Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

Estimating nitrogen and phosphorus contributions to water from discharges that are consented and permitted activities under NRRP

Report No. R12/18

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Executive Summary

Environment Canterbury is developing methods to manage the cumulative effects on Canterbury's freshwater bodies from nitrogen and phosphorus discharges. These methods include setting limits in Nutrient Management Allocation Zones (NMAZ) for nitrogen and possibly phosphorus. Setting these limits requires a stock-take of the nitrogen and phosphorus inputs from existing authorised discharges.

This report provides an estimate of the contribution of nitrogen and phosphorus to water from point source discharges authorised either by; a current discharge permit issued by Environment Canterbury, or by a permitted activity rule in the Canterbury Natural Resources Regional Plan (NRRP).

The estimates of nitrogen and phosphorus loads for each NMAZ have been derived from information contained on Environment Canterbury databases and electronic file record systems, census data and best estimates of nitrogen and phosphorus leaching and discharge rates for the various authorised discharges.

The estimates of annual loads for each of 38 Nutrient Management Allocation Zones are shown in Appendix 1.

On a regional scale, the total estimated annual loads of nitrogen and phosphorus leached from the principal consented and permitted activities that discharge nitrogen and phosphorus in the region are shown in Table ES1.

Table ES1: Estimated total annual loads of nitrogen and phosphorus leached from consented and permitted activity discharges in Canterbury Region

Source	N (t/yr)	P (t/yr)
On-site sewage effluent	280	75
Centralised sewage effluent	270	132
FDE ponds	62	12
Super Intensive Farming	575	150
Meat & Food processing wastewater	1140	24*
Milk processing wastewater	808	115
Totals	**3135**	**508**

* limited data available for P loads from this source

Discharges of human sewage effluent from both on-site systems and centralised sewerage systems account for about 20% of the nitrogen load from consented and permitted discharges in the region.

Other point source discharges of nitrogen and phosphorus include leakage from animal effluent storage ponds and offal pits.

The Nutrient Management Allocation Zones with the highest loads are those where there is a concentration of either meat or food processing operations, or where there is a relatively high concentration of on-site sewage systems and/or centralised sewerage systems.

The five Nutrient Management Allocation Zones with the highest annual nitrogen from leaching from point source discharges are shown in Table ES2.

Table ES2: Nutrient Management Allocation Zones with highest annual nitrogen loads from leaching from consented and permitted activity discharges

Nutrient Management Allocation Zone	N (t/yr)
Ashburton-Rakaia	1078
Ashburton	630
Selwyn-Waihora	472
Rangitata-Orari	306
Orari	208

The study encountered some significant limitations that affected the accuracy of the estimates for nitrogen and phosphorus discharges.

Recommendations are made for further work to increase the level of certainty for assessing and predicting nitrogen and phosphorus loads from consented and permitted discharges and to improve the nitrogen and phosphorus load accounting processes.

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1 Introduction

Environment Canterbury initiated the Land Use and Water Quality Project to address the cumulative effects on water quality of intensifying agricultural land use. The aim of the project is to develop an approach to manage the cumulative discharge of nutrients, nitrogen and phosphorus, into the region's freshwater bodies.

The "preferred' approach, which is endorsed by the Environment Canterbury Commissioners, requires the setting of catchment nutrient load limits in all major catchments in the region to satisfy the requirements of Canterbury Water Management Strategy (CWMS) and the National Policy Statement for Freshwater Management 2011 (NPS). Environment Canterbury is developing a new regional plan, the Land & Water Regional Plan (LWRP) to implement the management of nutrient losses to water from intensifying land use. It is proposed that the LWRP will include nutrient limits for both nitrogen and phosphorus. These limits will initially form the 'default position' for managing water quality in each of the Nutrient Management Allocation Zones (NMAZ) in the region (Figure 1). The development of these limits requires a 'stock take' of nitrogen and phosphorus inputs from existing diffuse and point sources within each catchment.

This report provides an estimate of the contribution of nitrogen and phosphorus to water from point source discharges authorised either by; a current discharge permit issued by Environment Canterbury, or by a permitted activity rule in the Canterbury Natural Resources Regional Plan (NRRP).

2 Discharge of Nitrogen and Phosphorus

Nitrogen that is discharged onto land and not taken up by plants, denitrified, immobilised by soil microbes or volatised is likely be leached from the soil into groundwater. Nitrogen in the form of nitrate is the most susceptible to leaching, but as organic nitrogen can be mineralised and ammonium nitrified to nitrate, all nitrogen is at risk of being leached. Nitrate leaching generally occurs during wet conditions; from rainfall, irrigation or wastewater discharge. Nitrogen discharged below the plant root zone has a higher risk of leaching as the opportunities for plant uptake and denitrification at the soil surface are lost. Nitrate is one of the main contaminants of interest in Canterbury groundwater and surface water as it can have toxic effects on aquatic biota, and in combination with phosphorus enhance aquatic plant growth (Bidwell and Norton 2009).

