Environment Waikato Technical Report 2004/19

# Nutrient Budgets for Waikato Dairy and Sheep/Beef Farms for 1997/98 and 2002/03

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# Executive Summary

This project involved use of the OVERSEER® nutrient budget model to estimate nutrient budgets and environmental emissions from farms in the Waikato region. A 'representative' selection of farms for 1997/98 and 2002/03 included 20 or 21 MAF Monitor sheep and beef farms, and 43 or 10 MAF Monitor dairy farms and 144 or 150 Dexcel ProfitWatch dairy farms, respectively.

Data from dairy farms for 2002/03 compared to 1997/98 indicate that milk production per hectare has increased in association with increased inputs from N fertiliser and brought-in supplementary feed. From the Dexcel ProfitWatch farm summary, this increased intensification was associated with an estimated increase in N leaching/runoff from 33 to 42 kg N/ha/yr and N concentration in drainage from 5 to 7 mg/L in 1997/98 versus 2002/03, respectively.

Nitrogen leaching/runoff losses from sheep and beef farms were about one-quarter of those from dairy farms on a per hectare basis. Differences between years were less clear than for dairy farms, with a similar range in estimates across farms in both years.
There was no difference between years in estimated P runoff (average of 1.3 kg P/ha/yr for ProfitWatch farms) from dairy farms. This coincided with lower P fertiliser inputs and farm P surplus in 2002/03 than 1997/98. However, soil Olsen P levels increased from 36 to 43 between 1997/98 and 2002/03, from the Dexcel ProfitWatch data.

Phosphorus runoff apparently increased over time on sheep and beef farms (1.0-1.7 kg P/ha/yr), although this will be due to differences between the years in the sample farms' characteristics of topography and soil type. Fertiliser P inputs and farm P surplus were the same for both years.

Total greenhouse gas emissions per hectare increased by 15% from dairy farms between 1997/98 and 2002/03. This was due to greater $N_2O$ and $CO_2$ emissions associated with the increased N fertiliser and supplementary feed inputs.

Sheep and beef farms showed an apparent increase in greenhouse gas emissions of 12% over time due to an increase in estimated methane emissions coinciding with an increase in stocking rate.

The farms used as part of both the MAF monitor program and the Dexcel ProfitWatch database, are chosen to be representative of the farms in the region. Despite this, some caution needs to be applied in interpretation of the results. This applies to the MAF Monitor farm data in particular, where the relatively small farm numbers (especially dairy farms) coincided with a wide variation between farms in calculated environmental emissions. Nevertheless, this wide variation indicates the potential for farm management practices to influence the magnitude of emissions and to increase overall farm efficiency.

# 1 Introduction

Nutrient losses from farmland are a contributor to excessive nutrient levels in ground and surface water. Better farm management can be used to reduce the amount of nutrients lost from the farm and into water bodies. A nutrient budget is one way of indicating amounts of nutrients that may be lost from the farm, and whether or not nutrients are accumulating in the soil. A series of nutrient budgets done over time can also indicate whether changing farm practises are having an impact on the amounts of nutrients lost to the environment.

Greenhouse gas emissions are also of interest to environmental issues and reflect aspects of the efficiency of productivity, and energy and nitrogen use on farms (Wheeler *et al.* 2003).

# 2 Objectives

- To determine the nutrient budgets for dairy farms and sheep and beef farms in the Waikato region for the years 1997/98 and 2002/03.

- To estimate the amounts of nutrients lost from the farms, nitrate-N concentrations in drainage water, and greenhouse gas emissions.

# 3 Methodology

The OVERSEER® nutrient budget model (version 5.10) was used on farm data sets for 2002/03 which covered:

- 21 sheep and beef farms from the MAF farm monitoring system for the Waikato region

- 10 dairy farms from the MAF farm monitoring system for the Waikato region

- 150 dairy farms from Dexcel's ProfitWatch system for the Waikato region.

It was also used on the original 1997/98 data set of MAF monitor farms covering dairy and sheep and beef farms (Roberts 1999).

Data from farms was summarised for soil test, fertiliser inputs, and nutrient and greenhouse gas losses to the environment.

Of particular interest to Environment Waikato are N leaching losses and P runoff losses from farms, Olsen P levels and greenhouse gas emissions.

# 4 Description of OVERSEER® nutrient budget model

## 4.1 Basis of the OVERSEER® nutrient budget model

Nutrient budgets are useful tools for assessing the sustainability of nutrient flows within a farm and for highlighting potential negative environmental impacts of nutrient use. The OVERSEER® nutrient budget program is a decision support model to help users develop nutrient budgets and evaluate implications of alternative management practices. The current version (updated in June 2003) of the model covers the four main nutrients; nitrogen (N), phosphorus (P), potassium (K) and sulphur (S), as well as the cations calcium (Ca), magnesium (Mg) and sodium (Na). It also includes an acidity budget and inventories of greenhouse gas emissions and energy use (Wheeler *et al*, 2003).

Nutrient budgets are a form of resource accounting. In its simplest form, resource accounting is a measure of inputs and outputs of the item of interest across a defined boundary. In the OVERSEER® nutrient budget program, the defined boundary is the farm or blocks within the farm. Greenhouse gas inventories have similar boundaries and can be derived from the same inputs required to develop nutrient budgets, which greatly facilitated their inclusion into the program.

The OVERSEER® nutrient budget program is an empirical, annual time-step model. It provides estimates of the fate of the nutrients in kg/ha/year, ignoring year-to-year variability due to weather. The model contains a number of databases for nutrient concentrations of fertiliser, animals and products. These are used for estimating the nutrient inputs or outputs on a per-hectare basis.

## 4.2 Input requirements for the model

The model is site-specific and therefore requires the entry of site-specific data (Table 1). Data entry is usually by simple tab-based selections. The model can be run for several sites or blocks and the results can be integrated on an area-weighed basis. Thus, a farmer could run the model for different productive blocks and integrate them on a farm basis. Similarly, a policy-maker could use it to integrate different areas within a catchment, region or country (Ledgard *et al.* 1999).

**Table 1: Information required by user to obtain a detailed nutrient budget from the OVERSEER® nutrient budget model**

| |
|---|
| **Block Information**<br>**Site information**<br>• Area (ha)<br>• Slope (steep, easy, rolling, flat, border-dyke)<br>• Soil group (pumice, volcanic, sedimentary, podzol, sand or peat)<br>• Soil drainage (free- or poor-draining)<br>• Distance from coast (km)<br>• Rainfall and irrigation (mm/year) |
| **Soil test information**<br>• Olsen P<br>• Quick-test K, Ca, Mg and Na<br>• Organic S test |
| **Fertiliser**<br>• Sulphate-S applied last year<br>• Rate of nutrients or fertilisers for current 12 months<br>• N and P applied in high risk months |
| **Farm Information**<br>**System information**<br>• Product yield (milksolids, wool, velvet)<br>• Pasture development status (developing, developed, highly developed) |
| **Management information**<br>• Stocking rate and animal type<br>• Feed brought-in or sold (t DM/ha, type)<br>• Dairy effluent management<br>• Winter management practices |

## 4.3 Input data sources

Data was supplied by Dexcel for average Waikato dairy farms from their ProfitWatch database, Peter Gault for MAF dairy monitor farms and Darren McNae, AgFirst, for MAF sheep and beef monitor farms.

**Table 2: Number of Waikato farms used in this evaluation**

| | 1997/98 | 2002/03 |
|---|---|---|
| MAF Monitor Sheep and Beef | 20 | 21 |
| MAF Monitor Dairy | 43 | 10 |
| ProfitWatch Dairy | 144 | 150 |

## 4.4 Assumptions and deficiencies in the input data

- Unless information was supplied on effluent disposal, it was assumed that the farm used effluent ponds. When the dairy farm effluent was applied to land, it was assumed that the effluent block received the same rates of fertiliser application as the rest of the farm.

- Where soil test data was not provided, typical soil test values were used from the OVERSEER® model based on means for an average farm obtained from aggregated data from soil samples submitted to e-lab.limited and its predecessors.

- Where the soil S test result was provided as Sulphate-S, OVERSEER® was used to estimate the organic S value.

- Distance from the coast, where not provided, was assumed to be 40 km. The model is relatively insensitive to this parameter after this distance, but this assumption would underestimate S, K, Ca, Mg and Na inputs on farms near the coast.

- The ProfitWatch data (Table 2) was supplied as averages for all farms (owners and sharemilkers), and as averages for both the top and the bottom 25% of farms on a milksolids production/ha basis. Consequently no statistical information is provided for this data.

- No information was provided on application of lime on any farms.

## 4.5 Greenhouse gases

The greenhouse gas inventory is based on models and algorithms used for New Zealand's greenhouse gas national inventory, but with modifications to include on farm management practices (Wheeler *et al.* 2003). Methane emissions are based on a metabolic energy intake model developed by Clark (2001). Nitrous oxide ($N_2O$) emissions are based on the New Zealand IPCC-based inventory, which includes the use of emission factors for direct $N_2O$ losses from excreta, fertiliser and effluent, and indirect losses from leached N and volatilised ammonia (de Klein *et al*. 2001). The amounts of effluent, leached N and volatilised ammonia are estimated from the associated N budget model. Carbon dioxide ($CO_2$) emissions from fuel and electricity, processing and some indirect contributions (e.g. fertiliser manufacturing) are largely based on the data of Wells (2001).

