Client Report

Prepared for the Waituna Landcare Group

August 2007

Nutrient budgets in the Waituna catchment

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1. Summary

The water quality of the Waituna lagoon is at risk of deteriorating to an undesirable level which will result in decreased recreational and aesthetic values of the lagoon. Losses of nutrients, particularly phosphorus, from the catchment are placing increasing environmental pressure on the lagoon. This report provides a snapshot of the current state of the water quality of the streams impacting on the Waituna lagoon and estimates the losses of nutrients from representative farms within the catchment. Compared to guideline values, the water quality in the creeks draining the Waituna catchment is poor. However, compared to the water quality in other intensively farmed catchments the water quality in the Waituna is typical. Modelled losses of nutrients from farms in the catchment indicate that current losses are similar to the Bog Burn catchment (also in Southland) but less than other areas in NZ. The risk for the future is that increasing intensification of farming in the Waituna could increase the nutrient losses resulting in further deterioration of water quality in the creeks, placing more pressure on the Waituna lagoon. A list of current BMPs to reduce phosphorus losses from farms is provided and these practices should be encouraged within the Waituna catchment to safeguard the future of the Waituna lagoon.

2. Introduction

The Waituna Lagoon is a shallow coastal lagoon that in 1976 received RAMSAR status in recognition of its international importance. Despite its international recognition, the water quality of the lagoon is currently under threat. In 2001 the Waituna Landcare Group (WLG) formed with the aim of preservation, restoration and guardianship of the lagoon. One of the key concerns of the WLG is the potential impact of intensive dairying on water quality in the streams and the subsequent impact on the lagoon.

In 2006, the Department of Conservation commissioned Drs' Marc Schallenburg and Claudine Tyrrell of the University of Otago to conduct a risk assessment for the aquatic flora of the Waituna Lagoon. The key finding of the Schallenburg report was that the lagoon is currently macrophyte-dominated but is at risk of flipping to a phytoplankton-dominated state. Macrophytes are aquatic plants that are visible to the naked eye. Phytoplankton is microscopic aquatic plants, such as algae, that live suspended (floating) in water. Phytoplankton are often visible as green-tinged water or as a scum on the surface. Macrophyte dominated lakes and lagoons have much greater recreational and aesthetic values. An important point it that other costal lagoons, such as lake Waihora/Ellesmere, that have flipped to a phytoplankton-dominated state have never recovered. It is important then that the Waituna lagoon is maintained in its current state where it is dominated by the macrophyte Ruppia. The Schallenburg study of the Waituna lagoon found that the “phytoplankton appear to be phosphorus-limited at times. Therefore, the reduction of phosphorus availability in the lagoon currently represents the best means for controlling phytoplankton growth and biomass accumulation.”

In 2007 the WLG secured funding from the Sustainable Farming Fund for ‘sensitivity and characterisation of nutrient loss analyses in the Waituna Catchment, Southland.’ The WLG then contracted AgResearch to provide a whole-catchment picture of nutrient losses. This information would then provide the WLG with information to target the most effective best management practices (BMPs) that they could then promote within the catchment. This report compiles the results of the catchment nutrient analyses and information on the current BMPs that can be recommended for the Waituna catchment.

3. Method

3.1 Water Quality

Water quality data was supplied by Environment Southland (ES) from the 5 sites in the Waituna catchment, covering 6 to 12 years of monthly monitoring at each site. Figure 1 shows the location of the 5 water quality monitoring sites. For each site the average concentration of the different contaminants was calculated and then expressed as a percentage of the Australian and New Zealand water quality guidelines (ANZECC 2000). Table 1 contains the actual standards used and a brief description of the water quality contaminant and its importance. Water quality data from the Waituna creek – Marshall Road site was then compared to water quality data from 4 other intensively farmed catchments from around NZ. The water quality data from these other catchments is provided through the “Best practice dairying catchments for sustainable growth” project. The location of 4 catchments is shown in Table 2. The Bog Burn catchment, also in Southland, will be the best catchment for comparison with the Waituna.

