Supplementary Report – Nutrient Management Tools/Models

Review of the Regional Fresh Water Plan for Taranaki

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April 2015

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This version TRC FRODO 1501001

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1 Executive Summary

The Taranaki Regional Council has identified that the cumulative effects of agricultural sourced discharges – whether to land or water – are a major human induced pressure on Taranaki's freshwater quality.

While it is understood that Taranaki's overall freshwater quality is relatively good, with mainly improving trends, Council's aim is to keep those water quality trends positive. The Council recognises that any interventionary measures must be justifiable in terms of effectiveness, efficiency, and need, with a staged implementation that reflects established urgency and criticality, as set out in Sections 32(3) and (4) of the RMA.

As part of the review of the Regional Freshwater Plan for Taranaki, Council is assessing the economic costs and benefits of adopting three policy options for the management of nutrient from dairy farms, in accordance with the recent amendments to Section 32 of the Resource Management Act 1991. These three policy options (discussed in Section 7 of this Report) are:

- Option One – Status quo
- Option Two – On-farm mitigation
- Option Three – Nutrient cap plus on-farm mitigation

In more recent years a number of regional councils have prepared regional plans that intend to regulate land use activities to manage nutrient losses and thereby maintain or enhance water quality, and a number of tools/models have been used in some instances in order to estimate and thereby regulate nutrient losses and demonstrate compliance. As regional councils prepare and review regional land and water plans, a range of mechanisms are being incorporated into plans to manage nutrients and the effects of nutrients on the environment. In particular, tools/models are being used to support the setting of limits and targets and to support the use of good management practices. Tools/models are also increasingly being used as part of conditions on consents and in compliance. The appropriateness of using these tools/methods in a regulatory setting has been and continues to be the subject of some considerable discussion.

This *Supplementary Report – Nutrient Management Tools/Models* intends to provide background information and opinion on current tools/models used in dairy farm nutrient management and the use of these tools/models in a regulatory setting including OVERSEER®, CLUES, the use of LUC and other mechanisms to assist the Taranaki Regional Council prepare a well-informed and carefully evaluated Economic Costs & Benefits Report.

A range of approaches have been developed by industry groups and councils to address issues associated with nutrient losses on farms, including good management practices, adaptive management, and regulation. To assist with a number of these approaches, tools and models have been developed as part of ensuring good management practices are been adopted, and adaptive management approaches are being effective. These tools and models include OVERSEER® which is primarily used to establish and monitor nutrient budgets on a year by year basis; CLUES which is a GIS based modelling system which assesses the effects of land use change on water quality and socio-economic indicators; and the use of LUC Classification.

A strength of OVERSEER® is that it is able to demonstrate the impact of the relative effect of changing some management practices, inputs or mitigations on nutrient loss from a farm or block. Another strength is that it estimates N loss (from the bottom of the paddock root zone) and P loss risk (to the farm boundary). However, users of the tool need to fully understand how to operate the model properly, its limitations across the range of farming activities and what the outputs actually mean. In addition, OVERSEER® is not an environmental management tool as it cannot assess the contribution of the farm's N and P losses to nutrient levels in, the receiving environment, let alone any consequent environmental effect.

Nutrient Budgets (prepared using OVERSEER® 6) estimate the amount (kg) of N/ha/yr lost to the atmosphere as gaseous forms of N and how much (kg) N/ha/yr is lost from beneath the farming system. This is primarily the estimate of how much N moves below the root zone in drainage water, particularly on flat land. However, it is not, nor should be interpreted as, the amount of N which necessarily enters receiving water (confined, unconfined aquifers or surface water). Given that the N loss estimate is what is leaving the root zone, it is inappropriate to use OVERSEER® loss estimates to solely determine N loss limits which are designed to protect or improve receiving water quality.

CLUES is a GIS based modelling system which assesses the effects of land use change on water quality and socio-economic indicators. It allows users to create both land use and farm practice change scenarios (stocking rates, mitigation) using a range of tools and results are available in map and tabular displays.

In summary, this analysis has identified a number of key findings:

- There are environmental (including climatic; hydrological; fresh water ecology; soil characteristics) and on-farm practice differences between Taranaki and those areas of New Zealand that are facing greatest pressure upon land use conversion, and that these differences present a different context within which to consider the use of modelling tools;
- The relationship between the nutrient losses from any particular farm, and the water quality at any particular point within a catchment, simply cannot be quantified;
- Models are mathematical approximations to reality, which cannot be perfectly represented no matter what the choice of equations, coefficients, and correction factors;
- Individual farms will not correspond exactly to categories used in models - there will be inevitable divergences in factors such as soil structure, climate, cow numbers, and farming practice;
- There is no representation of a farms impact on the wider environment as off-farm subsequent transportation and attenuation processes are not (yet) determined by the tools/models (new models are being developed to assist with this for P loss especially) - therefore individual on-farm practices on particular parts of a farm are treated by tools/models as equal, but not all parts of a farm contribute to off-site effects to the same degree – short term (but high impact) effects on critical source areas are not captured by the tools/models but rather long term estimates of the farm system as a whole are modelled;

- A regulatory regime that is based on a whole of catchment approach must of necessity take a starting point of regarding all farms as having an equal contribution and having to meet the same allocation imposition if target water quality is to be attained, when this does not reflect reality;
- Experience shows widely varying factors for attenuation between farm and receiving waters, so that OVERSEER® outputs cannot easily be related to actual water quality;
- By inherent limitation, a model cannot take account of innovative practices that are outside the model design, and so evolving practices cannot be recognised and rewarded;
- The use of an on-farm annual nutrient budget model to estimate in-stream receiving water quality is not supported as there is no quantifiable link between on farm N loss below the root zone and in-stream receiving water;
- In-stream water quality is the aggregation of field level interactions, soil, sub-soil, and edge-of-field buffering and release, soil capacity exceedances and renewal, hydrology of storm events and base climate, in-stream biological processing, deposition and re-suspension and dissolution and uptake and adsorption, and contribution from natural sources such as aerial deposition and erosion - to take a single field–scale intervention and attempt to relate it to chemical and biological water quality measures at the catchment scale is fraught with complexity.

The analysis set out in the following pages confirms that a range of issues arise from the use of tools/models in a regulatory setting. Broadly speaking these issues include: the tool/model was never intended to be used in a regulatory setting and any use should be appropriate and relevant to the issue being addressed; the regulatory setting and compliance requires certainty whereas the use of tools/models is inherently uncertain due to a range of factors including limitations in data availability and accuracy, the application of the tool/model, the input choices and operator competency; the limitations of the model to represent reality in farm systems; gaps in the science available to enable the tools/models to deliver the outcomes sought by the resource manager; validation and calibration of tools/models is near impossible; revisions of tools/models can change outputs that can lead to non-compliance with regulatory mechanisms.

Thus, the use of modelling tools within the Taranaki context does not meet statutory expectations for consents/rules in a regional plan, of relevance, certainty, clarity, necessity, effectiveness, and efficiency. This report examines the strengths and limitations of modelling tools; a companion report explores the implications of the findings of this examination for the application of modelling within a regulatory setting.

The implications of the above issues include:

- that the Taranaki Regional Council should not use tools/models (such as OVERSEER® and LUC) with regulatory force in their plans and decision making to endeavour to achieve environmental outcomes because of the reality of incomplete or inadequate input information (information gaps that are potentially very significant in terms of suitability within a regulatory setting);
- where there are gaps in the science or the tools/modelling, tools/models not 'fit for purpose' should not be adapted or utilised in the interim; and

- gaps in science/management need to be addressed, if indeed they can be, before tools/models will provide the certainty and outcomes required.

Of the three policy options being assessed by Council to address nutrient management issues in the Taranaki Region, Option 3 (Nutrient Cap plus other on-farm mitigation) is the least likely to satisfy the assessment criteria from a nutrient management perspective. There are a number of cumulatively compounding constraints associated with utilising existing tools/models in a regulatory setting that will impact on the overall effectiveness of this policy option.

2 Introduction

2.1 Purpose

The purpose of this *Supplementary Report – Nutrient Management Tools/Models* is to provide background information and an evaluation of current tools/models used in dairy farm nutrient management and the applicability of these tools in a regulatory setting to assist the Taranaki Regional Council (the Council) prepare an Economic Costs & Benefits Report.

This Supplementary Report is one of four reports commissioned by the Council to assist with its economic costs and benefits assessment and the wider discussion on what nutrient management approach should be taken in Taranaki. The other three Supplementary Reports are:

- Dairy Farm Practices and Management (prepared by DairyNZ);
- Review of Status of Freshwater in Taranaki (prepared by the Council); and
- Agricultural Economics (prepared by Harris Consultants)

The Economic Costs & Benefits Report will assess the economic costs and benefits of including different nutrient management options for dairy farming in the Taranaki Region into a reviewed Taranaki Regional Freshwater Plan. This report will assess options for setting nutrient limits for freshwater, via the use of OVERSEER® and, or other models for monitoring and compliance.

The Economic Costs & Benefits Report will then form the basis of a Section 32 Evaluation Report (to be prepared separately by Council) of the objectives and policies to be adopted in the reviewed Taranaki Regional Freshwater Plan.

2.2 Background

Over the last two decades, dairy farms in Taranaki have intensified their land use resulting in increased stocking rates, increased herd sizes, and increased quantities of fertiliser and agrichemicals being applied to the land. More recently though, there has been relatively little change in practices, especially compared with other parts of New Zealand where there has been widespread land use conversions.

The Taranaki Regional Council (the Council) has identified that the cumulative effects of agricultural sourced discharges – whether to land or water – are a major human induced pressure on Taranaki's freshwater quality[1]. While it is understood that Taranaki's overall freshwater quality is relatively good, with mainly improving trends, Council's aim is to keep those water quality trends positive. The Council

[1] Managing diffuse source discharges to land and water in the Taranaki Region; November 2012

recognises that any measures must be justifiable in terms of effectiveness, efficiency, and need, with a staged implementation that reflects established urgency and criticality, as set out in Sections 32(3) and (4) of the RMA.

As part of the review of the Regional Freshwater Plan for Taranaki, Council is assessing the economic costs and benefits of adopting three policy options for the management of nutrient from dairy farms, in accordance with the recent amendments to Section 32 of the Resource Management Act 1991. These three policy options (discussed in Section 7 of this Report) are:

- Option One – Status quo;
- Option Two – On-farm mitigation;
- Option Three – Nutrient cap plus on-farm mitigation.

In order to undertake this assessment, the Council has identified four 'focus areas' that it has commissioned Supplementary Reports on:

- Dairy Farm practices and management;
- Nutrient management tools/models and practices;
- Surface water and groundwater quality;
- Agricultural economics.

In more recent years a number of regional councils have prepared regional plans that intend to regulate land use activities to manage nutrient losses, and a number of tools/models have been used in some instances in order to estimate and thereby regulate nutrient losses and demonstrate compliance. These interventions have been especially focused on the consequences of dairy conversions in relatively drier areas. The appropriateness of using these tools/methods in a regulatory setting has been and continues to be the subject of some considerable discussion.

This *Supplementary Report – Nutrient Management Tools/Models* intends to provide background information and opinion on current tools/models used in dairy farm nutrient management and the use of these tools/models in a regulatory setting including OVERSEER®, CLUES, the use of LUC and other mechanisms to assist the Taranaki Regional Council prepare a well-informed and carefully evaluated Economic Costs & Benefits Report.

2.3 Scope

The scope of this *Supplementary Report – Nutrient Management Tools/Models* is to:

- Broadly describe the tools/models (including OVERSEER®) available to support nutrient management on dairy farms;
- Identifying issues associated with the use of these tools/models in a regulatory setting;
- Assess the three policy options identified above to determine which option best delivers from a nutrient management tools/models perspective;
- Provide an opinion on the three policy options from a nutrient management tools/models perspective, and recommending a preferred option;
- Address any other matters considered relevant in the Nutrient Management Tools/Models Report.

2.4 Structure

This *Supplementary Report – Nutrient Management Tools/Models* has eight sections:

Section 1 provides an Executive Summary of the key findings of the report.

Section 2 provides an introduction and outlines the purpose of this *Supplementary Report – Nutrient Management Tools/Models;* provides background to the preparation of the report; defines the scope of the report; and outlines the structure of the report.

Section 3 defines the issues facing dairy farm activities on water quality. In particular this section looks at diffuse source discharges from dairy farms; the effects of these discharges; management approaches adopted; and how compliance can be determined.

Section 4 provides an overview of the nutrient management tools/models currently used manage dairy farm nutrient losses. The tools/models looked at are OVERSEER®, CLUES and LUC. For each tool/model there is a description of what it is; what it does; limitations; and how it is updated.

Section 5 overviews how the tools/models have been used in a regulatory setting in other regions, and the regulatory approaches using tools/models.

