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**From decision-support to compliance tool: the social dimensions of
Overseer and the implications for farm nutrient management**

A thesis
submitted in partial fulfilment
of the requirements for the Degree of
Master of Natural Resources Management and Ecological Engineering

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Emma Brittany Barr

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Abstract of a thesis submitted in partial fulfilment of the
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by

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An increase of public and scientific pressure resulting in recent reforms of New Zealand's National Policy Statement for Freshwater Management (NPS-FM) has instigated a reliance on Overseer to regulate nutrient losses from agricultural land. Overseer was previously used as a qualitative tool for farmers to assess fertiliser requirements for the following season, but has now changed to a quantitative, compliance tool in use by a number of regional councils. Understanding farmers' perceptions of this new approach is vital to its effectiveness as a management technique. This research presents an analysis of fifteen semi-structured interviews of farmers and farm consultants from two locations in the Bay of Plenty: The Rangitāiki Plains, who use Overseer for decision-support, and the Rotorua Lakes, who use Overseer for compliance. This research has found that the role of numbers, power and authority, model credibility, perceived fairness, social identity, and the relationship to data production were significant to farmers' perceptions of Overseer. The perceptions farmers have of Overseer is a key influence in their acceptance of nutrient regulation and adoption of sustainable nutrient management practices. By taking the focus away from individual's technical understandings of scientific knowledge, this research has attempted to explore the social identities that characterise public responses to regulations. Trust and credibility emerged as key themes in the development of perceptions to the use of Overseer by farmers, shaped by the working relationships between farmers and council staff, council scientists, private consultants, members of the public, and industry representatives. It was found that when considering Overseer, many farmers focus on contextual factors surrounding its use,

rather than the practicalities of the model itself. This shows that continued efforts to improve the scientific accuracy of Overseer will not resolve issues of distrust between farmers and Overseer.

Keywords: Nutrient management, standardisation, environmental standards, environmental policy, Overseer®, trust in authority, modelling credibility, compliance, dairy farming

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Abbreviations

BOPRC	Bay of Plenty Regional Council
CSR	Case Study Research
LGA	Local Government Act 2002
LRPPC	Lake Rotorua Primary Producers Collective
MfE	Ministry for the Environment
MPI	Ministry for Primary Industries
NOF	National Objectives Framework
NPS-FM	National Policy Statement for Freshwater Management
Overseer	OVERSEER® Nutrient Budgets
RMA	Resource Management Act
RTALP	Rotorua Te Arawa Lakes Programme
RWLP	Regional Water and Land Plan

Chapter 1

Introduction

Responding to mounting public and scientific concern about the condition of the nation's water bodies, in 2009 the New Zealand government initiated a freshwater reform programme (Ministry for the Environment (MfE), 2013a). A fundamental component of the freshwater reform programme was the release of the 2011, and later amended 2014, National Policy Statement for Freshwater Management (NPS-FM), guided by the 1991 Resource Management Act (RMA). A key objective of the NPS-FM is to set enforceable limits for water quality and quantity in all regions of New Zealand, aiming to maintain or improve water conditions to meet community and tāngata whenua values (MfE, 2014a). The amended NPS-FM includes a National Objectives Framework (NOF) which requires regional councils across New Zealand to set water quality freshwater objectives, a term defined in the NPS-FM as "an intended environmental outcome in a freshwater management unit" (MfE, 2015, p. 20). The objectives are to be achieved by meeting environmental limits, defined as "the maximum amount of resource use available, which allows a freshwater objective to be met" (MfE, 2015, p. 21). The NOF aims to set out a nationally consistent process for objective setting (MfE, 2013b), with regional councils being required to assess, and if necessary, change regional policy statements and plans to ensure the NPS-FM objectives and policies are met (MfE, 2015).

In order to implement the NPS-FM and appropriately assess compliance with rules in regional plans, regional councils are now facing the challenges of setting resource limits and quantifying environment effects, in particular of the diffuse nutrient pollution arising from agriculture. While Europe has adopted what has become known in New Zealand as an inputs-based approach to nutrient management, which restricts, for example, the amount of fertiliser that can be used on land, New Zealand has adopted an outputs-based approach which regulates the level of nutrients leaving the root zone of land (Duncan, 2014). Nutrients can be a significant contributor to declining freshwater body values (MfE, 2015), and in order to limit the effects of agriculture and, in some regions, set relevant catchment limits, regional councils require data on current and expected amounts of nutrient outputs that can potentially make their way into water bodies. In many areas of New Zealand, agriculture, especially dairy farms, are a major supplier of nutrient input to waterways; diffuse farm sources of nitrogen and

phosphorus can cause negative impacts on stream, lake and estuary water quality (Murray et al., 2016). Landcare Research argues that measuring nitrogen losses from individual farms can cost tens of thousands of dollars per year due to soil and urine patch variability across paddocks (Lilburne et al., 2011). Due to this impracticability and expense of directly measuring nutrient outputs for individual farms, modelling is the most feasible way of estimating farm nutrient inputs into the waterways arising from the surrounding environment. Regional councils “will need to use modelling to identify and estimate diffuse [contaminant] discharges from farmland...” (MfE, 2015, p. 82) to gather the large volume of farm nutrient data required to facilitate compliance with regional freshwater requirements. The focus of this research is the use of the model Overseer that has become widely used for calculating nutrient losses from dairy farms around New Zealand.

OVERSEER® Nutrient Budgets (Overseer) is a New Zealand-developed management tool used to model the nutrient flows of farm blocks. Overseer was established to be a decision-support tool for farmers and farm consultants to estimate fertiliser requirements for a farm. Importantly, it has recently been adopted for regulatory purposes by regional councils. Along with Overseer’s comprehensible user-interface which has aimed to be user-friendly for farmers (Shepherd et al., 2013), regional councils have embraced Overseer partly because it allows them to employ an effects-based approach to controlling nutrient outputs rather than controlling farming inputs (like fertiliser volume and stock numbers), which create the nutrient losses (Arbuckle, 2015). Integrating years of applied farm research, Overseer produces a nutrient budget for an individual farm and evaluates the farm’s nutrient losses using farm system parameters. Farm nutrient management decisions can then be based on the models predicted outcomes, stimulating new management ideas to reduce nutrient losses, rather than reducing fertiliser applications or stock numbers (Murray et al., 2016). An effects-based control on outputs is seen by resource users as more “preferable to input controls as they are regarded as more flexible, efficient and effective” (Wasley, 2015, p. 5). Overseer aims to offer flexibility for farmers by analysing several farm nutrient management methods for their ability to reduce nutrient losses, thereby encouraging innovation in the primary sector. While Overseer’s popularity has increased within regional councils who are aiming to develop or update regional plans in response to the NPS-FM, its use as a policy tool is not new. Beginning in 2003, the Waikato Regional Council employed the use of Overseer to manage farm nutrient runoff into Lake Taupō (Waikato Regional Council, 2011). With the ability to aid council

regulation by quantifying nutrient losses on farms to meet water quality limits, and the familiarity farmers have with the model due to its use as a decision-support tool, Overseer's use by regional councils for regulatory and compliance purposes is predicted to increase (Arbuckle, 2015).

Setting freshwater quality and quantity limits under the NPS-FM is a significant task for regional councils. Overseer's growing use as a compliance tool to facilitate achieving regional water objectives opens important questions about the limitations of using models for environmental regulation. For the successful implementation of Overseer as a compliance tool, all persons affected by its estimates should feel confident in its use (OVERSEER®, 2015b). Dairy farmers affected by nutrient limits, via accredited consultants, will be required to work closely with Overseer to meet nutrient limits and individual reductions set by regional councils.

Overseer was designed to be a qualitative tool, providing descriptive feedback on the performance of different farming practices (McCrone, 2015). With its adoption by regional councils and increasing shift to use in regulation, Overseer has become a quantitative tool, with farmers either meeting or failing to meet compliance. The expectation has been that Overseer would provide certainty and clarity in the implementation of regional council nutrient management rules, regulations and limits. However, a range of challenges have been identified to achieve this vision. In particular, Duncan (2014) identifies the social-political dimensions of rule by numbers and models and predicts that farmer encounters with Overseer and how they use the model will be different depending on the stakes involved. Duncan (2014) argues that if the stakes are high, as they are in resource management, farmers are likely to look far more closely at the intricacies of the model and find ways to interpret the input requirements of the model to stay within the bounds of the numbered rules

To gain further insight into the social-political dimensions of quantification and the extent to which farmers are responding to the new quantitative regulatory regime, this research has focused on questions such as: What perception do dairy farmers hold on the use of Overseer as a quantitative regulatory model? How can the farm environment, a complex and dynamic series of processes and states be defined accurately by Overseer? What is compromised in Overseer's rendition of farm processes, and how do these compromises affect dairy farmer perceptions of the model? These questions examine the important relationship between

resource users and a regulatory tool, which usually escape critical attention. This research seeks to examine the perceptions of dairy farmers and farm consultants who use Overseer to quantify farming processes; specifically focusing on Overseer's shift from a decision-making to compliance tool for nutrient management. Overseer is currently in use, and will soon be rolled out in many places in New Zealand. It is being used to benchmark environmental states for future management and monitoring. Investigating these questions will help understand the implementation practicalities of using the model in compliance, gaining insight into whether the goal of sustainable nutrient management using an outputs-based model can be achieved via this method.

The research includes the development of a theoretical framework for analysing interview data that draws together ideas on quantification, the role of numbers in policy, and the challenges of standardising people and the environment from authors including Porter (1996), Duncan (2014), Stone (2002) and Busch (2011). Using the Bay of Plenty as a case study, dairy farmers and farm consultants from the Rotorua Lakes, where Overseer has been introduced for compliance and management of nutrient limits, and the Rangitāiki Plains, where Overseer has not been introduced in a policy setting, have been interviewed. With a focus on the relationship between resource user and regulatory tool, this research identifies potential implications and consequences for freshwater and agricultural management as a result of Overseer's regulatory use in policy.

1.1 Purpose of this research

The aim of this research is to investigate the perceptions of dairy farmers with and without the use of Overseer for regulation. Understanding how Overseer's change from a decision-support to a compliance tool has impacted upon how farmers encounter and engage with the model, its outputs and the regulations underpinned by the model outputs is important if farmers are to be meaningfully engaged in addressing the issue of water quality in New Zealand. To achieve this aim, the research question is:

- How has Overseer's shift from decision-support to compliance tool altered perceptions of regulation and the prospects of achieving sustainable nutrient management?

In order to answer this question, the research objectives are:

- a) Assess the differences in perception between farmers using Overseer for decision-support, versus farmers using Overseer for compliance purposes.
- b) Evaluate how standardisation affects perceptions of the on-farm applicability of Overseer and its credibility as a regulatory tool.
- c) Identify the implications of the use of Overseer as a compliance tool for nutrient management and the challenges these present for the implementation of water quality limits.

1.2 Structure of this thesis

Chapter 2 outlines the contextual background of this topic. This is followed by chapter 3, the theoretical framework used in this research. This includes a summary of the literature regarding the role of quantification, objectivity and numbers in policy, and an introduction to the theory of standards and standardisation. Chapter 4 revisits the research aim, questions and objectives, and outlines the methodology used to conduct this study, and collect and analyse data for this research. Chapter 5 sets out the results of this study. Chapter 6 discusses the results by linking the theoretical framework outlined in chapter 3 to the results set out in chapter 5. Chapter 7 provides a summary of the research, drawing conclusions, considering limitations and outlining the potential for future research.