Phosphorus can enter the aquatic environment via groundwater and overland flow. Even very small increases in phosphorus concentrations in surface water can have ecological consequences (Bidwell and Norton 2009). Phosphorus leaching has generally not been considered significant in New Zealand soils as it had been assumed that phosphorus remained bound with the soil (Webb *et al* 2007). However analysis of the vulnerability of Canterbury soils to leaching of phosphorus shows a wide range of vulnerability in different soil types, with moderate vulnerability over extensive areas of the Canterbury plains (Webb *et al* 2010). Phosphorus discharged below the topsoil will have a higher risk of leaching as opportunities for adsorption and immobilisation in soil organic matter are lost.

Discharges to surface water that contain phosphorus and nitrogen are direct pathways for the nutrients to enter the aquatic environment.

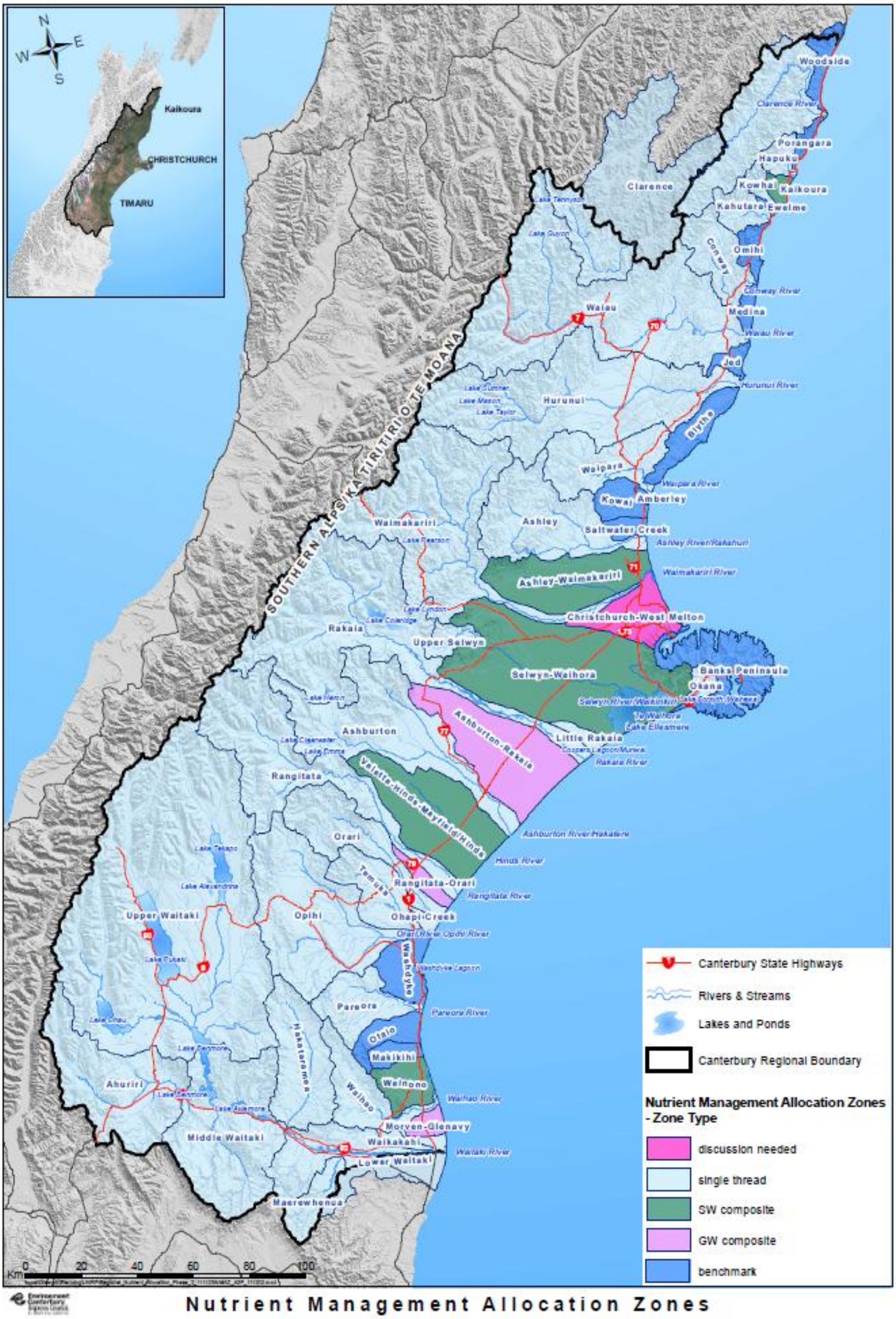

Figure 1 Nutrient Management Allocation Zones

3 Methodology

3.1 Identifying the discharge sources or land uses that are significant contributors of nitrogen and/or phosphorus to water

3.1.1 Discharges authorised by resource consent

Environment Canterbury provided a list of 38 Nutrient Management Allocation Zones, with accompanying spreadsheets from the Consents database that identified for each of the Zones, all discharges to land or water, or land use, which are authorised by a current resource consent. The activities that were identified as being potentially significant contributors of nitrogen and/or phosphorus are:

- Discharges to land or water of sewage effluent from dwellings, commercial premises, community and municipal sewerage treatment and disposal systems;
- Storage and treatment ponds and wetlands for community and municipal sewerage treatment systems;
- Discharges onto and into land or water, and the storage of animal effluent at large scale super-intensive farms[*];
- Discharges to land or water from processing milk, meat, vegetables, fruit, food and wine production.