Section 6 provides an overview of the issues associated with using tools/models in a regulatory setting. Each of the tools/models is discussed, and the overall implications are summarised.

Section 7 assesses the applicability of the tools/models to the Taranaki Region and overviews the three policy options being assessed; identifies assessment criteria; undertakes an assessment of the potential costs/benefits (from a nutrient management perspective) within a specific Taranaki context, and recommends a preferred option.

Section 8 provides a summary of the key findings of the assessments, and provides a conclusion on the costs and benefits from a nutrient management perspective of the preferred option.

2.5 Acknowledgements

The authors of this Report acknowledge the key contributions of the following people:

1. Dr Kit Rutherford, Principal Scientist – Catchment Processes (NIWA) who provided review comments on the wider nutrient management sections of this Report, and input and views on CLUES which is an area of expertise of Dr Rutherford;
2. Gary Bedford, Director – Environmental Quality (TRC) who has provided opinions and guidance on a range of matters relevant to the Council and the state of the Taranaki region's environment.

3 Defining the Issue – Dairy Farm Effects on Water Quality

3.1 Diffuse Source Discharges

There is a wide field of national and international literature identifying what diffuse or non-point source discharges are and the effects they can have on the environment, including surface water quality. The Council has prepared a discussion document as part of the review of the Regional Freshwater Plan entitled *"Managing diffuse source discharges to land and water in the Taranaki Region; November 2012"* that references a large number of this literature. The majority of the commentary below on diffuse source discharges in the Taranaki region has been sourced from this discussion document.

Nature of Diffuse Discharges

Diffuse (widespread) or non-point source discharges are those discharges to land or water that do not have a particular point of origin (e.g. are not introduced into receiving waters from a specific outlet), but arise from a wide or diffuse area. Diffuse source discharges are derived from a broad range of activities but are often attributable to poor land use practices such as the excessive use of fertilisers and agrichemicals to land, grazing of river and stream margins, high stocking rates, the direct entry of stock to water and water courses, and inappropriate land use on erosion prone land.

Dairy Farming in Taranaki

The Discussion Document goes on to identify Taranaki as one of the most intensively farmed regions in New Zealand and this places a considerable demand upon its soil and freshwater resources. Healthy soils are recognised as essential for a sustainable environment, the maintenance of farm productivity and opportunities for flexibility in land use, and for its vital role in maintaining surface and ground water quality.

Dairy Farm Effects on the Environment

Historically, from the 1990s to the early 2000s there was a substantial increase in the use of urea and in stock numbers in the Taranaki Region. Since 2002 stock numbers have remained static, but there has been an increase in the use of supplementary feed. There has also been a large increase in productivity per cow (>20% gain). Stocking rate per ha has increased only 4% in the decade 2002-2012.

The net effect of the historical expansion and intensification of dairying in the region is to increase the amount of nutrients, sediment, and animal effluent being applied to the land and dispersed into water bodies traversing the intensively farmed parts of Taranaki. These effects are made worse by the clearance of much of the riparian margins along streams and rivers over the last 160 years.

Nutrients

The Parliamentary Commissioner for the Environment[2] has identified nutrients as the pollutant of most concern. While on land they cause less of a problem, excessive nitrogen levels in soils can lead to nitrate leaching into either surface water or groundwater. This can be seen in the rapid growth of unwanted algae and aquatic weeds.

There are two nutrients that collectively cause water quality issues – nitrogen (N) and phosphorus (P). In the Taranaki context, the largest source of nitrogen is urine from livestock (including discharges from dairy effluent pond treatment systems) while the largest sources of phosphorus are from:

- Sediment (e.g. soil erosion from the mountain and eastern hill country);
- The leaching of soluble P from soils with high Olsen P levels;
- Surface runoff (including pasture runoff of fine clay with P attached; fertilisers);
- Stock access to river/stream banks (as a source of bound P); and
- Discharges from dairy effluent pond treatment systems.

Sediments

Sediment is a problem when in water rather than on land. There are a number of causes of sediment reaching water including:

- The loss of forests and other vegetation that retained the soil on land has led to an acceleration of natural erosion processes;
- Stock damage to stream banks; and

[2] Parliamentary Commissioner for the Environment – Water Quality in New Zealand; March 2012

- Surface runoff from damaged (pugged) pasture and raceways/roadways.

Excessive sediment levels in water damages aquatic life in the rivers by smothering and through the destruction of instream habitat. The sediment also carries phosphorus into the water.

Pathogens
Pathogens are invisible microbes (bacteria, viruses) that affect the health of people and animals and are obviously pollutants in terms of usage of water. However, they cause relatively little damage to the natural environment.

This Supplementary Report primarily focussed on nutrients, and in particular tools/models to support the management of nutrient losses from dairy farms.

Nutrient Losses to Water
The two nutrients (nitrogen and phosphorus) discussed above enter water by different routes.

Nitrogen occurs in forms that are highly soluble in water and so can travel via overland flow as well as leaching to groundwater (which may then flow to surface water). Nitrogen loss from the root zone (leaching) will be the largest source of diffuse pollution in Taranaki, although direct discharge of treated effluent from dairy pond systems is also a significant source. However, direct access of livestock to surface water is also a widespread pollution source. Direct livestock access to water adversely affects freshwater quality by:
- The physical damage to the banks of waterways caused by livestock treading and browsing, which increases the susceptibility of riparian margins to erosion, sediment loss and pollutant runoff;
- Direct excreta and urine deposits in water, which adds nitrogen, phosphorus and faecal microbes.

As discussed above, phosphorus enters water through a range of ways including with soil through farmland erosion, through leaching from soils, surface runoff, stock access to waterways and discharges from dairy farms effluent systems. The amount of phosphorus in the water is affected by the time of year; river flows; farming activities and farm management practices.

3.2 Environmental Effects of Nutrient Losses

On land or of themselves, nutrients are not a problem. The problem with excessive nutrient enrichment is how it may affect the physicochemical and biological condition of water once it escapes or seeps into our waterways or groundwater.

When other environmental conditions are right, excess nutrients can have significant effects on water bodies. Nitrogen and phosphorus stimulate plant growth, including nuisance periphyton growth as well as algal blooms (sometimes toxic), oxygen depletion, and ecological damage. Ammonia can kill fish, and elevated nitrate levels can make groundwater unsafe for drinking (with the risk mainly to very young infants). Concentrations of the nitrogen species in Taranaki waterways are well below those that cause the latter effects, and the primary potential adverse effect of concern is the possibility of excessive in-stream plant growth with its attendant consequences outlined above and below.

High levels of nitrogen and phosphorus contribute to the excessive ('nuisance') growth of plants, including algae, which, in turn, can smother the instream habitat, affect the attractiveness of water for swimming, impact on fish habitat, impede water flows and block water intakes.

Nuisance impacts on water quality vary across the country according to topography. The growth of nuisance aquatic weeds and algae in water 'eutrophication' can lead to increased diurnal fluctuations in dissolved oxygen and pH, and in extreme cases resulting in oxygen depletion and fish mortality. There may also be reductions in water clarity. This is especially an issue for lakes and streams with retention structures. Stream beds with high algal biomass tend to be dominated by macroinvertebrates (e.g., worms, snails, chironimids etc.) which are tolerant of 'organic enrichment' but which are regarded as 'less desirable' (e.g., as food species for trout). By comparison, streams with low algal biomass (which are often also cool, shallow with swift currents) tend to be dominated by 'desirable' macroinvertebrates (e.g., mayflies, stoneflies and caddisflies). The MCI index (widely used to monitor macroinvertebrates in streams) is high (typically >100) in streams dominated by mayflies, stoneflies and caddisflies and low (typically <80) in streams dominated by worms, snails and chironimids.

In Taranaki, nutrients are not such a problem because of fast flowing and relatively short rivers and streams. High rainfall leads to frequent flushing events in rivers and streams that provide natural scouring. Even in summer, most Taranaki rivers do not have large bodies of shallow sluggish warm flows along their length, which are conducive to the growth of nuisance aquatic weeds and algae.

However, cumulative impacts from diffuse and point source runoff have marked impacts increasing periphyton substrate cover particularly in the lower reaches of Taranaki waterways under warmer, low flow conditions.

A more in-depth description of the state of the Taranaki water resources is included in the *Supplementary Report – Surface Water and Groundwater Quality*.

3.3 Nutrient Management Approaches

A range of approaches have been developed to address the issues relating to the various sources of nutrient losses on farms, including:

- Good management practices;
- Adaptive management;
- Regulating land use activities.

Good management practices – relate to on-farm practices that have benefits to the farmer and the environment. Such practices include: better effluent management; better fertiliser management; improved feed conversion; matching stocking rates to land capability; hard stand feed areas etc.

These good management practices and the benefits to the farmer and environment are discussed in detail in the *Supplementary Report – Dairy Farm Practices and Management* prepared by DairyNZ.

Adaptive management – is where a farmer introduces approaches and systems to monitoring nutrient losses and then changing farming practices accordingly. These systems include the preparation of nutrient budgets to inform fertiliser application and use; nutrient management plans to manage nutrient use and losses; and the preparation of farm environment plans relating to all aspects of the operation of the farm, including monitoring and reporting systems. Where resource consents may be required for a particular farming operation, conditions on consents also often impose adaptive management approaches to manage environmental effects.

Regulation – is where a council develops policy and rules controlling land use activities in regional plans that require N and P loss to meet prescribed limits, compliance with good management practices, monitoring, auditing and reporting on programmes etc. The limits may be set as instream concentration limits; instream load limits; or a nitrogen cap or discharge allowance that can be leached from the root zone of the farm.

Regulations may also relate to the current state of the water quality of a catchment (priority catchments); the size of the property (above 5 ha or 10 ha); land use classifications; whether irrigation schemes exist; or to certain land use activities (such as dairy farms). Compliance with good management practices and monitoring, auditing and reporting is often implemented through conditions on resource consents, or the requirement of farmers to provide information to council on request.

In some regions a combination of the above approaches has been adopted.

To assist with a number of these approaches, tools and models have been developed as part of ensuring good management practices are been adopted, and adaptive management approaches are being effective. These tools and models include OVERSEER® which is primarily used to establish and monitor nutrient budgets; CLUES which is a GIS based modelling system which assesses the effects of land use change on water quality and socio-economic indicators; and the use of LUC Classification - these tools/models are discussed in detail in section 4 below.

Ronlyn Duncan in her 2014 research paper[3] describes how OVERSEER® and CLUES have been utilised:

"At the catchment scale, the nutrient load of a waterbody can be derived from predictions of a catchment's land use using Overseer®(see below) and a predictive model known as CLUES (Catchment Land Use for Environmental Sustainability). In effect, a CNL [Catchment Nutrient Load] is an aggregation of estimations of nutrient losses from the mix of different land use types which can be extrapolated via modelling into future land use and leaching scenarios. The estimations can be used to predict catchment-wide land use nutrient losses, as well as existing and potential future states of environmental impact in rivers and lakes in terms of the effects of nutrient enrichment. From these estimations, a calculated CNL can be apportioned into a farm scale NDA. In this way, the catchment and farm scale limits can be linked – the latter is derived from the former."

3.4 Compliance

Ongoing State of the Environment Monitoring and Reporting[4] show trends in water quality and stream health (viz., MCI) that can be used to determine whether the increase of dairying in Taranaki is having an adverse effect on the quality of the surface water and groundwater resources of the region (refer to the *Supplementary Report – Review of Freshwater Quality in Taranaki*; February 2015 prepared by the Council for a full commentary on the nutrient trends and MCI trends). If through this monitoring it is determined that there are adverse effects and the quality of the surface water or groundwater is deteriorating or not improving as it should, questions will need to be asked regarding whether the nutrient management approaches being adopted are effective, and where there is regulation, whether compliance has been/is being demonstrably achieved.

[3] R Duncan - Regulating agricultural land use to manage water quality; The challenges for science and policy in enforcing limits on non-point source pollution in New Zealand; May 2014
[4] TRC

In relation to good management practices, compliance is predominantly self-audited and reliant on the farmer recognising the benefits and adopting the practices. Some regional plans do require good management practices as a condition for permitted activity status as an interim regime while regulation is being introduced, or in catchments where there are no water quality issues and farming activities are small scale. Information may be requested from farmers to demonstrate good management practices in these cases.

In relation to adaptive management approaches, compliance is primarily through auditing and review of the approaches by the farmer. Where regional plans require adaptive management approaches as a condition of permitted activity status, or consent conditions have been granted, information may be requested from farmers to demonstrate adaptive management approaches are having a positive effect in these cases.

In relation to compliance with regulation, conditions on consents will require monitoring, reporting and review or as an alternative, enforcement action could be taken through s.17 RMA. Whenever there are rules relating to a permitted activity (or conditions within consent) it is expect the council will undertake credible monitoring/auditing of data and on-farm performance, to determine compliance.