Chapter 2

Background

2.1 New Zealand's legislative background

Replacing over 50 town planning and resource management laws in 1991, the Resource Management Act (RMA) is New Zealand's primary piece of natural resources legislation (Ministry for the Environment (MfE), 2017). The RMA presents a comprehensive system for the sustainable management of the country's land, air and water resources (MfE, 2015; Ruru, 2011) by outlining environmental protection, resource management, and urban planning requirements (RMA, 1991). Under the RMA's structure of responsibilities, the role of central government is to address national concerns and issues as they arise, and influence the running of the RMA through nationally binding environmental standards and national policy statements. Environmental governance is delegated to two levels of local government: regional councils and territorial authorities, who operate in accordance with the Local Government Act 2002 (LGA). Local governments develop regional policy statements and identify resource issues and develop strategies to manage and resolve these (Ruru, 2011).

2.1.1 Resource consents

At its core, the RMA works on the basis that no individual or company can perform any activities which contradict any one rule in a relevant regional plan, unless allowed otherwise. For example, by obtaining a resource consent; regional councils authorise consents that permit resource use (e.g., water takes or discharges to water) under specified conditions. As stated, the RMA embraces an 'effects-based' approach to assess the suitability of proposed activities. The concept of 'sustainable management' underpins this 'effects-based' legislation, which directs that the effects of any activity are regulated, not the activities themselves (Berke et al., 2006). All applications for resource consent must include a detailed 'assessment of environmental effects' outlining any potential effects from the proposed activity. As described in the RMA, the term 'effects' includes, and is not limited to, any positive or adverse, temporary or permanent, and cumulative effects caused by any aspect of the proposed activity (RMA, 1991). An activity or development is likely to gain consent if the effects of the activity can be demonstrated to not adversely affect the environment, or if the effects can be avoided or suitably mitigated (Berke et al., 2006). By adopting an effects-based approach, it is

expected that flexibility is provided within the consent process where an extensive range of techniques can be integrated to mitigate or avoid adverse environmental effects (Berke et al., 2006).

2.1.2 The National Policy Statement for Freshwater Management

In response to concerns about water quality and aiming to strengthen the legislative framework of the RMA, the NPS-FM was introduced in 2011 and later reformed in 2014 by the Ministry for the Environment (MfE) (MfE, 2015). The purpose of the NPS-FM is to introduce quantitative environmental limits for water quality and quantity which are to be decided and enforced by local authorities. As part of the NPS-FM 2014 reform process, a National Objectives Framework (NOF) was established to provide guidance to local authorities on the setting of objectives for water quality across New Zealand. The NOF affects all water bodies, “freshwater 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” (MfE, 2015, p. 25). The framework aims to specify which quality and quantity attributes require management within a freshwater body, and the minimum accepted environmental states within that attribute. Attributes are described as “a measurable characteristic of fresh water, including physical, chemical and biological properties” (MfE, 2014a, p. 7). Regional councils can use the framework when setting freshwater objectives and in regional plans, by considering which quality and quantity attributes are relevant and desired at what level by the community of the catchment or what is known under the NPS-FM as a freshwater management unit (FMU). The limits required to be set under the NPS-FM (which are separate from the NOF) are expected to achieve the objectives communities set. One aim of limit-setting under the NPS-FM is to reduce resource over-allocation, which describes a situation where the resource has been divided up for users beyond a limit where the freshwater objectives for quality and/or quantity are no longer being met (Environment Foundation, n.d.). Another aim is to identify the capacity of the resource for reallocation or what has become known as ‘headroom’ which is the extent of the resource not being used below a limit (Duncan, 2014)

2.1.3 Changing conditions for governance

The RMA was initially welcomed as a progressive method of managing natural resources due to its effects-based approach and the delegation of responsibility to local government (Lennox et al., 2011). Regional councils may release regional plans to identify and address

environmental issues in their jurisdiction, however, often these plans are delayed or not released or only partially released due to the amount of time taken to gain approval. Without a regional plan in place, resource allocation and management around the country has, in many regions, relied solely on the authorization of resource consents (Gunningham, 2008; Lennox et al., 2011). Often there are no overarching limits or thresholds managing the allocation of a resource, rather, resource consent has been allocated on a first-in, first-served, consent-by-consent basis, resulting in a lack of sustainable future-proofing for many areas of New Zealand (Gunningham, 2008), especially those with scarce resources. Critics have argued that the lack of nationally consistent policy, and the reliance on resource consents under the RMA has led to the continued decline of New Zealand's water resources (Gunningham, 2008).

While water quality has been brought to the foreground as an important concern for New Zealand, diffuse pollution remains a challenging policy issue for the government (MfE & Stats NZ, 2017). Quantifying and mitigating the effects of nutrient losses with regulation remains difficult due to the crossing of complex spatial and temporal scales. For example, diffuse pollution from a dairy farm can take years to filtrate through the soil profile to reach groundwater (MfE & Stats NZ, 2017) , and has the potential to travel great distances from the source by groundwater (DairyNZ, 2013; Murray et al., 2016). For these reasons, regulating nutrients is burdened with the practical challenges of assigning responsibility for nutrient losses.

As instigated by the NPS-FM, regional councils are now reviewing and updating their regional plans to address the most pressing environmental water issues affecting their region. Following the objectives in the NOF, regional councils across the country are expected to set freshwater limits specific to regional community needs by modelling the extent of the resource (MfE, 2013a). Regional councils must ensure appropriate limits and land use rules and nutrient discharges are put in place to mitigate, manage or reduce resource degradation. The NPS-FM encourages regional councils to employ a model-guided environmental accounting regime to identify over and under-allocation (MfE, 2014) due to the apparent benefits quantification and numbers have in policy implementation (Norton et al., 2009; Porter, 1996).

2.2 Regulating the New Zealand dairy industry

New Zealand's success in international markets is characterised by its primary sector, with the dairy industry bringing in a forecasted three billion dollars to the national economy (DairyNZ, 2016). It is expected that the dairy industry will continue to grow for the foreseeable future (2016). Recent farming intensification has mainly been driven by the success of dairy farming, with the total area of dairy farming land in New Zealand increasing by 28% between 2002 and 2012 (MfE & Stats NZ, 2015). In catchments dominated by agriculture, the results of past land management practices, for example, excessive fertiliser use, deforestation, and grazing on erosive slopes, are meeting with the latest effects of nutrient losses from intensified land use and water abstraction (Duncan, 2017; MfE, 2009; Parliamentary Commissioner for the Environment (PCE), 2015).

Degraded conditions of waterways in New Zealand have been explored in scientific studies by researchers (Gluckman (2017); Houlbrooke et al. (2004); Smith et al. (2013); Wilcock et al. (1995)) and have also been acknowledged by members of the public (Hughey et al., 2013). Hughey et al. (2013) found that the wider public has a predominantly negative view of dairy farming due to the effects of the industry on water quality degradation. Complementing these views are numerous scientific studies which find correlations between depleting water quality and catchments containing high-intensity dairy farms (Houlbrooke et al., 2004; Smith et al., 2013; Wilcock et al., 1995). Due to the financial benefits of continued development of the dairy industry, the compromise between the economy and the environment is managed through policy regulations aiming to not hinder industry growth while minimising environmental damage (Hughey et al., 2013).

2.2.1 Environmental issues

Farming intensification increases stock numbers and escalates cultivation cycles, usually alongside additional inputs of fertiliser, feed supplements, water, and energy; all aiming to harvest more food from the same land area. Studies by Harding et al. (1999) and Hamill and McBride (2003) both found that the degree of negative environmental impact directly correlates to livestock density in a catchment. Alongside the addition of concentrated nitrogen and phosphorus to the environment, one of the most significant environmental impacts from stocking rates and cultivation cycles is soil compaction, which can result in increasing nutrient run-off and leaching, alongside a reduction in N-fixation by plants (Mackay, 2008; Menneer et

al., 2005). MfE & Stats NZ (2015) summarised regional council soil surveys which reported 78% of dairy farm sites not meeting the target for soil physical status. Mackay (2008)'s report also highlighted the continued depletion of organic carbon and nitrogen in soils due to intensive pastures, and the on-going addition of harmful soil contaminants (cadmium and fluoride), which are supplied from phosphorus fertilisers and zinc tablets (used for facial eczema).

Nitrogen & Phosphorus

Elliott et al. (2005) found using national scale modelling to determine nutrient volumes lost from land and transported to the sea, that diffuse sources accounted for 97% of the total nitrogen load, and 98% of the total phosphorus load. Gluckman (2017) summarises that on a per hectare basis, land used for dairy farming inputs a disproportionately large load of nitrogen into waterways; dairy farming holds the greatest diffuse pollution footprint for nitrogen in the country. A MfE & Stats NZ (2015) report highlights that one of the most significant impacts of nitrogen in New Zealand's rivers is nuisance slime and algae growth. Growth of these can decrease dissolved oxygen levels, change river flows and cause blockages of irrigation and water supply intakes, among other impacts. 49% of monitored river sites in the report contained enough nitrogen to trigger nuisance slime and algae growth.

The cycle of nutrients in a simplified dairy farm include the inputs: fertilisers, imported feeds, and plant nitrogen-fixation; and the outputs; (meat, milk, feed etc.), gaseous losses to the atmosphere, surface run-off to waterways, and leaching down into groundwater (DairyNZ, 2013). New Zealand has a pasture-based dairy production system, with supplementary feed being grown on the farm as maize, or bought in externally. Dairy shed effluent and urine patches from dairy cows add high levels of nitrates to the soil, with very high nutrient concentration levels found in random locations as cows urinate randomly (PCE, 2004). The nitrogen from urine patches can be transported through the soil profile into groundwater sources, resulting in an influx of nitrogen into lakes and rivers potentially far from the source (DairyNZ, 2013).

Farmers add nutrients (nitrogen, phosphorus, sulphur, magnesium etc.) to pasture blocks to maximise grass growth, resulting in higher milk production and therefore, higher economic gain (PCE, 2004). It is in a dairy farmer's best interest, economically, to use fertilizers on their land. In terms of environmental degradation, surplus nutrients not required for plant growth or significant rainfall events result in runoff and leaching within the soil profile into

groundwater, runoff into surface streams and into the atmosphere. While it is not profitable for a farmer to have excess nutrients, in many cases the fertilizer rates are more likely to be overestimated than underestimated, as the initial expense is out-weighed by the potential production gain (PCE, 2004).

2.3 Nutrient limits and regulation

2.3.1 Farm-scale modelling for limit setting

The availability of farm scale models is critical to the vision of limit setting for nutrient losses from agricultural land; the approach of limiting land intensification before environmental thresholds are breached is necessary. The forecasted growth of the dairy industry, coupled with the push from public and science sectors to improve conditions of the country's freshwater resources, has brought nutrient management into the foreground as a leading challenge in environmental management.

It would be more certain for environmental outcomes, fairer, less time-consuming and more cost effective, if appropriate water quality objectives and related nutrient load limits were established before the assimilative capacity of a lake (or a river system) is exceeded... Measurable plan objectives and nutrient load caps would clearly quantify the sustainable capacity of the lakes in terms of catchment land use (Norton et al., 2009, as cited in Duncan, 2014, p. 379).