# 5 Results

The individual nutrient budget printouts showing the estimated nutrient inputs and outputs, and the summary report for each farm are presented in separate Appendices. The 2002/2003 season data are presented in Appendices 1, 2 and 3 for the MAF monitor sheep and beef farms, MAF monitor dairy farms and ProfitWatch dairy farms, respectively. The corresponding data for the 1997/98 season are presented in Appendices 4, 5 and 6.

# 5.1 Farm input data

## 5.1.1 MAF Monitor sheep and beef farms

The average soil test results for the MAF monitor sheep and beef farms tended to be lower for Olsen P and QT K at 18 and 6 in 2002/03 compared to 21 and 8 in 1997/98, respectively. The reverse trend was evident for Organic S at 15 and 11, respectively (Tables 3 and 4). However, there was a wide variation between farms with a similar magnitude in both years.

The average fertiliser inputs for the four main nutrients (kg/ha/yr) of N, P, K and S were 9, 31, 8 and 28, respectively in 2002/03. These values were very similar to those in 1997/98.

Data from 1997/98 was obtained from the previous report by Roberts (1999). Some of the input details have changed slightly with the latest version of the OVERSEER® nutrient budget program. As a consequence, some information is presented in a different manner than required for inputting into the latest version of the program. One example of this is for sheep and beef farms. Previously, data was provided for total stock units and only the dominant animal type was presented. Thus, it was not possible to identify the actual sheep and beef stock units for 1997/98 and they are presented as either only sheep or only beef.

## 5.1.2 MAF Monitor dairy farms

On average the soil test results for the MAF Monitor dairy farms for 2002/03 were 44 for Olsen P, 10 for QT K and 16 for Organic S. These values tended to be higher than those from the 1997/8 farms of 37 for Olsen P, 9 for QT K and 12 for Organic S (Table 5 and 6). However, there was wide variation with a 3-10 fold difference between lowest and highest soil test values across farms.

The average fertiliser inputs in 2002/03 for the four main nutrients (kg/ha/year) of N, P, K and S were 160, 44, 71 and 55 respectively. The N and K inputs were both higher than the average 1997/98 values, which were 36 kg N/ha and 60 kg K/ha. Inputs for P and S in 2002/03 were lower than the average 1997/98 values of 53 kg P/ha and 58 kg S/ha.

## 5.1.3 Dexcel ProfitWatch dairy farms

The average soil Olsen P value for all 150 ProfitWatch farms in 2002/03 was 43, with the average for the top 25% producing farms being 50 and the average for the lower 25% being 39. The average Olsen P values from 1997/98 farms were all lower at 36, 41 and 31 for the average, upper and lower producing farms, respectively (Tables 7 and 8).

The average annual fertiliser inputs for all farms in 2002/03 were 125 kg N/ha, 50 kg P/ha, 54 kg K/ha and 58 kg S/ha. Nitrogen inputs were almost two-fold higher than the 1997/98 average of 68 kg N/ha/year. In contrast, fertiliser P, K and S inputs were higher in 1997/98 at 62 kg P/ha, 75 kg K/ha and 67 kg S/ha respectively.

**Table 3: MAF Monitor Sheep and Beef Farms 1997/98 - farm input data**

| Farm | Farm size (ha) | Soil Test Result | | | Fertiliser Inputs (kg/ha/year) | | | | Production | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olsen P | QT K | Organic S | N | P | K | S | Wool yield (kg) | Sheep SU | Beef SU |
| 4 | 316 | 18 | 9 | 10 | 0 | 18 | 9 | 23 | 5478 | 3655 | |
| 5 | 166 | 20 | 8 | 7 | 30 | 36 | 3 | 4 | 1826 | 1895 | |
| 8 | 350 | 30 | 4 | 7 | 0 | 32 | 6 | 32 | 11564 | 3143 | |
| 10 | 230 | 20 | 9 | 10 | 0 | 16 | 0 | 21 | 9444 | 2630 | |
| 20 | 165 | 13 | 8 | 8 | 0 | 44 | 0 | 56 | | | 1345 |
| 21 | 390 | 15 | 5 | 7 | 0 | 24 | 23 | 30 | 4695 | 2734 | |
| 22 | 305 | 24 | 14 | 12 | 0 | 27 | 5 | 35 | | | 3248 |
| 23 | 493 | 15 | 9 | 5 | 3 | 47 | 6 | 16 | 12107 | 2398 | |
| 24 | 190 | 30 | 9 | 25 | 0 | 14 | 0 | 18 | 1330 | 1510 | |
| 46 | 158 | 20 | 9 | 12 | 6 | 33 | 3 | 0 | 4033 | 2373 | |
| 47 | 199 | 18 | 9 | 6 | 0 | 42 | 0 | 54 | 5051 | 2401 | |
| 48 | 245 | 20 | 5 | 8 | 0 | 34 | 0 | 44 | 10247 | 2633 | |
| 50 | 163 | 18 | 10 | 7 | 0 | 28 | 28 | 36 | | | 1379 |
| 62 | 377 | 28 | 10 | 25 | 0 | 29 | 28 | 36 | 3393 | 337 | |
| 63 | 118 | 29 | 8 | 7 | 0 | 25 | 0 | 32 | | | 433 |
| 90 | 223 | 18 | 10 | 13 | 23 | 34 | 7 | 41 | 4643 | 2585 | |
| 96 | 240 | 30 | 10 | 11 | 10 | 36 | 3 | 28 | 5696 | 1426 | |
| 97 | 96 | 22 | 9 | 10 | 0 | 15 | 36 | 19 | 864 | 945 | |
| 98 | 240 | 20 | 4 | 25 | 38 | 68 | 91 | 79 | 16337 | 3999 | |
| 99 | 205 | 20 | 9 | 14 | 0 | 20 | 5 | 25 | | | 2366 |
| Average | 243 | 21 | 8 | 11 | 6 | 31 | 13 | 31 | 6447 | 2311 | 1754 |
| Minimum | 96 | 13 | 4 | 5 | 0 | 14 | 0 | 0 | 864 | 337 | 433 |
| Maximum | 493 | 30 | 14 | 25 | 38 | 68 | 91 | 79 | 16337 | 3999 | 3248 |
| Std dev | 101 | 5 | 2 | 6 | 11 | 13 | 22 | 18 | 4497 | 971 | 1079 |

**Table 4: MAF Monitor Sheep and Beef Farms 2002/03 - farm input data**

| Farm | Farm size (ha) | Soil Test Result | | | Fertiliser Inputs (kg/ha/year) | | | | Production | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olsen P | QT K | Organic S | N | P | K | S | Wool yield (kg) | Sheep SU | Beef SU |
| 1 | 612 | 17 | 2 | 8.5 | 0 | 23 | 0 | 29 | 16000 | 3550 | 2876 |
| 2 | 584 | 20 | 4 | 14.2 | 0 | 27 | 0 | 35 | 17000 | 3562 | 2862 |
| 3 | 380 | 15 | 3.3 | 8.7 | 5 | 23 | 0 | 29 | 12000 | 1900 | 1900 |
| 4 | 323 | 8 | 6 | 13 | 5 | 0 | 0 | 0 | 7000 | 1034 | 1034 |
| 5 | 732 | 12 | 13 | 17.9 | 2 | 23 | 0 | 29 | 32000 | 3001 | 3001 |
| 6 | 585 | 17 | 14 | 10.2 | 18 | 27 | 19 | 25 | 20053 | 2925 | 4037 |
| 7 | 120 | 23 | 8.5 | 8 | 29 | 27 | 0 | 1 | 3000 | 624 | 864 |
| 8 | 300 | 27 | 5.5 | 16.5 | 3 | 29 | 14 | 27 | 12500 | 1830 | 2160 |
| 9 | 465 | 22 | 8 | 13.6 | 5 | 26 | 0 | 29 | 15000 | 2790 | 2325 |
| 10 | 452 | 18 | 9 | 21.5 | 0 | 28 | 0 | 36 | 10000 | 2170 | 3978 |
| 11 | 178 | 30 | 7 | 8 | 9 | 29 | 0 | 32 | | 356 | 2136 |
| 12 | 320 | 15 | 6 | 20 | 7 | 23 | 23 | 29 | 3500 | 1056 | 3104 |
| 13 | 630 | 10 | 5 | 17 | 0 | 27 | 0 | 35 | 13000 | 3843 | 2583 |
| 14 | 600 | 12 | 4 | 20 | 0 | 27 | 0 | 35 | 16500 | 3780 | 2520 |
| 15 | 440 | 12 | 5 | 27 | 31 | 41 | 0 | 30 | 11600 | 2112 | 2948 |
| 16 | 155 | 20 | 4.5 | 22.6 | 0 | 74 | 0 | 0 | 4900 | 930 | 822 |
| 17 | 214 | 20 | 7 | 15 | 2 | 26 | 0 | 29 | 4500 | 1434 | 770 |
| 18 | 442 | 20 | 5 | 4.5 | 5 | 70 | 40 | 76 | 8000 | 1459 | 3050 |
| 19 | 280 | 20 | 6 | 23.2 | 9 | 54 | 77 | 70 | 7900 | 1680 | 1316 |
| 20 | 500 | 14 | 4 | 8 | 32 | 25 | 0 | 1 | 10000 | 2550 | 2800 |
| 21 | 424 | 22 | 3 | 18.7 | 32 | 30 | 0 | 2 | 16000 | 3053 | 2671 |
| Average | 416 | 18 | 6 | 15 | 9 | 31 | 8 | 28 | 12023 | 2173 | 2369 |
| Minimum | 120 | 8 | 2 | 4.5 | 0 | 0 | 0 | 0 | 3000 | 356 | 770 |
| Maximum | 732 | 30 | 14 | 27 | 32 | 74 | 77 | 76 | 32000 | 3843 | 4037 |
| Std dev | 172 | 6 | 3 | 6 | 12 | 16 | 19 | 20 | 6799 | 1073 | 959 |