As second generation regional plans are being prepared that set limits or require consents to control land use activities that potentially have nutrient losses, councils are looking to adopt more stringent compliance mechanisms. This has led to some plans looking to use tools/models developed to establish nutrient losses and to guide on-farm practice change(s) as a mechanism to determine compliance with limits or environmental outcomes. This issue is discussed in Section 5 below.

4 Overview of Nutrient Management Tools/Models

4.1 OVERSEER®

Background to OVERSEER®

OVERSEER® is owned jointly by the Ministry of Primary Industries (MPI); the Fertiliser Association of New Zealand (FANZ) and AgResearch (who are also the lead science provider). The model is constantly being updated and refined to respond to farming practices, new technology and new findings about nutrient losses.

In the initial years (mid 1990s onwards) OVERSEER® was used by AgResearch staff and some agricultural consultants to help explain fertiliser nutrient cycling and requirements to farmers. From the early 2000s, increasingly fertiliser company frontline staff began using OVERSEER® generated nutrient budgets to assist in informing their recommended fertiliser nutrient and lime requirements to farmers. Taking account of imported nutrients from supplementary feed brought into the farm and nutrients redistributed within the farm (e.g., from land application of farm dairy effluent) allowed staff to reduce fertiliser nutrient inputs to take advantage of these other nutrient sources.

A major strength, and current use, of OVERSEER® is that it is able to demonstrate the impact of the relative effect of changing some management practices, inputs or mitigations on nutrient loss from a farm or block. However, the user of OVERSEER® must be conversant with its operating principles to ensure that the consequences of any changes made are consistent with all the other input parameters used to set up the original nutrient budget. Scenario testing provides the farmer or farm consultant with valuable information to assess what management changes he/she could make to reduce nutrient loss if that is required. Further analysis of the costs associated with changes to management and indeed the practical feasibility of changes also need to be completed outside of the OVERSEER® analysis.

It is worth reiterating that OVERSEER® is a model (i.e., a mathematical expression of complex biological systems) and therefore may not always accurately reflect what is actually occurring with respect to nutrient cycling in the real world. Therefore, care must be taken when using the numerical estimates of nutrient loss in either a voluntary or regulatory context.

Overview of OVERSEER®
OVERSEER® is a decision support system (DSS) farm model for farmers, advisors and increasingly national and regional policy makers and is widely used throughout New Zealand. It allows nutrient budgets to be constructed for many enterprises including: dairy, sheep, beef, deer; fruit; vegetables and arable crops. The OVERSEER® boundary is defined as the actual farm boundary, 1 metre above the ground and the bottom of the root zone. The model does not include losses due to poor management practices (good management practice or best management practice is assumed), direct discharges into waterways (e.g., runoff from raceways, bridges, roads or stock crossings), or losses due to catastrophic events (e.g., earthquakes, storms or volcanic eruptions).

The key elements of OVERSEER® are:

- OVERSEER® calculates budgets for the major nutrients including N, P, K, S, and Ca, Mg, Na and H+ (acidity).
- OVERSEER® has the ability to do "what if" scenarios, and its use can demonstrate flexibility in achieving a N or P loss 'target' or 'cap'.
- The aim of the model has been to use input data that are reasonably easily obtainable by farmers or consultants. Default values are built into the model. These may not necessarily be representative of the actual on-farm conditions at either individual paddock or farm scales.
- It is based on summaries of New Zealand (and overseas) research: OVERSEER® relies on sound science generated from research programmes funded by both Government and Industry. It has strong development support (MAF, AgResearch, FANZ) for regular updates. Model development started in the 1990s and has continued ever since, with regular additions/improvements to the model since then.

OVERSEER® differs from other farm models in that it aims to be a practical tool relying on input data that are readily obtained, and aims to model most major farm systems across all regions of New Zealand. This broad scope is both a strength and a weakness of the model. OVERSEER® is an annual time step, long term equilibrium model. As such it currently does not reflect year to year or within year variability accurately and should not be used for this purpose.

OVERSEER® is not an environmental management tool as it cannot assess the effect of the farm's N and P losses on the receiving environment. However, OVERSEER® does estimate N loss (from the bottom of the paddock root zone) and P loss risk (to the farm boundary) but users of the tool need to fully understand how to operate the model properly, its limitations across the range of farming activities and what the outputs actually mean.

Outputs of OVERSEER®

1. Calculates a nutrient balance (inputs – outputs) for blocks and whole farms
2. Shows the sources and fate of the nutrients cycling through farm systems
3. Calculates maintenance fertiliser nutrient and lime requirements.
4. Estimates losses to the environment i.e.;
    - N loss from gaseous emission, leaching and run-off
    - P loss risk from surface and subsurface flow

- Greenhouse gas emissions such as CH4, N_2O, CO^2.

OVERSEER® can assess the effects of a wide but not fully comprehensive range of management options and mitigation practices which affect nutrient loss.

OVERSEER® Nutrient Budgets

OVERSEER® nutrient budgets allow farms to comprise one or more management blocks (defined as an area of the farm that has common physical and management attributes). Nine separate types of management block are available: pastoral, fodder crop, cut and carry, fruit, vegetable/arable cropping, trees and scrub, riparian, wetland and house. AgResearch advises that up to 30 different blocks may be specified.

A nutrient budget provides average estimates of the fate of the nutrients nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), sodium (Na) in kg/ha/year as well as hydrogen ions (H^+), for different nutrient inputs and management practices (e.g., stocking rate, supplementary feed inputs), based on 'average' years (e.g. climate, farm management practices, etc.).

Nutrient balances are valuable indicators of the long-term sustainability of farm systems. They indicate where inputs of nutrients are inadequate relative to outputs, thereby leading to a decline in the soil nutrient status. Conversely, they can indicate where excessive inputs result in nutrient surplus and give an estimate of potential nutrient losses to the environment. Nutrient budgets also provide a method for comparing nutrient flows associated with different management practices on a farm. Fertiliser nutrients represent an important resource input on farms. High efficiency of nutrient use through conversion into agricultural produce is beneficial for profitable production and to reduce the nutrient surplus or potential for loss into the environment.

Updating OVERSEER® Model

The OVERSEER® model is constantly being maintained (bug fixes) and updated (new science, farm systems etc.). The current version of OVERSEER® is version 6.1.3, but in April 2015 version 6.2 is to be released. A number of bug fixes will be included but significant changes have been made to what input information is required to deal with fresh water irrigation on pastoral and arable farms. This change in the OVERSEER® model will mean more realistic results which are likely to mostly increase the N loss estimates of irrigated farms despite no other system changes.

There are a number of implications that arise from the updating of the OVERSEER® model including:

- Newer versions of OVERSEER® can calculate nutrient losses that are at variance with calculations using earlier version – the Horizons One Plan example discussed later in this Report is a case in point, and in the Waiokura catchment[5] in Taranaki, changing from OVERSEER® 5 to OVERSEER® 6 meant that the calculated N loss jumped from 48 kg N/ha/year to 78 kg N/ha/year, a change of more than 60% for the same input data;

[5]R Singh, A Rivas, P Espanto, A Elwan, D Horne, J Roygard, A Matthews, B Clothier. 2014 FLRC workshop manuscript (final) - 'Assessment of transport and transformation of nitrogen in the subsurface environment of Manawatu River catchment-work in progress'

R Singh, A Rivas, P Espanto, A Elwan, D Horne, L Burkitt, J Roygard, A Matthews, B Clothier, M Hedley. 2015 FLRC workshop presentation - 'Understanding and enhancing nutrient attenuation capacity in NZ agricultural catchments'

- Where discharge losses from earlier OVERSEER® modelling has been locked into policies in plans, or conditions on consents, the validity of these calculations (and thus the policies built on these calculations) can be at question if new versions of OVERSEER® produce new numbers;
- Once a new version or updated version of OVERSEER® is available, the earlier model is often removed from the OVERSEER® website meaning farmers are unable to get access to an earlier model that their nutrient losses have been based on;
- Regional Councils need to have a mechanism by which to deal with version changes as, except in the case of the Waikato Regional Council's Variation 5 (West Taupo catchment) previous nutrient budgets calculated using earlier versions are overwritten as soon as these electronic files are opened in the latest version.
- The above notwithstanding, it is also germane to note that while the <u>estimate</u> of N loss (viz., kg/N/yr) has changed, the contribution of N to the receiving waters (viz., the %age of the cumulative N loss from all farms in the catchment) will not have changed, all other things being equal.

OVERSEER® 6
The model calculates budgets (inputs and outputs) for each separate management block and a whole farm weighted average for the nutrients N, P, K, S, Ca, Mg, Na and H^+ (acidity - pastoral block only). Additionally, the model estimates animal pasture intake, pasture production, calculates maintenance fertiliser nutrient and lime requirements and estimates losses to the environment (i.e., N loss below the root zone (leaching), P run-off risk and greenhouse gas emissions).

There are a considerable number of misconceptions around the OVERSEER® nutrient budget model, how it operates, how it should operate and what it can and cannot do. The commentary below focuses on pastoral land uses, and not vegetable/arable/crops which are not the subject of this Supplementary Report.

In terms of the pastoral agricultural model (dairy, sheep, beef, deer etc.) the centrepiece model is not based on a pasture growth or soil fertility driven model but is actually an animal intake model. The model calculates the energy requirements of the block/farm based on the livestock information (milk production, stock numbers and classes, management etc.) provided by the user. With this information plus an energy calculation from any supplementary feed used the model then estimates the amount of pasture dry matter (taking into account pasture quality) that must have been consumed.

Once the pasture intake has been calculated the model can estimate pasture grown (by using default or entered pasture utilization information). Further to this, because pastoral farms are complex in nature many of the other data input requirements are required to understand nutrient transfers around the farm, mainly but not exclusively by the animals depositing dung and urine but also effluent applications and so on. The information generated around how much nutrient is deposited when and where is then also used elsewhere, such as in the N leaching and P run off sub models.

What an N Loss Estimate from OVERSEER® Actually Means
The nutrient budget (using OVERSEER® 6) estimates the amount (kg) of N/ha/yr lost to the atmosphere as gaseous forms of N and how much (kg) N/ha/yr is lost to water. This is primarily the estimate of how much N moves below the root zone in drainage water, particularly on flat land. <u>It is not, nor should be interpreted as, the amount of N which necessarily enters receiving water</u> (confined, unconfined aquifers or surface water).

In grazed pastoral systems, the N loss to water is primarily driven by surplus N derived from urine patches but other sources include direct loss from N fertiliser, non-urine patch soil, runoff, direct losses to water, border dyke outwash etc. also contribute to N loss.

N lost to water is more correctly an estimate of the N which enters the area of soil and parent material beneath the root zone but above the water table – sometimes referred to as the vadose zone.

Given that the N loss estimate is what is leaving the root zone, it is inappropriate to use OVERSEER® loss estimates to solely determine N loss limits which are designed to protect or improve receiving water quality. This is because between the end of the root zone and the receiving water there are mixing, assimilation and attenuation processes which may increase or decrease the concentration of N reaching those receiving waters.

In an effects based framework (in accordance with the RMA and plan provisions), the allocation of N loss limits (if this is to be pursued as a management option) needs to be determined by understanding the load the receiving water can assimilate without breaching the water quality standards desired for that receiving water and the degree of assimilation/attenuation occurring to N being lost from the root zone and using these data to back calculate acceptable N loss per hectare on a catchment and land use basis.

Once that is achieved and a farmer knows what N loss limit must be achieved for his/her property, OVERSEER® can be used to monitor how the farm is performing relative to the N loss limit and also to demonstrate the impact of changing management, inputs or mitigations on N loss from a farm or block.

4.2 Catchment Land Use for Environmental Sustainability (CLUES) model

CLUES is a GIS based modelling system which assesses the effects of land use change on water quality and socio-economic indicators. It was developed by NIWA for MAF and is an amalgamation of existing modelling and mapping procedures contributed by various research organisations, including MfE, AgResearch, Landcare Research, Plant and Food Research and Harris Consulting.[6]

CLUES allows users to create both land use and farm practice change scenarios (stocking rates, mitigation) using a range of tools. Results are available in map and tabular displays. A number of existing modelling and mapping procedures, developed by various research organisations, have been amalgamated to produce CLUES. The impetus for development of the system came from MPI, who wanted 'what if' scenarios to be modelled at large scales.[7]

CLUES currently models annual average Total Nitrogen, Total Phosphorus, E. coli and sediment loads in streams nationally (576,000 stream reaches, sub-catchments of 0.5 km^2 on average) and predicts a range of socio economic indicators such as farm employment and associated GDP, based largely on MPI monitor farm information. CLUES also predict concentrations of Total Nitrogen and Total Phosphorus.

Land-use maps are provided with CLUES, but the user can create new land use scenarios by modifying the land use interactively or importing a new land-use. Mitigation factors and stock intensification can also be specified to create new scenarios.