The central purpose of the NPS-FM is to establish quality and quantity limits for all freshwater bodies, enforceable by local government (MfE, 2015). Norton et al. (2010) states that by linking water quality objectives to the setting of resource use limits, an increased clarity surrounding predicted environmental outcomes can be achieved. This is alongside the ability to estimate and manage diffuse nutrient losses, and predict their cumulative effects on the environment. Attempting to resolve the aforementioned practical challenge of assigning responsibility to breaching nutrient limits, enforcement has been made more achievable by the employment of quantitative models that are, at least in theory, able to link catchment scale nutrient loads with individual farm scale compliance. Norton et al. (2009) explain that farm scale models can be used to determine nutrient limit allocations for singular properties and entire catchments, resulting in the development of preventative (and any currently needed) nutrient management measures before, or as a result of, breaching the nutrient limit.

2.3.2 The rise of Overseer® Nutrient Budgets into policy

Overseer is a nutrient budgeting model co-owned by AgResearch, Ministry for Primary Industries (MPI) and Fertiliser Association of New Zealand (FANZ). Overseer was developed by AgResearch in the mid-1990s as a complete farm-system nutrient budgeting approach, replacing the simple ‘farm-gate’ nutrient accounting which only compared total nutrient inputs and outputs within a property.

In order to calculate a nutrient budget, Overseer requires users to enter information about their property. This is achieved by selecting from attributes from a list, and entering figures which represent:

- Stock
- Production
- Fertiliser
- Soils
- Crops
- Feed
- Location
- Effective Areas
- Effluent
- Rainfall

Using this information specific to an individual's property, Overseer then calculates a nutrient budget by estimating all nutrient inputs. For the nitrogen budget, Table 2.1 lists the following inputs and outputs which represent most of the nitrogen within the farming system (Overseer, 2015a):

Table 2.1 Overseer's nutrient inputs and outputs

Nutrient inputs:	Nutrient outputs:
Atmospheric (e.g. nutrients in rain)	Produce (e.g. milk, meat)
Fertiliser	Animal Transfers Out (e.g. in gut of animal)
Animal transfer (e.g. in gut of animal)	Supplements (e.g. hay, silage)
Supplements fed on block	Atmospheric Losses (e.g. nitrous oxide)
Irrigation (e.g. nutrients in water)	Leaching/ Runoff

The nutrient budget represents the amount of nutrients entering the property, against the amount of nutrients leaving the property. Regional council are mainly interested in the leaching and runoff output, as this is what significantly effects water quality (Freeman et al., 2016). There is no practical way to accurately measure leaching and runoff (Lilburne et al., 2011). Put simply, Overseer estimates the figure by calculating the difference between

nutrient inputs and nutrient outputs (i.e. all attributes listed above, excluding Leaching/Runoff), alongside the incorporation of farm-specific data provided by the model user.

Using a model to estimate future nutrient losses enables an 'effects-based' approach to nutrient management (Overseer, 2016), which aligns well with the RMA which is focused on "avoiding, remedying or mitigating any adverse effects of activities on the environment". Model owners and regional councils maintain that output controls are more flexible, efficient and effective than input controls for nutrient management (Wasley, 2015, p. 5).

The programme is designed to aid farmer nutrient and lime application decisions, nutrient use efficiencies on the farm and provide numbers for environmental reporting (Massey University, 2016a). Due to the impracticability of routinely measuring diffuse nutrient losses from farming systems and the ability to focus on output parameters, the use of Overseer to model nutrient discharges from properties is attractive to regional councils. Overseer's appeal includes having a farmer-friendly interface, representing farm and singular block (e.g. pasture, effluent, crop) scales, using relevant New Zealand data and providing feedback on mitigation options. As an empirical model, the data used to create Overseer is managed through AgResearch, utilising both New Zealand and overseas research.

Overseer is being used as a regulatory tool, producing separate reports on nutrient budgets (farm and separate blocks), nitrogen and phosphorus reports, greenhouse gases, energy, pasture production and maintenance nutrient requirements (Massey University, 2016b). Once users run the Overseer model for a property, they are presented with these reports for review and are able to compare any mitigation options. For example, if Overseer shows a high nitrogen leaching potential, the user can try different mitigation options like reducing nitrogen fertilizer application amounts or rates, reduce the stocking rate of the farm, or winter-off cows from the property. The user can then input the new data and, checking that all relating inputs have been amended, can receive a new report from Overseer for review. In order to accurately use Overseer, the user requires sound technical understanding on the use of the programme and have significant farm system knowledge (Watkins & Selbie, 2015). It is this aspect of the model that is intended to foster good management practices and drive down nutrient losses from the farm.

2.3.3 Use of Overseer by regional councils

All regions are now required to implement the objectives set by the NPS-FM. This means regional councils will review and update regional plans to set and manage freshwater quality limits. Overseer has become central to limit-setting under the NPS-FM which means the use of Overseer has shifted into a regulatory setting as a tool for implementing nutrient limits due to the benefits of quickly modelling complicated environmental processes and predicting the nutrient losses for any farm system changes.

Arbuckle (2015) provides a stocktake of regional council Overseer use, which is a review of regional plans and literature with staff from seven different regional councils. Key issues identified in the Arbuckle (2015) report include the acknowledgement from various regional council staff that while Overseer has been designed as an advisory tool in the past, it has an important role as a regulatory tool. Councils also acknowledge that there are major challenges in utilising Overseer as a regulation tool in policy development. Arbuckle (2015) found that currently, the following regional councils have included the use of Overseer as a regulatory tool within a regional plan:

- Waikato Regional Council
- Bay of Plenty Regional Council (BOPRC)
- Hawkes Bay Regional Council
- Horizons Regional Council
- Environment Canterbury Regional Council
- Otago Regional Council

Waikato Regional Council's Variation 5 changes rules in its regional plan for managing land use in the Taupō catchment (Mackay, 2008). Management is based on a 'grandfathering' approach where previous losses of nitrogen for each farm are calculated using a baseline which relies on Overseer, and this figure is used as a cap for nitrogen leaching from each property.

2.3.4 Challenges of using Overseer for regulation – a recent example

A different management system has been adopted by the Horizons One Plan whereby nutrient losses from current land use are linked to the natural soil characteristics for each property. The plan allocated nitrogen loss limits on the basis of the natural capital of the soil (Clothier et al., 2008). Following the release of the Horizon's One Plan, an administrative issue quickly emerged after an expected model update. Due to Overseer's version change which updated the science, the number of land owners requiring a consent review went from 20% to 80%, resulting in a large, unexpected burden on the administrative staff at the regional council and a large, unexpected number of unhappy land owners (Duncan, 2014). What happened with Horizon's One Plan provides insight into the complicated relationship between improving scientific certainty in the model and how this overlaps, on practical terms, into effective policy (Duncan, 2017). Reducing scientific uncertainties in Overseer, through updating the model, resulted in a loss of credibility in the One Plan's regulation process. Overseer has also been used by regional councils for farm extension and nutrient use advice, catchment modelling, and limit setting. Arbuckle (2015) concluded that regional council use of Overseer will continue to significantly increase in the future due to all councils updating their regional water management and limit setting policies in accordance with the NPS-FM.

2.3.5 Emerging concerns in model use

Murray et al. (2016) discusses how the challenges of using modelled information in regulation are now being tested in several regional plans, including the Bay of Plenty Regional Plan, regarding the Rotorua lake catchment. The requirement to manage diffuse nutrient discharges from farms has raised expectations of employing Overseer as a regulatory compliance tool; along with the requirement of a strong analytical understanding of Overseer as a model, having a good understanding of farming systems is essential for appropriate compliance use (Murray et al., 2016).

Another concern emerges from Overseer's apparent ability to calculate multiple 'correct' nutrient budget figures depending on who is inputting the data. Discrepancies between users of Overseer can result in very different results from the same farm inputs. Roberts and Watkins (2014) discuss how important consistent inputs from consistent users are for accurate nutrient discharge estimates. Inputs into the model have a major effect on the final output. In particular, the descriptive elements of the model can cause the largest effects, where

variations due to personal opinions and farm systems knowledge are more apparent. To address the issue of personal bias, Overseer 'Best Practice Data Input Standards' (Overseer2015a) were developed by a technical advisory group, drawing on their personal knowledge of dairy management and guidelines from several other agricultural organisations. The standards were reviewed and later endorsed by a number of government and industry organisations including MPI, MfE, and Irrigation New Zealand. As a result, the user standards aim to provide consistent outputs for comparable situations (i.e. fit for purpose) and employ a rating system of assessing the certain definitions requested by Overseer (Roberts & Watkins, 2014).

A 2015 article in *The Press* by John McCrone (2015), reported on several concerns from farmers regarding the uncertainties of Overseer standards. Overnight updates to the model, altering some of the environmental inputs, resulted in large changes to nutrient estimates. These rapid changes altered user faith in the model as estimates rose or fell, some drastically different from the previous day (McCrone, 2015). Other users commented on the fact that (at this time in 2015) Overseer assumed blackcurrants were the same as grapes, resulting in a shift from 6 kg/ha to 45 kg/ha of nitrogen leaching from the property. These changes might be acceptable when Overseer is being used as a decision-support tool as users are able to adjust their estimates when it is most feasible, but changes like this during Overseer's tenure as a compliance tool creates problems for perception of model credibility (Duncan, 2014). Due to compliance use, alterations in user faith of Overseer result in tension as users are faced with large number changes and the prospect of needing to alter farming management practices well beyond what was expected to meet with compliance.

Model assumptions

The assumptions embedded in Overseer are openly documented (Massey University, 2016a), and they include:

- *Long-term annual averages:* Overseer uses many long-term average inputs, which result in annual average outputs, not compensating for monthly, weekly or daily variations (e.g. rainfall is recorded by Overseer as average rainfall over one month, whereas in reality, the total monthly rainfall may be one singular large storm event in 24 hours).

- *Near equilibrium conditions:* Overseer assumes minimal changes to the farm. If a farm has recently, or will be converting to another agricultural type (i.e. sheep and beef to dairy), significant changes to farming inputs can last up to 10 years. For example, changes to the soil structure due to different stocking types (e.g. sheep to dairy) will instead be assumed to be constant from year to year.
- *Actual and reasonable data inputs:* If parameters are changed in one part of the programme, Overseer will not recognise that all associated input parameters require change. This can be a problem when mitigation features are later added and Overseer will not alert to any issues, it is up to the user to confirm all inputs have been modified.
- *Good management practices:* Overseer cannot distinguish between farmers who follow good farming practices and those who do not. This must be checked by the user (e.g. is the fertilizer being spread evenly across the field away from natural water features? The answers influence significant changes to nutrient run-off risk).

Notwithstanding the issues, drawing from a workshop with staff representing several regional councils in November 2013, Park (2014) discusses how council officers perceived that there was no realistic alternative to using Overseer, therefore making it the most suitable for nutrient regulation at this time. Given that millions of dollars and countless hours of time have been invested in Overseer, it is unlikely that regional councils will withdraw their use of it for compliance (Arbuckle, 2015). Currently, Overseer's legitimacy and credibility come from testimonials stating it is the "best product of its type currently available" and its use for compliance is suitable when it is "used correctly and its limitations are understood" (Canterbury Regional Council, 2012, p. 2). However, there is growing concern that Overseer is being used beyond its essential purpose resulting in inappropriate compliance use (see Duncan, 2014; Arbuckle, 2015; McCrone, 2015). Hence, understanding the social dimensions of the use of Overseer and its implications as a compliance tool for nutrient management is essential for guiding sustainable nutrient management in the future.

2.4 Summary

With dairy farming having the largest footprint for diffuse nitrogen pollution in the country and with growth of the dairy industry forecasted to increase, nutrient management has been

brought into the foreground as a leading challenge in environmental management as nutrient limit setting is implemented nationwide.