**Table 5: MAF Monitor Dairy Farms 1997/98 - farm input data**

| Farm | Farm size (ha) | Soil Test Result | | | Fertiliser Inputs (kg/ha/year) | | | | Production | | Supplements |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olsen P | QT K | Organic S | N | P | K | S | Yield kg MS | Stocking rate (cows/ha) | (t wet) |
| 4 | 54 | 30 | 8 | 20 | 33 | 72 | 131 | 130 | 52800 | 3.63 | |
| 5 | 57 | 33 | 9 | 20 | 10 | 39 | 88 | 50 | 46600 | 3.33 | |
| 9 | 55 | 39 | 2 | 10 | 68 | 31 | 44 | 63 | 29751 | 2.85 | 70 |
| 30 | 40 | 50 | 11 | 6 | 58 | 101 | 99 | 131 | 40245 | 3.48 | |
| 35 | 50 | 48 | 6 | 22 | 166 | 50 | 70 | 39 | 57942 | 4.84 | 92 |
| 40 | 50 | 56 | 13 | 9 | 110 | 72 | 41 | 27 | 43300 | 4.00 | |
| 42 | 62 | 40 | 10 | 10 | 59 | 78 | 133 | 95 | 69000 | 3.37 | 160 |
| 43 | 80 | 35 | 13 | 20 | 46 | 64 | 64 | 72 | 72500 | 3.61 | |
| 52 | 56 | 25 | 8 | 7 | 0 | 39 | 0 | 51 | 36398 | 2.79 | |
| 54 | 91 | 32 | 5 | 14 | 0 | 41 | 58 | 52 | 66050 | 2.67 | |
| 55 | 67 | 26 | 12 | 9 | 7 | 53 | 53 | 59 | 50000 | 4.37 | 185 |
| 56 | 49 | 55 | 6 | 10 | 0 | 76 | 108 | 97 | 39116 | 2.98 | |
| 57 | 77 | 30 | 6 | 20 | 90 | 62 | 52 | 26 | 61000 | 3.83 | |
| 58 | 78 | 16 | 6 | 3 | 38 | 39 | 32 | 24 | 32470 | 2.76 | 38 |
| 60 | 57 | 40 | 10 | 20 | 119 | 89 | 0 | 67 | 54000 | 4.39 | |
| 61 | 60 | 38 | 20 | 17 | 48 | 53 | 0 | 5 | 39500 | 3.67 | |
| 63 | 57 | 44 | 15 | 15 | 69 | 51 | 44 | 84 | 45600 | 4.02 | |
| 64 | 47 | 52 | 11 | 7 | 0 | 46 | 66 | 59 | 38670 | 3.62 | |
| 65 | 98 | 43 | 3 | 16 | 120 | 55 | 55 | 99 | 98000 | 3.95 | 98 |
| 66 | 62 | 60 | 6 | 20 | 53 | 16 | 39 | 39 | 51500 | 3.60 | |
| 67 | 53 | 28 | 7 | 8 | 68 | 57 | 28 | 6 | 41500 | 3.74 | |
| 68 | 81 | 30 | 10 | 20 | 136 | 123 | 59 | 69 | 57500 | 3.33 | |
| 69 | 84 | 35 | 10 | 20 | 39 | 41 | 73 | 53 | 57500 | 3.11 | |
| 70 | 90 | 46 | 13 | 10 | 0 | 39 | 56 | 50 | 61887 | 2.91 | |
| 71 | 60 | 35 | 8 | 8 | 0 | 23 | 33 | 30 | 31350 | 2.65 | |
| 72 | 44 | 17 | 10 | 10 | 0 | 18 | 25 | 23 | 14829 | 3.70 | |
| 74 | 63 | 27 | 6 | 9 | 0 | 33 | 48 | 43 | 42000 | 3.46 | |

**Table 5 continued**

| Farm | Farm size (ha) | Soil Test Result | | | Fertiliser Inputs (kg/ha/year) | | | | Production | | Supplements |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olsen P | QT K | Organic S | N | P | K | S | Yield (kg MS) | Stocking rate (cows/ha) | (t wet) |
| 75 | 60 | 40 | 15 | 7 | 0 | 46 | 63 | 58 | 76000 | 5.00 | |
| 76 | 119 | 28 | 9 | 9 | 0 | 55 | 79 | 71 | 117000 | 4.48 | 52 |
| 77 | 64 | 30 | 12 | 8 | 22 | 66 | 108 | 80 | 42500 | 3.75 | |
| 78 | 41 | 50 | 8 | 20 | 0 | 47 | 67 | 60 | 34400 | 4.05 | |
| 79 | 116 | 40 | 4 | 10 | 0 | 40 | 58 | 52 | 84000 | 3.35 | 8 |
| 81 | 41 | 40 | 10 | 9 | 0 | 73 | 105 | 94 | 53300 | 4.20 | 23 |
| 83 | 83 | 36 | 10 | 20 | 0 | 42 | 60 | 54 | 18200 | 1.17 | |
| 84 | 70 | 28 | 8 | 5 | 80 | 50 | 69 | 37 | 54500 | 3.26 | |
| 85 | 38 | 27 | 7 | 11 | 45 | 83 | 47 | 48 | 36000 | 3.13 | |
| 87 | 284 | 35 | 9 | 13 | 0 | 55 | 78 | 70 | 278000 | 4.24 | |
| 88 | 40 | 30 | 6 | 11 | 23 | 25 | 0 | 33 | 26300 | 3.23 | |
| 89 | 142 | 30 | 7 | 8 | 44 | 49 | 97 | 74 | 79000 | 2.76 | |
| 91 | 110 | 35 | 9 | 13 | 0 | 56 | 80 | 72 | 110100 | 4.51 | |
| 92 | 55 | 30 | 8 | 10 | 0 | 39 | 56 | 51 | 38500 | 3.20 | |
| 93 | 81 | 55 | 5 | 17 | 0 | 47 | 67 | 60 | 67500 | 4.46 | |
| 94 | 74 | 27 | 8 | 5 | 0 | 40 | 57 | 51 | 42000 | 3.11 | |
| Average | 73 | 37 | 9 | 12 | 36 | 53 | 60 | 58 | 57868 | 4 | 17 |
| Minimum | 38 | 16 | 2 | 3 | 0 | 16 | 0 | 5 | 14829 | 1.17 | 0 |
| Maximum | 284 | 60 | 20 | 22 | 166 | 123 | 133 | 131 | 278000 | 5 | 185 |
| Std dev | 40 | 10 | 3 | 5 | 44 | 21 | 31 | 27 | 40750 | 0.7 | 42 |

**Table 6: MAF Monitor Dairy Farms 2002/03 - farm input data**

| Farm | Farm size (ha) | Soil Test Result | | | Fertiliser Inputs (kg/ha/year) | | | | Production | | Supplements |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olsen P | QT K | Organic S | N | P | K | S | Yield (kg MS) | Stocking rate (cows/ha) | (t DM) |
| **2** | 56 | 39 | 16 | 12 | 217 | 7 | 5 | 0 | 53380 | 3.04 | 20 |
| **7** | 106 | 30 | 6 | 45 | 90 | 53 | 97 | 80 | 89975 | 2.88 | |
| **14**[a] | 56 | 21 | 8 | 8 | 160 | 41 | 37 | 45 | 49929 | 3.34 | |
| **35** | 82 | 38 | 4 | 10 | 170 | 26 | 65 | 25 | 90000 | 2.74 | 169 |
| **42**[a] | 82 | 50 | 8 | 10 | 146 | 78 | 136 | 99 | 96928 | 2.54 | 298 |
| **43** | 79 | 60 | 14 | 23 | 186 | 51 | 51 | 24 | 81420 | 2.91 | 78 |
| **63** | 57 | 45 | 20 | 8 | 146 | 49 | 35 | 65 | 49860 | 3.16 | 56 |
| **65** | 96 | 50 | 6 | 17 | 228 | 44 | 169 | 49 | 119680 | 3.54 | 157 |
| **68**[a] | 80 | 58 | 12 | 11 | 125 | 45 | 114 | 56 | 74865 | 2.71 | 5 |
| **70** | 70 | 51 | 9 | 11 | 135 | 44 | 0 | 111 | 77880 | 3.14 | 3 |
| Average | 76 | 44 | 10 | 16 | 160 | 44 | 71 | 55 | 78392 | 3.00 | 98 |
| Minimum | 56 | 21 | 4 | 8 | 90 | 7 | 0 | 0 | 49860 | 2.54 | 3 |
| Maximum | 106 | 60 | 20 | 45 | 228 | 78 | 169 | 111 | 119680 | 3.54 | 298 |
| Std dev | 17 | 12 | 5 | 11 | 42 | 18 | 56 | 35 | 22580 | 0.3 | 103 |

