 cows/ha. While the farms total environmental footprint includes its support land (grass silage, replacements and wintering), this exercise refers only to the milking platform.





Data Collection:

LUDF is managed by the South Island Dairying Development Centre (SIDDC) on behalf of Lincoln University as a commercial demonstration farm. Daily and weekly data collection and transparency of inputs, strategies and results has created a substantial database of the farms performance over time.

Overseer® 6.0

Recognising Overseer® is a long term equilibrium model, intended to predict long term annual average outputs, the Lincoln University Dairy Farm provides a multi-year dataset to compare the effect over time of varying input choices, within a consistent framework.

LUDF's data from an individual year reflects the tactical and management responses to seasonal conditions as they evolve. Inputting actual data over multiple years with a consistent methodology (see decision rules below) provides one means of assessing the effect of a set of decision rules on the outcome over time. The combined data set from consecutive years is likely to more closely resemble a long term average than any individual year.

N Loss to Water:

Only the N-losses to water are considered in this analysis, in part due to the greater emphasis currently placed on this output. (Overseer reports Nutrients removed in five categories – products, exported effluent, supplements and crop residues, atmosphere, and to water. N–losses to water refer to nitrogen lost below the root zone and therefore potentially available to leach into water.) Other losses of nitrogen remain of interest, both agronomically, in relation to the lost opportunity, and in the case of losses to the atmosphere, losses that may in the future form part of more specific on farm accounting for Nitrous Oxide emissions.

Decision Rules:

The phrase 'Decision rules' is used in this paper to describe the specific set of input conditions used across a range of years, to consider the impact of those inputs on the predicted loss of N from the rooting zone at LUDF. Multiple variations of decision rules could be used to drive a particular range of outputs if the user desired. In this set of examples, the default values were chosen, then largely, a single change or set of like changes were made in one area, using the actual LUDF data across years, while all other values were left the same. Thus the results endeavour to explore the sensitivity of Overseer® to various input fields, but do not attempt to define a set of variables or combination of variables to deliver a specific outcome. The use of actual data from LUDF over time, rather than simple 'what-if' analysis enables the results to more closely resemble the intent of a long term average annual model.

Disclaimer:

The LUDF data used in the creation of the following Overseer® scenarios is widely available and has generally been discussed in the context of the farms performance in many different forums. Other users of Overseer® theoretically should be able to recreate the same scenarios and therefore arrive at the same conclusions. Nevertheless, errors may have occurred in data entry, or assumptions made, and, importantly, the results remain specific to LUDF and the input data used. Whilst the results show significance or otherwise of various decision rules on the predicted N loss for LUDF, this should not be taken to infer the same effect or significance will occur on other farms.

Standard Inputs:

Actual milk production per year, stocking rate, off farm winter grazing days, N fertiliser used and supplements purchased reflected actual farm practice each year. Eco-n (DCD) (as used each year) was included within the default values. Cow numbers were inputted based on peak cows milked, except for the comparison with monthly cow numbers. N-loss to water was then averaged across years for each set of decision rules.

Irrigation was defined as ‘Centre Pivot’ with Overseer® calculating the irrigation volume and months of application (using deficit irrigation) as the default or standard input. Irrigation was available for application from September through to (and including) April.

Input choices considered:

The following input choices were considered in creating the decision rules for various scenarios using the LUDF dataset. These inputs were selected based on general discussions regarding the availability of accurate data on typical farms, expectation of effect on results, need to report for other purposes, and perception of uniqueness to farms like LUDF, compared to an average farm. For example the protein percentage of milk supplied is a little higher, suggesting more N may be exported than an ‘average farm’.