Methods to model and manage nutrients at the farm scale have been developed in an attempt to overcome the issue of assigning responsibility for nutrient losses. The Overseer modelling program has resulted, and can be used for establish a regulatory link between the individual farm and the catchment, aiding in the implementation of nutrient management and mitigation measures before, or as a result of, breaching a nutrient limit.

Accurate use of Overseer requires sound technical understanding on the use of the programme as well as significant farm system knowledge; this is intended to incite good management practices and drive down nutrient losses from the farm. There is growing concern that Overseer is being used beyond its essential purpose for estimating nutrient budgets, resulting in regulation that uses inaccurate representations of the interactions of farm systems and the environment. The issues that emerged in the Horizon's One Plan show that in addition to technical competency, understanding the social dimensions of Overseer and its implications as a compliance tool for nutrient management, is essential for guiding sustainable nutrient management in the future.

This thesis will argue that the claims of gaining clarity surrounding nutrient regulations, due to the employment of a quantitative model (Overseer) to quantify nutrient losses, fails to recognise the importance of user-acceptance of modelling and associated numbers in quantification. The case study aims to highlight important challenges in the enforcement of nutrient limit policy, which links modelling and numbers to compliance and enforcement.

Chapter 3

Theoretical Framework

This chapter introduces the theoretical framework used to direct the analysis of data derived from the case study.

The previous chapter explored the actions that have led to the key role of Overseer in improving New Zealand's freshwater management. Due to the continued deterioration of waterways and the escalation of agricultural intensification around the country (see: Cullen et al. (2006) and Mackay (2008)), using Overseer is considered to be the most suitable method of regulating nutrient management for compliance within regional plans (Arbuckle, 2015). However, criticism of the model from researchers such as Duncan (2014), Williams et al. (2013), and Edmeades (2013) argue that Overseer is being used beyond its essential purpose, and policy does not take into consideration the many limitations of using a numeric regulatory approach and relying on a highly contingent computer model to generate the policy numbers. This chapter presents a critical examination of the role of numbers in public policy. The chapter explores the political processes involved in the ordering of nature, the use of numbers, and the role technology in modern environmental policy. In this chapter, the themes of quantification, objectivity, and standardisation in policy are derived from work by Porter (1995, 1996), Stone (2002), Busch (2000, 2011) and (Latour, 1992, 1999), among others.

Quantifying, or assigning numbers to represent complex processes and aspects of nature, has been the hallmark of science used in policy. Quantification is the foundation of standardisation, which has been described by researchers including (Scott, 1998b), and Lampland and Star (2009) as a process of using numbers to make the dissimilar, regular. Objectivity is an assumed key attribute of numbers. Porter (1953) argues that objectivity, as a theoretical concept, is an essential component necessary in measurement, in which order is obtained by following rules. Attaining objectivity with the use of numbers is assumed to overcome distance and generate trust, as numbers are perceived to be universal and rule-bound (Porter, 1995). Quantification encompasses the idea that "through measurement, counting, and calculation, [quantification] is among the most credible strategies for rendering nature or society objective" Porter (1995, p. 74).

Overseer is a nutrient budgeting model that represents farming systems using software which relies on the language of mathematics. This type of numeric representation has been highly useful for nutrient measurement and management, but is now being used for environmental regulation. Overseer has been branded as providing clarity of farm-system processes and holding the ability to be used within and across regions of New Zealand. By analysing dairy farmer perceptions of Overseer through the lens of quantification, it is hoped that a clearer understanding of the model's acceptability will emerge.

3.1 Quantification and the pursuit of objectivity

'Objectivity' arouses the passions as few words can. Its presence is evidently required for basic justice, honest government, and true knowledge... Mapping the mathematics onto the world is always difficult and problematical. Critics of quantification in the natural sciences as well as in social and humanistic fields have often felt that reliance on numbers simply evades the deep and important issues. Even where this is so, an objective method may be esteemed more highly than a profound one. Any domain of quantified knowledge, like any domain of experimental knowledge, is in a sense artificial. (Porter, 1995, pp. 3-5).

According to Porter (1995), quantification, as a form of measurement, is vital when attempting to achieve homogeneity across distances and overcome distrust among actors. Quantification, or measurement, is the representation of an object's or phenomenon's characteristics on an arbitrary scale, usually represented with a numerical value. Examples of these "characteristics" include mass, height, and volume, with possible "values" being numbers relating to kilograms, metres, and cubic metres, respectively. Values could also be represented by descriptive scales: small, medium, high. The definition of objectivity can be explained by its similarity to terms such as neutral, impartial, and fair. Porter (1995) explains that in policy, recommendations using quantitative estimates are sometimes given reasonable backing even without compelling validity. This is because decisions using numbers, or clear-cut rules, project the appearance of being fair and objective.

3.1.1 Objective policy

It is favourable to pursue objectivity during the process of quantification and in producing corresponding policy; objectivity offers favourable policy characteristics such as neutrality, impartiality, and fairness. Porter (1995) explains that "in a political culture that idealizes the rule of law, it seems bad policy to rely on mere judgement, however seasoned" (p. 8) and

seeming objective results in a “lending [of] authority to officials” (p. 8); the public is more likely to trust and accept what is perceived to be objective policy. When considering objectivity within quantification, Busch (2011) lists the following positive attributes:

- the ability to measure things precisely
- avoiding human subjectivity by using non-human measurement techniques
- the emergence of standards from a community or practitioners
- respecting the outcomes of environmental processes.

Busch’s first attribute refers to the application of appropriate methods and measures to quantify the item of interest. Busch’s second attribute of objectivity is the removal of human perceptions and bias from measurement techniques by employing computers and models. This is similar to how Porter describes objectivity, where objectivity removes researcher bias from any study outcomes through the use of sanctioned scientific methods. This is obtained from the use of numbers derived by means of impersonal rules and calculations. These methods can derive neutral, objective facts, separate to expert knowledge gained through a career tainted by personal experiences. Busch’s third positive attribute of objectivity describes the ability to reach expert consensus; and lastly, objectivity preserves the matching of theory to reality, so that concepts remain true across all environments.

When considering the practicalities of maintaining objectivity within policy, Jasanoff (1990) explains one issue where scientists often have the tendency to personalise their opinion of scientific data even when they are without proof of the objectiveness of the research. “When an objective or scientific test of experimental quality is unavailable ... scientists freely turn to non-scientific criteria of excellence, such as faith in the experimenter’s honesty, the size and prestige of the laboratory, and even personal qualities like nationality or professional group affiliations” (Jasanoff, 1990, p. 14). There is an assumption that science guarantees truth and scientific opinions are objective, thus indispensable to policy making. While the ideals of objectivity are sought by policy makers for the creation of good policy, Jasanoff explains that in practice, objectivity is difficult to achieve and measure (or prove). In policy contexts, resorting to objective criteria is usually impossible and decisions about ‘good policy’ are often left to perceptions regarding social factors (e.g. trust, reputation, and credibility of those issuing policy).

3.1.2 Ordering nature

Quantification, or measuring, is a process of ordering. Ordering aims to overcome messiness and bring structure to complex realities. Nature is complex and messy, made up of intertwining processes and phenomena. Porter (1995) explains that the desire to order nature derives from the appeal of establishing power and control over nature. Porter suggests that measurement goes hand in hand with expectations of precision and objectivity, which then impose control over nature through the ability to simplify and categorise natural occurrences as measured phenomena (see also Scott 1998). Ordering and measuring processes invoke ideas of authority and control. The act of measuring an object or phenomenon comes with the assumption that it is actually possible to measure the object or phenomenon. Porter (1995) explains that the measurer defines the boundaries for where the object or phenomenon does and does not exist, portraying confidence to others that it can be quantifiable and, thereby, able to be controlled. When aspects of nature are measured, the attributes can be assigned by the measurer, resulting in a form of control over this aspect of nature.

In environmental policy, Stone (2002) maintains that the first step for inciting change is to measure and quantify the item or issue of interest. In today's world, the process of measuring incites the need for action, as measurement only occurs when change is already desired, otherwise there is no point measuring it in the first place (Stone). Measurement implies that something is important enough to quantify and understand, and conveys a message to others that the phenomenon, regardless of its quantity, could have wider effects and interactions. Stone uses an example of the phrase "parts per billion" in a scientific context where, on one hand, the substance amount is very small and rare, but on the other hand, because the substance has actually been measured, it carries a certain significance and appears toxic.

3.1.3 Constructing scientific facts

Science produced for policy is different than science generated in a pure research environment. Jasanoff (1990) examined this, explaining how science and policy are closely integrated at each step of policy science production, alongside the fact that the understanding of science created for policy is influenced by the ways in which society then uses the knowledge. Jasanoff (1990) describes scientific knowledge for policy as being produced and constructed by a social process, from "the laboratory, where most scientific claims originate"

to “wider communities, including the news media and the lay public” (pp. 13). To simplify, social factors, imperatives and institutions influence what research is undertaken, and which facts are deemed true. Jasanoff argues that “scientific activity in any period is merely that which conforms to the prevailing paradigm” that defines “what problems are worth solving and shapes scientists’ expectations of what they are likely to see when they investigate nature” (pp. 13). Jasanoff (1990) also goes on to explain how facts are socially constructed; facts are regarded as true due to endorsement from perceived experts. The construction of facts begins in the laboratory, but ends up in the hands of the public and media. Scientific facts are tested and questioned alongside objective criteria; accepted scientific procedures conform to the current model in society (Jasanoff, 1990). Issues requiring scientific interjection are defined by this paradigm, shaping the perceptions of scientist’s and public expectations and understandings of what they see in nature.

In policy, the apparent impartiality of numbers allows decisions to be made without the appearance of a subjective decision by policymakers. Describing issues in terms of numbers offers confidence in a resolution. Once a problem has been quantified, its chosen parameters can be manipulated and measured against other variables with the same denominator (kilograms, metres, degrees Celsius etc.). As Stone (2002) states, “[numbers] make it possible to reduce conflicts to the single dimension of size – big versus little, more versus less” (p. 197). Stone is referring to the ability of numbers to take a complex process or object and define it in a way that allows comparisons, resulting in an argument for or against change. Disregarding the complex context of the process or object, having a numerical representation focuses attention on the numbers. When measurements are undertaken using universally accepted methods they are trusted to be true and authoritative (Porter, 1995). In New Zealand, multiple scientific reports show the decline of the same freshwater quality parameters in New Zealand lowland rivers (Houlbrooke et al. (2004); Smith et al. (2013); Wilcock et al. (1995)). As a result of the consistency of reports, freshwater quality is underpinned by the quantification of these similar freshwater parameters,

3.1.4 Remaining credible with a black box

Overseer’s internal processes, which take input figures and calculate a variety of output figures, are hidden from the view of the user. The term ‘black box’ is used to describe complex scientific or technical processes in which the inputs and outputs can be known, but the internal mechanisms which drive the process and derive the outputs are not accessible and hence not

understood. Shwed and Bearman (2010) describe an example of a black box as a computer, where the keyboard is its input and the screen is its output. The internal processes are invisible to its user. Latour (1987) describes a set of decisions we make when presented with a black box: “Do we take it up? Do we reject it? Do we reopen it? Do we let it drop through lack of interest? Do we make it more solid by grasping it without any further discussion? Do we transform it beyond recognition?” (pg. 29). Buying a machine or believing a fact without question strengthens its credibility, making it more of a black box. A weakening of the black box only occurs during questioning of, or disbelief in the machine or fact, resulting in the reopening of the black box to assess its internal components. Using Shwed and Bearman (2010)’s computer example, it is only after malfunction or the results produced are questioned when the computer is opened up and its internal processes are investigated; the opening of a black box occurs when changes are required for the system.