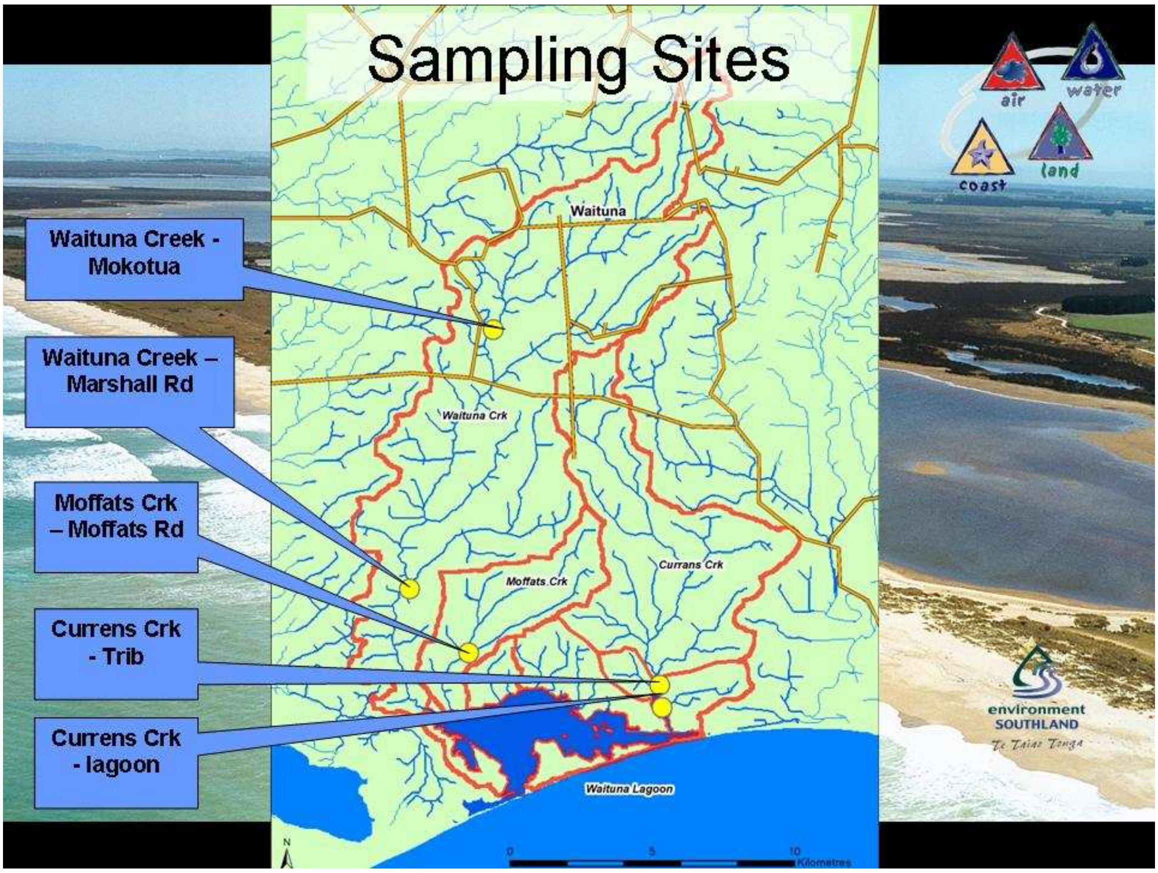

Figure 1 Location of the 5 sites where Environment Southland monitor water quality in the Waituna catchment.

Table 1
A brief description of the water quality contaminants and the guideline concentrations used in this report.