[a] Farms with effluent applied to land

**Table 7: Dexcel ProfitWatch 1997/98 - farm input data**

| Farm | Farm size (ha) | Soil Test | Fertiliser Inputs (kg/ha/year) | | | | Production | | Brought in Supplements | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Olsen P | N | P | K | S | Yield (kg MS) | Stocking rate (cows/ha) | Hay Equiv. (t DM) | Silage Equiv. (t DM) |
| Average | 90 | 36 | 68 | 62 | 75 | 67 | 76892 | 2.8 | 13.8 | 18.9 |
| Upper 25 % | 85 | 41 | 92 | 64 | 74 | 69 | 91814 | 3.2 | 25.0 | 44.6 |
| Lower 25 % | 94 | 31 | 37 | 56 | 67 | 59 | 58967 | 2.42 | 11.5 | 6.1 |

**Table 8: Dexcel ProfitWatch 2002/03 - farm input data**

| Farm | Farm size (ha) | Soil Test | Fertiliser Inputs (kg/ha/year) | | | | Production | | Brought in Supplements | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Olsen P | N | P | K | S | Yield (kg MS) | Stocking rate (cows/ha) | Hay Equiv. (t DM) | Silage Equiv. (t DM) |
| Average | 91 | 43 | 125 | 50 | 54 | 58 | 91773 | 2.94 | 20.1 | 55.6 |
| Upper 25 % | 79 | 50 | 157 | 51 | 66 | 68 | 98882 | 3.43 | 18.6 | 97.1 |
| Lower 25 % | 96 | 39 | 93 | 46 | 51 | 48 | 72312 | 2.49 | 9.9 | 14.5 |

# 5.2 OVERSEER N and P budget data

## 5.2.1 MAF Monitor sheep and beef farms

Average atmospheric N inputs from clover and rain were similar in both years at 60-67 kg N/ha (Tables 9 and 10) and represented the dominant N input at 7-10 times that from N fertiliser.

Losses through N outputs in the form of product removal were similar in both years at 11-12 kg N/ha and equated to 14-18% of total N inputs.

The average N outputs through atmospheric gaseous losses, leaching/runoff, and immobilisation were 17, 10 and 38 kg N/ha, respectively for 2002/03. These values tended to be slightly higher than those seen in 1997/98 at 14, 8 and 27 kg N/ha, respectively.

Losses through P output in product averaged 2 kg P/ha in both years. Estimated P runoff tended to be higher in 2002/03 than 1997/98 at 1.7 versus 1.0 kg P/ha, respectively (also summarised in Table 21).

**Table 9: MAF sheep and beef farms 1997/98 - OVERSEER N and P budget data**

| Farm | Inputs | N Outputs | | | | P Outputs | | |
|---|---|---|---|---|---|---|---|---|
| | Atmospheric N (clover & rain) | Product (meat & wool) | Atmospheric ($NH_3$, $N_2O$, $N_2$) | Leaching /runoff | Immobilisation | Product | Runoff/ leaching | Immobilisation/ absorption |
| 4 | 67 | 13 | 16 | 8 | 29 | 2 | 0.5 | 20 |
| 5 | 53 | 12 | 20 | 7 | 43 | 2 | 1.4 | 16 |
| 8 | 50 | 13 | 12 | 6 | 19 | 2 | 1.8 | 29 |
| 10 | 66 | 17 | 15 | 8 | 26 | 2 | 0.5 | 21 |
| 20 | 53 | 10 | 15 | 8 | 27 | 2 | 0.6 | 16 |
| 21 | 41 | 8 | 9 | 5 | 19 | 1 | 0.5 | 17 |
| 22 | 75 | 13 | 18 | 12 | 32 | 3 | 0.5 | 25 |
| 23 | 28 | 8 | 6 | 4 | 13 | 1 | 0.6 | 18 |
| 24 | 49 | 8 | 10 | 6 | 25 | 1 | 0.4 | 20 |
| 46 | 84 | 17 | 22 | 11 | 40 | 3 | 0.5 | 22 |
| 47 | 74 | 15 | 14 | 10 | 35 | 2 | 0.2 | 21 |
| 48 | 62 | 16 | 13 | 8 | 24 | 2 | 0.7 | 22 |
| 50 | 60 | 10 | 13 | 10 | 26 | 3 | 0.6 | 20 |
| 62 | 74 | 10 | 14 | 6 | 19 | 2 | 1.3 | 28 |
| 63 | 36 | 4 | 4 | 4 | 5 | 1 | 1.0 | 19 |
| 90 | 74 | 14 | 19 | 10 | 23 | 2 | 0.6 | 20 |
| 96 | 32 | 9 | 10 | 4 | 19 | 1 | 0.8 | 30 |
| 97 | 54 | 10 | 16 | 5 | 24 | 2 | 1.1 | 16 |
| 98 | 82 | 26 | 23 | 19 | 51 | 3 | 1.3 | 23 |
| 99 | 81 | 14 | 16 | 15 | 36 | 3 | 0.8 | 21 |
| Average | 60 | 12 | 14 | 8 | 27 | 2 | 1.0 | 21 |
| Minimum | 28 | 4 | 4 | 4 | 5 | 1 | 0.2 | 16 |
| Maximum | 84 | 26 | 23 | 19 | 51 | 3 | 1.8 | 30 |
| Std dev | 17 | 5 | 5 | 4 | 11 | 0.7 | 0.4 | 4 |

**Table 10: MAF sheep and beef farms 2002/03 - OVERSEER N and P budget data**

| Farm | Inputs | N Outputs | | | | P Outputs | | |
|---|---|---|---|---|---|---|---|---|
| | Atmospheric N (clover & rain) | Product (meat & wool) | Atmospheric ($NH_3$, $N_2O$, $N_2$) | Leaching /runoff | Immobilisation | Product | Runoff/ leaching | Immobilisation/ absorption |
| 1 | 63 | 11 | 15 | 8 | 29 | 2 | 1.8 | 13 |
| 2 | 66 | 9 | 16 | 9 | 32 | 2 | 2.1 | 15 |
| 3 | 59 | 8 | 15 | 6 | 35 | 2 | 2.1 | 12 |
| 4 | 47 | 7 | 12 | 5 | 28 | 1 | 1.1 | 8 |
| 5 | 72 | 11 | 17 | 7 | 38 | 2 | 1.8 | 11 |
| 6 | 67 | 13 | 17 | 10 | 45 | 2 | 2.2 | 18 |
| 7 | 69 | 12 | 17 | 19 | 50 | 3 | 1.5 | 23 |
| 8 | 80 | 14 | 17 | 13 | 38 | 3 | 2.1 | 26 |
| 9 | 64 | 12 | 16 | 10 | 32 | 2 | 1.5 | 23 |
| 10 | 84 | 14 | 19 | 10 | 41 | 3 | 1.6 | 19 |
| 11 | 86 | 15 | 22 | 11 | 47 | 4 | 1.8 | 29 |
| 12 | 84 | 13 | 22 | 14 | 43 | 3 | 0.8 | 14 |
| 13 | 61 | 10 | 16 | 5 | 30 | 2 | 0.9 | 11 |
| 14 | 62 | 11 | 17 | 7 | 27 | 2 | 0.9 | 12 |
| 15 | 61 | 12 | 22 | 11 | 47 | 2 | 1.1 | 12 |
| 16 | 68 | 12 | 15 | 10 | 31 | 2 | 1.3 | 23 |
| 17 | 60 | 10 | 14 | 6 | 32 | 2 | 3.3 | 14 |
| 18 | 63 | 10 | 14 | 11 | 33 | 2 | 1.7 | 23 |
| 19 | 61 | 11 | 12 | 11 | 35 | 2 | 2.7 | 21 |
| 20 | 58 | 11 | 17 | 15 | 48 | 2 | 1.4 | 16 |
| 21 | 70 | 14 | 19 | 17 | 52 | 3 | 2.1 | 22 |
| Average | 67 | 11 | 17 | 10 | 38 | 2 | 1.7 | 17 |
| Minimum | 47 | 7 | 12 | 5 | 27 | 1 | 0.8 | 8 |
| Maximum | 86 | 15 | 22 | 19 | 52 | 4 | 3.3 | 29 |
| Std dev | 10 | 2 | 3 | 4 | 8 | 1 | 0.6 | 6 |

### 5.2.2 MAF Monitor dairy farms

Atmospheric N inputs from clover and rain were 91 kg N/ha in 2002/03 and 160 in 1997/98 (Tables 11 and 12). The lower $N_2$ fixation in 2002/03 will be due to higher N fertiliser application leading to substitution of fertiliser N uptake by clover for $N_2$ fixation (Ledgard *et al.* 2001).