The CLUES project included creating national maps of land use, soils databases predicting nitrogen leaching for horticultural and cropping land, and links to simplified versions of OVERSEER®. Land-use

[6] NIWA website - https://www.niwa.co.nz/freshwater-and-estuaries/our-services/catchment-modelling/clues-%E2%80%93-catchment-land-use-for-environmental-sustainability-model
[7] MPI website - http://archive.mpi.govt.nz/environment-natural-resources/water/clues

types which can be analysed include several sheep, beef, dairy, and deer farming variations along with arable, horticulture, and forestry land uses.

4.3 Other Tools/Methods (including LUC)

Land Use Classification System (LUC)
The LUC system has been used in New Zealand to help achieve sustainable land development and management on individual farms, in whole catchments, and at the district, regional and national level since 1952.[8]

The LUC Classification is defined as *"a systematic arrangement of different kinds of land according to its properties that determine its capacity for long term sustained production."* Capability is used in the sense of *suitability for productive use or uses* after taking into account the physical limitations of the land.

The LUC system has two components: firstly a Land Resource Inventory (LRI) is compiled as an assessment of physical characteristics considered to be critical for long-term land use and management (including rock types; soils; landform and slopes; erosion types and severity; and vegetation cover). The LRI is supplemented with information on climate, flood risk, erosion history and the effects of past practices. Secondly, the inventory is used for LUC Classification where land is classified into eight classes according to its long-term capability to sustain one or more productive uses.

The LUC Classification has three levels: Firstly an inventory polygon is categorised into one of eight LUC Classes according to its general capacity for sustained production – Class I being 'best' and Class VIII being 'worst'. Secondly, each class can be further categorised using one of four LUC sub-classes based on the dominant limitation – erodibility; wetness; soil and climate. Lastly each Class/Sub-class combination can be further differentiated into LUC Units that group areas of land that require similar approaches to management and have similar capabilities regarding yields and crop suitability.

As with any model, assumptions are made in the LUC Classification on matters such as:
- The permanent physical limitations of the land remain;
- The rectifiable limitations may be removed;
- An above-average level of land management is practised;
- Appropriate soil conservation measures will be applied and maintained.

Physical limitations include: permanent limitations that cannot be removed (such as rock type attributes; adverse climate; slope angle etc.); removable limitations that may not be easy and require investment (such as gravel and boulders on the land surface; wetness through drainage; flooding through management schemes; soil moisture deficit through irrigation); modifiable through ongoing management and investment (such as erosion; nutrient deficiency; soil moisture deficit).

Nutrient Management Plans
Whilst an OVERSEER® nutrient budget is useful in itself, the real value is when it is used in a Nutrient Management Plan (NMP) to develop a farm strategy that takes into account productivity, environmental losses against consent conditions (if any) and other factors important to the business.

[8] LUC Survey Handbook; 3rd Edition

Nutrient Management Plans are central to 'Whole Farm Plans' and come in many formats, but they usually have the following in common:

- A farm map and description of the business;
- An OVERSEER® nutrient budget as the central component;
- An assessment of environmental risks;
- A summary of consent requirements;
- Recommended actions for addressing identified issues, including:
  - Scenario analyses;
  - Details of fertiliser requirements.

It is essential that NMPs should be prepared by trained advisors, competent in the use of OVERSEER® and with a detailed understanding of farm systems, nutrient cycling and environmental issues.

NMPs are increasingly being used by regional councils as a part of the consents process. However, they should never be considered simply as something to do to meet regulatory requirements. NMPs are invaluable business tools, with potential to save the farm money by increasing efficiency of nutrient use as well as decreasing discharges to the environment.

5 Use of Nutrient Management Tools/Models in a Regulatory Setting

5.1 Summary of Approaches in Other Regions

The following provides a brief summary of the nutrient management approach taken in regional plans in other regions.

Waikato

In general:

- Nutrient Management Plan for nitrogen fertiliser application over 60kg/N/ha/yr – permitted activity standard.

In relation to Lake Taupo:

- Nutrient leaching cap – use OVERSEER® (Version 5.3.4 not available to anyone else except WRC) to determine Nitrogen Discharge Allowance for each property imposed via its consents;
- Consents required if a farmer leaches above Nitrogen limit;
- A trading scheme has been introduced.

Bay of Plenty

In lake catchments:

- Sets water quality targets (e.g., nutrient input to the lake and/or trophic lake index);
- Land use Permitted Activity if site <.4ha and leaches less than 10kg/N/ha/yr; phosphorus fertiliser less than 10kg/ha/yr;
- Requires a nutrient benchmark to be determined;
- Controls increases in nutrient leaching + or – 10% of benchmark;
- Council is looking to introduce Nitrogen Discharge Allowance and farm nutrient plans;
- Council is looking to introduce a trading scheme.

Horizons Manawatu RC

In the One Plan the Council adopts the following approach:

- Sets water quality outcomes;
- LUC Classification used to set farm scale limits on N leaching – Controlled Activity status if meets LUC Maximum Allowable N (MAN) loss Sets a Nitrogen cap;
- Requires consent (controlled activity or Restricted Discretionary activity if LUC MAN loss not met) for existing land uses in 'priority areas';
- Requires consent for new conversions elsewhere.

Hawkes Bay

In Variation 6 to the Plan (relating to the Tukituki Proposal):

- Requires Farm Environment Management Plan for farms over 4ha;
- Nutrient budgets and Phosphorus Management Plan required;
- LUC Natural Capital and Nitrogen leaching rates set;
- Not apply to low intensity farming systems where farm property or farming enterprise less than 10ha;
- Sets water quality concentration limits and targets for dissolved inorganic nitrogen (DIN); nitrate-nitrogen (NO_3-N); and dissolved reactive phosphorus (DRP);
- Requires industry good practice to minimise N losses.

Canterbury

In Canterbury there are a number of approaches adopted in separate regional plans including:

In the Proposed Canterbury Land & Water Regional Plan (PCLWRP) the following approach is adopted:

- Establishes freshwater outcomes including water quality limits; environmental flows;
- Controls discharge of animal effluent to land;
- Controls feed pads; effluent storage ponds; reticulated sewerage networks;
- Requires good practice or better for farming activities with nutrient losses;
- Sets a Catchment Nutrient Load (CNL) limit;
- Sets on-farm Nutrient Discharge Allowances (NDA) or nutrient loss calculation;
- Includes an exemption for small properties;
- Requires the setting of a nitrogen baseline limit (average of 2009 to 2013 N loss estimates);
- Identifies priority areas (Nutrient Allocation Zones) for nutrient management;
- Requires preparation of Farm Environment Plans - nutrient budgets required using OVERSEER®;
- Requires nutrient losses quantified by OVERSEER® or meeting specified or good management practices as part of regulatory standards to be met;
- Provides a modified regime for use of land part of an irrigation scheme.

In the Selwyn Te Waihora Variation 1 to the PCLWRP the following approach is adopted:

- Introduces a baseline land use which is used to define the nitrogen baseline;
- Introduces Good Management Practice Nitrogen and Phosphorus Loss Rates which means nitrogen and phosphorus loss rates (in kilograms per hectare per annum) from a property (including losses below the root zone of a property) for different soils, rainfall and farm type operating at good management practice;
- Introduces mechanisms to reduce the discharge of nitrogen and phosphorus by not exceeding nitrogen baseline where a property's nitrogen loss calculation is more than 15 kg/N/ha/yr; implement good management practices; implement a Farm Environment Plan (where property N loss >10 kg N/ha and within Lake Area); and stock exclusion;

- After 1 January 2017 implement a Farm Environment Plan for properties over 50ha; where property's nitrogen loss calculation over 15 kg/N/ha/yr meet good management practice and Phosphorus Loss Rates for baseline land use;
- From 1 January 2022 implement a Farm Environment Plan for properties over 20ha; where property's nitrogen loss calculation over 15 kg/N/ha/yr require additional % reductions on good management practices for different land use activities;
- By 2037 no property or farm enterprise leach more than 80 kg/N/ha/yr;
- Set Irrigation Scheme nitrogen limits for all farming activities within the command area of an irrigation scheme.

In the Hinds Variation 2 to the PCLWRP the following approach is adopted:

- All farming activities are to operate at good management practice by 2017;
- Dairy and dairy support farms are then required to further reduce nitrogen loss rates by 45% and 25% respectively by 2035;
- Change in land use or land use intensification is provided for on a maximum of 30,000ha provided the nitrogen loss is no more than 27 kg/N/ha/yr;
- Limit placed on concentrations of nitrogen in shallow groundwater in Lower Hinds/Hekeao Plains area; good management practices required in the Upper Hinds/Hekeao Plains Area;
- Introduces a baseline land use which is used to define the nitrogen baseline;
- Introduces Good Management Practice Nitrogen and Phosphorus Loss Rates which means nitrogen and phosphorus loss rates (in kilograms per hectare per annum) from a property (including losses below the root zone of a property) for different soils, rainfall and farm type operating at good management practice;
- Introduces mechanisms to reduce nitrogen and phosphorus discharges including stock exclusion; farm management practices; Farm Environment Plans – nutrient budgets required using OVERSEER®;
- Capping discharges of nitrogen in the Upper Hinds/Hekeao Plains Area to 114 tonnes of N/yr and requiring good management practices to reduce phosphorus;
- Set target load for Lower Hinds/Hekeao Plains Area at 3,400 tonnes N/yr by 2035;
- Use of nitrogen baseline mechanism.

The Hurunui Waiau River Regional Plan the following approach is adopted:

- Sets water quality limits for periphyton biomass; dissolved reactive phosphorus concentrations; nitrate-nitrogen concentrations;
- Sets nitrogen and phosphorus load limits in Hurunui Catchment;
- Requires current average dissolved reactive phosphorus be maintained;
- Manages the cumulative effects from non-point source discharges from existing and new land uses through best nutrient management practises including an industry certification system, a catchment agreement, an irrigation scheme management plan or lifestyle block management plan;
- Nutrient losses are benchmarked through recording and calculating annual average losses using OVERSEER® nutrient budget modelling.

Otago

In the Otago Plan Change 6A to the Regional Plan : Water for Otago the following approach is adopted:

- Controls on how much fertiliser can be applied to land;
- Controls on stocking rates;
- Controls on discharge of animal effluent by spraying;
- Sets a 30 kg/N/ha/yr N loss limit (estimated using OVERSEER®) for the 'rest of Otago';
- Sets a 20 kg/N/ha/yr in 'sensitive catchment areas';

- Sets a 15 kg N/ha/yr for properties around high country lakes.

5.2 Summary of Regulatory Approaches Using Tools/Models

A summary of the regulatory approached using tools/models in regional plans is included in **Table 1** below:

	Waikato	Bay of Plenty	Horizons MW	Hawkes Bay	Canterbury	Otago
Nutrient leaching cap	√		√		√	√
Nutrient Discharge Allowance (NDA)	√	?		√	√	
Catchment Nutrient Load (CNL)				√	√	
Nutrient Management Plan (NMP)	√					
Nutrient Budgets				√	√	
Water Quality Targets		√	√	√	√	
LUC Classification			√	√		
Farm Management Plans (FMP)		?			√	
Good Management Practice (GMP)					√	
Consents	√	√	√	√	√	
Controls P				√	√	
Trading Schemes	√	?				
Nitrogen baseline or benchmark		√		√	√	
Nutrient Allocation Zones or Priority			√		√	√

Areas						

Symbol ? – council thinking about introducing this measure.

Table 1 - Summary of the regulatory approached using tools/models in regional plans

6 Issues Associated with using Tools/Models

6.1 OVERSEER®

Introductory

There are a number of issues that arise from the use of OVERSEER®, not only in the preparation of nutrient management budgets and plans, but also when using OVERSEER® in a regulatory setting. Many of these issues have been well documented in previous reports and in expert evidence that have been presented to plan hearings and the Environment Court.

Use of OVERSEER® in a regulatory setting

Issue: OVERSEER® is being used more and more in the regulatory setting as a tool/model to be used to determine nutrient losses or to demonstrate compliance, and in some cases to set limits.

From the outset it should be stated that OVERSEER® was never designed or intended to be used as a regulatory tool. This is not to say that OVERSEER® cannot be a helpful tool when used in a regulatory setting. The key point is that OVERSEER® was designed and intended to support decision making on managing nutrient use and losses at a farm level and as such does not in itself compel a farmer to follow any advice derived from this process. Any use of OVERSEER® in a regulatory setting needs to be appropriate and relevant to the issues being addressed.

Inherently the regulatory setting requires certainty and accuracy to ensure environmental effects are identified and assessed. There is an onus on the resource user to demonstrate or prove what the effects of their activities will be. Similarly the regulatory authority has to be able to demonstrate or prove where non-compliance with plan provisions or resource consent conditions has occurred, and relies on certainty and accuracy in this setting. A regulatory regime that is based on a whole of catchment approach must of necessity take a starting point of regarding all farms as having an equal contribution and having to meet the same allocation imposition if target water quality is to be attained, when this does not reflect reality.