Latour identifies scientific facts and technologies as black boxes. Latour describes how people are more likely to accept scientific facts if they are deemed precise. Paradoxically, the more precise and successful science and technology are, the more hidden their black boxes become (Latour, 1999). The more concealed a black box is, the more difficult it is to reopen. If the science is still being developed or highly contested (as is the case with high stake policy issues), the interactions between the scientific statement’s internal features can be made visible when the black box is reopened.

3.1.5 Ambiguous numbers and science in policy

In the translation of numbers into policy, it is important to remember that numbers themselves are representations of the real world, not a direct reflection of it. Examining the process of creating numbers, Stone (2002) discusses the politics of counting, where measurement does not always remain objective due to ambiguity in the interpretation of numbers by different stakeholders. Stone maintains that the supremacy of numbers in policy discussions is potentially a temporary phenomenon in political history, rather than some fundamental reality of numbers themselves (Stone, 2002). While it is difficult to imagine public policy without numbers, it needs to be recognised that they render a particular view of the world.

While numbers can define a problem, they must then be verified against the interpretation of the problem. Citing Porter (1996), in order to achieve consistent and transparent

measurements, investigations into compliance with the numbers is a continual process which requires increasing effort and resources to evidence the numbers as credible (Duncan, 2014). Along with the potential of undermining the trustworthiness of numbers by not increasing resources into verifying compliance, “risks lie in assuming that numbers can speak for themselves to resolve conflict” (Duncan, 2014, p. 380). Maintaining consistency and transparency of numbers in public policy requires increasing effort and resources, which potentially undermine their primary characteristic of clarity and certainty for which they are deployed in the first place. As the interpretations of numbers change, this can “lead to the loss of trust in policy frameworks and regulatory agencies thus creating challenges for implementation” (Duncan, 2014, p. 380).

Jasanoff (1990) believes that science has succeeded “in acquiring and maintaining cognitive authority in a distrustful world” (p. 14), however this is coupled with the fact that scientific knowledge is provisional and contextual. While science operates on the basis of, and is driven by, questioning and uncertainty, in the political arena the level of (scientifically acceptable) uncertainty is inappropriate for policy. Problems arise when science is produced to steer uncertain and inherently political topics: “how can [scientists] maintain their authority as neutral experts, especially when challenged in the media or the courts?” (Jasanoff, 1990, pp. 8-9). As a solution, Jasanoff (1990) suggests to increase the dependence on scientific advice, and investment in more power to scientists alongside political neutrality, balanced peer-review systems and standardisation of scientific methods. Since “there can be no perfect, objectively verifiable truth,” what we can “hope for is a serviceable truth: a state of knowledge that satisfies tests of scientific acceptability and supports reasoned decision making, but also assures those exposed to risk that their interests have not been sacrificed on the altar of an impossible scientific certainty” (Jasanoff, 1990, p. 250). Scientific knowledge needs to hold authority and persuasion in order to provide reasonable solutions to society: “by drawing seemingly sharp boundaries between science and policy, scientists in effect post ‘keep out’ signs to prevent non-scientists from challenging or reinterpreting claims labelled as ‘science’” (Jasanoff, 1990, p. 236).

3.1.6 Authority across boundaries

Stone (2002, p. 197) states that numbers are able to “reduce conflicts to the single dimension of size”. Using the phrase ‘doubt strategy’ with reference to politics, Stone (2002) states: “when the stakes are money rather than morals, the misuse of science takes a ... politically

effective form. If scientific research shows a product to be dangerous or unsafe, the affected industry can create doubt about the research as a tactic to delay of stop regulation” (p. 319). Stone (2002) uses the example of the tobacco industry, where expert consultants were paid to question every study, method and conclusion using science. The industry is able to publish reports from their hired consultants and push people to doubt the original science, undermining the ideal of scientific objectivity. In policy, “science can be and is increasingly used as an instrument of influence in political conflict” (Stone, 2002, pp. 319-320). The doubt strategy plays an important role in regulation policy as there are high stakes involved. People are likely to subscribe to opposing arguments and contest regulation, through the exploitation of its scientific uncertainties, if it means the regulations imposed on them could be changed.

A problem with numbers is that they can be used to serve more than one interest. Even so, numbers are assumed to be neutral, accurately describing a particular aspect of the environment without serving any interests, promoting any agendas or persuading individuals. It is when numbers are linked back to their contexts, that they may become deconstructed and questioned. In a context of political conflict where, for example, the financial stakes are high, claims of objectivity can be challenged and undermined in courts of law or through political processes of policymaking (Jasanoff, 1987). Boundary work (also see (Gieryn, 1983)) allows scientists to enhance their authority: “when an area of intellectual activity is tagged with the label “science”, people who are not scientists are de facto barred from having any say about its substance; correspondingly, to label something “not science” is to denude it of cognitive authority” (Jasanoff, 1990, p. 14). In order to gain control of regulation processes, if participants are able to represent their contributions as scientific, they have standing and authority.

3.1.7 Acceptance of scientific knowledge

Examining public responses towards risk and risk information from persons of authority, Wynne (1980, 2013) explains that responses are largely based on social perceptions, or “are rationally based upon their experience and judgment of the credibility and trustworthiness of the institutions, which claim to be in charge” (Wynne, 2013, p. 283). Attention to this topic stems from concern among scientists and policy makers to the significance of public unwillingness to accept scientific information provided by experts. People experience knowledge as part of a “social package” (Wynne, 2013, p. 284) which includes the social relationships, interactions, and interests that identify with the individual. Looking closer,

Wynne (2013) clarifies that “trust ... and credibility are relational terms, about the nature of the social relationships between the actors concerned. They are not intrinsic to either actor nor to the information said to be transmitted between them” (Wynne, 2013, p. 284). In other words, public understanding of science information is exposed to individual perceptions and context depending on the on-going experiences of the person. Wynne (2013) furthers the significance of on-going experience by describing trust and credibility as being contingent variables, influencing the uptake of new information through dependence on relationships and identities between knowledge providers or producers and knowledge receivers or users.

Distance from the data: the certainty trough

Examining the acceptance of science, Jasanoff (1990) states that “scientific uncertainty and the pressures of decision-making lead to a forced marriage between science and politics” (p. 8). Science in policy usually encounters either an under-critical or over-critical environment. While science may be under-criticised when policy consensus exists prior to research, over-critical analysis will occur in an environment with divided opinions and heightened scrutiny by experts in rival camps.

The certainty trough is a useful heuristic developed by MacKenzie (1990) (and also in (Duncan, 2008)) to explain how perceptions of uncertainty change in relation to the distance from the site of knowledge production. The site of knowledge production can refer to a theory, a model, a research agenda or a piece of technology. Figure 3.1 illustrates the varying levels of uncertainty from the site of knowledge production.

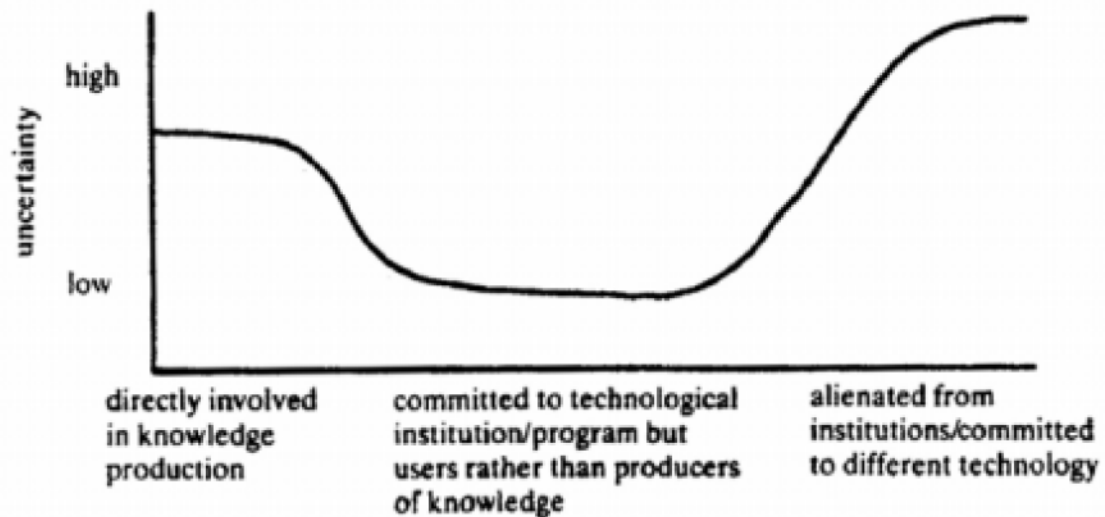


Figure 3.1 The certainty trough (source: (MacKenzie, 1990, as cited in Duncan, 2008, p. 56))

Figure 3.1 describes how those closest to the site of knowledge production (far left) have moderate levels of uncertainty, owing to their close proximity and involvement in the production of that technology. These are usually the scientists or model makers. They are close enough to understand the uncertainties inherent in their conclusions or their model. Those persons represented by the middle area of the trough, usually the users of the model or technology (e.g. policy-makers and decision-makers), perceive low uncertainty. In other words, this where high levels of certainty are perceived and hence the term 'certainty trough'. These relatively high levels of certainty are due to the commitment actors in this zone have to the idea or technology. Those on the right of the graph are described as a group of persons who are so removed from or resistant to the technology or programme that they perceive a very high level of uncertainty. Their distrust of the technology may be brought about by a commitment to alternative technologies or a lack of understanding or alienation from the technology. Duncan (2008), quoting MacKenzie (1990), explains that the certainty trough shows how a "disconnection occurs as knowledge claims move from the hands of knowledge 'producers' to knowledge 'users'" (p. 57). This idea of disconnection plays a significant role in the acceptance of technology by users, especially as users move further away from the site of production.

Farmers' acceptance of science

Wynne (2013) employed a qualitative case study investigating the acceptance of scientific information by sheep farmers from scientists and political leaders in Northern England

following a nuclear accident at the Chernobyl nuclear reactor in 1986. The study revealed that trust and credibility were central factors in the farmer's acceptance of scientific advice from scientists, identifying the following seven factors as measures for social credibility of science which Wynne terms as "lay criteria for judgement of science" (Wynne, 2013, p. 302).

1. Does the scientific knowledge work? (e.g. theories and predictions can fail in real life)
2. Do scientific claims pay attention to other available knowledge? (e.g. significant simplifications in scientific theories due to lack of local knowledge)
3. Does scientific practice pay attention to other available knowledge? (e.g. unrealistic environment field experiments by scientists)
4. Is the form of the knowledge as well as the content recognizable? (e.g. degrees of certainty and standardisation by scientific theory)
5. Are scientists open to criticism? (recognition of other knowledge, acknowledging errors)
6. What are the social/institutional affiliations of experts? (e.g. agendas, bias and openness)
7. What issue "overspill" exists in lay experience? (scientists aware of lay past social experiences)

Wynne maintains that it is through these criteria laypeople perceive the credibility of science and the authority of expert knowledge. Wynne argues that the "credibility [of science] was influenced not so much by what it said directly and explicitly, [rather] in the way it was institutionally and intellectually organized, including lack of recognition of its own cultural and institutional biases" (Wynne, 2013, p. 301). These biases describe the aggregation and standardization influences surrounding the specific presentation of scientific data. The criteria above highlight how science requires "reflexive recognition of its own conditionality" (Wynne, 2013, p. 302), a prerequisite for public acceptance of science knowledge. Wynne's case study found that farmers were able to self-reflect and develop their social position towards science acceptance depending on the seven criteria listed above. This was in contrast to the members of the science community, who were less reflexive on their scientific practices and understanding of the limitations of their methodologies that assumed the straightforward

translation of conclusions about soils and their response to public query. Trust and credibility are described as products of social identity, in which the understanding and acceptance of new information is dependent on individual beliefs and experiences (Wynne, 2013). Wynne's case study showed that a reform of the organisation, control and social relations that influence the production of science can be achieved through the inclusion of reflexivity, which as a derivative of social identity can improve public knowledge perception and acceptance.