Losses through N outputs in the form of product removal were slightly higher in 2002/03 than in 1997/98 at 79 and 71 kg N/ha, respectively. The loss from transfer to lanes and effluent ponds were slightly lower at 9 compared to 13 kg N/ha in 1997/98, but this will be due to the required assumption that all farms in 1997/98 used effluent ponds whereas the 2002/03 data accounted for known farms with land application of effluent.

The average N outputs through atmospheric gaseous losses, leaching/runoff, and immobilisation were 72, 42 and 64 kg N/ha, respectively in 2002/03. These values tended to be higher than those seen in 1997/98 at 54, 33 and 26 kg N/ha. While N leaching losses have apparently increased over time, the relatively small number of dairy farms in 2002/03 means that care is needed in interpreting this data.

Losses through P outputs were similar for both years with product removal, transfer, and runoff/leaching in 2002/03 being 14, 2 and 1 kg P/ha, respectively (13, 3, and 1 in 1997/98).

### 5.2.3 Dexcel ProfitWatch dairy farms

For all the ProfitWatch farms, the atmospheric N inputs through clover and rain were 109 and 120 kg N/ha in 2002/03 and 1997/98, respectively (Tables 13 and 14).

Losses through N outputs in the form of product losses, transfer to lanes and shed, atmospheric gaseous losses, leaching/runoff and immobilisation at 80, 12, 62, 40 and 51 kg N/ha all tended to be higher in 2002/2003 than in 1997/98, with the latter being 69, 11, 47, 32 and 33 kg N/ha, respectively.

These trends are seen in all the outputs for N and P for both the upper and lower 25% producing farms. Outputs of N and P from the upper 25% producing farms were 30-70% higher than from the lower 25% producing farms.

## Table 11: MAF Monitor Dairy Farms 1997/98 - OVERSEER N and P budget data

| Farm | Inputs | N Outputs | | | | | P Outputs | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Atmospheric N (clover & rain) | Product (milk, meat) | Transfer (to lanes, dairy) | Atmospheric ($NH_3$, $N_2O$, $N_2$) | Leaching/ runoff | Immobilisation | Product | Transfer | Runoff/ leaching | Immobilisation/ absorption |
| 4 | 179 | 82 | 13 | 54 | 31 | 32 | 15 | 3 | 1.7 | 29 |
| 5 | 162 | 70 | 13 | 48 | 30 | 13 | 13 | 3 | 0.3 | 30 |
| 9 | 89 | 48 | 9 | 51 | 19 | 36 | 9 | 2 | 1.6 | 21 |
| 30 | 165 | 83 | 14 | 62 | 39 | 24 | 15 | 3 | 0.4 | 44 |
| 35 | 173 | 99 | 19 | 88 | 68 | 73 | 18 | 4 | 1.4 | 39 |
| 40 | 155 | 76 | 15 | 77 | 48 | 49 | 14 | 4 | 0.4 | 46 |
| 42 | 162 | 90 | 15 | 59 | 44 | 29 | 16 | 3 | 0.4 | 36 |
| 43 | 166 | 77 | 13 | 57 | 35 | 29 | 14 | 3 | 0.9 | 31 |
| 52 | 138 | 56 | 11 | 45 | 21 | 7 | 10 | 2 | 0.2 | 18 |
| 54 | 128 | 59 | 9 | 34 | 21 | 6 | 10 | 2 | 0.2 | 29 |
| 55 | 194 | 78 | 15 | 59 | 29 | 36 | 14 | 3 | 1.0 | 26 |
| 56 | 157 | 67 | 12 | 9 | 23 | 7 | 12 | 3 | 0.5 | 29 |
| 57 | 127 | 67 | 12 | 69 | 29 | 40 | 12 | 2 | 1.5 | 20 |
| 58 | 114 | 49 | 9 | 44 | 19 | 32 | 9 | 2 | 0.5 | 17 |
| 60 | 169 | 83 | 17 | 75 | 59 | 54 | 15 | 4 | 0.4 | 37 |
| 61 | 132 | 62 | 12 | 52 | 27 | 27 | 11 | 2 | 0.4 | 23 |
| 63 | 165 | 71 | 14 | 67 | 37 | 43 | 13 | 3 | 0.9 | 37 |
| 64 | 176 | 71 | 13 | 48 | 30 | 15 | 13 | 3 | 1.3 | 41 |
| 65 | 130 | 81 | 14 | 78 | 36 | 48 | 15 | 3 | 2.3 | 23 |
| 66 | 158 | 72 | 14 | 58 | 39 | 29 | 13 | 3 | 0.5 | 45 |
| 67 | 152 | 69 | 14 | 62 | 37 | 38 | 13 | 3 | 0.2 | 27 |
| 68 | 112 | 62 | 13 | 70 | 47 | 57 | 11 | 3 | 0.3 | 32 |
| 69 | 137 | 60 | 11 | 47 | 25 | 34 | 11 | 3 | 1.6 | 30 |
| 70 | 144 | 59 | 10 | 40 | 23 | 11 | 11 | 3 | 0.9 | 37 |
| 71 | 125 | 47 | 9 | 33 | 18 | 18 | 9 | 2 | 1.5 | 29 |
| 72 | 173 | 66 | 13 | 50 | 31 | 13 | 12 | 2 | 0.1 | 17 |
| 74 | 162 | 61 | 12 | 46 | 29 | 12 | 11 | 3 | 0.2 | 25 |

## Table 11: Continued

| Farm | Inputs | N Outputs | | | | | P Outputs | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Atmospheric N (clover & rain) | Product (milk, meat) | Transfer (to lanes, dairy) | Atmospheric ($NH_3$, $N_2O$, $N_2$) | Leaching/runoff | Immobilisation | Product | Transfer | Runoff/ leaching | Immobilisation/ absorption |
| 75 | 255 | 107 | 19 | 71 | 45 | 12 | 19 | 4 | 0.3 | 35 |
| 76 | 211 | 86 | 16 | 58 | 36 | 21 | 16 | 4 | 0.8 | 27 |
| 77 | 168 | 67 | 14 | 54 | 34 | 21 | 12 | 3 | 0.2 | 29 |
| 78 | 190 | 74 | 14 | 52 | 32 | 18 | 14 | 3 | 1.3 | 40 |
| 79 | 160 | 63 | 12 | 38 | 31 | 16 | 12 | 3 | 1.6 | 33 |
| 81 | 236 | 106 | 17 | 62 | 41 | 11 | 19 | 4 | 0.3 | 38 |
| 83 | 190 | 72 | 13 | 50 | 28 | 27 | 13 | 3 | 1.8 | 31 |
| 84 | 115 | 64 | 11 | 60 | 27 | 33 | 11 | 2 | 0.3 | 20 |
| 85 | 152 | 78 | 12 | 47 | 29 | 32 | 14 | 3 | 1.5 | 27 |
| 87 | 207 | 84 | 16 | 59 | 37 | 11 | 15 | 3 | 0.3 | 32 |
| 88 | 143 | 58 | 11 | 45 | 28 | 24 | 11 | 2 | 0.8 | 26 |
| 89 | 115 | 49 | 10 | 49 | 24 | 26 | 9 | 2 | 0.3 | 20 |
| 91 | 217 | 87 | 16 | 52 | 42 | 20 | 16 | 4 | 1.4 | 31 |
| 92 | 153 | 61 | 11 | 42 | 26 | 14 | 11 | 2 | 0.8 | 27 |
| 93 | 183 | 75 | 14 | 63 | 23 | 8 | 14 | 3 | 1.8 | 27 |
| 94 | 145 | 55 | 11 | 29 | 32 | 18 | 10 | 2 | 1.7 | 24 |
| Average | 160 | 71 | 13 | 54 | 33 | 26 | 13 | 3 | 1.0 | 30 |
| Minimum | 89 | 47 | 9 | 9 | 18 | 6 | 9 | 2 | 0.1 | 17 |
| Maximum | 255 | 107 | 19 | 88 | 68 | 73 | 19 | 4 | 2.3 | 46 |
| Std dev | 34 | 14 | 3 | 14 | 10 | 15 | 3 | 0.7 | 0.6 | 8 |

## Table 12: MAF Monitor Dairy Farms 2002/03 - OVERSEER N and P budget data

| Farm | Inputs | N Outputs | | | | | P Outputs | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Atmospheric N (clover & rain) | Product (milk, meat) | Transfer (to lanes, dairy) | Atmospheric ($NH_3$, $N_2O$, $N_2$) | Leaching/ runoff | Immobilisation | Product | Transfer | Runoff/ leaching | Immobilisation/ absorption |
| 2 | 83 | 77 | 13 | 91 | 53 | 73 | 14 | 3 | 0.2 | 32 |
| 7 | 116 | 69 | 11 | 50 | 40 | 35 | 12 | 2 | 0.4 | 28 |
| 14[a] | 103 | 74 | 0 | 69 | 46 | 75 | 13 | 0 | 0.6 | 21 |
| 35 | 81 | 86 | 13 | 73 | 43 | 71 | 15 | 3 | 0.9 | 31 |
| 42[a] | 68 | 91 | 0 | 57 | 37 | 74 | 16 | 0 | 0.4 | 42 |
| 43 | 88 | 82 | 12 | 79 | 46 | 69 | 14 | 3 | 1.4 | 46 |
| 63 | 98 | 72 | 12 | 71 | 38 | 62 | 13 | 3 | 0.9 | 37 |
| 65 | 102 | 99 | 16 | 110 | 47 | 77 | 17 | 4 | 1.8 | 25 |
| 68[a] | 100 | 75 | 0 | 61 | 37 | 54 | 13 | 0 | 0.4 | 46 |
| 70 | 74 | 61 | 9 | 59 | 30 | 52 | 11 | 2 | 1.0 | 40 |
| Average | 91 | 79 | 9 | 72 | 42 | 64 | 14 | 2 | 1.0 | 35 |
| Minimum | 68 | 61 | 0 | 50 | 30 | 35 | 11 | 0 | 0.2 | 21 |
| Maximum | 116 | 99 | 16 | 110 | 53 | 77 | 17 | 4 | 1.8 | 46 |
| Std dev | 15 | 11 | 6 | 18 | 7 | 14 | 2 | 2 | 0.5 | 9 |