The certainty and accuracy of using OVERSEER® in a regulatory setting are further complicated by:

- OVERSEER® cannot accurately model any specific farm, farming system, or farming operation - currently the generally advised error rate in the N loss estimate for OVERSEER® is +/- 30 percent, although this is for a much older version of OVERSEER® than 6.1 or 6.2. The OVERSEER® owners are well aware of this issue and various attempts have been made to outline and fund a study to determine error or uncertainty;
- Outputs from OVERSEER® will vary depending on the operator - there is a need to ensure operators are adequately trained and certified in OVERSEER® use and includes a good knowledge of farm systems in order to fairly represent the actual farm system being modelled. As with any model, variability in outputs can be generated by choice of inputs. This is why a number of protocols have been created to guide the construction of nutrient budgets in OVERSEER®. The overarching one is the Best Practice Data Input Standards which was first produced in late 2013. This is updated as OVERSEER® versions change. However, the dairy industry has a separate protocol (its Audited Nutrient Management scheme) which does have some differences in advice on entering data from the Input Standards.

Therefore, while OVERSEER® is a tool/model that provides information to inform decisions for managing nutrient use and losses on-farm, by itself OVERSEER® will not deliver what is expected in the regulatory setting.

Using OVERSEER® to Estimate Nutrient Loss Limits/Targets
Issue: OVERSEER® is seen as the tool/model to set a nutrient loss limit/number rather than a mechanism to see whether nutrient management practices adopted are achieving the outcomes sought.

Where OVERSEER® is to be used as a means of estimating nutrient loss limits/targets, the actual numerical estimates should be treated with a degree of caution and more emphasis needs to be placed on the **relative change over time** (i.e. the trend in N loss estimates) between OVERSEER® analyses as adaptive management is undertaken by land owners to reduce N and P loss from their farms, where necessary.

For policy purposes, the reason for using a modelling approach is that direct measurements of nitrogen leaching are impractical. Landcare Research maintains that measuring nitrate losses from grazed pasture requires many sampling devices costing tens of thousands of dollars per year. The problem is that cows urinate randomly and, given the variation in so many variables across a typical Canterbury Plains paddock, it is not possible to representatively sample urine patches and thus directly and accurately measure nitrogen losses (Lilburne et al., 2011). This same conclusion can be extrapolated across dairy grazed pastures throughout New Zealand. Therefore, modelling is the only realistic option for regulatory purposes. Of course, these limitations make modelled conclusions difficult to verify.[9]

Using OVERSEER® to set limits in receiving waters
Issue: Can OVERSEER® be used to set limits in receiving waters?

Essentially the use of OVERSEER® by itself as a tool to set limits in receiving waters is outside the scope of the purpose and use of the model. This is valid because of the reasons already discussed and reiterated below.

Long Term vs Short Term N Loss Estimation and Mitigation
Issue: The use of OVERSEER® to estimate short term N loss – how daily on-farm decisions can affect a farm's nutrient losses.

The use of the OVERSEER® programme to estimate the long term equilibrium N losses, rather than within and between year N loss fluctuations, from pastoral and other farm types is valid. An N loss estimate from OVERSEER® may be used to assist farmers to determine how their farm is performing over the long term relative to any imposed N loss limit and may be used to test the effectiveness of management practices and technologies which will assist in achieving N loss reductions over time. OVERSEER® is not primarily a tool to determine short term N loss or to drive day to day on-farm management decisions. Even if annual input information is used to create a nutrient budget the N loss estimate will still be driven in part by 30 year average climate data (i.e. long term average ET, rainfall and rainfall distribution) imbedded in the model. The modeller would need to have both access to an individual year's ET, rainfall and distribution and be able to enter this in the model to give a better individual year estimate.

[9] R Duncan

N Loss at Root Zone vs N loss to water
Issue: Can OVERSEER® be used to calculate N loss that will enter water?

OVERSEER® does not take into account what happens to nutrients once they leave the farm boundaries (horizontal and vertical). OVERSEER® does not represent a farm's impact on the wider environment. Science indicates that management decisions on a day by day basis are responsible for much of a farm's nutrient loss e.g., a decision whether or not to graze/stand cows in a particular paddock near a particular waterway with particular soil moisture saturation for a particular length of time will have a very significant impact upon how much nitrogen is lost through the soil and how much sediment, phosphate, and nitrogen will be lost across the surface. OVERSEER® simply does not capture such short term effects, but rather gives a long term estimate of the farm system modelled.

Two processes influence how N losses from farms affect N inputs to streams. First, drainage through the vadose zone and into groundwater causes delays (termed 'groundwater lags') between changes in land use and N loss (e.g., intensification) and changes in N inputs to streams (e.g., increases resulting from land use intensification). Second, nitrogen transformations occur along the pathways between where N leaves the farm (e.g., the bottom of the root zone) and where it enters the stream. Further changes occur along the stream network above the site where stream nutrients may be monitored. These changes are collectively termed 'attenuation' and typically result in N loads at the catchment outlet being lower than the sum of OVERSEER® losses from the root zone within the catchment. In the Waiokura catchment in Taranaki, ongoing measurements of specific yield demonstrate that the catchment's nitrogen load measured in-stream is somewhere between less than one half, to only about one quarter, (depending upon the version of OVERSEER used) of the predicted N loss from land. The Manawatu-Wanganui Regional Council has recently reported [10] attenuation rates showing in-stream loadings to range between 30% less than, down to only one quarter of, the predicted N loss.

Using OVERSEER® to estimate P loss
Issue: Can OVERSEER® be used to estimate P losses?

The P loss estimate in OVERSEER® is actually a P loss risk estimate for the following reasons:

- P loss is often confined to small areas of farms, or critical source areas (CSAs), and the identification of these as well as determining whether these CSAs are connected to transport pathways which terminate at surface water is paramount in estimating the impact of P loss on water quality and the necessity of mitigating this impact. Where there may be sources of potential P loss, hydrologic processes determine whether the losses actually enter receiving water bodies and hence lead to water quality issues;
- Using OVERSEER® to estimate P loss risk is less applicable than it is for estimating N loss, with the way farm nutrient budgets are currently constructed. It is important to remember that the P loss estimate from OVERSEER® does not spatially identify CSAs, other than in the broadest sense of management areas e.g., effluent blocks, high soil P fertility, timing of fertiliser application and inherent features e.g., topography, soil anion storage capacity, water holding capacity);
- As with N, OVERSEER® only provides a prediction of P loss to the block or farm boundary;
- Using OVERSEER® alone in a regulatory framework to reduce the impacts of P losses to surface water could lead to farmers having to incur costs of instituting mitigations which may be misplaced and therefore ineffective. Conversely, important CSAs contributing P to receiving waters may be missed, hence undermining the ability to protect water quality.

[10] Elwan, A; Singh, R; Horne, D J; Roygard, J; Clothier, B – Moving farms systems to improve attenuation; Occasional Report No. 28; Fertiliser and Lime Research Centre, Massey University; 2015

Using OVERSEER® in compliance
Issue: Can OVERSEER® be used as a compliance tool?

Despite the fact that there is an unclear understanding of the fate of the N leaving the root zone with respect to its impact on receiving water, OVERSEER®can assist in compliance because it is logical to assume that the amount of N eventually reaching the receiving water of interest is somehow proportional to that leaving the root zone. Thus, in catchments with fully or over allocated receiving waters, OVERSEER® can be used to assist adaptive farm management practice change and monitor reductions in root zone N loss over time.

This approach could also be used in a semi-quantitative manner, as at Taupo in Variation 5 to the Regional Plan.[11] For example, if the desired outcome is to reduce long-term average stream loads by (say) 25%, then reducing cumulative OVERSEER® losses by 25% may be an acceptable starting point. The challenge for managers/scientists is to agree on the required %age reduction in long-term average stream loads to meet water quality or ecological health standards/guidelines/targets in the receiving streams. All the work to define standards/guidelines/targets for (say) N and P concentration, and/or MCI score and/or algal biomass is only getting us PARTWAY to managing land use.

What is missing is the link between cumulative OVERSEER® losses and the instream standards/guidelines/targets. This is where attention needs to be focused by managers/scientists.

It could be argued that the prime driver for eutrophication is nutrient loss and the 'best' tool to manage nutrient losses is OVERSEER®. It may be possible to look for relationships between cumulative OVERSEER® N and P losses in a catchment, and ecosystem health measures (like) MCI score and/or algal biomass/cover. There is also a need to consider other confounding factors – for example a flood-prone river (e.g., Stoney River) may have a different relationship between ecosystem health and cumulative OVERSEER® losses than a more stable flow river. Also stream gradient (quantified by altitude and/or distance from source) will affect bed substrate type and current speed which are known to affect how much algal biomass can accumulate and hence the habitat likely to develop for macroinvertebrates.

For some time it has been known that maximum algal biomass can be related to annual average DIN (and DRP) concentrations (which give a measure of eutrophication and are related to cumulative OVERSEER® losses) together with flood frequency (given that floods 'reset' biomass)[12]. However, while the Biggs equations fitted data from a sub-set of mostly South Island streams, they gave poor predictions in some large North Island rivers (e.g., Mohaka). Note that the Biggs equations require annual average DIN and DRP concentrations to be measured or predicted – a non-trivial task.

The question remains whether a robust model can be developed between cumulative OVERSEER® losses and algal biomass/cover and/or MCI using TRC data? Developing such a model would involve:

1. Establish relationships between cumulative OVERSEER® losses and algal biomass/cover and/or MCI;
2. These relationships to take into account the nature of the stream bed and its susceptibility to bed movement;
3. These relationships to take into account other confounding influences including shading and water temperature;
4. These to be based on historic TRC monitoring data;

[11] Opinion provided by Dr Kit Rutherford
[12] Biggs (2000)

5. Then the effect of (say) a 25% increase in cumulative OVERSEER® losses on algal biomass/cover and/or MCI can be estimated.

While in theory this approach could be done, in its practical application it would require a huge amount of work and would be site-specific. This leads to a more immediate question: is there anywhere in Taranaki that such an effort could be justified? While such a question is outside scope of this report, it is noted that the volume of work required to make this approach work would be substantial and with no certainty that a clear and simple relationship would be established.

If made a regulatory tool, it would be impractical to think the correct use of OVERSEER® by 1,800 dairy farmers could ever be monitored and thus compliance or otherwise determined to the level of proof required by Courts. There is a tremendous amount of time and effort being spent of developing Input Standards, capability training and development of auditing programmes at different levels such that OVERSEER®can assist in the compliance process.

Rainfall Data
Issue: How reliant is OVERSEER® on accurate rainfall data?

The calculation of the long term annual drainage, which together with the surplus soil nitrate-N, largely determines the N loss estimate is therefore dependent on the accuracy of the long term annual rainfall and its distribution.

Rainfall inputs are based on 30 year average annual rainfall distributed in an average manner. Thus, OVERSEER® will not take into account what happens in a drier or wetter year, or a year with overall less intensive or more intensive rainfall events. It is well known that N loss from the root zone varies hugely from year to year driven primarily by annual differences in soil drainage and to a lesser extent changes in farm management within and between years.

Validation/Calibration of OVERSEER®
Issue: How easy it is to validate/calibrate OVERSEER®.

OVERSEER® N loss estimates have been validated against farmlet system N losses but most of these studies occur where annual average rainfall is no greater than 1200mm. The model extrapolates to higher rainfall based on first principles and the known interactions between rainfall and soil properties. Many of the catchments in the Taranaki ring plain, which have their source in the Egmont National Park, have an annual rainfall of between 1100mm to 7178mm (at 900m above sea level). OVERSEER® does not take account of any transformations, attenuation, or dilution (due to high rainfall in the Egmont National Park) once nutrients cross the farm boundary, nor take into account all sources of on-farm nutrient run-off.

OVERSEER® P loss output is calibrated to runoff (surface and sub-surface flow) up to second order streams. However, the OVERSEER® model has no ability to account for surface water bodies either inside or outside of the farm boundary (with the exception of wetlands). Thus, an OVERSEER® analysis of a farm system could identify high P loss but unless the CSAs are connected to receiving water bodies there will be no impact on water quality.

There are still many soil property/climate combinations in which it has not been 'validated' and for which calibration data is not available.

Revision/Updating of OVERSEER®
Issue: OVERSEER® is constantly being upgraded and updated to meet changing farming practices and new technologies.