Contaminant	Guideline value	Description of Contaminant
Nitrate N	0.444 g L^{-1}	Nitrate N is a negatively charged form of nitrogen that is easily leached through soil with drainage water. Nitrogen is an important nutrient for plant and animal growth. In waterways, nitrate stimulates the growth of nuisance plants and phytoplankton.
Ammonium N	0.9 g L^{-1}	Ammonium N is a positively charged form of nitrogen that tends to be retained in soil by the negatively charged soil particles. Ammonia is toxic to many fish species.
Total P	0.033 g L^{-1}	Phosphorus is also an important nutrient for plant and animal growth. Total P is the total amount of Phosphorus in a sample. However, a lot of P is closely bound to soil particles and may not be easily taken up by plants or phytoplankton for growth.
DRP	0.01 g L^{-1}	Dissolved Reactive Phosphorus (DRP) is P that is immediately available to stimulate nuisance plant or phytoplankton growth in waterways.
E. coli	126 cfu $100mL^{-1}$	*Escherichia coli (E. coli)* is used as a faecal indicator organism. The faeces of animals can contain microorganisms that cause disease in humans. *E. coli* is found in the faeces of humans and animals. If you find *E. coli* in water then it means that the water has been contaminated with faeces. The higher the concentration of *E. coli* in the water the higher the risk that disease organisms will also be in the water.

Table 2
Approximate locations of the 4 best practice dairy catchments used for the water quality comparisons.

Catchment Name	Location
Toenepi	Waikato near Morinsville
Waiokura	Taranaki near Manaia
Waikakahi	South Canterbury near Glenavy
Bog Burn	Southland near Winton

3.2 Catchment Loads

Water quality data is presented in concentrations which is a measure of how much in a set volume of water i.e grams per litre (g L^{-1}). The concentration data is important for the water quality in a stream. However, when the stream discharges into a lake, as in the Waituna lagoon, it is the total amount of nutrients discharged to the lake that is important. This total amount of nutrients discharged by the streams is referred to as a catchment load i.e. kilograms per year (kg y^{-1}). Obviously the larger the catchment then the greater the load produced per year which makes it difficult to compare different catchments. To take the size of a catchment into account the annual load is divided by the area of the catchment to calculate the average load per hectare (kg ha^{-1} y^{-1}). A simple estimate of the catchment loads of nutrients can be calculated by multiplying the average concentration of the contaminant by the total volume of water discharge by the stream. The total volume of water discharge can be calculated from flow recordings on the stream.

Flow records for the Waituna creek at Marshall Road were provided by ES and cover 4 years of flow records. Due to the tidal nature of the lower end of the Waituna catchment flow records are not available from below this site or for Moffats Creek and Currans Creek that also discharge to the Waituna Lagoon. We estimate that only half of the water from the entire Waituna catchment drains through the Waituna creek at Marshalls Road (see Figure 1). This means that the estimated catchment load calculated for this report will be significantly less than the actual load discharged to the Waituna Lagoon. A best guess, based on approximate area of the catchment draining through the Marshall road site, is that the actual load may be twice the estimate.

The estimated load of nutrients lost from the Waituna catchment was compared to estimates from the 4 best practice dairy catchments used for the water quality comparisons.

3.3 Farm Nutrient Budgets

Water quality issues occur at a catchment scale and this is impacted by the nutrients leaking from all of the land within the catchment. But within a catchment the land-use is managed at a farm scale. It is useful to compare the losses of nutrients at the catchment scale with estimates of the losses from the farms in the catchment. This can be done using computer models, such as Overseer™, to calculate the nutrient losses from the farms. The losses of nutrients from farms are dependent on both the management of the farm and the soil type.

Calculating nutrient budgets for every farm in a catchment can be very expensive and time consuming. In this report the management of the farms was determined from surveys of a number of dairy and non-dairy farms in the catchment. The survey data was averaged to calculate the data for a typical dairy farm and typical non-dairy farm (sheep and beef). The surveys were conducted by the WLG and the survey data sent to AgResearch for analysis. The entire catchment was then split into dairy and non-dairy land uses and the area of each land use calculated from maps using geographical information software (GIS).

The Waituna catchment has been assessed as having 14 different soils types. However, many similar soils can be grouped together to simplify the nutrient budget analyses. For this analysis the 14 soils were classified into 3 main soil types: Brown soils; organic/peat soils; and podzol/gley soils. The distribution of the 3 soil groupings across the Waituna catchment is shown in Figure 2; this information was added to the GIS information on land use.