[a] Farms with effluent applied to land

**Table 13: Dexcel ProfitWatch 1997/98 - OVERSEER N and P budget data**

| Farm | Inputs | N Outputs | | | | | P Outputs | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Atmospheric N (clover & rain) | Product (milk, meat) | Transfer (to lanes, dairy) | Atmospheric ($NH_3$, $N_2O$, $N_2$) | Leaching/ runoff | Immobilisation | Product | Transfe r | Runoff/ leaching | Immobilisation/ absorption |
| Average | 120 | 69 | 11 | 47 | 32 | 33 | 12 | 2 | 1.3 | 31 |
| Upper 25 % | 135 | 86 | 13 | 59 | 39 | 40 | 15 | 3 | 1.3 | 35 |
| Lower 25 % | 104 | 52 | 9 | 35 | 24 | 24 | 9 | 2 | 1.0 | 28 |

**Table 14: Dexcel ProfitWatch 2002/03 - OVERSEER N and P budget data**

| Farm | Inputs | N Outputs | | | | | P Outputs | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Atmospheric N (clover & rain) | Product (milk, meat) | Transfer (to lanes, dairy) | Atmospheric ($NH_3$, $N_2O$, $N_2$) | Leaching/ runoff | Immobilisation | Product | Transfer | Runoff/ leaching | Immobilisation/ absorption |
| Average | 109 | 80 | 12 | 62 | 40 | 51 | 14 | 3 | 1.3 | 36 |
| Upper 25 % | 123 | 99 | 15 | 76 | 51 | 57 | 17 | 3 | 1.5 | 40 |
| Lower 25 % | 94 | 61 | 9 | 47 | 31 | 42 | 11 | 2 | 1.4 | 32 |

**Table 15: MAF Monitor Sheep and Beef 1997/98 - OVERSEER N summary data**

| Farm | Nutrient loss indices | | | | | Greenhouse gas emissions | | | |
|---|---|---|---|---|---|---|---|---|---|
| | N leached | Farm N surplus | Farm P surplus | N conversion efficiency | Average nitrate conc in drainage | Methane | $N_2O$ | $CO_2$ | Total |
| | | (kg/ha/yr) | | (%) | (mg N/L) | (kg $CO_2$-equivalent/ha/year) | | | |
| 4 | 8 | 54 | 19 | 20 | 2 | 2729 | 901 | 81 | 3711 |
| 5 | 7 | 71 | 37 | 14 | 1 | 2693 | 956 | 157 | 3806 |
| 8 | 6 | 37 | 33 | 27 | 1 | 2119 | 583 | 67 | 2769 |
| 10 | 8 | 49 | 17 | 25 | 2 | 2698 | 871 | 73 | 3642 |
| 20 | 8 | 49 | 45 | 17 | 2 | 1845 | 615 | 97 | 2557 |
| 21 | 5 | 33 | 26 | 20 | 1 | 1654 | 547 | 77 | 2278 |
| 22 | 12 | 62 | 27 | 17 | 3 | 2411 | 883 | 87 | 3381 |
| 23 | 4 | 23 | 49 | 27 | 1 | 1148 | 385 | 82 | 1615 |
| 24 | 6 | 41 | 16 | 16 | 1 | 1875 | 707 | 54 | 2636 |
| 46 | 11 | 72 | 33 | 19 | 2 | 3543 | 1210 | 118 | 4871 |
| 47 | 10 | 59 | 43 | 20 | 2 | 2846 | 1081 | 109 | 4036 |
| 48 | 8 | 46 | 35 | 26 | 1 | 2535 | 822 | 93 | 3450 |
| 50 | 10 | 50 | 28 | 17 | 2 | 1915 | 711 | 92 | 2718 |
| 62 | 6 | 64 | 30 | 14 | 1 | 2338 | 660 | 81 | 3079 |
| 63 | 4 | 32 | 27 | 12 | 1 | 831 | 299 | 49 | 1179 |
| 90 | 10 | 83 | 35 | 14 | 2 | 2735 | 1061 | 169 | 3965 |
| 96 | 4 | 33 | 38 | 22 | 1 | 1402 | 511 | 100 | 2013 |
| 97 | 5 | 44 | 16 | 19 | 1 | 2322 | 643 | 68 | 3033 |
| 98 | 19 | 94 | 68 | 22 | 1 | 3931 | 1596 | 330 | 5857 |
| 99 | 15 | 67 | 20 | 17 | 2 | 2613 | 985 | 81 | 3679 |
| Average | 8 | 53 | 32 | 19 | 2 | 2309 | 801 | 103 | 3214 |
| Minimum | 4 | 23 | 16 | 12 | 1 | 831 | 299 | 49 | 1179 |
| Maximum | 19 | 94 | 68 | 27 | 3 | 3931 | 1596 | 330 | 5857 |
| Std dev | 4 | 18 | 13 | 5 | 0.6 | 748 | 303 | 61 | 1084 |

## Table 16: MAF Monitor Sheep and Beef 2002/03 - OVERSEER Summary Data

| Farm | Nutrient loss indices | | | | | Greenhouse gas emissions | | | |
|---|---|---|---|---|---|---|---|---|---|
| | N leached | Farm N surplus | Farm P surplus | N conversion efficiency | Average nitrate conc in drainage | Methane | $N_2O$ | $CO_2$ | Total |
| | | (kg/ha/yr) | | (%) | (mg N/L) | ($kg\ CO_2$-equivalent/ha/year) | | | |
| 1 | 8 | 52 | 24 | 17 | 1 | 2480 | 724 | 58 | 3262 |
| 2 | 9 | 57 | 28 | 14 | 1 | 2598 | 771 | 65 | 3434 |
| 3 | 6 | 56 | 24 | 13 | 1 | 2362 | 491 | 72 | 2925 |
| 4 | 5 | 45 | 2 | 14 | <1 | 1890 | 395 | 37 | 2322 |
| 5 | 7 | 63 | 24 | 15 | 1 | 2907 | 583 | 69 | 3559 |
| 6 | 10 | 72 | 28 | 15 | 1 | 2811 | 685 | 130 | 3626 |
| 7 | 19 | 86 | 27 | 13 | 1 | 2930 | 1282 | 168 | 4380 |
| 8 | 13 | 68 | 29 | 17 | 1 | 3142 | 968 | 88 | 4198 |
| 9 | 10 | 57 | 27 | 17 | 1 | 2598 | 801 | 77 | 3476 |
| 10 | 10 | 70 | 28 | 16 | 1 | 3213 | 637 | 73 | 3923 |
| 11 | 11 | 80 | 28 | 16 | 2 | 3309 | 708 | 101 | 4118 |
| 12 | 14 | 79 | 23 | 14 | 2 | 3072 | 1122 | 124 | 4318 |
| 13 | 5 | 51 | 28 | 17 | 1 | 2409 | 457 | 63 | 2929 |
| 14 | 7 | 51 | 28 | 18 | 1 | 2480 | 713 | 64 | 3257 |
| 15 | 11 | 80 | 42 | 13 | 1 | 2717 | 1009 | 170 | 3896 |
| 16 | 10 | 56 | 75 | 18 | 1 | 2669 | 793 | 98 | 3560 |
| 17 | 6 | 52 | 27 | 17 | 1 | 2432 | 481 | 66 | 2979 |
| 18 | 11 | 57 | 71 | 15 | 1 | 2410 | 769 | 153 | 3332 |
| 19 | 11 | 59 | 55 | 16 | 1 | 2527 | 825 | 172 | 3524 |
| 20 | 15 | 80 | 26 | 12 | 1 | 2693 | 1060 | 150 | 3903 |
| 21 | 17 | 88 | 30 | 14 | 1 | 3189 | 1207 | 161 | 4557 |
| Average | 10 | 65 | 32 | 15 | 1 | 2707 | 785 | 103 | 3594 |
| Minimum | 5 | 45 | 2 | 12 | <1 | 1890 | 395 | 37 | 2322 |
| Maximum | 19 | 88 | 75 | 18 | 2 | 3309 | 1282 | 172 | 4557 |
| Std dev | 4 | 13 | 16 | 2 | <1 | 352 | 248 | 44 | 558 |

# 5.3 OVERSEER summary data

## 5.3.1 MAF Monitor sheep and beef farms

The range in N leaching losses was similar for 1997/98 and 2002/03, but the average for the latter tended to be higher (Tables 15 and 16). Average farm N surplus also tended to be higher in 2002/03 than 1997/98.