3.2 The incentive to standardise

3.2.1 Standards

The term 'standard' has multiple definitions, this research utilises that which describes a required level of attainment; also called norms, rules, or criterion. Standards are important because they facilitate order and stability in a complex world. Busch (2011) explains that reality is imperfect and sometimes disconnected, where choices are often irrational, and accurate information is not readily available for everyone to use. For these reasons, standards fill gaps and smooth over reality, employing the ability to organise ourselves, other people, things, processes, and language. In the realm of politics, the rules governing the formation of standards should be agreed upon by groups of professionals (Bowker & Star, 1999; Busch, 2011); ensuring scientific consensus is a characteristic of objectivity. Standards rely on quantification, in which an object or phenomenon can be represented by the level of attainment of a particular condition or benchmark.

Busch (2011) states that standards have the ability to empower and disempower people. Empowerment can arise by the efficiency of standards to categorise and streamline processes, whereas disempowerment may occur due the tight control over following designated processes. Busch also argues that following a standard could result in missed opportunities to be creative and potentially gain different benefits. Whether or not an individual is likely to follow a standard is dependent on the perceived utility of the standard. Lampland and Star (2009) describe how standards often deploy uneven levels of power across different social landscapes, where individuals are more likely to attempt to meet a standard if they deem it consequential. For example failure to meet a standard, otherwise known as failure to meet compliance, could result in a financial penalty or restriction of the activity (Busch, 2000, 2011). Standards are a key tool in environmental regulation. If a standard is enforced from a place of power, i.e. a regulatory authority, it will more likely be attempted to be met.

An example which explains how the power of standards shapes the choices of an individual can be described by the current and intended use of Overseer for compliance by regional councils. Farmers may not wish to create farm nutrient plans and alter their management practices, but not completing this may result in a breach of their farm consent, ensuing financial penalties or business termination. Put simply, the standard in this example is the requirement of calculating and managing their farm nutrient plan to meet compliance and the power of this standard is the financial penalty and business termination if failure to meet this standard occurs. Depending on the perceived power, standards can guide an individual or group towards certain pathways and constrain them from choosing alternative options.

3.2.2 Types of standards

Busch (2011) describes four types of standards, each of which can relate to people and things. Olympic standards are those for which a singular or small number of winners can be found. The standards are designed in a way to produce single winners, with many losers. Filter standards describe a process in which a group of people or things pass through the filter, eliminating any unsuitable actors resulting in generalised improvements to the remaining pool of people or things. Rank standards form a process of categorising a selection of people or things in order of preference in adherence to the standard. The standards for attaining the higher positions are, in principle, harder to reach than lower ranks. All people or things within the group receive a rank. Rank standards often result in rewards for higher ranks and penalties for lower ranks, and for this reason ranks are frequently challenged. Division standards are categories which are unranked. While individuals may prefer one category over the other, there is no defining ranking for the categories. Often, standards do not exist by themselves, but rather a complex system of interlocking and interrelated categories.

Table 3.1 Examples of objects and people for the different standard types

Standard type	Example for objects	Example for people
Olympic	Car of the year	Time Magazines' person of the year
Filter	Foods suitable for gluten intolerance	Persons above legal drinking age
Ranks	Grading of appliance energy efficiency	Positions within the military
Division	Varieties of potatoes	Religious allegiance

Overseer represents a filter type of standard. Filter standards are designed to separate the acceptable from the unacceptable. At least initially, regional councils were expecting Overseer to produce results for management on a wide scale, providing a quantitative 'limit met' or 'limit not met' answer for nutrient output compliance.

3.2.3 Standardisation

Standardisation is a central, but mostly invisible, process of ordering our lives and shaping the modern world. Timmermans and Epstein (2010) state that while standardisation ceases to exist without standards, standards do not hold any power without being imposed across social domains (this domain was seen in the medication example previously). In other words, individually, standards are inconsequential. The process of standardisation is where power and authority arises, where objects and phenomena are ordered and categorised in the real world. Standardisation is the process of forming consistency across boundaries of time and space, using pre-determined rules or categories. For example, students take identical exams to measure learning ability; the exam is the standard and the requirement to take the exam to achieve a grade is the process of standardisation. As a process of ordering, standardisation brings legibility and simplification to the real world (Scott, 1998a), for example, through examination processes where the vast array of capabilities of students can be ranked by relative learning ability. Timmermans and Epstein (2010) describe examples of standardisation as including quantitative technologies and information systems that aim to offer legibility to society through governance. Standardisation is the process of creating, imposing, and enforcing compliance using standards.

3.2.4 Standardising people

Individuals and groups are subjected to standardisation as governments attempt to fit society into categories in order to exercise control over large populations for the greater good. Scott (1998a) examines the urge of political leaders to standardise people by discussing how creating populations with pre-determined standardised characteristics are easier to manage. Common standardisations of people include population census, taxation, and testing in education. Issues with standardising people are described by Porter (1995) using the context of objectivity where: “an excess of [objectivity] crushes individual subjects, demeans minority cultures, devalues artistic creativity, and discredits genuine democratic political participation” (p.1). According to Porter, people often resist government and social standardisation due to these reasons. Scott (1998a) argues similarly, using an example of the Spanish government attempting to introduce surnames to the entire population of the Philippines in the mid 1800’s, which aimed to categorise people for censuses, land ownership and taxation purposes. Within villages around the country, everyone knew who everyone was already and the idea of receiving an additional name was resisted by many as it took away the personal, descriptive

names people already had for themselves. The problem arose as the state sought to standardise people across the region, not considering the small-scale communities the public lived in and existing social relations. This was the 'top down' approach of the state that enforced surname compliance by insisting on rule following, punishing those without a surname by withdrawing certain human rights (e.g. the ability to legally own land). Scott (1998a) argues that people respond negatively to being standardised and quantified as assigning numbers to values and processes suggests simplification, taking away individualism and variability.

When governments create standards to address significant issues, it is beneficial that individuals and wider collectives are in agreement on any regulations introduced, as behaviours and activities may need to be altered for compliance with any new standards. Stone (2002) maintains that the acceptance of a rule or standard, in part, is determined by the fairness of the process used to produce the rule or standard. In a process which is already standardised, both the results and the decision-making process need to portray fairness. Stone (2002) highlights this issue of equity where "for many things in life ... we are quite willing to accept unequal results so long as we know the process is fair" (p. 55). When governments establish standards and allocate resources, often they seek to maintain objectivity, equating objectivity with fairness. In reality, this focus on demonstrating objectivity is undermined by the public's need for clearly portraying fairness in the process of producing standards. The public respond to perceptions of fairness within the government process itself, rather than seeking objectivity.

Alongside perceived fairness, the shifting of power and control between the public and government agencies influences the acceptability of standardisation. Myles et al. (2015) examined a positive response of people being standardised, where the power relations and identities of water users were reconfigured as a result of standardisation. Myles et al. (2015) explored how standards and technologies were introduced in Canterbury to better understand and manage water use and resource users, finding that water users responded positively to the standards as they were able to demonstrate to the state (the regional council) their compliance. The implementation of measurement practices aided in the transformation of power relations of water users and the state, where water users were able to contest dominant cultural narratives of resource exploitation by proving compliance with the rules (i.e. water take meters). By having measured data, the water users were able to confidently

deploy their narrative as a resource protector, reducing the power of the state's authority on water management in the region.

Meeting compliance can be subjected to conscious and unconscious manipulation from those being measured. While Porter (1995) explains that governments use standards (through regulations) to influence the behaviours of individuals in order to meet compliance, Stone (2002) states: "people react to being counted or measured, and try to 'look good' on the measure" (p. 203). The incentive to manipulate can occur when people perceive their performances are being evaluated, and their performance will be used to determine a range of outcomes. This is applicable when associated with high-stake issues like resource allocation and compliance, where there is motivation to deceive (Duncan, 2014; Porter, 1996). Rather than falsifying the numbers, people often alter their behaviour as a response of being measured. Stone (2002) described an example where in 2002 in order to receive federal aid, schools in The United States had to prove their students met minimum proficiency standards. Due to the financial incentive to perform well, many states lowered their cut-off scores for 'proficiency' and were able to maintain federal assistance. Feeling threatened by authoritative measurement and standardisation, especially concerning performance scores, schools were motivated to manipulate their categories and their data to achieve the appropriate standard that resulted in a financial gain. This example illustrates how compliance can be subjected to conscious and unconscious influence, whereas a response of being measured, people will often alter their behaviour when interacting with a high stake issue.

3.3 Summary

The ability to quantify an attribute with a number creates a sense of power and control. Assigning numbers offers confidence in the authoritative understanding of the attribute, where once it has been quantified, it may be measured against other related attributes. In policy, the numbers are seen as impartial and trustworthy, free from the subjectivity of policymakers. Policy which utilises quantitative estimates is sometimes given reasonable backing without compelling legitimacy due to the fairness and objectiveness numbers impose.

Trust and credibility are described as products of social identity, in which the understanding and acceptance of new information is dependent on individual beliefs and experiences. People experience knowledge as part of a social package which includes the social relationships, interactions, and interests that identify with the individual. In other words, public

understanding of science information is exposed to individual perceptions and context depending on the on-going experiences of the person. Trust and credibility are contingent variables, influencing the uptake of new information through dependence on relationships and identities between knowledge providers or producers and knowledge receivers or users.

There is a need for clearly showing fairness during the process of producing standards. In the production of standards, governments often focus on maintaining objectivity, equating objectivity with fairness. In reality, the public respond to perceptions of fairness within the government itself, rather than seeking objectivity. As a response of being measured, people will often alter their behaviour when interacting with a high stake issue. This is applicable when associated with high-stake issues like resource allocation and compliance. Rather than falsifying the numbers, people will often consciously and unconscious alter their behaviour.

Chapter 4

Methodology

This chapter provides an account of the methods used to conduct this research. Firstly, it revisits the research aim, question and objectives of the study. This is followed by an introduction to the research theory, justification of the case studies, and an explanation of the data collection and analysis processes applied during the course of this study.

4.1 Research aim, questions and objectives

As stated in chapter 1, the purpose of this research will be to investigate the perceptions of dairy farmers and farm consultants with Overseer's change from a decision-support to compliance tool. To achieve this, the research question is:

- How has Overseer's shift from decision-support to compliance tool altered perceptions of regulation and sustainable nutrient management?

In order to answer this question, the research objectives are:

- a) Assess the differences in perception of Overseer between farmers using Overseer for decision-support verses farmers using Overseer for compliance purposes.
- b) Evaluate how standardisation affects perceptions of the on-farm applicability of Overseer and its credibility as a regulatory tool.
- c) Identify the implications of the use of Overseer as a compliance tool for nutrient management and the challenges these present for the implementation of water quality limits.