Discharges of stormwater to land or water are not included within the scope of this project. While stormwater discharges may, at times contain significant concentrations of nitrogen and phosphorus, due to the intermittent and varying nature and scale of these discharges, the estimation of nutrient loads from stormwater will require a more detailed analysis than this project could provide.

3.1.2 Permitted activities

The Natural Resources Regional Plan (NRRP) contains the rules for Canterbury that authorise discharge of contaminants to land or into freshwater as a permitted activity[†], and control the use of land for water quality management purposes. Most permitted activities are not recorded by Environment Canterbury so quantifying the extent of some activities, e.g. offal pits, was not practicable within the scope of this project.

The contribution of nitrogen and phosphorus from some permitted activity discharges will be included in the assessment of diffuse discharges from various land uses e.g. nitrogen and phosphorus contribution from spreading of animal effluent or fertiliser will be included in the calculations for the land use.

The activities that are authorised as a permitted activity by regional rules and were identified as being potentially significant contributors of nitrogen and/or phosphorus, but not accounted for in the calculations for the land use are:

- Discharges on-site wastewater systems at dwellings;
- Use of land for storing animal effluent.

[*] "Super Intensive Farming" is defined in NRRP Chapter 4 as commercial agricultural production carried out in buildings or outdoor areas where the stocking density precludes the maintenance of pasture or groundcover.

[†] subject to conditions set down in a regional plan and do not require resource consent

3.2 Estimating nitrogen and phosphorus contributions

3.2.1 Storage and discharges of sewage effluent and industrial wastewater

Sewage effluent from centralised community and municipal sewerage systems, septage from septic tank cleaning and wastewater from the processing of meat, milk, fish, poultry and vegetables can contain significant concentrations of nitrogen and phosphorus.[‡] In Canterbury, most centralised sewerage systems, include land-based effluent storage and treatment facilities, and many sewerage systems and industrial wastewater systems discharge treated effluent onto or into land. There are still a small number of municipal sewerage systems in Canterbury that discharge to surface fresh waterbodies.

These types of discharges are controlled by discharge permits. Since 2004, when NRRP water quality rules were notified, the storage of effluent has also required resource consent.

To determine the nitrogen and phosphorus loadings from the sewerage and wastewater systems required an estimate of:

- leakage rate from storage ponds and oxidation ponds;
- leaching from land discharge areas and constructed wetlands;
- discharge to surface water.

The details[§] of each discharge permit for sewerage or wastewater systems were inspected to determine, where possible:

- the annual volume of wastewater or effluent authorised to be discharged;
- any limits on the seepage rate from effluent or wastewater storage facilities;
- any limits in the discharge permit on loadings of nitrogen or phosphorus;
- the area of land over which the effluent or wastewater is discharged.

In many instances some of this information could not be obtained from the resource consent, or Environment Canterbury's consents database. Limits relating to nitrogen, and particularly phosphorus, were often not specified in consent conditions. For most discharges to land, the area of land was shown on a plan that was referred to in consent conditions but not attached to the electronic version of the consent document or the decision file. The land area, was generally not specified on the consent document or the attached plan or on the database, and in such cases it was necessary to refer to the application for resource consent to determine the area of land (hectares) used for the land discharge.

The expected concentrations of nitrogen and phosphorus in sewage effluent and wastewater discharges were estimated from:

- Typical sewage effluent quality (Potts and Ellwood 2000);
- When available, wastewater quality sampling results submitted to Environment Canterbury by consent holders in fulfilment of consent compliance monitoring.

The potential for leaching of nitrogen and/or phosphorus from land disposal areas increases under high wastewater or effluent application rates and under high nitrogen or phosphorus loadings. Therefore, to assess potential leaching under land disposal systems requires the land area information and the volume of and concentrations of nitrogen and phosphorus in the wastewater. This information was often not easily accessible.

For discharge onto land systems where 'cut and carry' herbage removal practices are employed, the 'net' application of nitrogen (or difference between N applied – N removed) was assumed to be potentially available for leaching. Although, in most cases, the removal rates for nitrogen were required to be reported in annual monitoring reports, this information was only available from the consent file.

[‡] http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/index.cfm, and http://en.wikipedia.org/wiki/Eutrophication
[§] These can be inspected on Environment Canterbury's website

For land application sites where there is no ‘cut and carry’ system to remove nitrogen in herbage, it was assumed that nitrogen applied in excess of 200 kg nitrogen per hectare per year[**] would potentially be available for leaching.

Where effluent or wastewater is applied to land as flood irrigation or border-dyke irrigation it was assumed that, due to the very high hydraulic loading, all nitrogen applied is potentially leached.