Farm P surplus was the same in both years at 32 kg P/ha/yr. N conversion efficiency at 19% in 1997/98 was higher than the 15% in 2002/03.

Total greenhouse gas emissions tended to be higher in 2002/03 than 1997/98 at 3594 and 3214 kg $CO_2$-equivalent/ha/year, respectively. About three-quarters of emissions occurred as methane.

## 5.3.2 MAF Monitor dairy farms

The MAF monitor dairy farms were similar in both years for estimated losses of N and P to waterways from effluent ponds, with average values equivalent to 3 and 1 kg/ha/yr, respectively (Tables 17 and 18). Average N leaching, farm N surplus and the nitrate concentration in drainage have all seen higher trends from 33, 127 kg N/ha/yr and 6 mg N/L in 1997/98 to 42, 186 and 10 respectively in 2002/03. Average farm P surplus and N conversion efficiency at 36 kg P/ha and 30% in 2002/03 tended to be lower than in 1997/98 at 44 kg P/ha and 36%, respectively.

The average estimates of total greenhouse gas emissions were slightly higher in 2002/03 than 1997/98 at 8878 and 8628 kg $CO_2$-equivalent/ha/year, respectively. This was due to an apparent increase in both $N_2O$ and $CO_2$, whereas methane decreased.

## Table 17: MAF Monitor Dairy Farms 1997/98 - OVERSEER Summary Data

| Farm | Nutrient loss indices | | | | | | | Greenhouse gas emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N leached | N loss to waterways from ponds | P loss to waterways from ponds | Farm N surplus | Farm P surplus | N conversion efficiency | Average nitrate conc in drainage | Methane | $N_2O$ | $CO_2$ | Total |
| | (kg/ha/yr) | | | | | (%) | (mg N/L) | (kg $CO_2$-equivalent/ha/year) | | | |
| 4 | 31 | 3.1 | 0.6 | 130 | 60 | 39 | 5 | 6279 | 2213 | 561 | 9053 |
| 5 | 30 | 3 | 0.8 | 104 | 32 | 40 | 6 | 5517 | 2134 | 384 | 8035 |
| 9 | 19 | 2.6 | 0.6 | 116 | 27 | 29 | 4 | 3763 | 1837 | 479 | 6079 |
| 30 | 39 | 3.3 | 1.0 | 139 | 91 | 37 | 8 | 6188 | 2729 | 651 | 9568 |
| 35 | 68 | 4.4 | 1.3 | 248 | 36 | 29 | 12 | 7828 | 4223 | 978 | 13029 |
| 40 | 48 | 3.6 | 1.1 | 189 | 61 | 29 | 10 | 6407 | 3323 | 676 | 10406 |
| 42 | 44 | 3.5 | 1.0 | 147 | 67 | 38 | 7 | 6120 | 2794 | 731 | 9645 |
| 43 | 35 | 3.1 | 0.9 | 135 | 51 | 36 | 7 | 6093 | 2485 | 513 | 9091 |
| 52 | 21 | 2.5 | 0.6 | 83 | 32 | 40 | 5 | 4576 | 1680 | 236 | 6492 |
| 54 | 21 | 2.1 | 0.6 | 70 | 35 | 46 | 5 | 4104 | 1490 | 297 | 5891 |
| 55 | 29 | 3.5 | 1.0 | 140 | 42 | 36 | 6 | 6606 | 2175 | 426 | 9207 |
| 56 | 23 | 2.7 | 0.8 | 90 | 69 | 43 | 6 | 5149 | 1853 | 394 | 7396 |
| 57 | 29 | 2.9 | 0.7 | 151 | 53 | 31 | 5 | 5310 | 2567 | 592 | 8469 |
| 58 | 19 | 2.1 | 0.5 | 105 | 33 | 32 | 5 | 4252 | 1586 | 348 | 6186 |
| 60 | 59 | 4 | 1.1 | 205 | 77 | 29 | 9 | 7020 | 3715 | 727 | 11462 |
| 61 | 27 | 2.7 | 0.7 | 118 | 46 | 34 | 6 | 5024 | 2192 | 404 | 7620 |
| 63 | 37 | 3.3 | 1.0 | 162 | 41 | 31 | 10 | 6275 | 2770 | 535 | 9580 |
| 64 | 30 | 3 | 0.9 | 104 | 37 | 40 | 6 | 5896 | 2074 | 336 | 8306 |
| 65 | 36 | 3.3 | 0.9 | 176 | 45 | 32 | 6 | 5745 | 5957 | 801 | 12503 |
| 66 | 39 | 3.2 | 1.0 | 139 | 6 | 34 | 7 | 5893 | 2644 | 446 | 8983 |
| 67 | 37 | 3.3 | 0.8 | 151 | 47 | 31 | 10 | 5927 | 2753 | 497 | 9177 |
| 68 | 47 | 3 | 0.8 | 186 | 115 | 25 | 8 | 5316 | 3099 | 778 | 9193 |
| 69 | 25 | 2.5 | 0.8 | 117 | 33 | 34 | 4 | 5006 | 1861 | 410 | 7277 |
| 70 | 23 | 2.4 | 0.8 | 85 | 32 | 41 | 6 | 4807 | 1671 | 282 | 6760 |
| 71 | 18 | 2 | 0.6 | 78 | 18 | 38 | 3 | 4143 | 1297 | 203 | 5643 |

**Table 17 continued**

| Farm | Nutrient loss indices | | | | | | | Greenhouse gas emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N leached | N loss to waterways from ponds | P loss to waterways from ponds | Farm N surplus | Farm P surplus | N conversion efficiency | Average nitrate conc in drainage | Methane | $N_2O$ | $CO_2$ | Total |
| | (kg/ha/yr) | | | | | (%) | (mg N/L) | (kg $CO_2$-equivalent/ha/year) | | | |
| 72 | 31 | 3.1 | 0.7 | 107 | 9 | 38 | 7 | 5791 | 2194 | 250 | 8235 |
| 74 | 29 | 2.9 | 0.8 | 101 | 26 | 38 | 6 | 5410 | 2049 | 271 | 7730 |
| 75 | 45 | 4.5 | 1.3 | 147 | 30 | 42 | 10 | 8464 | 3155 | 459 | 12078 |
| 76 | 36 | 3.8 | 1.1 | 131 | 46 | 39 | 8 | 7107 | 2526 | 435 | 10068 |
| 77 | 34 | 3.2 | 0.9 | 123 | 57 | 35 | 7 | 5862 | 2391 | 428 | 8681 |
| 78 | 32 | 3.3 | 1.0 | 116 | 37 | 39 | 7 | 6401 | 2269 | 342 | 9012 |
| 79 | 31 | 2.7 | 0.8 | 97 | 33 | 39 | 4 | 5367 | 1935 | 298 | 7600 |
| 81 | 41 | 4.1 | 1.2 | 131 | 60 | 45 | 8 | 7613 | 2803 | 549 | 10965 |
| 83 | 28 | 3.1 | 1.0 | 118 | 34 | 38 | 5 | 6318 | 1996 | 324 | 8638 |
| 84 | 27 | 2.6 | 0.6 | 131 | 44 | 33 | 7 | 4758 | 2284 | 563 | 7605 |
| 85 | 29 | 2.7 | 0.8 | 120 | 73 | 39 | 4 | 5675 | 2075 | 524 | 8274 |
| 87 | 37 | 3.7 | 1.0 | 123 | 44 | 41 | 8 | 6942 | 2604 | 399 | 9945 |
| 88 | 28 | 2.6 | 0.7 | 108 | 17 | 35 | 6 | 5072 | 1971 | 289 | 7332 |
| 89 | 24 | 2.4 | 0.6 | 110 | 43 | 31 | 5 | 4326 | 1921 | 416 | 6663 |
| 91 | 42 | 3.7 | 1.1 | 130 | 45 | 40 | 5 | 7290 | 2626 | 409 | 10325 |
| 92 | 26 | 2.6 | 0.7 | 93 | 33 | 40 | 5 | 5148 | 1816 | 287 | 7251 |
| 93 | 23 | 3.3 | 0.9 | 108 | 37 | 41 | 6 | 6107 | 2163 | 357 | 8627 |
| 94 | 32 | 2.5 | 0.7 | 90 | 34 | 38 | 2 | 4859 | 1804 | 265 | 6928 |
| Average | 33 | 3 | 1.0 | 127 | 44 | 36 | 6 | 5762 | 2412 | 455 | 8628 |
| Minimum | 18 | 2 | 0.5 | 70 | 6 | 25 | 2 | 3763 | 1297 | 203 | 5643 |
| Maximum | 68 | 4.5 | 1.3 | 248 | 115 | 46 | 12 | 8464 | 5957 | 978 | 13029 |
| Std dev | 10 | 0.6 | 0.2 | 35 | 21 | 5 | 2 | 1047 | 807.5 | 172 | 1755 |