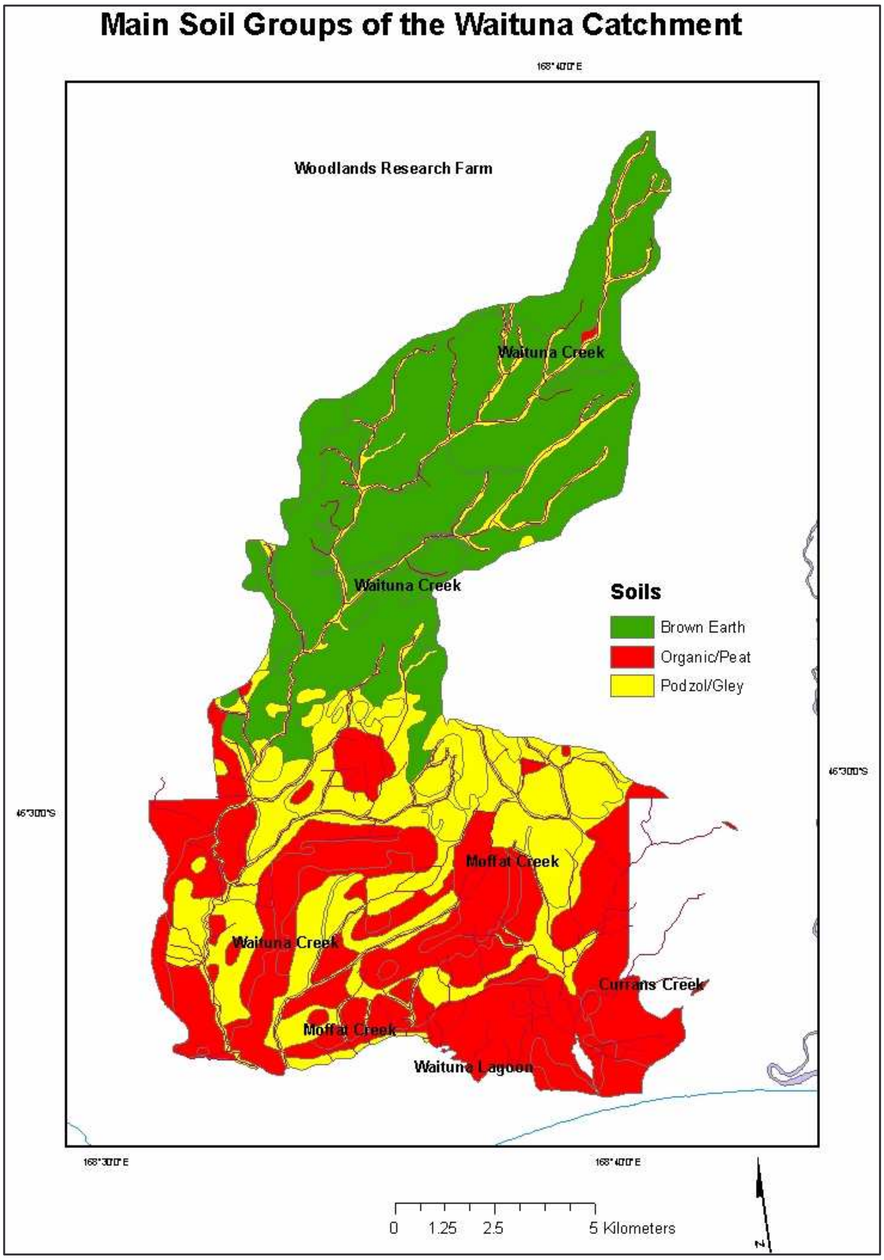

Figure 2 Distribution of the 3 soil grouping across the Waituna catchment.