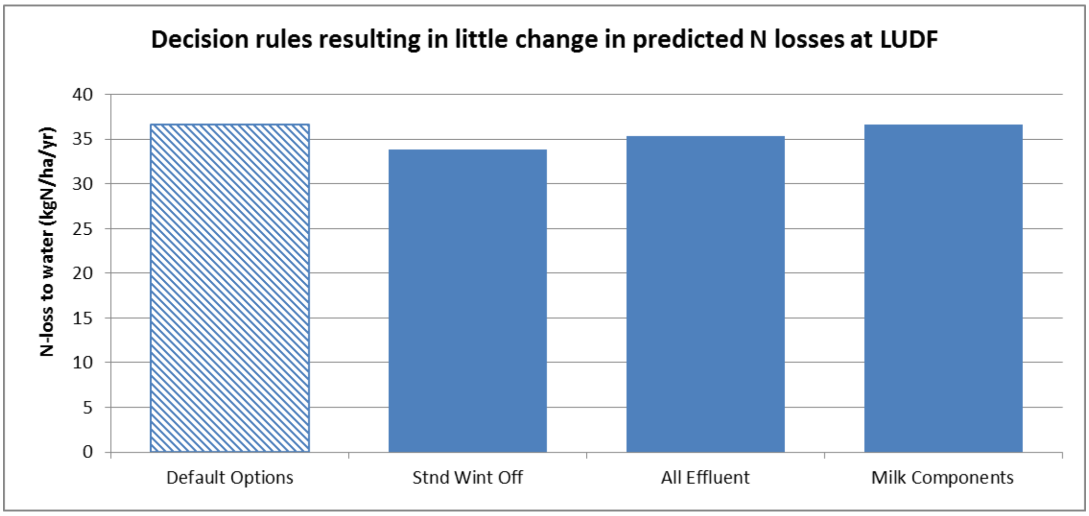
1. Clover levels – using documented clover content on farm (see LUDF Focus Day handouts, including February 2010 and February 2011).
2. Pasture quality (MJME/kgDM) and N concentration in pasture using feed quality analysis from each year
3. On farm irrigation volume records
4. Livestock numbers (specifying monthly livestock rather than enabling Overseer® to calculate stock numbers from peak cows milked)
5. Milk components (milk fat and protein percentage)
6. Grouping some of the soil types together to reduce complexity of data entry
7. Standardising the effect of cows wintered off farm
8. Increasing the effluent area to the whole farm
9. Changing from Centre Pivot irrigation (using Overseer® calculated ‘deficit’ irrigation) to actively managed irrigation*
10. Increasing average annual rainfall from the NIWA local grid prediction to the highest recorded annual rainfall over the past 6 years

** Overseer® defines actively managed irrigation as the application method and management that results in no direct additional drainage from the irrigation application (ie no leakages, overlaps etc) and presumes no rain within 5 days after application.*

Effects of Decision Rules at LUDF - averaged over 5 seasons:

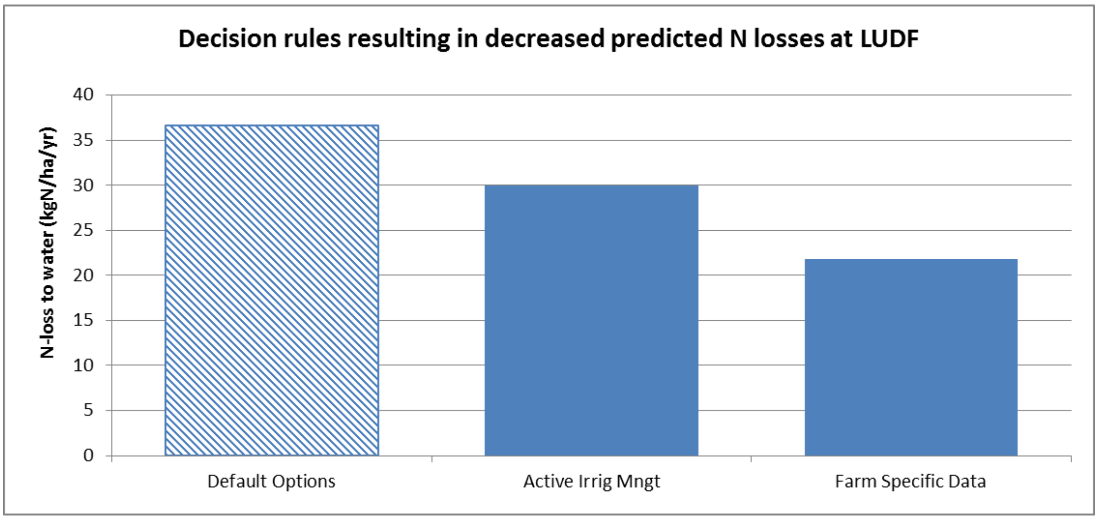
Decision rules resulting in limited change in predicted N losses to water include:

- standardising wintering off,
- increasing the size of the farms effluent area to the whole milking platform and
- changing the milk composition to reflect the slightly higher protein content of milk supplied by LUDF.