There is greater uncertainty about the dynamics of phosphorus leaching, and considerably less information on the rate and quantity of phosphorus losses in discharges. Consequently, there is likely to be greater uncertainty with the estimates of phosphorus leaching, and the extent of phosphorus leaching from point sources is primarily under estimated.

Phosphorus leaching was assume to occur where effluent or wastewater was discharged below the soil, for example, as leakage from storage ponds, and from land discharge systems where phosphorus is applied in effluent at a rate in excess of 20 kg phosphorus per hectare per year. Discharge permits for many wastewaters did not have phosphorus limits or requirements to monitor phosphorus concentrations. In these cases, due to the absence of data, it was assumed there was no leaching of phosphorus.

3.2.2 On-site sewage systems

Domestic sewage effluent contains a range a contaminants, including nitrogen and phosphorus. The nutrient load in untreated sewage and septic tank effluent is around 10 grams of nitrogen per person per day and 3 grams of phosphorus per person per day (Potts & Ellwood 2000). The average occupied dwelling in Canterbury has 2.5 residents (Census 2006). The typical wastewater flow per person is 180 litres per day (AS/NZS 1547:2000), 450 litres per day for the average household. Therefore the effluent from an average household will have concentrations of total nitrogen of about 60 grams per cubic metre (g/m^3), and concentrations of total phosphorus of about 15 g/m^3.

On-site sewage systems generally compromise a sewage tank and land discharge system. The sophistication of, and level of effluent treatment provided by, on-site sewage systems ranges from the traditional septic tank and soakage pit to aerated wastewater treatment units and recirculating textile packed bed reactors with pressurised drip irrigation disposal systems.

Traditional septic tank systems and subsurface discharge systems have little effect on nitrogen concentrations in sewage effluent (Scholes 2006). However, there has been, since about 2006, an improvement in the technologies utilised in some on-site systems, aimed particularly at reducing nitrogen concentrations in the treated effluent. This has been driven in part by requirements in rules in some regional plans that for an on-site sewage effluent discharge to be authorised without resource consent, it must not contain more than 15 g/m^3[††] or 25 g/m^3[‡‡] Total Nitrogen.

Phosphorus concentrations in sewage effluent have also been reduced in more sophisticated on-site treatment systems. These systems can achieve total phosphorus concentrations of around 5 g/m^3 in the effluent discharged.

Testing the performance of on-site domestic wastewater systems is undertaken by the On-site Effluent Treatment National Testing Programme (OSET-NTP)[§§] Results from the testing programme show that a number of proprietary on-site sewage treatment systems available can achieve these nitrogen and phosphorus standards.

[**] This application rate for nitrogen is frequently recommended as a maximum ‘equilibrium’ rate – see Cameron K C, Di H J and McLaren R G. 1999 *Comparison of Nitrogen Leaching Losses from Different Forms and Rates of Organic Wastes, Fertilisers and Animal Urine Applied to Templeton Soil Lysimeters.* In: (Currie L, ed.) Best Soil Management Practices for Production. Massey University, Palmerston North, New Zealand, pp. 241–249.

[††] Bay of Plenty On-site Effluent Regional Plan Rules 11 and 13

[‡‡] Waikato Regional Plan Rule 3.10.6.3

[§§] OSET-NTP is operated by WaterNZ in conjunction with Bay of Plenty Regional Council and Rotorua District Council.

Most domestic sewage effluent is discharged via sub-surface disposal systems, such as field tiles or excavated trenches, although there is an increasing use of low pressure shallow sub-surface drip irrigation to discharge treated effluent. As discussed above, the use of disposal systems that are beneath the soil and plant root zone will by-pass opportunities to further limit nitrogen or phosphorus leaching.

For the purpose of the project on-site sewage systems installed before 2006 were assumed to contribute:

Nitrogen:	55 g/m^3 or 9 kg N/dwelling/year
Phosphorus:	12 g/m^3 or 2 kg P/dwelling/year

On-site systems installed since 2006 were assumed to be capable of reducing nitrogen and phosphorus concentrations in the effluent discharged, and to contribute:

Nitrogen:	20 g/m^3 or 3 kg N/dwelling/year
Phosphorus:	5 g/m^3 or 1 kg P/dwelling/year

There are a small number of discharges of wastes other than domestic sewage via on-site systems. These include vehicle and stock truck washing facilities. The discharge from these systems was assumed to be the same as domestic sewage.

3.2.2.1 Estimating the number of on-site sewage discharges

On-site sewage systems are generally only installed at dwellings outside urban areas with reticulated sewerage systems.

Data from Census 2006[***] provided the number of occupied dwellings in each census area unit. Census area units for towns and cities closely match the municipal boundary so these were taken to be the extent of a sewerage network for a town. Outside the census area units for cities and townships with sewerage systems, it was assumed that all dwellings have an on-site sewage system that discharges into land.

In some areas, the census area units were close to the NMAZ boundaries, but some large rural census area units traversed NMAZ boundaries. In these situations the dwelling numbers were apportioned between Zones. The number of dwellings in each NMAZ was estimated as at 2006 and these systems were attributed with the higher loads of nitrogen and phosphorus given above.