The land-use and soil grouping data were then combined and the area of land for each of the 6 combinations of land-use and soil type was calculated as shown in Table 3. Non-agricultural land, such as swamp and wetlands, were not included in the analysis. The Overseer™ nutrient budgeting software was then used to model the nutrient losses for each of the 6 combinations of land-use and soil type. The average for the 2 land-uses was then calculated across the catchment. Modelled losses from the dairy farms in the Waituna catchment were then compared to the modelled losses from the 4 best practice dairy catchments used for the water quality comparisons.

Table 3
Hectares of land for each land-use and soil group in the Waituna catchment.

Soil Group	Dairy	Non-Dairy	Totals
Brown earth	2773	3232	6005
Organic/Peat	913	4025	4937
Podzol/Gley	1494	3096	4590
Totals	5179	10353	15532

4. Results and Discussion

4.1 Water Quality

The water quality of the streams in the Waituna catchment is summarised in Figure 3. The nitrate N levels are below guideline values in the Currens and Moffat Creeks but above the guidelines in Waituna creek. The drainage characteristics of the soils can explain the differences in nitrate N water quality in the 3 creeks. As mentioned in Table 1, nitrate N is very mobile in drainage water. The Waituna creek contains most of the free draining Brown soils which will leak a lot of nitrate N into drainage water. Currens and Moffat creeks are dominated by the poorly drained soils and will leak much less nitrate N. The lowest nitrate N site was the Currens tributary and this sub-catchment is predominantly wetland with only a small area farmed. All monitoring sites were low for ammonium N, which is good. The total Phosphorus and DRP levels are above guideline values at all water quality monitoring sites. The fact that phosphorus levels are high in the wetland-dominated site of the Currens tributary indicates that there are high background losses of P from this sub-catchment. This is important as the Waituna lagoon is considered to be phosphorus limited. The *E. coli* levels are above the guidelines at 4 sites, indicating there is faecal material getting into the creeks. The low *E. coli* levels at the Currens tributary site is again likely to be due to the small area of land in this sub-catchment that is actually farmed.

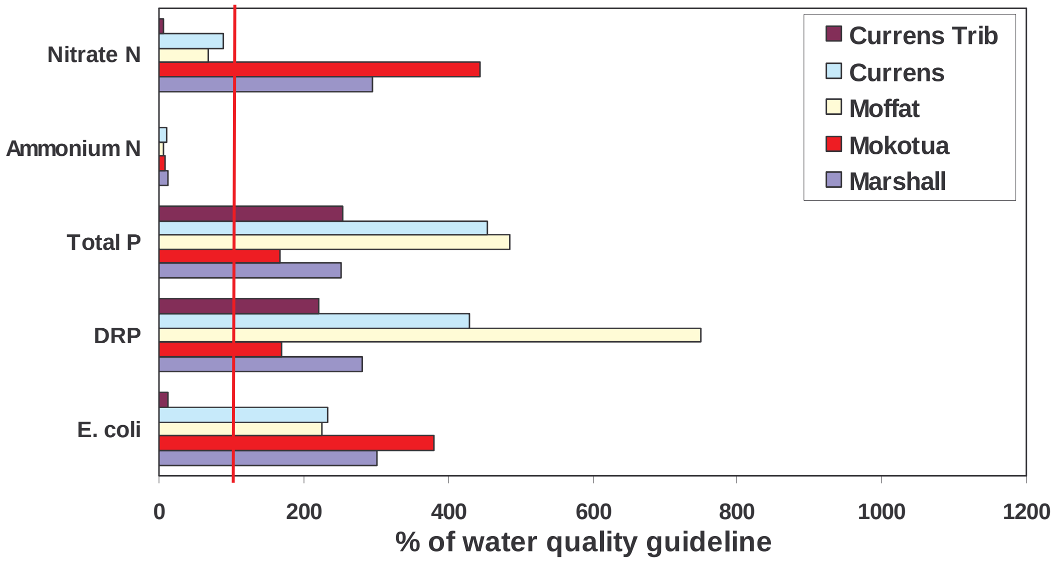

Figure 3 Water quality of the 5 monitoring sites in the Waituna catchment.