Major upgrades (such as the introduction of OVERSEER® 6) have resulted in changing N loss estimates from the use of previous versions of OVERSEER®. An example is the Horizons One Plan where a farm business that was calculated to be leaching on average 28 kg/ha/pa of nitrogen with OVERSEER® v5 was leaching 44 kg/ha/pa with OVERSEER® v6. The farm's limit, according to the regional plan, was to be 22 kg/ha/pa. Therefore, the required reduction in nutrient losses went from 6 to 22 kg/ha/pa with the change in OVERSEER® version. For the regional council this resulted in 80 rather than 20 per cent of consents in need of review (Bell, 2013). This was a considerable and unexpected administrative burden with far more constituents caught in the regulatory net.[13] Horizons Manawatu Regional Council have said that they would re- run every OVERSEER®consent nutrient budget each time there is an new Version released.[14]

In addition, some councils have locked in the use of one version of OVERSEER®in their plans and consent conditions (e.g., Waikato Regional Council Variation 5 (Lake Taupo) uses Version 5.3.4). This may lead to non-compliance and the need for resource consent variations when one version of OVERSEER® is replaced by another.

It needs to be remembered that as a result of version change and a difference in the N loss estimate, the actual amount of N the receiving water is subject to is unchanged.

6.2 CLUES

Introduction
CLUES is a catchment-based model developed to address "what if" scenarios under different land use at large scales. CLUES predicts the impacts of land use changes on river quality and socio-economic indicators, e.g. GDP, or employment. It also identifies sensitive and at risk catchments.[15]

Currently CLUES enables aggregation of N and P losses to predict long term average fluxes (e.g., tN/y) at (say) the catchment outlet. It can also quantify what each farm contributes to the total. However, what it cannot yet do is predict the impact of these nutrient fluxes on algal biomass or MCI. Efforts are being made to predict nutrient concentrations – with mixed success. [16]

Links to socio-economic models mean that the effects of a large-scale change in land-use, say from grazing livestock to viticulture, on local communities can also be predicted. The CLUES project includes creating national maps of land use, soils, and pollution risk, plus extensive databases predicting nitrogen leaching for many combinations of crop, fertiliser, climate, and soils. Land-use types which can be analysed include arable, horticulture, forestry, and several sheep, beef, dairy, and deer farming variations.

CLUES is based on MPI monitor farm information, which will not be representative of all dairy farms within the Taranaki ring plain. The error level of CLUES is not defined.

The CLUES database utilises current land use, climate, soils, and the catchment and drainage network. CLUES relies on the outputs from the following component models:

- EnSus – nitrogen leaching risk to inform the databases used;

[13] R Duncan
[14] A Roberts: Personal communications
[15] Envirolink website - http://tools.envirolink.govt.nz/dsss/catchment-land-use-for-environmental-sustainability/
[16] Input from Dr Kit Rutherford

- OVERSEER® - pasture N and P to identify contaminant sources;
- SPASMO – horticulture and crops N to identify contaminant sources;
- SPARROW – microbes, sediment, N and P from other sources; contaminant transport to identify contaminant sources and accumulation and losses in the stream network;
- HARRIS – triple bottom line effects to identify economics and employment.

Examples of the Use of CLUES in water management

Examples of projects[17] applying CLUES to water management issues are shown in **Table 2** below.

Region / Catchments	Who	Comments
National, Various Dairy Best Practice Catchments	NIWA for P21	Testing the model. Identified additional sources required for P, and role of groundwater in some catchments
Waikato (Waipapa, whole catchment)	Environment Waikato	Effect of conversions in Waipapa, tailored land-use approach in the Waikato catchment
Waikato	Independent Scoping Study	Effects of land use change and interventions on E. Coli
Manawatu	NIWA for Envirolink	Comparison with measurements, identification of contribution from different sources
Southland / Oreti River	AgResearch and NIWA for ES	Mitigation measure effectiveness
Waikato	NIWA for P21	Identified hot-spots, reaches that exceed concentration standards under various land-uses.
Canterbury / Hurunui Catchment	NIWA for P21	Current work identifying loadings
National / NZ estuaries	NIWA	Linking catchment model to estuary model
Bay of Plenty / Lake Rotorua	NIWA for Environment Bay of Plenty	University of Waikato
Southland /Mataura River	Environment Southland	Land use change scenarios (irrigation) and mitigation measures
National	DOC	Nutrient loadings to lakes, fish habitat stressor, FWENZ

Table 2 - Examples of projects applying CLUES to water management issues

Using CLUES to estimate nutrient loss limits/targets
CLUES is a predictive model whose original aim was to determine the impacts of land use change scenarios on water quality expressed in terms of annual loads of TN, TP sediment and pathogens.

One current 'mistake' is for managers to focus on setting 'standards' or 'guidelines' for either nutrient concentration or MCI and then hoping that OVERSEER® or CLUES will tell them what land use mix is required to meet those standards. The authors of this report[18] believe there are not yet strong scientific links between long term average nutrient losses from farms (OVERSEER®) or nutrient fluxes in

[17] MPI website - http://archive.mpi.govt.nz/environment-natural-resources/water/clues
[18] Roberts; Rutherford; Hansen

streams (CLUES) and periphyton biomass or MCI index. Those links are the subject of ongoing research which is not yet mature.

Using CLUES to calculate N loss that will enter water

The CLUES project quantified 'attenuation' at a national scale by matching observed and predicted annual N and P loads across a number of monitoring sites throughout New Zealand. It is difficult to separate the effects of groundwater lags from land use intensification when analysing stream nutrient monitoring data, and both may have affected CLUES estimates of attenuation where there are large aquifers (e.g., Canterbury Plains) and/or significant changes in land use intensity.

Using CLUES in compliance?

It is considered difficult if not impossible to determine whether a particular farm has caused the stream load to exceed a target/standard/guideline. While in theory a model could be used to show that the increase in OVERSEER® loss from a particular farm would explain the observed increase in stream load (provided the losses from all other farms were also known and did not increase), current models are not robust enough to be used in this manner. [19]

Relationship of CLUES with OVERSEER®

As CLUES relies on the outputs of OVERSEER® (along with a number of other models/tools), the issues discussed above relating to OVERSEER® apply.

6.3 LUC

The authors oppose the use of the Land Use Classification (LUC) system to determine the allowable current and future allowable N losses from farms. This opposition is on the basis that the system was not designed for this purpose and leads to distortions in allowable N losses that will adversely impact on farm productivity. The LUC is, as explained elsewhere, a classification of the suitability of land for one or more productive uses after consideration of the land's physical limitations, rather than its productive potential in either an unimproved or improved state. The classification takes into account the physical resources of the land such as rock type, soil type, slope, erosion type and severity and vegetation cover. Climate and previous land use effects are also assessed. The physical resources are used to divide land into 8 classes. There is no objective assessment of the actual productivity of the land within the eight classes.

The LUC then divides each class into a subclass identifying the dominant physical limitation such as erodibility, wetness (poor drainage or flooding risk), soil (shallow soil, pans, stoniness, low water holding capacity, low fertility etc.) and climate (summer drought, excess rainfall, frost, snow, wind and salt spray). Again, no objective assessment of actual productivity is used in the sub class, even though logic suggests that many of the potential limitations described above will impact on productivity. However, modern agricultural technology allows land managers to overcome some of these physical limitations through flood protection, drainage, enhancing soil properties through soil management techniques such as building organic matter, fertiliser use and introducing irrigation – all of which can be successfully undertaken where the economics of the enterprise allows.

It is only when the LUC unit, the most detailed level of the classification, is arrived at that a productivity index is considered. The LUC unit describes land which is homogenous with respect to management requirements, conservation treatment and suitability for the same type of crops, pasture or forestry

[19] View expressed by Dr Kit Rutherford

with similar potential yields. With respect to pastoral use this is based on stock carrying capacity. The productivity indices (i.e. attainable potential carrying capacity) listed in the extended legend of the LUC worksheets, are based on the capability for long-term sheep and beef livestock production from back in the late 1970's. The attainable potentials were based on a well-managed legume based pasture system.

Moreover, stock carrying capacity is itself a moving target as technology, knowledge and experience allows land managers to improve pasture productivity and hence either carry more animals per hectare or increase per animal performance (both of which equate to an increase in stocking rate or carrying capacity).

Furthermore, within each land class, subclass and unit will be land managers who have a range of skills and abilities which will enable the best ones to exceed the stock carrying capacity allocated, while others will not be able to approach this figure and all will be treated the same.
The authors believe that using the LUC system at the class level does not fairly attribute allowable N losses to farms within each class because it takes little or no account of productivity differences within and between classes.

6.4 Implications

The above issues identified with the various tools/models have implications for nutrient management and the validity of the approaches being taken by different councils. A key implication is that councils are using tools/models (such as OVERSEER® and LUC) in their plans and decision making to achieve environmental outcomes based on incomplete or inadequate information.

A fundamental principle that needs to be adhered to is ensuring that any tools/models are used for the purpose for which they were designed. Where there are gaps in the science or the tools/modelling, tools/models not 'fit for purpose' should not be adapted or utilised in the interim. A regulatory regime that is based on a whole of catchment approach must of necessity take a starting point of regarding all farms as having an equal contribution and having to meet the same allocation imposition if target water quality is to be attained, when this does not reflect reality.

At present there are some fundamental gaps in the science/management thinking that need to be addressed including;

- There is a need to find a link between farm-scale Nitrogen Discharge Allowance or loss limit and catchment nutrient load;
- There is a need to find a link between nitrogen leaving the root zone and P leaving the farm boundary, on the one hand, and nitrogen and P entering water on the other;
- Even if the above links are established, there is a need to ask what use is to be made of the catchment nutrient load;
- There is a need to establish which operational or environmental parameter is to be subject to regulatory limitation: - if a limit is set on the %reduction in cumulative N loss as determined by OVERSEER® (Taupo Regional Plan Variation 5), then management becomes (relatively) easy; if limit is set on stream nutrient concentration to maintain/enhance 'ecosystem health' two difficult issues arise - First, while there is a general deterioration of ecosystem health when nutrient concentrations are excessively high, that relationship is complex and hard to quantify - is ecosystem health best measured using algal biomass, MCI or fishability (three common measures)?; Second, the relationship between nutrient concentration and algal biomass varies from stream type to stream type depending on flood frequency, shade, and bed substrate type; Regardless of these issues, there is still a need to relate stream nutrient concentration to land use on each and every farm in a way that can be enforced in a legal framework and the current tools (CLUES, TRIM) do not yet allow that – although they are a step along the path.

- There is a need to develop mechanisms that can ensure accurate limit setting and equally accurate testable compliance outcomes;
- There is a need to ensure any conditions imposed on consents use the best science available and follow best practice – enforceable; for a resource management purpose; certain; relevant; fair, reasonable and practicable etc.

7 Assessment of Applying Tools/Models of Taranaki

7.1 Regional Context

In contrast to much of the rest of New Zealand, and in particular those areas of New Zealand facing pressure from land use change to intensive farming, rainfall in Taranaki is relatively consistent year round and more significantly is characterised by heavier rainfall events throughout the year. Because of the pattern of repeated flushings at regular intervals[20], the annual loading of nutrients is not an issue as temporal accumulation does not occur. Rather, deteriorations in instream ecology occur only at very limited times for limited durations and only in particular circumstances[21]. This in turn means that use of models that deal in annual average scenarios lack relevance to effective management of water quality in the region. Further, again unlike much of the rest of New Zealand, the region is characterised by a very large number of very small catchments with very short retention periods. The sheer number of catchments, let alone the diversity of on-farm and inter-farm variables within any single catchment (climate, hydrology, soil characteristics, on-farm practices etc.) which mean high individual variability in the degree of any contribution to water quality on a farm by farm basis, preclude any efficient means of collectively relating each individual farm's activity to desired water quality outcomes via modelling. The sheer scale of trying to calibrate OVERSEER® on a catchment by catchment basis across the region precludes such an approach in practical terms, even if nutrient restriction was to be deemed necessary.

Taranaki's short-run rivers do not present the same scale and homogeneity of other catchments elsewhere throughout New Zealand, where cumulative impacts are pronounced and catchment scale interventions are therefore efficient and potentially effective.

7.2 Overview of Taranaki Policy Options

The following three policy options are being assessed in the *Nutrient Management Tools/Models Report*:

Option One – *Status Quo*

This option involves continuation of the voluntary Riparian Management Programme which involves the following initiatives:

- Eventual completion across an anticipated 90% of the region of existing voluntary fencing of waterways;
- Eventual completion across an anticipated 90% of the region of existing voluntary planting of waterways;

[20] *Review of status of freshwater quality in Taranaki; Technical Report- Report No 103;TRC; February 2015*
[21] *Review of status of freshwater quality in Taranaki; Technical Report- Report No 103;TRC; February 2015*

- On-going liaison and support;
- Encourage the existing trend of increasing disposal of farm dairy effluent to land;
- Encourage good management practices (GMP) on dairy farms (including feed pads and nutrient budgeting);
- Control the application of farm dairy effluent onto or into land not exceeding 200kg N/ha/yr and with separation zones between application areas and waterways.