The number of on-site sewage systems installed since 2006 is available from the Environment Canterbury. The consents database records all on-site sewage tank systems that have been installed since 2006, whether authorised under the permitted activity rule or by consent.

The database records, include on-site sewage systems installed at schools, commercial, sports and recreation premises in rural areas. Many of these systems required resource consent, as the volume of effluent discharged exceeds the permitted activity rule threshold. As the effluent discharged from these premises is domestic sewage, the volume authorised for discharge by the resource consent was converted to ‘equivalent dwellings’ and this added to the number of ‘dwellings’ in the NMAZ.

3.2.3 Storage of farm dairy effluent

There are about 930 dairy farms in Canterbury, each with a farm dairy effluent (FDE) storage facility and a system for discharging effluent to land. The contribution of nitrogen and phosphorus in the FDE spread onto land is accounted for in the assessment of the diffuse nutrient load from the land use.

The average dairy herd in Canterbury is about 1000 cows. The size of an effluent storage pond that has been recommended by Dairy NZ for a herd of this size in Canterbury is 1500 cubic metres. Data from the ECan Consents database indicates that about 65% of dairy farms in Canterbury have a

[***] Available at www.stats.govt.nz/tools_and_services/tools/boundary-map.aspx

storage pond. While the database records the existence of an FDE pond on some dairy farms, the size of the pond is not recorded, so it was assumed that all ponds are the recommended size. Other farms use small capacity concrete sumps and solids removal systems without significant storage capacity.

Effluent storage systems, such as ponds which do not have an impermeable liner, will leak effluent into the ground. There is a range of accepted leakage rates for effluent pond liners, including;

- max 1 mm/day [1.0 litres per m^2 per day] for any pond liner (ECan 2011 operative Regional Rule WQL26)
- max 1 x 10^{-8} m/s [0.9 litres per m^2 per day] for a clay liner (ECan 2004 proposed Regional Rule WQL29)
- max 1 x 10^{-9} m/s [0.09 litres per m^2 per day] for a clay liner (Waikato Regional Plan, USEPA *Guidelines for Protecting Groundwater*)
- max 0.1 mm/day [0.1 litres per m^2 per day] for a synthetic liner (USEPA *Guidelines for Protecting Groundwater)*

For the purpose of this study, it is assumed that a storage pond containing 1500 m^3 of effluent stored to depth of 3 metres will have 400m^2 surface area in the pond floor and 240 m^2 surface area in the pond walls, a total of 640 m^2 exposed to the FDE. A leakage rate of 1 millimetre per day – 1 litre per square metre – means that 640 litres per day of FDE could discharge directly into the ground from the pond, and potentially into groundwater. While some ponds may seal naturally, especially those constructed with soils with higher clay content, those constructed in free draining soils with low clay content may discharge continuously and potentially at higher rates than 1 millimetre per day. In estimating the load of nitrogen and phosphorus from this source, it is assumed that all FDE storage ponds leak at the rate of 640 litres per day, 365 days per year.

The concentrations of nitrogen and phosphorus in FDE vary over the milking season, and nitrogen concentrations in FDE have increased significantly since 1984 (Longhurst *et al* 2000). Typical contemporary mean concentrations[†††] in FDE are;

Nitrogen:	0.44 kg/m3
Phosphorus:	0.07 kg/m3

The annual load of nitrogen and phosphorus leaking from an FDE pond is estimated to be:

Nitrogen:	0.10 tonnes per year
Phosphorus:	0.02 tonnes per yea

The Environment Canterbury consents database records all dairy farms in each NMAZ. It was assumed that 65% of the dairy farms in each NMAZ have a 1500 m^3 storage pond and that each pond is discharging the estimated annual load of nitrogen and phosphorus.

Where the animal effluent collection, storage and disposal systems for super intensive farms, such as beef feedlots, comprised effluent storage ponds, effluent infiltration basins and other point sources of nitrogen or phosphorus, the discharge of nitrogen and phosphorus was estimated from:

- the area of the stock pads and effluent storage ponds – assuming a leakage rate of $1x10^{-8}$ m/s; and
- the volume authorised to be discharged into or onto land.

The concentration of nitrogen and phosphorus in the animal effluent from super-intensive farms was assumed to be the same as FDE.

[†††] Sources: Waikato Regional Council: www.waikatoregion.govt.nz/Environment/Natural-resources/Land-and-soil/Applying-effluent-to-land/, and
Hills Laboratories: www.hill-laboratories.com/page/pageid/2145845327/Effluent_Testing

4 Results

The estimates of annual loads of nitrogen and phosphorus leached from discharges to land authorised by resource consents and under permitted activity rules in the Natural Resources Regional Plan for each of 38 Nutrient Management Zones Allocation Zones are listed in Appendix 1.

On a regional scale, the total estimated annual loads of nitrogen and phosphorus leached from the principal consented and permitted activities that discharge nitrogen and phosphorus in the region are shown in Table 1.