Figure 4 shows the water quality from the Waituna creek at Marshall Road compared to the water quality from 4 intensively farmed dairy catchments throughout NZ. The key point evident here is that the water quality in the Waituna catchment is actually typical of that observed in other intensively farmed catchments.

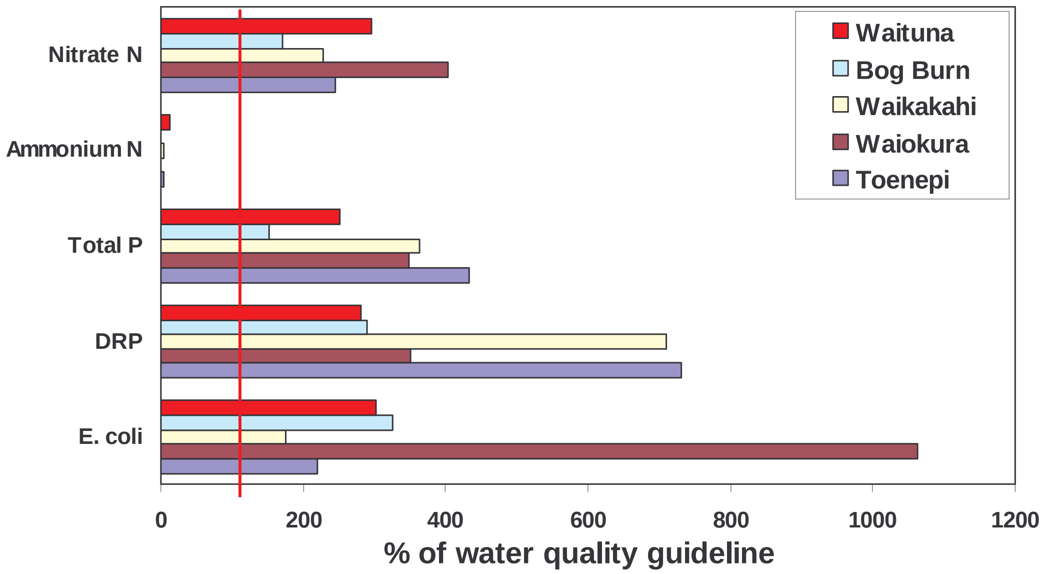

Figure 4 Water quality of the Waituna creek at Marshall Road compared to the 4 Dairy best practice catchments (Wilcock et al. 2007).

4.2 Catchment Nutrient Loads and Farm Nutrient Budgets

The measured losses of nutrients in Waituna creek draining through the Marshall road site, and for the 4 other dairying catchments, is shown in Figures 5 and 6 for nitrogen and phosphorus, respectively. The measured loss from Waituna creek appears to be lower than the reported losses from comparison catchments. We caution this finding as the measured losses from the Waituna creek at Marshall's road will be significantly less than the actual total losses to the Waituna Lagoon. However, even doubling the losses measured in the Waituna creek at Marshall's road will still result in catchment scale losses within the range reported for intensively farmed catchments.

The modelled losses of nutrients from the Waituna catchment was based on the farm survey data supplied by the WLG. In total there were surveys from 6 non-dairy farms but only 3 dairy farms. In light of the small number of dairy farm survey respondents, the modelled outputs from the dairy farms should be treated with caution. Averaged input data for the typical dairy and non-dairy farm used in the Overseer™ model analysis, and the predicted outputs from these typical farms, are shown in Table 4.

Table 4
Farm management data used as inputs for the Overseer™ nutrient budget analysis and the predicted environmental losses of nitrogen and phosphorus from the modelled farms.