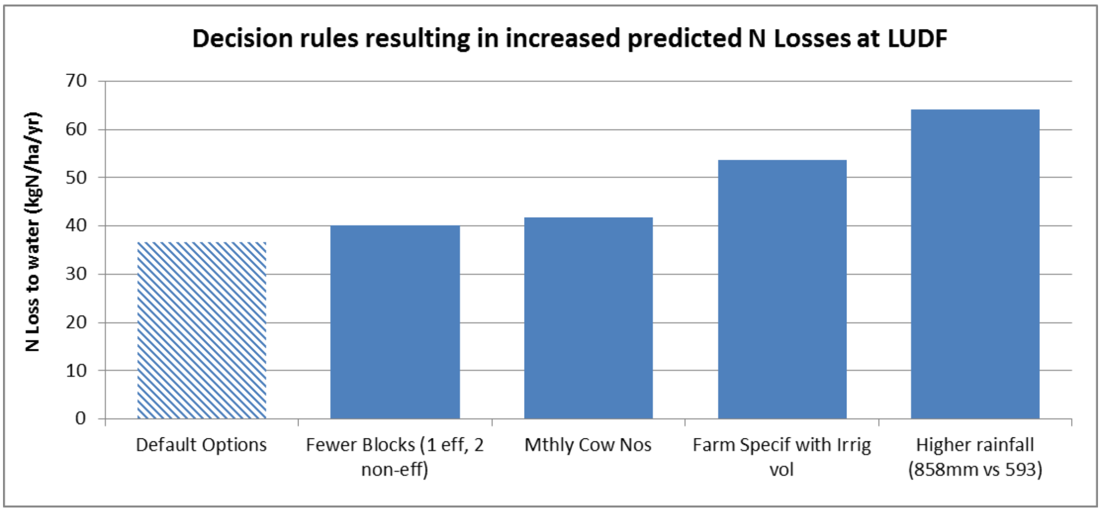
Decision rules resulting in decreased predicted N losses to water include:

- using farm specific data for as many inputs as possible, except irrigation volume and timing. Farm specific inputs included pasture quality, clover content, replacement rates, cow liveweight, milk composition etc
- active management of irrigation also resulted in decreasing the predicted N loss



Decision rules resulting in increases in the predicted N losses to water at LUDF include:

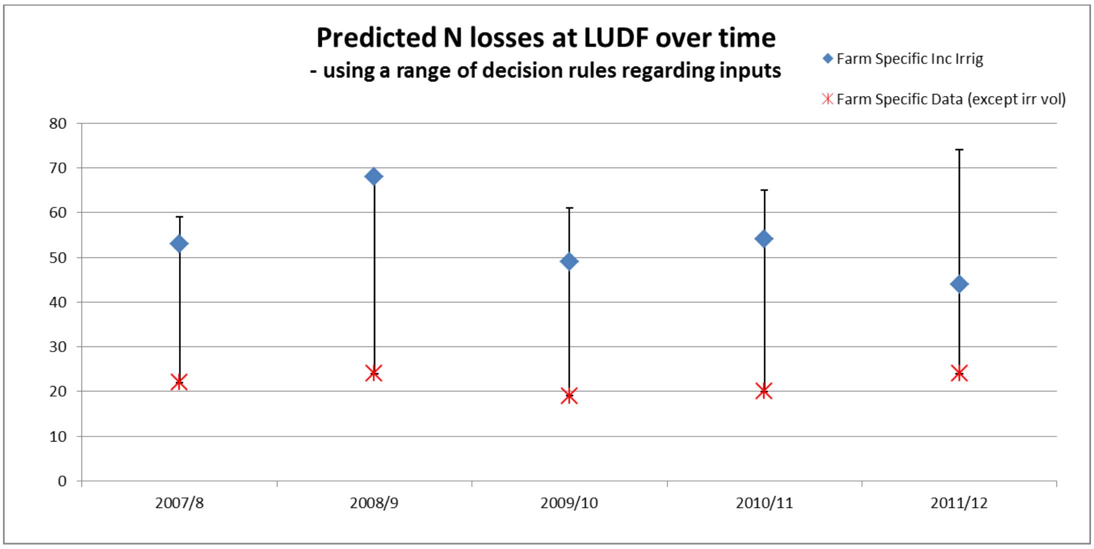
- reducing the number of blocks (effectively soil type variations)
- using monthly cow numbers rather than peak cow numbers
- adding actual irrigation volume and timing of irrigation
- increasing annual rainfall to the actual rainfall as occurred in 2008/09



Effects of Decision Rules on year to year variation:

The LUDF data set also enabled a comparison of the year to year variation in predicted N losses for a given set of decision rules. Most decision rules responded in a similar manner, typically showing an increase in losses year on year, however some decision rules resulted in a downward trend in predicted N losses year on year while others showed year to year variation but no trend.