Table 1: Estimated total annual loads of nitrogen and phosphorus leached from consented and permitted activity discharges in Canterbury Region

Source	N (t/yr)	P (t/yr)
On-site sewage effluent	280	75
Centralised sewage effluent	270	132
FDE ponds	62	12
Super Intensive Farming	575	150
Meat & Food processing wastewater	1140	24*
Milk processing wastewater	808	115
Totals	**3135**	**508**

* limited data available for P loads from this source

The principal point sources of nitrogen and phosphorus in Canterbury are the discharges of wastewater onto land from meat, food and milk processing industries, with over 60% of the estimated nitrogen load from consented and permitted discharges from these sources. The lack of data available has made the estimate of the phosphorus load from these sources unreliable, and it is likely to underestimate the phosphorus load.

The five Nutrient Management Allocation Zones with the highest annual nitrogen from leaching from point source discharges are shown in Table 2.

Table 2: Nutrient Management Allocation Zones with highest annual nitrogen loads from leaching from consented and permitted activity discharges

Nutrient Management Allocation Zone	N (t/yr)
Ashburton-Rakaia	1078
Ashburton	630
Selwyn- Waihora	472
Rangitata-Orari	306
Orari	208

The highest nitrogen load is estimated for the Ashburton-Rakaia NMAZ. In this Zone, there are four large-scale meat or food processing operations, each which discharges wastewater onto land. The consents for these discharges allow nitrogen to be discharged onto land at rates ranging from 400 to 700 kilograms of nitrogen per hectare per year.

The storage and discharge of human sewage effluent from on-site systems and community and municipal systems each account for less than 10% of the nitrogen load from consented and permitted discharges in Canterbury. There are about 38,000 dwellings and ‘dwelling equivalents’ with on-site sewage systems in the region. About 5000 of these systems have been installed since 2006. The Selwyn-Waihora NMAZ has the highest number of on-site sewage systems, with over 8000 systems, of which almost 3000 have been installed since 2006. In that Zone, human sewage effluent accounts for about 50% of the nitrogen and phosphorus load from consented and permitted activities.

5 Discussion

The figures for nitrogen and phosphorus loads in this report are estimates only, and provide an initial 'stock-take' of the contribution from point sources authorised as either consented or permitted activities in each NMAZ. Further detailed assessment will need to be undertaken on a zone by zone basis. This work should include:

- detailed assessment of nitrogen and phosphorus in consented discharges;
- site specific factors influencing potential leaching of nitrogen and phosphorus from consented activities, such as soil types and history of land use.

While best endeavours have been made within the scope of the project to develop realistic estimates for the load of nitrogen and phosphorus contributed by point source discharges, the study encountered several significant limitations. These include:

- uncertainty with the dynamics of leaching susceptibility and processes, particularly for phosphorus;
- very few discharge permits set a limit on phosphorus concentrations in the discharge or contained a requirement to monitor phosphorus;
- lack of relevant information in the Consents database including the concentrations of contaminants, volume, land area and application rate for effluent and wastewater discharges to land;
- difficulties accessing and extracting information from electronic files;
- information from consent holder monitoring reports is often not analysed for compliance monitoring reports.

The information that is specified on consents, the records that are available as essential documents, information recorded on the Consents database, and the monitoring information feed-back all need to be improved if Environment Canterbury wishes to establish an effective accounting system for nitrogen and phosphorus loads in each zone, or to track nutrient trading.

The establishment and implementation of catchment limits for nitrogen and phosphorus will require detailed and accurate accounting of all the sources of these nutrients. Several types of activities, e.g. meat processing wastewater and centralised sewage systems discharges appear to be significant contributors of nitrogen and phosphorus. To accurately measure or predict the scale of those contributions will require more specialised assessment procedures than a 'desk-top' exercise.

6 Conclusion

In the Ashburton and Ashburton–Rakaia NMAZs a few consented point source discharges from meat and food processing and super intensive farming comprise a significant proportion of nitrogen and phosphorus load in these zones, while in other zones it is the cumulative contribution from many small sources, including on-site sewage that comprises the bulk of the nitrogen and phosphorus load.

Managing nitrogen and phosphorus loads will require that the contribution from all sources is accurately assessed. This indicative 'stock-take' of the contribution from some consented and permitted activities discharges can assist to identify the relative scale of nitrogen and phosphorus contributions from the consented and permitted activity discharges, but considerable additional work would be required to definitively determine the actual or potential contribution of nitrogen and phosphorus from permitted and consented activities in each NMAZ.