Model data	Dairy	Non-dairy
Inputs		
Nitrogen fertilizer	58 kg/ha/y	13 kg/ha/y
Phosphorus fertilizer	29 kg/ha/y	34 kg/ha/y
Stocking rate	2.9 cows/ha	11 sheep/ha 4 beef/ha
Soil Olsen-P	40.9	37.2
Outputs		
Nitrogen leaching	10 kg/ha/y	11 kg/ha/y
Phosphorus losses	0.6 kg/ha/y	0.5 kg/ha/y

The predicted outputs from the modelled dairy and non-dairy farms is very similar. If an individual farm has higher input values than those used in Table 4 then the environmental outputs will also be higher. In discussions at a recent field day in the Waituna catchment it was felt that the average fertilizer inputs on dairy farms in the catchment would be twice the values used in the modelling analysis. Further, all of the 3 dairy farms surveyed wintered their cows off farm which would lead to a considerable reduction in nutrient losses from these farms. There are a number of dairy farms in the Waituna catchment that winter their cows on farm. If actual dairy farms in the Waituna catchment have higher fertilizer inputs and winter cows on the farm then the losses of nutrients from these farms will be higher than the modelled outputs in Table 4.

The modelled losses of nutrients from the Waituna catchment are less than predicted and measured for the Waikakahi, Waiokura and Toenepi catchments. The Bog Burn catchment in Southland is the most directly comparable catchment to the Waituna and the modelled losses from these 2 catchments is very similar (Monaghan et al. 2007). For some of the catchments there is a large difference between the measured and modelled losses which can be explained by understanding the difference between the 2 analyses. The measured losses are nutrients that leave the catchment in streams and creeks which are surface waters. The modelled losses are predicted losses from the farms, but not all of the losses from the farms are to surface waters. In some catchments (particularly the Waikakahi and Waiokura) most nutrients will be lost to ground water rather than surface water. Additionally in-stream processes will account for some of the N and P removed as water flows through a catchment to its outlet.

From this analysis and comparison it appears that the current state of the Waituna catchment is similar to other intensively farmed catchments in NZ. The risk is that intensification of farming in the Waituna carries a risk of water quality deteriorating in the future. Deteriorating water quality in the streams increases the risk of the Waituna lagoon flipping from its current desirable macrophyte-dominated state to an undesirable phytoplankton-dominated state. Current best management practices (BMPs) should be applied to farms in the catchment to improve water quality in the streams or at least maintain the current water quality in the face of increasing intensification of farming in the catchment. BMPs focused on reducing phosphorus (P) losses will have the greatest effect on the lagoon.