Option Two – *On-farm Mitigation*

This option involves regulating the effects of land uses by:

- Making fencing and riparian management mandatory for all waterways through intensive pastoral land use;
- Requiring timely full completion of the Riparian Management Programme;
- Requiring land disposal of dairy farm effluent in all except exceptional circumstances;
- Encourage good management practices (GMP) on dairy farms (including feed pads and nutrient budgeting);
- All by 2020.

Option Three – *Nutrient Cap plus other on-farm mitigation*

This option involves a scenario for setting nutrient caps e.g.:

- Set a nitrogen baseline of either 48 kg N/ha/year or 30 kg N/ha/year (defined as the discharge of nitrogen below root zone as modelled by OVERSEER® expressed in kg/ha/yr) and any activity (i.e. any farm) that causes the nitrogen baseline to be exceeded is a discretionary or even non-complying activity.

Background rationale: DairyNZ have previously (using 2010 OVERSEER®) reported that 25% of dairy farms in Taranaki were losing more than 50 kg N/ha/year, and 33% were losing less than 35 kg N/ha/year. The latest 'Sustainable Dairying Water Accord' report ('One year on') reports the average Taranaki dairy farm as losing a modelled 48 kg N/ha/year. If TRC were to go the route of controlling N losses to a modelled limit, then 48 kg/ha/year would seem to capture the 'leakiest' 25% of farms give or take; a limit of 30 kg N/ha/year is reflective of limits being set elsewhere and hence already entering into public consciousness as the 'right' level for dairying.

It is important to note that, for the sake of a discussion of policy options, Council has provided some 'indicative numbers'. While the rationale for the two number nominated is set out in the paragraph above, they were never chosen on the basis of an assumed particular environmental outcome. Their purpose is to be able to ask the question "*what are the consequences if this number or that number is chosen"*.

7.3 Assessment Criteria

In order to assess the three policy options and the costs/benefits from a tools/methods perspective of adopting each policy option, the following criteria has been adopted[22]:

- Relevance – how effective the policy option is in achieving the outcomes sought;
- Feasibility – within council's powers, responsibilities and resources; degree of risk and uncertainty in achieving outcomes sought; ability to implement, monitor and enforce;
- Acceptability – level of equity and fair distribution of impacts; level of community acceptance; likely political acceptance;
- Benefits – list key benefits – determined by how and what is likely to benefit; level of benefit achieved;
- Costs – list key costs - determined by how and what is likely to cost; level of costs incurred.

7.4 Assessment – Potential Costs/Benefits from a Nutrient Management Perspective

Introduction
It should be noted that this Supplementary Report is confined to looking at the nutrient management tools and models available to farm managers and resource managers. The intention of the following sections is not to determine whether one particular option is better than another, but to provide comment on how nutrient management tools/models might assist with the implementation of the option. This comment is intended to inform the overall economic costs and benefits assessment contained in the Economic Costs & Benefits Report.

General Comments on Nutrient Management Costs/Benefits
The true costs of trying to manage diffuse source nutrient losses from pastoral farm systems primarily lie, not in the costs of obtaining the necessary consent from Council (although these are real costs), but are wholly dependent on a nutrient limit set by a Plan and the degree with which the farm estimate of nutrient loss exceeds the limit.

In the case of N loss, a skilled farm consultant could assist maybe up to 60% of dairy farmers (this is a very rough guess) reduce N loss by between 1 and a maximum of 10 kg N/ha by introducing management actions that 'tighten up' the farm system. These changes are in better matching feed demand with supply, adjusting N fertiliser rates (usually downwards) and supplementary feed types and amounts as well as adjusting autumn and spring grazing management. In most cases these changes are relatively minor and can often lead to cost savings with no loss in farm productivity. That said, in the Mangatainoka Catchment where all dairy farmers are going through a Restricted Discretionary Activity consenting process with Horizons Manawatu RC, Dairy NZ and private consultants helping these farmers are finding that most low cost mitigations are only reducing N loss by 1 or 2 kg N/ha (Adam Duker, Dairy NZ *personal communication)*. This is mainly because these dairy farms operate on free draining soils under relatively high rainfall and if major reductions in N loss were required the only real mitigation would be to reduce N intake by reducing herd numbers and milk solids production. While this might also reduce annual farm expenses it will have a significant impact on farm profitability.

[22] A guide to section 32 of the Resource Management Act 1991; MfE; Dec. 2014

The free draining soils and good to high rainfall of Taranaki mean that the situation outlined above in the Mangatainoka catchment is also likely to be the case in Taranaki.

Mitigation Practices (adapted from AgResearch website)
"There are a wide range of mitigation practices currently available that can reduce the impact of intensive farming on water quality. However, each mitigation measure differs in its effectiveness, cost and likely impact on receiving waters. This depends on factors that include soil type, climate, topography and the regional sensitivity of water bodies. Consequently, it can be difficult for land managers to select a mitigation measure or combination of mitigation practices most appropriate for their farm. AgResearch has developed a Toolbox of Best Management Practices that provides an assessment of the cost and effectiveness of a suite of mitigation options. It also provides an indicative ranking of where expenditure should be prioritised to ensure that maximum benefit is obtained for each dollar invested. Given the very large capital costs associated with some mitigation measures, this ranking process is becoming increasingly important as farmers come under greater pressure to reduce farming footprints in nutrient-sensitive catchments.

Research by social scientists shows that providing economic information coupled with information about the effectiveness of each mitigation option is an important step in aiding the adoption of environmental technologies. This research has also shown that land users have shown a strong preference for selecting from a range of mitigation options available to them, as opposed to more prescriptive approaches.

Some of the mitigation measures currently in the Toolbox include improved methods for applying farm dairy effluent to land, the use of restricted grazing strategies and herd shelters, riparian protection, wetlands, grass buffer strips and improved nutrient balances in animal diets."

Examples of the toolbox concept showing the $ cost/ kg nutrient saved and its relative effectiveness were provided to the authors by Dr Ross Monaghan, AgResearch [23]and are reproduced in **Figure 1** and **Figure 2** below (Please note that many Tier practices are targeted at faecal contamination and that nitrification inhibitors are no longer available (Tier 2):

[23] P Monaghan; AgResearch

Tier 1 BMPs

BMP	Target	Cost effectv.	
		N	P
Improved FDE management - storage, low rate & low depth applic.	P, ***E. coli***, NH_4-N	M	L
Stock exclusion from streams wetlands swales & wet gullies (esp on winter crops)	P, ***E. coli***, NH_4-N, sediment	H	H
Nutrient management plans	N, P	H	H
Tracks and lanes sited away from streams & lane runoff diverted to land	P, ***E. coli***, NH_4-N, sediment	M	M
Facilitated wetlands	N, sediment, *E. coli*	H	*L-M*

		N	P
Cost effectiveness, $/kg	*High*	*<25*	*<100*
	Med	*25-75*	*100-250*
	Low	*>75*	*>250*

agresearch

Figure 1 - Tier 1 Best Management Practices – toolbox - $ cost/ kg nutrient saved

Tier 2 BMPs

BMP	Target	Cost effectv.	
		N	P
Nitrification inhibitors	NO_3-N	H	na
Wintering cows in Herd Shelters	NO_3-N, P, *E. coli*, NH_4-N, sediment	M	L
- with restricted autumn grazing	NO_3-N	M	?
Substituting N-fertilised pasture with low N feeds	NO_3-N	M-H	na
Constructed wetlands	NO_3-N, *E. coli*, NH_4-N, sediment	M	L
Grass buffer strips	NO_3-N, P, *E. coli*, NH_4-N, sediment	L	L
Limiting N fertiliser use	NO_3-N	M-H	na

		N	P
$/kg	*High*	*<25*	*<100*
	Med	*25-75*	*100-250*
	Low	*>75*	*>250*

agresearch

Figure 1 - Tier 2 Best Management Practices – toolbox - $ cost/ kg nutrient saved

Comment on Monaghan Approach
One key matter that Monaghan does not address is whether there is a cost-benefit advantage in making NMPs compulsory (through an RMA consent), or whether they can be left as industry best practice promoted by the key stakeholders (dairy companies, dairy farm advisors, fertiliser company advisors, and regional council land managers). The economic value of NMPs to farmers leads to a generally positive approach to using and implementing them, and that positive view may be negatively affected if they were made obligatory by a regulatory agency. The compulsory requirement for NMPs may not be necessary as the industry as a collective whole is moving in the direction of their implementation in any case for on-farm benefit purposes. Overall there are both serious shortcomings using MNPs as a robust regulatory tool and regional (on-farm and off-farm) costs to a regulated N limit regime via certification, consenting, reporting, audit, and compliance.

Comment on TRC Policy Options
With the above general comments on assessing the costs/benefits of nutrient management in mind, determining economic, the following are comments primarily relating to nutrient management model/tools perspective that will assist with the overall assessment of the options using the criteria listed above (in the Economic Costs & Benefits Report):

Option One - Status Quo
Relevance – nutrient budgeting would assist to achieve GMP. CLUES able to assist to track land use changes.

Feasibility – resources exist to provide the nutrient budgets required within the longer timeframes; OVERSEER® would assist in assessing impact of the effect of changing management practices, inputs or mitigations on nutrient loss from a farm. CLUES able to assist to predict land use change impacts and mitigation outcomes.

Acceptability – nutrient budgets are a normal part of farm operations.

Benefits – business as usual; whole of farm management; established methods available; long term data available.

Costs – cost effective; costs to prepare nutrient budgets; costs to mitigate.

Option Two - On-farm Mitigation
Relevance – nutrient budgeting would assist to achieve GMP. CLUES able to assist to track land use changes.

Feasibility – resources exist to provide the nutrient budgets required within the 2020 timeframe; OVERSEER® would assist in assessing impact of the effect of changing management practices, inputs or mitigations on nutrient loss from a farm. CLUES able to assist to predict land use change impacts and mitigation outcomes.
Acceptability – nutrient budgets are a normal part of farm operations.

Benefits – business as usual; whole of farm management; established methods available; long term data available.

Costs – cost effective; costs to prepare nutrient budgets; costs to mitigate.

Option Three - Nutrient Cap plus other on-farm mitigation
Relevance – difficulty with models/tools available to accurately set nutrient cap and monitor.

Feasibility – resources required to establish nitrogen baseline may limit progress – no timeframes stated; nutrient cap established may not achieve water quality outcomes sought; difficult to monitor or enforce.

Acceptability – may be reluctance for farmers to accept modelling results; Council may try to use model/tools to take enforcement action.

Benefits – certainty regarding whether the nutrient cap being met.

Costs – constraints on farm operations if nutrient cap too low or wrong; costs relating to mitigation to keep within nitrogen baseline.

A summary of the assessment of options from a nutrient management tools/models perspective is provided in **Table 3** below.

Criteria	Option One	Option Two	Option Three
Relevance (effectiveness)	M	M	L
Feasibility	H	H	L
Acceptability	H	M	L
Benefits	M	H	M
Costs	H	M	L

Assessment of options from a nutrient management tools/models perspective based on:
Low means the option is unlikely to be contribute or makes a small contribution to the criteria being assessed
Medium means the option will make some contribution to the criteria being assessed
High means the option makes a demonstrable contribution to the criteria being assessed

Table 3 - Assessment of options from a nutrient management tools/models perspective

Overall Option 3 is the least likely to contribute the assessment criteria from a nutrient management perspective. There are a number of constraints associated with utilising existing tools/models in a regulatory setting that will impact on the overall effectiveness of this policy option and will have economic costs and benefits that are to be assessed in the Economic Costs & Benefits Report.

8 Summary and Key Findings

The Taranaki Regional Council has identified that the cumulative effects of agricultural sourced discharges – whether to land or water – are potentially the single greatest human induced pressure on Taranaki's freshwater quality.

While it is understood that Taranaki's overall freshwater quality is relatively good, with mainly improving trends, Council's aim is to keep those water quality trends positive. The Council recognises that any measures must be justifiable in terms of effectiveness, efficiency, and need, with a staged implementation that reflects established urgency and criticality, as set out in Sections 32(3) and (4) of the RMA.

As part of the review of the Regional Freshwater Plan for Taranaki, Council is assessing the economic costs and benefits of adopting three policy options for the management of nutrient from dairy farms, in accordance with the recent amendments to Section 32 of the Resource Management Act 1991. These three policy options (discussed in Section 7 of this Report) are:

- Option One – Status quo;
- Option Two – On-farm mitigation;

- Option Three – Nutrient cap plus on-farm mitigation.

In more recent years a number of regional councils have prepared regional plans that intend to regulate land use activities to manage nutrient losses, and a number of tools/models have been used in some instances in order to estimate and thereby regulate nutrient losses and demonstrate compliance. The appropriateness of using these tools/methods in a regulatory setting has been and continues to be the subject of some considerable discussion.