7 Recommendations for further work

There are number of areas where further work will be needed to improve the nitrogen and phosphorus load accounting processes. These include:

- Investigation and assessment of the potential for phosphorus leaching from discharges onto or into land;
- Determining vulnerability of different Canterbury land and soil types to leaching of nitrogen and/or phosphorus under differing land uses;
- For consented discharges to land that contain nitrogen or phosphorus ensure that:
    - applications for discharge permits assess effects of both nitrogen and phosphorus, if relevant;
    - consent conditions specify;
        - the concentrations of these contaminants,
        - the volume of effluent discharged,
        - land area to be used for discharge;
        - the frequency of discharge;
        - application rate for effluent,
        - monitoring and reporting of these elements of the discharge;
    - monitoring reports are analysed to determine actual application rates for nitrogen and phosphorus;
    - the consents database includes this information from consent conditions and from monitoring;
- Review of the regional plan provisions relating to the storage of FDE to address the potential effects of leakage from storage facilities;
- Assessment of nitrogen and phosphorus contributions from stormwater discharges;
- Quantification of nitrogen and phosphorus contributions from other unaccounted for sources such as offal pits.

8 References

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Appendix 1 Estimated annual nitrogen and phosphorus loads from consented and permitted activities by Nutrient Management Allocation Zone

NMAZ	Source	Number of sources	N (t/yr)	P (t/yr)
Ahuriri	On-site sewage - post 2006	25	0.8	0.03
	On-site sewage - pre 2006	90	0.8	0.2
	FDE ponds	2	0.2	0.04
	Centralised sewerage systems	1	8	1.6
			9.8	**1.87**
Amberley	On-site sewage - post 2006	27	0.08	0.9
	On-site sewage - pre 2006	465	4.2	0.9
	Centralised sewerage systems	1	9	1.2
			13.28	**3**
Ashburton	On-site sewage - post 2006	460	1.4	0.5
	On-site sewage - pre 2006	860	7.7	0.9
	FDE ponds	82	8.2	1.6
	Super Intensive Farming	1	575	150
	Centralised sewerage systems	1	40	12
			632.3	**165**
Ashburton-Rakaia	On-site sewage - post 2006	270	0.8	0.3
	On-site sewage - pre 2006	780	7	1.6
	FDE ponds	90	9	1.8
	Centralised sewerage systems	2	3.7	1.4
	Meat & Food processing	4	1058	15*
			1078.5	**20.1** *limited data
Ashley	On-site sewage - post 2006	440	1.3	0.9
	On-site sewage - pre 2006	625	5.6	1.3
	FDE ponds	14	1.4	0.3
			8.3	**2.5**
Ashley-Waimakariri	On-site sewage - post 2006	1737	5.2	3.5
	On-site sewage - pre 2006	4000	36	8
	FDE ponds	57	5.7	1.1
	Centralised sewerage systems	6	6.6	0.5
			53.5	**13.1**
Blythe	On-site sewage - post 2006	19	0.06	0.04
	On-site sewage - pre 2006	100	0.9	0.2
	Centralised sewerage systems	1	3.2	0
			4.16	**0.24**
Christchurch-West Melton	On-site sewage - post 2006	710	2	1.4
	On-site sewage - pre 2006	4259	38	8.5
	FDE ponds	3	0.3	0.05
	Vegetable processing wastewater	1	40	no data
			80.3	**9.95**

NMAZ	Source	Number of sources	N (t/yr)	P (t/yr)
Hakataramea	On-site sewage - post 2006	4	0.1	0.01
	On-site sewage - pre 2006	100	0.9	0.2
			1	**0.21**
Hurunui	On-site sewage - post 2006	160	0.5	0.3
	On-site sewage - pre 2006	650	5.9	1.3
	FDE ponds	66	6.6	1.3
	Centralised sewerage systems	5	1.9	0.3
	Piggery solid waste composting	1	0.1	0.02
	Milk processing	1	18	4.5
			33	**7.72**
Jed	On-site sewage - post 2006	25	0.1	0.05
	On-site sewage - pre 2006	378	3.4	0.8
	Centralised sewerage systems	2	27	4.0
			30.2	**4.85**
Kowai	On-site sewage - post 2006	134	0.4	0.1
	On-site sewage - pre 2006	465	4.2	1
	FDE ponds	2	0.2	0.04
			4.8	**1.14**
Little Rakaia	On-site sewage - post 2006	26	0.08	0.1
	On-site sewage - pre 2006	80	0.7	0.2
	FDE ponds	8	0.8	0.2
			1.58	**0.5**
Lower Waitaki	On-site sewage - post 2006	79	0.3	0.2
	On-site sewage - pre 2006	100	0.9	0.2
	FDE ponds	36	3.6	0.7
	Milk processing	1	40	10
	Centralised sewerage systems	1	5	1.4
			44.8	**11.1**
Maerewhenua	On-site sewage - post 2006	14	0.04	0.03
	On-site sewage - pre 2006	100	0.9	0.2
			0.94	**0.23**
Makikihi	On-site sewage - post 2006	17	0.05	0.03
	On-site sewage - pre 2006	230	2	0.5
	FDE ponds	10	1	0.2
	Potato processing wastewater		8	no data
			11.05	**0.73**
Middle Waitaki	On-site sewage - post 2006	22	0.07	0.04
	On-site sewage - pre 2006	150	1.4	0.3
			1.47	**0.34**