## Table 18: MAF Monitor Dairy Farms 2002/03 - OVERSEER Summary Data

| Farm | Nutrient loss indices | | | | | | | Greenhouse gas emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N leached | N loss to waterways from ponds | P loss to waterways from ponds | Farm N surplus | Farm P surplus | N conversion efficiency | Average nitrate conc in drainage | Methane | $N_2O$ | $CO_2$ | Total |
| | (kg/ha/yr) | | | | | (%) | (mg N/L) | (kg $CO_2$-equivalent/ha/year) | | | |
| **2** | 53 | 3 | 0.8 | 229 | -2 | 25 | 14 | 5194 | 3605 | 967 | 9766 |
| **7** | 40 | 2.7 | 0.7 | 137 | 44 | 34 | 5 | 4922 | 2550 | 648 | 8120 |
| **14**[a] | 46 | 0 | 0 | 190 | 31 | 28 | 10 | 5490 | 3287 | 813 | 9590 |
| **35** | 43 | 3 | 0.8 | 199 | 20 | 30 | 9 | 4654 | 2938 | 1078 | 8670 |
| **42**[a] | 37 | 0 | 0 | 167 | 80 | 35 | 8 | 4094 | 2706 | 1295 | 8095 |
| **43** | 46 | 2.9 | 0.9 | 206 | 42 | 28 | 11 | 5049 | 3166 | 1023 | 9238 |
| **63** | 38 | 2.8 | 0.8 | 183 | 41 | 28 | 10 | 4931 | 2809 | 857 | 8597 |
| **65** | 47 | 3.8 | 1.1 | 251 | 36 | 28 | 11 | 5967 | 3834 | 1347 | 11148 |
| **68**[a] | 37 | 0 | 0 | 151 | 35 | 33 | 10 | 4940 | 2840 | 774 | 8554 |
| **70** | 30 | 2 | 0.6 | 149 | 36 | 29 | 8 | 3980 | 2322 | 704 | 7006 |
| Average | 42 | 2 | 1 | 186 | 36 | 30 | 10 | 4922 | 3006 | 951 | 8878 |
| Minimum | 30 | 0 | 0 | 137 | -2 | 25 | 5 | 3980 | 2322 | 648 | 7006 |
| Maximum | 53 | 3.8 | 1.1 | 251 | 80 | 35 | 14 | 5967 | 3834 | 1347 | 11148 |
| Std dev | 7 | 2 | 0.4 | 37 | 21 | 3 | 2 | 592 | 470 | 238 | 1130 |

[a] Farms with effluent applied to land

### 5.3.3 Dexcel ProfitWatch dairy farms

For all ProfitWatch farms including the upper and lower 25% of producing farms, there was a trend for nutrient loss indices to increase in 2002/03 compared to 1997/98 (Tables 19 and 20). In contrast, the farm P surplus and N conversion efficiency decreased.

Greenhouse gas emissions all showed higher trends in 2002/03 than in 1997/98, with the average total emissions increasing from 7530 in 1997/98 to 8635 kg $CO_2$-equivalent/ha/year in 2002/03.

**Table 19: Dexcel ProfitWatch Dairy Farms 1997/97 - OVERSEER Summary Data**

| Farm | Nutrient loss indices | | | | | | | Greenhouse gas emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N leached | N loss to waterways from ponds | P loss to waterways from ponds | Farm N surplus | Farm P surplus | N conversion efficiency | Average nitrate conc in drainage | Methane | $N_2O$ | $CO_2$ | Total |
| | | | (kg/ha/yr) | | | (%) | (mg N/L) | (kg $CO_2$-equivalent/ha/year) | | | |
| Average | 32 | 2.5 | 0.7 | 123 | 54 | 36 | 5 | 4745 | 2184 | 601 | 7530 |
| Upper 25 % | 39 | 3.1 | 0.9 | 152 | 54 | 36 | 7 | 5532 | 2645 | 779 | 8956 |
| Lower 25 % | 24 | 2 | 0.6 | 92 | 50 | 36 | 4 | 3867 | 1643 | 415 | 5925 |

**Table 20: Dexcel ProfitWatch Dairy Farms 2002/03 - OVERSEER Summary Data**

| Farm | Nutrient loss indices | | | | | | | Greenhouse gas emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N leached | N loss to waterways from ponds | P loss to waterways from ponds | Farm N surplus | Farm P surplus | N conversion efficiency | Average nitrate conc in drainage | Methane | $N_2O$ | $CO_2$ | Total |
| | | | (kg/ha/yr) | | | (%) | (mg N/L) | (kg $CO_2$-equivalent/ha/year) | | | |
| Average | 40 | 2.8 | 0.8 | 164 | 41 | 33 | 7 | 5091 | 2713 | 831 | 8635 |
| Upper 25 % | 51 | 3.5 | 1 | 199 | 40 | 33 | 9 | 5925 | 3288 | 1063 | 10276 |
| Lower 25 % | 31 | 2.2 | 0.6 | 129 | 39 | 32 | 5 | 4210 | 2154 | 603 | 6967 |

# 6 Discussion

## 6.1 N leaching and N concentration in drainage

Data from dairy farms for 2002/03 compared to 1997/98 indicate that milk production per hectare has increased in association with increased inputs from N fertiliser and brought-in supplementary feed. From the Dexcel ProfitWatch farm summary, this increased intensification was associated with an estimated increase in N leaching/runoff from 32 to 40 kg N/ha/yr and N concentration in drainage from 5 to 7 mg/L in 1997/98 versus 2002/03, respectively (summarised in Table 21).

Estimates of N leaching from the OVERSEER® nutrient budget model have been validated against a range of field studies, and include some N immobilisation into soil organic matter. If soil organic N was 'saturated', the apparent effects can be estimated within the model by selecting 'highly developed' status. If this was done for the average ProfitWatch farms in 2002/03, it would result in an estimated increase in N leaching from 40 to 51 kg N/ha/yr. However, there is considerable uncertainty around the latter value and estimation of 'N saturation' status in the field is difficult due to high variability in soil C and N status.

Nitrogen leaching/runoff losses from sheep and beef farms were about one-quarter of those from dairy farms on a per hectare basis (Table 21). Differences between years were less clear than for dairy farms, with a similar range in estimates across farms in both years.

## 6.2 P runoff and farm P status

There was no difference between years in estimated P runoff from dairy farms. This coincided with lower P fertiliser inputs and farm P surplus in 2002/03 than 1997/98. However, soil Olsen P levels increased from 36 to 43 between 1997/98 and 2002/03, from the Dexcel ProfitWatch data.

Phosphorus runoff apparently increased over time on sheep and beef farms (Table 21), although this will be due to differences between the years in the sample farms' topography, with no farms being classified as steep in 1997/98 but nearly one-third of farms being steep in 2002/03. The steeper slopes give rise to increased P runoff risk. Additionally, a greater proportion of farms in 2002/03 were classified as having sedimentary soils, which are also prone to greater P runoff than farms on ash soils (Morton *et al.* 2003). Fertiliser P inputs and farm P surplus were the same for both years.

**Table 21: Summary table of the main environmental emissions**

| | Year | N leaching/ runoff | Average nitrate conc in drainage (mg N/L) | P runoff /leaching | Total GHG (kg $CO_2$-equivalent/ha/year) |
|---|---|---|---|---|---|
| MAF Sheep and Beef | 1997/98 | 8 (4-19) | 2 (1-3) | 1.0 (0.2-1.8) | 3214 (1179-5857) |
| | 2002/03 | 10 (5-19) | 1 (<1-2) | 2.0 (0.8-3.3) | 3594 (2322-4557) |
| MAF Dairy | 1997/98 | 33 (18-68) | 6 (2-12) | 1.0 (0.1-2.3) | 8628 (5643-13029) |
| | 2002/03 | 42 (30-53) | 10 (5-14) | 1.0 (0.2-1.8) | 8878 (7006-11148) |
| Dexcel ProfitWatch | 1997/98 | 32 (24-39) | 5 (4-7) | 1.3 (1-1.3) | 7530 (5925-8956) |
| | 2002/03 | 40 (31-51) | 7 (5-9) | 1.3 (1.4-1.5) | 8635 (6967-10276) |

## 6.3 Greenhouse gas emissions

Total greenhouse gas emissions per hectare increased by 15% from dairy farms between 1997/98 and 2002/03. This was due to greater $N_2O$ and $CO_2$ emissions associated with the increased N fertiliser and supplementary feed inputs. The latter include the emissions associated with manufacturing of N fertiliser and with the production of supplementary feed (Wheeler *et al.* 2003).

Sheep and beef farms showed an apparent increase in emissions of 12% over time due to an increase in estimated methane emissions coinciding with an increase in stocking rate.

## 6.4 Caution in data interpretation

The farms used as part of both the MAF monitor program and the Dexcel ProfitWatch database, are chosen to be representative of the farms in the region. Despite this, some caution needs to be applied in interpretation of the results, as the total dairy farms from these sources are only 160. This is only a small percentage of the greater than 4000 dairy farms in the South Auckland region.

This applies to the MAF Monitor farm data in particular, where the relatively small farm numbers (especially dairy farms) coincided with a wide variation between farms in calculated environmental emissions. Nevertheless, this wide variation indicates the potential for farm management practices to influence the magnitude of emissions and to increase overall farm efficiency.

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