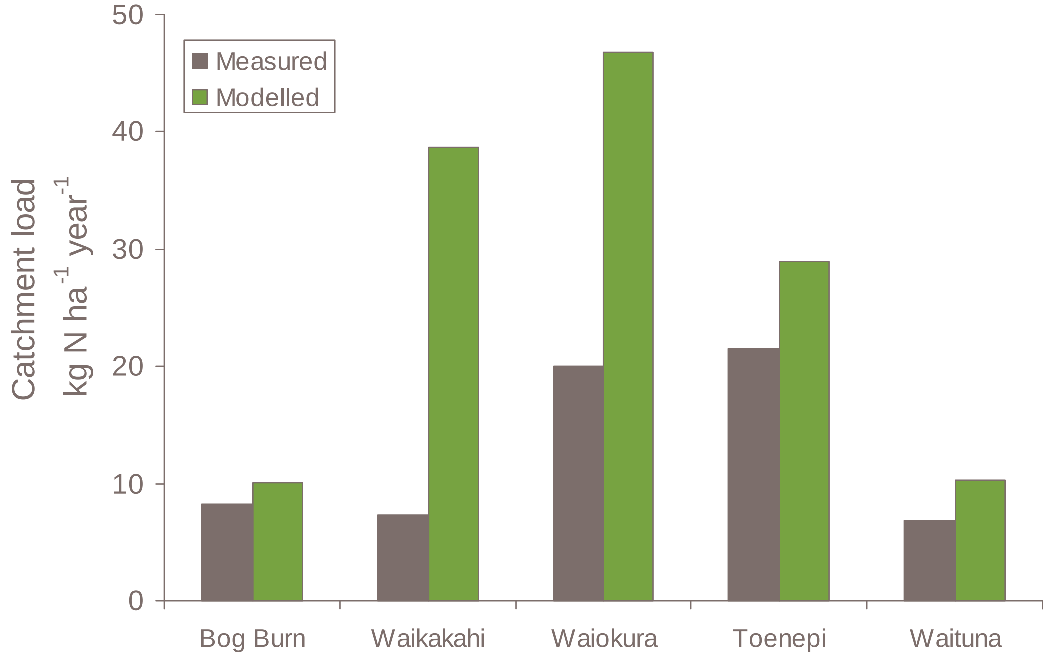

Figure 5 Measured and modelled losses of nitrogen in the streams draining the 5 intensively farmed catchments. Modelled losses of nitrogen from the farms were predicted by nutrient budget analyses.

Figure 6 Measured and modelled losses of phosphorus in the streams draining the 5 intensively farmed catchments. Modelled losses of phosphorus from the farms were predicted by nutrient budget analyses.

5. Conclusions

- Water quality in the Waituna catchment is poor:

When compared to most water quality guidelines the water quality in the Waituna catchment is poor. However, when compared to other intensively farmed catchments throughout New Zealand the water quality is typical.

- Nutrient losses from dairy and non-dairy farms appear similar:

This finding must be cautioned by the small data set (3 farm surveys) on which the dairy farm data is based. Higher fertilizer inputs and wintering of stock on-farm will both significantly increase the predicted losses from the dairy farms.

- Intensification of farming in the catchment is a risk to the lagoon

Measured and modelled estimates of nutrient losses from the Waituna catchment indicate that current losses are low relative to other intensively farmed catchments in NZ. If farming in the Waituna intensifies, then the losses from the catchment are likely to increase - increasing the risk of deteriorating water quality in the Waituna Lagoon.

- Mitigation options should focus on reducing phosphorus losses as Waituna lagoon is P limited.

6. Recommended BMPs for the Waituna catchment

- Fence off streams and drains

The fencing of streams and drains will prevent the direct input of faecal material to the stream which is an important potential source of P. Soil particles, or sediment, are also an important source of P. Fencing will prevent bank erosion caused by hoof damage to the banks which increases sediment loss to the stream.

- Good dairy shed effluent (DSE) management

Dairy shed effluent is an important source of P. Effluent should not be allowed to be discharged directly to streams. During irrigation of DSE some effluent can be lost directly to streams, particularly via mole and tile drain systems. DSE losses to steams occur when the amount of effluent applied to the soil is greater than the absorption capacity of the soil. Twin rotating gun effluent irrigators typically apply effluent at high rates of approximately 100 mm/h. DSE losses can be reduced by using low-rate application systems (such as K-Line) which apply effluent at 4 mm/h. DSE losses also occur when the soils being irrigated are already saturated. Losses can be minimised by using large storage ponds to store the effluent when the soils are saturated. In the Waituna catchment you would need 3 to 4 months storage to get through the wet spring period and irrigate the effluent during summer to maximise the nutrient and water value of the DSE.

- Reduce soil Olsen-P values

Phosphorus losses from farms are closely related to soil losses. The higher the concentrations of P in the soil, the greater the P losses for the same amount of soil loss. Olsen-P values in the surveyed farms are currently around 40 for both the dairy and non-dairy farms. Econometric analysis suggests that soil Olsen-P values should be 30-40 for the dairy farms and 20-30 for the non-dairy farms. Farms with Olsen-P values above the recommended range should reduce P fertilizer inputs to below maintenance rates until the soil test results fall to the desired range. Fertilizer reps will be able to assist in designing a fertilizer program to achieve this.

- Winter management

Treading damage caused by animals walking on wet soils can increase the losses of sediment and, by association, P. Environment Southland is shortly bringing in new rules on set-back distances between the stream and the grazed area. Remember that these values are minimum distances only. The aim should be to prevent sediment reaching the stream. Use larger set-back distances where you think the risk of contaminating the stream is higher.

7. References

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