Overall the variation in predicted N losses ranged from a minimum of 19 kgN/ha/yr to a maximum of 24kgN/ha/yr using farm specific data with default irrigation (a range of 26%) to 44 to 69 kgN/ha/yr (a range of 55%) for farm specific data with actual irrigation volume and timing. Measured losses (reported elsewhere) have shown similar ranges in year to year N-loss to water, reinforcing the need to consider long term average effects, not an individual year's results (whether measured or modelled).



The predicted loss for LUDF in the years analysed in this exercise demonstrate average N loss to water could range from 19 to 74 kgN/ha/year. This shows the importance of the input decisions, particularly when the Overseer® data will be used to compare with other farms or over multiple seasons. The range in predicted N losses between years for some decision rules is greater than the effect of some of the choices contributing to a set of decision rules.

Impact of farm specific data

Farm specific data without actual irrigation volume generally resulted in the lowest predicted N-losses to water, while adding actual irrigation volume and timing of irrigation resulted in higher predicted losses. The decision regarding actual irrigation volume versus the calculated deficit irrigation is therefore significant in estimating the likely scale of predicted N-losses. Neither option is necessarily ideal, one ignores actual data which, along with actual N-fertiliser applied, supplements used and milk production reflects the management decisions and outcome of a specific season; the other endeavours to compare actual irrigation against long term average rainfall. Ignoring actual irrigation volume may distort comparisons between farms if some farmers with high irrigation reliability irrigate more while others buy in more supplements or change other management practices (including drying off early).

Pasture quality and clover content are two important contributors to the lower N losses that occur within the farm specific (without irrigation volume) set of decision rules. The documented loss of clover in 2009/10, correlates with Overseer®'s prediction of less clover fixed N in the later years of comparison. The reduction in clover fixed N reduces the total available N and therefore surplus N.

High pasture quality across the year at LUDF is a function of irrigation, pasture species and pasture management, all combining to lift milk production. Overseer® estimates higher intakes would be required when using the default pasture parameters, compared to the actual pasture quality at LUDF. Lower intakes would result in lower N excretion and hence lower predicted leaching when using the actual pasture quality data at LUDF.

Discussion:

Using Overseer® to predict on-farm N losses from a given set of inputs, management strategies and production outcomes can contribute to a greater understanding of part of the environmental footprint for a specific farm. Consideration is required however of the intended use of the Overseer® output which could range from compliance with supplier protocols or regional council requirements to internal understanding, benchmarking and / or seeking on-farm efficiencies.

In the absence of greater clarity (and agreement) on the use of farm specific input data, and the effect of this on the predicted N-losses, these potential alternative uses may require, or benefit from different decision rules regarding input data. In all cases the consistent use of a set of decision rules for a specific purpose, year to year will provide more meaningful data.

This is of increased significance if the individuals creating Overseer® files for a farm change over time.

Further there is the concept of long term average effects, and the decisions regarding the amalgamation of individual year's inputs and production, modelled against long term average climatic data. Is a long term average of input data the effective means of ensuring relevancy and consistency against a long term climatic data set; and if so, is the reporting and averaging of individual years results more appropriate, or the averaging of multi-year input data to create an on-going rolling average output?

Valid arguments can also be made to simplify as much of the data input as possible, relying largely on default values and perhaps seeking decision rules that either minimise the predicted N loss, or the year to year variation. Alternatively, using more farm specific data has the potential to increase the relevance of the output to an individual farm operation, and thus drive greater nutrient efficiency as the significance of changes in farm practice are reflected in Overseer® outputs.

Farmers, regulators, individuals generating Overseer® reports and industry participants have the opportunity to influence the decision rules regarding the use of input choices within Overseer® 6. Questions of the intended use of the output need to be considered along with the desire for a predicted N-loss to water that is relevant to the specific farm and consistent with other properties and targets when benchmarked.

Analysis of the input data from five consecutive and broadly similar years at LUDF shows it is difficult (and possibly inappropriate) to pinpoint an exact N-loss for this farm. A range of losses or average loss over time will more correctly describe the impact of LUDF's management on the predicted loss of nitrogen from the root zone.