NMAZ	Source	Number of sources	N (t/yr)	P (t/yr)
Morven-Glenavy	On-site sewage - post 2006	20	0.06	0.04
	On-site sewage - pre 2006	250	2.3	0.5
	FDE ponds	23	2.3	0.5
			4.66	**1.04**
Ohapi Creek	On-site sewage - post 2006	11	0.03	0.02
	On-site sewage - pre 2006	100	0.9	0.2
	FDE ponds	2	0.2	0.04
			1.13	**0.26**
Opihi	On-site sewage - post 2006	261	0.8	0.5
	On-site sewage - pre 2006	200	1.8	0.4
	FDE ponds	27	2.7	0.5
			5.3	**1.4**
Orari	On-site sewage - post 2006	76	0.2	0.2
	On-site sewage - pre 2006	500	4.5	1
	FDE ponds	37	3.7	0.7
	Milk processing	1	200	20
			208.4	**21.9**
Otaio	On-site sewage - post 2006	47	0.1	0.1
	On-site sewage - pre 2006	230	2	0.5
	FDE ponds	5	0.5	0.1
			2.6	**0.7**
Pareora	On-site sewage - post 2006	36	0.1	0.1
	On-site sewage - pre 2006	230	2	0.5
	FDE ponds	6	0.6	0.1
			2.7	**0.7**
Rakaia	On-site sewage - post 2006	92	0.3	0.2
	On-site sewage - pre 2006	1062	9.5	2
	FDE ponds	10	1	0.2
	Centralised sewerage systems	1	0.2	0.05
			11	**2.45**
Rangitata	On-site sewage - post 2006	47	0.1	0.1
	On-site sewage - pre 2006	24	0.2	0.05
	FDE ponds	34	3.4	0.7
	Trout hatchery	1	no data	no data
			3.7	**0.85**
Rangitata-Orari	On-site sewage - post 2006	84	0.3	0.2
	On-site sewage - pre 2006	500	4.5	1
	FDE ponds	19	2	0.4
	Milk processing	4	300	30
			306.8	**31.6**

NMAZ	Source	Number of sources	N (t/yr)	P (t/yr)
Saltwater Creek	On-site sewage - post 2006	145	0.4	0.3
	On-site sewage - pre 2006	507	4.6	1
	FDE ponds	4	0.4	0.08
	Timber Processing wastewater & sewage	1	2.2	no data
			5.4	**1.38**
Selwyn-Waihora	On-site sewage - post 2006	2940	9	6
	On-site sewage - pre 2006	5255	47	11
	FDE ponds	164	16	3
	Centralised sewerage systems	6	155	106
	Meat & Food processing	9	35	9
	Milk processing	3	210	40
			463	**175**
Te Muka	On-site sewage - post 2006	200	0.6	0.4
	On-site sewage - pre 2006	400	3.6	0.8
	FDE ponds	32	3.2	0.7
	Centralised sewerage systems	2	0.4	0.04
			7.8	**1.94**
Upper Selwyn	On-site sewage - post 2006	4	0.01	0.01
			0.01	**0.01**
Upper Waitaki	On-site sewage - post 2006	156	0.5	0.3
	On-site sewage - pre 2006	540	4.9	1.1
			5.4	**1.4**
Valetta-Hinds	On-site sewage - post 2006	450	1.4	0.5
	On-site sewage - pre 2006	1332	12	2.7
	FDE ponds	142	14.2	2.8
			27.6	**6**
Waiau	On-site sewage - post 2006	265	0.8	0.5
	On-site sewage - pre 2006	1150	10	2.3
	FDE ponds	35	3.5	0.7
	Centralised sewerage systems	2	12	4
	Milk processing	1	0.01	<0.01
	Abbattoir	1	<0.01	<0.01
	Winery wastewater	1	<0.01	<0.01
	Dead animal disposal pit	1	0.5	<0.01
			26.81	**7.3**
Waihao	On-site sewage - post 2006	11	0.03	0.02
	On-site sewage - pre 2006	200	1.8	0.4
	FDE ponds	2	0.2	0.04
			2.03	**0.46**

NMAZ	Source	Number of sources	N (t/yr)	P (t/yr)
Wainono	On-site sewage - post 2006	100	0.3	0.2
	On-site sewage - pre 2006	200	1.8	0.4
	FDE ponds	15	1.5	0.3
	Milk processing	1	40	10
			43.6	**10.9**
Waikakahi	On-site sewage - post 2006	14	0.04	0.03
	On-site sewage - pre 2006	250	2.3	0.5
	FDE ponds	13	1.3	0.3
			3.64	**0.83**
Waimakariri	On-site sewage - post 2006	99	0.3	0.2
	On-site sewage - pre 2006	400	3.6	0.8
	FDE ponds	1	0.1	0.02
			4	**1.02**
Waipara	On-site sewage - post 2006	240	0.7	0.5
	On-site sewage - pre 2006	350	3	0.7
	Winery wastewater	14	0	0
			3.7	**1.2**
Washdyke	On-site sewage - post 2006	300	0.9	0.6
	On-site sewage - pre 2006	650	5.9	1.3
	FDE ponds	18	1.8	0.4
			8.6	**2.3**

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

Everything is connected

Promoting quality of life through balanced resource management

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