4.2 Qualitative social research theory

This study required a research methodology which would provide rich, descriptive data portraying the opinions and experiences of farmers and farm consultants, to draw conclusions about the perceptions of Overseer for decision-support and compliance use. Qualitative research approaches aim to investigate individuals' experiences and perceptions. The approach adds value and depth to inquiries, and is able to highlight the unique contribution of social knowledge to policy research. Koutiva et al. (2016) examines the benefits of semi-

structured interviews, explaining how this technique encourages a more detailed analysis regarding the shaping of attitudes, perceptions, cognitions and their link to behaviour and decision-making. Popay and Mallinson (2010) also discuss the usefulness of qualitative approaches to policy research by being able to answer questions relating to people's behaviour, the relationships between policies and practices, and understanding social structures.

The empirical resources used in this study provide context and identify gaps and questions in the literature. These resources include key policy documents, government reports, government legislation and other academic material relating to nutrient management and modelling in New Zealand's dairy industry and the use of Overseer as a compliance tool by regional councils. Reviewing empirical resources directed the development of the research aim, question and objectives. A theoretical framework, chapter 3, has been used to guide data collection and analysis - it is the lens through which to view the collected data (Elliot & Higgins, 2012). The theoretical framework guiding this research focuses on the role of quantification, and more specifically standardisation, in shaping perceptions of Overseer and how these perceptions compare when the model is used for decision-support versus compliance with land use rules.

Based on the requirements of the research aims and questions regarding perceptions relating to Overseer, a qualitative research approach was selected as the most appropriate method for guiding this research. The research design is a comparative case study using semi-structured interviews, and a thematic analysis.

4.3 Comparative case study: The Rotorua Lakes and the Rangitāiki Plains

Research which utilises a case study methodology allows the exploration of an experience or event from a variety of perspectives, resulting in an in-depth, balanced picture of the experience (Taylor & Thomas-Gregory, 2015). Woodside (2010) explains that case study research (CSR) is appropriate for four objectives: description, explanation, prediction, and control of the attribute being studied. With a 'description' objective, CSR addresses the who, what, where, and how questions. 'Explanation' objectives address why questions. 'Prediction' includes the estimation of future behavioural states of the individuals. 'Control' aims to influence cognitions held by an individual. Considering the four objectives together, Woodside (2010, p. 6) proposes that the main objective of CSR is really to gain "*deep understanding of*

the actors, interactions, sentiments, and behaviours occurring for a specific process through time". Deep understanding refers to the analysis of an individual's (person, group, organisation) perceptions and interpretation on their actions and thinking processes as a result of their perceptions. In order to answer the research question for this study, a deep understanding of the perceptions of dairy farmers and farm consultant regarding Overseer is required. It is essential to examine the 'description', i.e. who, what, where, how, and 'explanation', i.e. why questions relating to farmer/consultant perception of Overseer, alongside the 'prediction' evaluative analysis of likely future behaviours as a result of these current perceptions. The investigation of these three objectives directly relate to the fourth 'control' objective which begins to influence the perceptions held by farmers and consultants concerning Overseer.

Collier (1993) describes three situations in which different types of comparative case study is appropriate, examining covariation for casual analysis, portraying a analogous concept applicable among cases, and examining differences between cases. The case for this research is defined as the comparison between the introduction of Overseer for regulatory purposes in the Rotorua Lakes area, and Overseer for decision-support on the Rangitāiki Plains. Both areas are located in the Bay of Plenty. Overseer was introduced into the Rotorua Lakes area throughout 2005, but the temporal boundary for this research was confined to the use of Overseer in more recent years, leading to the end of the data collection period (November 2016). With the case studies, Overseer has been used to portray how the use of a model for either decision-support or compliance purposes results in different perceptions of the model. Although Overseer for compliance and decision-support purposes is employed for a wide range of agricultural practices, this case concentrates solely on the dairy farming sector. While the socio-economic consequences of the use of Overseer for compliance purposes are expected to be most significant for individuals involved in the dairy industry, other parties are affected such as mining and paper mill companies, sheep and beef farmers, lifestyle block owners, and the general public who are mentioned throughout the study.

4.3.1 Case study: The Rotorua Lakes – using Overseer for compliance

The Rotorua Lakes are situated in the Bay of Plenty of the North Island of New Zealand, known for the system of ancient volcanic caldera lakes in the area (see Rotorua below in figure 4.1). Lake Rotorua is the largest lake in the district, with a surface area of 8,060ha and a catchment area of 50,060ha (RTALP, 2017b). With the city of Rotorua right on its shores and its close

association with popular Māori legends, Lake Rotorua is highly valued for its cultural significance, recreation and tourism opportunities, and containing the country's most productive trout fishery (RTALP, 2017b).

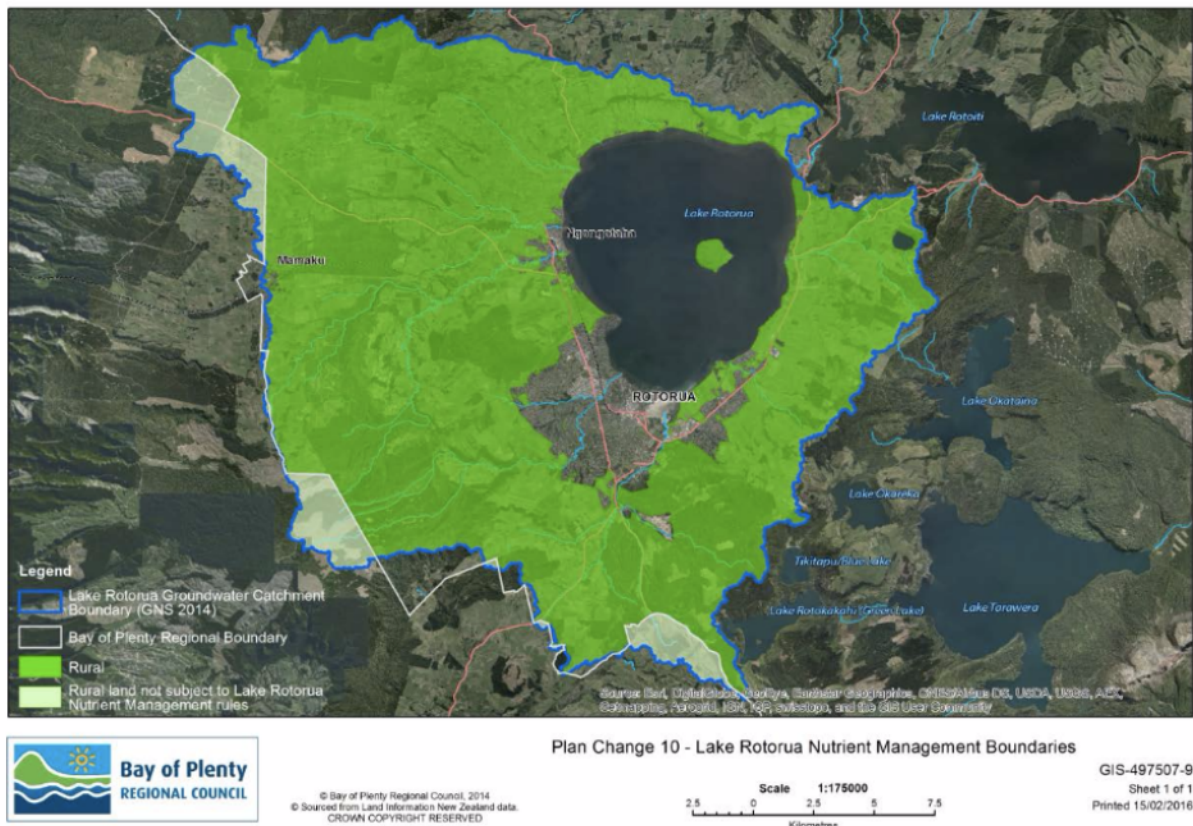


Figure 4.1 Rotorua Lakes surface water catchment area (green colour) (source: Bay of Plenty Regional Council (BOPRC) (2016))

Due to the areas fertile soils and wet climate, dairy farming has had success and become a significant industry in the area (Environment Bay of Plenty et al., 2009). Rotorua's most significant environmental issue has been the decline in water quality of several lakes in the area, associated with high levels of nitrogen and phosphorus. As a short term measure of increasing the water quality of the lake, BOPRC has been dosing aluminium sulphate into two streams which flow into the lake (RTALP, 2017b). Aluminium sulphate locks phosphorus onto sediment, removing it from the water column and resulting in less phosphorus available for algal growth. One of the most significant contributors to the levels of nitrogen and phosphorus in Lake Rotorua is dairy farming; reducing nutrients lost from land-use is key to improving water quality in the area.

In order to develop a long term solution for water quality in Lake Rotorua, a Stakeholder Advisory Group was formed with representatives from pastoral, water quality, forestry and

īwi sectors (RTALP, 2017b). This co-operative forum has developed an integrated framework for the reduction of nitrogen entering Lake Rotorua, most significantly the development of Plan Change 10.

Policy in the Rotorua Lakes area

The Rotorua Te Arawa Lakes Programme (RTALP) was developed to reduce nitrogen loads from entering Lake Rotorua (Rotorua Lakes, 2016b). Policy change began in 2005 with the introduction of Rule 11, which aimed to ensure there was no increase to the amount of nutrients entering the lakes in Rotorua. Rule 11 placed a limit on nitrogen and phosphorus entering the areas lakes from properties within the catchments by benchmarking properties based on their land use from 2001 to 2004 (RTALP, 2017c). Rule 11 did not improve water quality in the area, rather the objective was to prevent further environmental damage by capping nutrient losses. For addressing water quality, Plan Change 10 (Lake Rotorua Nutrient Management) was developed as a change to the Regional Water and Land Plan (RWLP) that the BOPRC with the Rotorua Lakes Council and Te Arawa Lakes Trust have established. Plan Change 10 aims to meet the objectives set by the Operative Regional Policy Statement and Operative RWLP, which are:

Regional Policy Statement Objective 28: Enhance the water quality in the lakes of the Rotorua District and other catchments at risk (BOPRC, 2014b, p. 98).

Regional Water and Land Plan Objective 11: The water quality in the Rotorua lake is maintained or improved to meet the Trophic Index of 4.2 for Lake Rotorua (BOPRC, 2008, p. 34).

To meet these objectives, Plan Change 10 introduces rules to limit the amount of nutrients entering Lake Rotorua. The Rotorua Lakes Programme has set a target of a sustainable annual nitrogen limit of 435 tonnes, using nitrogen benchmark levels from a historical report by Rutherford et al. (1989). Rutherford et al.'s report concluded that in order to meet suitable water quality levels, a target of pre-1960 lake conditions should be met. The sustainable lake load must be met by 2032, with 70% met by 2022 (Rotorua Lakes, 2016b). There is also a required reduction of 10 tonnes of phosphorus in the lake. Park (2014) explained that the removal of 270 tonnes of nitrogen from the system is required from the pastoral sector, which includes dairy, sheep and beef, and other livestock farms as well as lifestyle blocks. In order to implement this reduction by the pastoral sector, a Nitrogen Discharge Allowance (NDA) has been allocated to each property owner, which states the maximum amount of nitrogen loss

to occur from the property after 2032 (Rotorua Lakes, 2016a). All dairy farmers will be given a NDA, which will be enforced from July 1, 2017, and must be met by 2032 (RTALP, 2016). The NDA, and all corresponding calculations are calculated by a land use advisor from the Bay of Plenty Regional Council using the latest version of Overseer (updated with each version change) based on each property's 2001-2004 nutrient discharges as the benchmark.