This *Supplementary Report – Nutrient Management Tools/Models* intends to provide background information and opinion on current tools/models used in dairy farm nutrient management and the use of these tools/models in a regulatory setting including OVERSEER®, CLUES, the use of LUC and other mechanisms to assist the Taranaki Regional Council prepare a well-informed and carefully evaluated Economic Costs & Benefits Report.

A range of approaches have been developed by industry groups and councils to address issues associated with nutrient losses on farms, including good management practices, adaptive management, and regulation. To assist with a number of these approaches, tools and models have been developed as part of ensuring good management practices are been adopted, and adaptive management approaches are being effective. These tools and models include OVERSEER® which is primarily used to establish and monitor nutrient budgets on a year by year basis; CLUES which is a GIS based modelling system which assesses the effects of land use change on water quality and socio-economic indicators; and the use of LUC Classification.

A strength of OVERSEER® is that it is able to demonstrate the impact of the relative effect of changing some management practices, inputs or mitigations on nutrient loss from a farm or block. Another strength is that it estimates N loss (from the bottom of the paddock root zone) and P loss risk (to the farm boundary). However, users of the tool need to fully understand how to operate the model properly, its limitations across the range of farming activities and what the outputs actually mean. In addition, OVERSEER® is not an environmental management tool as it cannot assess the contribution of the farm's N and P losses to nutrient levels in, the receiving environment, let alone any consequent environmental effect.

Nutrient Budgets (prepared using OVERSEER® 6) estimate the amount (kg) of N/ha/yr lost to the atmosphere as gaseous forms of N and how much (kg) N/ha/yr is lost from beneath the farming system. This is primarily the estimate of how much N moves below the root zone in drainage water, particularly on flat land. However, it is not, nor should be interpreted as, the amount of N which necessarily enters receiving water (confined, unconfined aquifers or surface water). Given that the N loss estimate is what is leaving the root zone, it is inappropriate to use OVERSEER® loss estimates to solely determine N loss limits which are designed to protect or improve receiving water quality.

CLUES is a GIS based modelling system which assesses the effects of land use change on water quality and socio-economic indicators. It allows users to create both land use and farm practice change scenarios (stocking rates, mitigation) using a range of tools and results are available in map and tabular displays.

In summary, this analysis has identified a number of key findings:

- There are environmental (including climatic; hydrological; fresh water ecology; soil characteristics) and on-farm practice differences between Taranaki and those areas of New Zealand that are facing greatest pressure upon land use conversion, and that these differences present a different context within which to consider the use of modelling tools;
- The relationship between the nutrient losses from any particular farm, and the water quality at any particular point within a catchment, simply cannot be quantified;
- Models are mathematical approximations to reality, which cannot be perfectly represented no matter what the choice of equations, coefficients, and correction factors;
- Individual farms will not correspond exactly to categories used in models - there will be inevitable divergences in factors such as soil structure, climate, cow numbers, and farming practice;
- There is no representation of a farms impact on the wider environment as off-farm subsequent transportation and attenuation processes are not (yet) determined by the tools/models (new models are being developed to assist with this for P loss especially) - therefore individual on-farm practices on particular parts of a farm are treated by tools/models as equal, but not all parts of a farm contribute to off-site effects to the same degree – short term (but high impact) effects on critical source areas are not captured by the tools/models but rather long term estimates of the farm system as a whole are modelled;
- A regulatory regime that is based on a whole of catchment approach must of necessity take a starting point of regarding all farms as having an equal contribution and having to meet the same allocation imposition if target water quality is to be attained, when this does not reflect reality;
- Experience shows widely varying factors for attenuation between farm and receiving waters, so that OVERSEER® outputs cannot easily be related to actual water quality;
- By inherent limitation, a model cannot take account of innovative practices that are outside the model design, and so evolving practices cannot be recognised and rewarded;
- The use of an on-farm annual nutrient budget model to estimate in-stream receiving water quality is not supported as there is no quantifiable link between on farm N loss below the root zone and in-stream receiving water;
- In-stream water quality is the aggregation of field level interactions, soil, sub-soil, and edge-of-field buffering and release, soil capacity exceedances and renewal, hydrology of storm events and base climate, in-stream biological processing, deposition and re-suspension and dissolution and uptake and adsorption, and contribution from natural sources such as aerial deposition and erosion - to take a single field–scale intervention and attempt to relate it to chemical and biological water quality measures at the catchment scale is fraught with complexity.

The analysis above confirms that a range of issues arise from the use of tools/models in a regulatory setting. Broadly speaking these issues include: the tool/model was never intended to be used in a regulatory setting and any use should be appropriate and relevant to the issue being addressed; the regulatory setting and compliance requires certainty whereas the use of tools/models is inherently uncertain due to a range of factors including limitations in data availability and accuracy, the application of the tool/model, the input choices and operator competency; the limitations of the model to represent reality in farm systems; gaps in the science available to enable the tools/models to deliver the outcomes sought by the resource manager; validation and calibration of tools/models is near impossible; revisions of tools/models can change outputs that can lead to non-compliance with regulatory mechanisms.

Thus, the use of modelling tools within the Taranaki context does not meet statutory expectations for consents/rules in a regional plan, of relevance, certainty, clarity, necessity, effectiveness, and efficiency. This report examines the strengths and limitations of modelling tools; a companion report explores the implications of the findings of this examination for the application of modelling within a regulatory setting.

The implications of the above issues include:

- That the Taranaki Regional Council should not use tools/models (such as OVERSEER® and LUC) with regulatory force in their plans and decision making to endeavour to achieve environmental outcomes because of the reality of incomplete or inadequate input information (information gaps that are potentially very significant in terms of suitability within a regulatory setting);
- Where there are gaps in the science or the tools/modelling, tools/models not 'fit for purpose' should not be adapted or utilised in the interim; and
- Gaps in science/management need to be addressed, if indeed they can be, before tools/models will provide the certainty and outcomes required.

Of the three policy options being assessed by Council to address nutrient management issues in the Taranaki Region, Option 3 (Nutrient Cap plus other on-farm mitigation) is the least likely to satisfy the assessment criteria from a nutrient management perspective. There are a number of cumulatively compounding constraints associated with utilising existing tools/models in a regulatory setting that will impact on the overall effectiveness of this policy option.

9 Definitions and acronyms

Catchment refers to the entire area from which a stream or river receives its water. When it rains, the water flows naturally over and through the soil to the lowest point on the land, forming into springs, wetlands, and small streams that feed into larger streams and rivers as they run downhill. Eventually, all the streams and rivers in a catchment join and have the same outlet to the sea. Natural features such as ridges and hills form the boundaries of a catchment.

Contaminant includes any substance (including gases, liquids, solids, and microorganisms) or energy (excluding noise) or heat, that either by itself or in combination with the same, similar, or other substances, energy, or heat:
(a) when discharged into water, changes or is likely to change the physical, chemical or biological condition of water; or
(b) when discharged onto or into land or into air, changes or is likely to change the physical, chemical, or biological condition of the land or air onto or into which it is discharged.

Controlled activity means an activity which:
(a) is provided for, as a controlled activity, by a rule in a plan or proposed plan; and
(b) complies with standards and terms specified in a plan or proposed plan for such activities; and
c) is assessed according to matters the consent authority has reserved control over in the plan or proposed plan; and
(d) is allowed only if a resource consent is obtained in respect of that activity.

Council refers to the Taranaki Regional Council.

Diffuse discharge means a discharge that does not have a particular point of origin or is not introduced into receiving waters from a specific outlet, but arises from a wide or diffuse area.

Discharge includes emit, deposit and allow to escape.

Discretionary activity means an activity:
(a) which is provided for, as a discretionary activity by a rule in a plan or proposed plan; and
(b) which is allowed only if a resource consent is obtained in respect of that activity; and
(c) which may have standards and terms specified in a plan or proposed plan; and
(d) in respect of which the consent authority may restrict the exercise of its discretion to those matters specified in a plan or proposed plan for that activity.

Dissolved oxygen refers to the concentration of free oxygen dissolved in water, and usually expressed as g/m3 or mg/l.

Drainage refers to the movement of excess water (including effluent water) through the soil body.

E. coli refers to *Escherichia coli*, which is the main coliform found in the gut of warm blooded animals.

Effluent means liquid waste including slurries.

Environmental values refer to the values that reflect the community's aspirations for the water in its region, and the level of water quality desired. They can include ecological function and biodiversity, natural character, natural features and landscape, cultural and spiritual values, scenic and amenity values, contact recreation, and mauri (life force) and mahinga kai (customary places where food is collected or produced).

Farm dairy includes every area of the dairy cow (or goat) milking process and includes covered and uncovered areas where cows reside for longer than five minutes for the purpose of milking (including a stand-off pad or yard) but does not include raceways.

Farm dairy effluent means contaminated waste which is predominantly composed of organic matter (dung and urine) and water, applied, deposited or used in the farm dairy.

Fertiliser means a substance used, or suitable for, sustaining or increasing the growth, productivity, or quality of plants by its application to those plants or the soil in which they grow or will grow; and includes a substance imported, manufactured, or being manufactured, with the intention that it be so.
Fresh water means all water except coastal water and geothermal water.

Ground water refers to the freshwater that occupies or moves through openings, cavities, or spaces in geological formations in the ground.

K refers to Potassium.

Land treatment refers to the use of the soil matrix as a medium for removing contaminants either dissolved or suspended, in effluent water or slurries.

Leaching means the drainage of nutrients through the soil beyond the active root zone.

Limit is the maximum amount of resource use available, which allows a freshwater objective to be met.

MCI refers to macroinvertebrate community index.

N refers to Nitrogen.

NDA refers to nitrogen discharge allowances.

Non-point source discharge refers to a discharge of water or contaminant that enters a water body from a diffuse source.

NPS refers to the *National Policy Statement - Freshwater Management 2011*.

Nutrient budget refers to the identification of the nutrient inputs on a farm, such as fertiliser, clover nitrogen fixation, urine, dung, effluent/manure, compost and supplements. It also identifies a farmer's nutrient outputs, such as milk, fibre, meat and supplements sold, as well as environmental losses.

Nutrient management plan means a plan prepared annually in accordance with the Code of Practice for Nutrient Management (NZ Fertiliser Manufacturers' Research Association 2014) which records (including copies of the OVERSEER® input and output files used to prepare the plan) and takes into account all sources of nutrients for dairy farming and identifies all relevant nutrient management practices and mitigations, and which is prepared by a person who has both a Certificate of Completion in Sustainable Nutrient Management in New Zealand Agriculture and a Certificate of Completion in Advanced Sustainable Nutrient Management from Massey University.

P refers to Phosphorus.

Periphyton refers to algae that grow on the beds of rivers, streams and lakes that turn dissolved nutrients into nutritious food (periphyton biomass) for invertebrates, which are themselves food for fish and birds.

Permitted activity means an activity allowed by a regional plan without a resource consent if it complies in all respects with any conditions specified in the plan.

Point source discharge means a discharge that occurs at an identifiable location.

Prohibited activity means an activity which a plan expressly prohibits and describes an activity for which no resource consent shall be granted.

Resource consent means a permit to carry out an activity that would otherwise contravene the Resource Management Act 1991. Requirements included as part of the resource consent are known as resource consent conditions.

Riparian management means the collection of activities and practices that can be applied to the riparian margin in order to improve the natural characteristics and functioning of the whole riparian zone (which includes the waterway itself as well as the riparian margins.

Riparian margin means a strip of land of varying width adjacent to a waterway and which contributes or may contribute to the maintenance and enhancement of the natural functioning, quality and character of the waterway and its margins.

River or stream refers to a continually or intermittently flowing body of fresh water. This includes a stream and modified watercourse. It does not include any artificial watercourse (such as an irrigation canal, a water supply race, a hydroelectric canal, or a farm drain).

RMA refers to the Resource Management Act 1991.

RPS refers to the *Regional Policy Statement for Taranaki 2010*.

Soil health refers to the biological, chemical and physical state of the soil and the maintenance of soil ecosystems.

State of the environment –refers to a type of environmental monitoring and reporting that provides a snapshot of information about the environment and how it is changing over time.

Surface water refers to water in all its physical forms that is on the ground, flowing or not, but excludes coastal water and geothermal water.

Target is a limit that must be met at a defined time in the future. This meaning only applies in the context of over-allocation.

Water—
(a) means water in all its physical forms whether flowing or not and whether over or under the ground:
(b) includes fresh water, coastal water, and geothermal water:
(c) does not include water in any form while in any pipe, tank, or cistern.

Water body means fresh water or geothermal water in a river, lake, stream, pond, wetland, or aquifer, or any part thereof, that is not located within the coastal marine area.

Water quality refers to the physical, chemical and biological characteristics of water that affect its ability to sustain environmental values and uses.

Waterways or **waterbodies** includes any watercourse or internal drain that flows intermittently or continuously.

Wetland includes permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions.

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