Appendix 1: Overview of Soil Details and Rainfall Records

Soils / Blocks	Area	% of total area	Soil description	Top Soil Texture
Eyre - Effluent Blk	3.0	1.89%	Sandy Loam	Stony / Not Compacted
Eyre - Non Effluent	5.0	3.1%	Sandy Loam	Stony / Not Compacted
Templeton - Effluent Blk	26.7	16.7%	Silt Loam	Not Stony / Not Compacted
Templeton - Non Effluent	45.3	28.3%	Silt Loam	Not Stony / Not Compacted
Wakanui - Effluent Blk	4.3	2.7%	Silt Loam	Not Stony / Not Compacted
Wakanui - Non Effluent	43.8	27.3%	Silt Loam	Not Stony / Not Compacted
Temuka - Non Effluent	32.0	20.0%	Clay Loam	Not Stony / Not Compacted
Total Productive Area	160.1	98.11%		
Non Productive Area	6.7			
Total Farm Area	166.8			

The comparison using 'fewer blocks' ignored the Eyre soils (adding this area to the Templeton soils), added the Wakanui effluent block to the Templeton effluent block to result in a single effluent block only, and combined the remaining Wakanui and Temuka non-effluent blocks, choosing 'Wakanui' as it dominates this combined block (44 vs 32 ha).

Rainfall

	2007-8	2008-9	2009-10	2010-11	2011-12
Jun	62	86	14	109	42
Jul	75	149	36	37	21
Aug	35	90	52	111	67
Sep	29	41	15	45	30
Oct	79	22	79	24	105
Nov	40	11	10	52	54
Dec	59	77	36	39	58
Jan	19	46	49	37	31
Feb	108	61	21	33	72
Mar	23	35	23	59	37
Apr	38	68	25	73	24
May	57	171	153	51	10
Total	**624**	**858**	**512**	**670**	**549**

Appendix 2: Nitrogen Application and Irrigation Volume

Nitrogen Applications - Total kg N applied per ha per month (Separated into Effluent and non-Effluent Areas in years where Nitrogen fertiliser was applied to effluent blocks)

Season	**2007-08**	**2008-09**	**2009-10**	**2010-11**		**2011-12**	
	Non-Effluent	**Non-Effluent**	**Non-Effluent**	**Non-Effluent**	**Effluent**	**Non-Effluent**	**Effluent**
Area (ha)	126	126	126	126	34	126	34
July	11						
August	11	23	29	19		20	16
September	27	40	18	50		32	17
October	31	30	33	39		41	
November	9	16	21	33		59	49
December	16	41	13	41	9	57	12
January	9		21	31	27	47	21
February	26	25	13	28		40	0
March	28	25	35	43		50	54
April	11	40	32	24		30	9
May	9	11	10	8		7	
Ave. kg/N /ha/yr	**187**	**250**	**225**	**256**		**340**	

Total Irrigation Volume (mm/ha) applied each month*

	2007-08	**2008-09**	**2009-10**	**2010-11**	**2011-12**
September		9	17		
October		75	17	70	
November	126	116	125	139	44
December	72	110	87	133	90
January	180	128	64	110	128
February	48	70	75	70	51
March	72	23	78	41	
April		17	35		
Total	498	548	498	563	313

* Note: Irrigation volumes are ‘as recorded’ from water meters at LUDF. The water meters were upgraded prior to the 2012/ 13 season to accommodate the requirements of the National Regulations and Reporting Water Takes 2010.

Appendix 3: Clover content / Pasture Quality Parameters and Wintering off details

	2007/8	2008/9	2009/10	2010/11	2011/12
Clover levels	medium	medium	low	v. low	v.low
N Concentration in Pasture (From Protein %)	3.6	3.7	3.5	3.5	3.6
Metabolisable Energy					
Jan - July (MJMJE)	12.2	12.2	12.2	12.2	12.2
Aug - Sep	12.6	12.6	12.6	12.6	12.6
Oct	12.2	12.2	12.2	12.2	12.2
Nov -Dec	12	12	12	12	12

Notes:

1. Clover levels interpreted into 'medium'. 'low', or 'very low' based on description of clover in page 7, LUDF focus day notes, February 2010.
   a. 2008-9 season – Clover root weevil present in many pastures, not considered an economic problem
   b. 2009-10 season – Clover root weevil obvious in much greater numbers. Now considered to be making a negative impact on quantity and quality of pasture.
2. Pasture utilisation left as default values
3. Pasture samples are collected on a regular basis and analysed for quality. The sample is representative of the 'as grazed' pasture – ie harvested to the same height / pasture residual as the cows were expected to graze to.

Wintering Off	**2007/8**	**2008/9**	**2009/10**	**2010/11**	**2011/12**
Replacement rate (of cows wintered)	24	28	23	24	21
No Cows Wintered Off	546	547	570	652	650
Weeks off	9	7	9	8.4	9.8
Total grazing days off	34,398	26,803	35,910	38,338	44,590
Max Cows Wintered	704	704	685	694	665
Equiv days off (whole herd)	49	38	52	55	67
June	100%	100%	100%	100%	100%
July	61%	26%	72%	81%	75%
Aug	-	-	-	-	45%

Appendix 4 – Other assumptions in the Overseer® Model for LUDF

2 ha Native Trees established in 07/08 and therefore farm area changes at the beginning of 2008/09 Season. 1 ha each from Templton and Wakanui taken for trees

Purchased silage storage conditions – excellent, type - baled silage, well stored
Silage utilisation - left as average (default)
Eco-n (DCD) - applied April and July - 25 day rotation in April, 70 in July, no N within 7 days. Three applications occurred in 2011/12, with the first in March, also on a 25 day rotation
Mature Cow weight - Default (439kg)
Breeding replacement rate - Default (23%)
Calving time not specified
Milk solids entered - not separated by milk fat and protein
Mg, Salt, Limeflour not added

Cultivated in last 5 years - not ticked
Dist from sea -30km
Annual rainfall - 593
Rainfall variability – low (As per Overseer® data file / map)
Temperature - 11
PET 685
Potential ET - moderate (As per Overseer® data file / map)

Soil described by 'type'
Average Soil test results used 10/11 soil test data used for all years
Default ASC used
Default TBK used

Effluent – Liquid, Spray from sump, <12mm, actively managed
(All Eff option - Spray from sump, Low application, actively managed).

Irrigation - Assumed Overseer® calculates required volume in all months - Sept to April inclusive
Pasture Quality - Default
Clover content - Default

OAD Never (except specific cow number option below)

	2007/8	2008/9	2009/10	2010/11	2011/12
Farm area (effective)	162	160	160	160	160
Peak Cows Milked	680	683	660	669	632
Cow Liveweight (Dec)	490	490	470	458	471
Milk Solids produced	278,560	261,424	273,605	264,460	297,720
Milk Solids per cow	410	383	415	395	471
Milk Solids per ha	1,720	1,634	1,710	1,653	1,861
Tot Purch. Supplement	284,240	233,586	170,940	309,078	226,888
Purch Supp - kgDM/cow	418	342	259	462	359

Appendix 5: Multi-year Summary of Nitrogen Inputs and Outputs:

All years average	Default Options	Farm Spec. Data (except irr vol)	Active Irrig Mngt	Stnd Wint Off	All Effluent	Milk Com-ponents	Fewer Blocks (1 eff, 2 non-eff)	Mthly Cow Nos	Farm Specif with Irrig vol	Higher rainfall (858mm vs 593)
RESULTS										
Fertiliser N added	228	228	228	228	228	228	228	228	228	228
Rain / Clover N Fixation	132	60	131	116	129	132	126	142	58	138
Irrigation	6	6	5	6	6	6	6	6	12	3
Supplements Imported	43	43	43	43	43	43	43	43	43	43
N Exported in Products	128	130	128	128	128	128	128	126	130	128
N lost to atmosphere	104	70	100	100	104	104	81	114	71	105
N lost to water	37	22	30	34	35	37	40	42	54	64
Highest N Loss (Eyre)	63	38	55	59	65	63	61	73	81	121
Lowest N Loss (Temuka)	4	3	4	4	4	4	24	4	11	6
N Surplus	280	207	278	265	279	282	275	293	211	284
N Conversion efficiency	32	39	32	33	32	32	32	30	39	31

Appendix 6: Predicted Farm N Loss to water - Individual Year Results

Comparison of Farm N Lost to Water	2007/8	2008/9	2009/10	2010/11	2011/12	Average (all years)
Default Options	33	35	34	37	44	37
Farm Specific Data (except irr vol)	22	24	19	20	24	22
Active Irrig Mngt	26	29	28	31	36	30
Stnd Wint Off	30	32	32	34	41	34
All Effluent	32	34	33	36	42	35
Milk Components	33	35	34	37	44	37
Fewer Blocks (1 eff, 2 non-eff)	36	38	38	41	48	40
Mthly Cow Nos	37	38	39	43	52	42
Farm Specif with Irrig vol	53	68	49	54	44	54
Higher rainfall (858mm vs 593)	59	62	61	65	74	64