A report by Park (2014) summarises the regulatory and practical challenges of using Overseer in the Rotorua Lakes area, and concluded with "the Overseer nutrient budget model is fit for the purpose of regulating N loss in the Lake Rotorua catchment" (Park, 2014, p. 3). Along with this endorsement, Park (2014)'s report outlines the challenges BOPRC may come across during implementation. Some of the recommendations include:

- The latest Overseer version should be used
- Compliance should be assessed against a rolling three-year average of the outputs
- Enhance farm nutrient plan efficiency (through suitable farm plans)
- Latest Overseer Best Practice Data Input Standards are to be complied with
- Create a secure and efficient national database for accessing Overseer input and output data.

Plan Change 10 was publically notified in February 2016, submissions were closed late April 2016 and the hearings were held from the 13th of March to the 4th of May, 2017, and will formally close once all requests for additional information are received. The hearing panel now has the responsibility to consider all information submitted and make a recommendation on Plan Change 10 to the BOPRC. BOPRC will then consider the recommendation and make a decision on releasing the Plan Change (BOPRC, 2017a; BOPRC, 2017b).

Alongside Plan Change 10, there are several other initiatives to achieve long term improvements to water quality. The Gorse Conversion Programme contains a \$2.5 million fund to remove 30 tonnes of nitrogen from entering the lake as gorse absorbs nitrogen from the atmosphere and has the ability to leach excess nitrogen into the soil (RTALP, 2017a). The programme aims to convert mature gorse into production forestry, native bush or any other low nitrogen leaching activities. Another initiative is the Lake Rotorua Incentives Programme,

where a \$40 million fund will be used to remove 100 tonnes of nitrogen from the system through voluntary land use and management changes (RTALP, 2017b). The incentive scheme will allow land owners to sell nitrogen (as represented by their current NDA figure), as long as they permanently alter a portion of their property to a low nitrogen loss land use. The BOPRC will also employ engineering solutions to remove 50 tonnes of nitrogen from reaching Lake Rotorua, these will include weed harvesting, establishing floating wetlands, installing detainment bunds and upgrading the waste water treatment plant (RTALP, 2017b).

The Rotorua Lakes will also be affected by the Regional Water and Land Plan Change 9, which improves the efficiency of water allocation in the region. The improvements are sought by strengthening existing limits for water allocation and requirements for water users to meter and report water use, and introduce further policy that reflects tāngata whenua values when processing consents (BOPRC, 2017a). Plan Change 9 is still receiving submissions and a final decision is aimed for release in March 2018.

4.3.2 Case study: The Rangitāiki Plains – using Overseer as decision-support

The Rangitāiki Plains is a small flood plain, about 30,000ha in area, situated at the northern end of the Rangitāiki catchment (see shaded grey/green area circled in Figure 4.2 below), in the Eastern Bay of Plenty of the North Island of New Zealand (BOPRC, 2013). The Rangitāiki Plains are located south-east from the Rotorua Lakes area. The Rangitāiki plains contain the Rangitāiki River, which begins in the northern Hawkes Bay to the east of the Kaingaroa Forest, flowing northeast into the Pacific Ocean. As in the Rotorua Lakes, the Bay of Plenty Regional Council (BOPRC) governs this area.

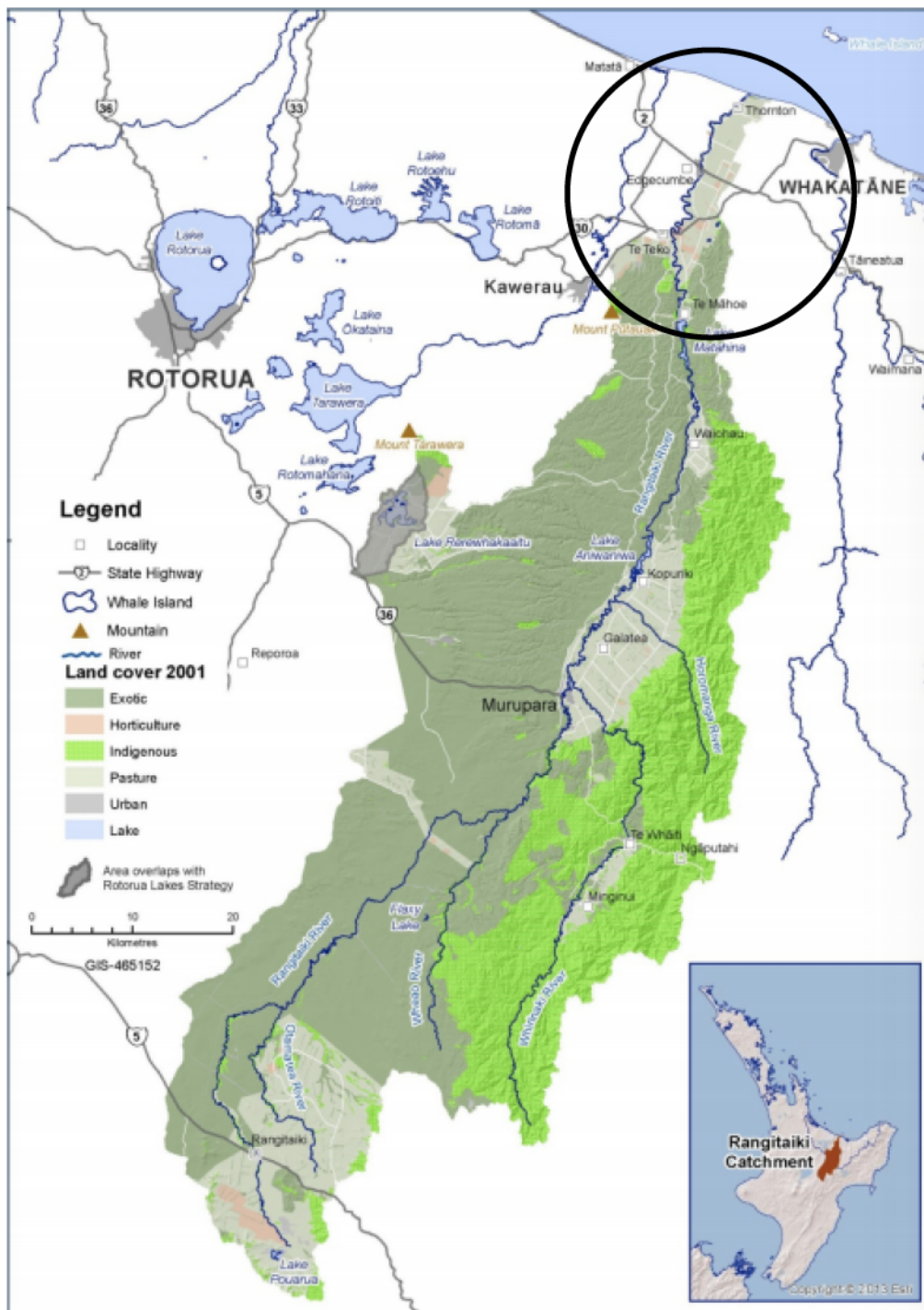


Figure 4.2 Map of the Rangitāiki Catchment, the Rangitāiki Plains located at the northernmost section of the river (light grey/green colour) (source: Bay of Plenty Regional Council (BOPRC) (2014a))

The Rangitāiki River is considered of great importance to past, present and future generations (BOPRC, 2015). Over the past century, the Rangitāiki River has benefitted the local economy by generating hydro-electricity, providing water for agriculture and horticulture, and supported forestry, tourism and recreation.

At present, the Rangitāiki Plains in the lower catchment is used extensively for agriculture, predominantly dairy farming, which represents 80% of the land area, while horticulture represents 3% (BOPRC, 2013). As of 2013, 10% of the Rangitāiki Plains was irrigated, with 7% of that being dairy farm land. There has been significant interest for increasing irrigation in the area, in particular for dairy farms, which has resulted in investigations into a community irrigation scheme on parts of the Rangitāiki Plains (BOPRC, 2013). The unsuitable condition of the Rangitāiki River has recently come under the spotlight, with those in the area requesting water quality that meets drinking water and food source safety levels, alongside being suitable for swimming and ceremonies (BOPRC, 2015).

Policy on the Rangitāiki Plains

The Rangitāiki River Forum was founded in 2012, and is a joint committee made up of representatives from the BOPRC, the Whakatāne District Council, the Taupō District Council, and members from all relevant iwi within the Rangitāiki catchment. The forum was created in order to fulfil the Regional Council's responsibilities under the Ngāti Manawa and Ngāti Whare Treaty Settlement Claims Acts 2012, which states that the Bay of Plenty Regional Policy Statement is obligated to recognise and provide for policy from the iwi in any future regional and district plans (BOPRC, 2015). The purpose of the forum is to ensure:

The protection and enhancement of the environmental, cultural, and spiritual health and wellbeing of the Rangitāiki River and its resources for the benefit of present and future generations (Rangitāiki River Forum, 2017, p. 3).

The forum released the document 'Te Ara Whānui o Rangitāiki – Pathways of the Rangitāiki' in 2014 to guide the understanding of the mauri (life supporting capacity) and well-being of the Rangitāiki (Rangitāiki River Forum, 2017). As a result, the BOPRC is amending the Bay of Plenty Regional Policy Statement with Plan Change 3 (Rangitāiki River). The plan change aims to introduce the new issues, objectives, policies and methods outlined by the 'Te Ara Whānui o Rangitāiki – Pathways of the Rangitāiki' document (BOPRC, 2017a). At present Plan Change 3 has completed receiving submissions and has hearings scheduled for June 2017, with a decision aimed for release in August 2017.

In response to the NPS-FM, the BOPRC is setting limits on water quality, minimum flows and allocation limits across the entire region, with the Rangitāiki being one of the first catchments to be focused on (BOPRC, 2015). Plan Change 12 (Freshwater Futures) sets out intended

freshwater environmental outcomes, or objectives, for the Rangitāiki, Kaituna (excluding Lake Rotoiti and Rotorua catchments), Pongakawa, and Waitahanui catchments (BOPRC, 2017a). In order to meet the objectives, freshwater quality and quantity limits will be established, along with rules and other management methods. Plan Change 12 will give effect to the freshwater quality and quantity aspects introduced by Plan Change 3. Pre-draft work and engagement is scheduled for 2017, with the draft plan change hoped for release in 2018, and final council decision in 2019 (BOPRC, 2017a). The Rangitāiki Plains will also be affected by the Regional Water and Land Plan Change 9, explained above in the Rotorua Lakes case study section.

The farmers on the Rangitāiki Plains use Overseer as a decision-support tool. However, while the BOPRC is not currently using Overseer to monitor nutrient limits for the Rangitāiki River, it is a good case study location for this research due to its potential use in the future (in particular with Plan Change 12 on the horizon).

4.4 Data collection

The primary source of data for this research was collected during fifteen interviews with three participant groups:

1. Rangitāiki Plains dairy farmers (seven participants)
2. Rotorua Lakes dairy farmers (six participants)
3. Bay of Plenty farm consultants (two participants)

Accompanying these interviews is the examination of documents relating to the case study, including policy legislation, scientific reports, opinion pieces in the media, and industry information.

4.4.1 Interviews

Kelly (2010) described the term ‘qualitative interview’ as an interview technique that provides textually rich data, unlike structured or standardised interviews which aim to create data that fits to quantitative analysis. Interviews offer the opportunity to fully engage with the individual persons and are able to increase the depth of responses by asking follow-up questions as needed (Opdenakker, 2006). In order to address the research objectives, the interviews were semi-structured, with prompting exploratory questions and the opportunity for the researcher to pursue different topics as necessary.

All interviews were held face-to-face at a location of the participants choosing, generally at the individual's home with some in the farm shed. The interviews were recorded using a digital voice recorder, with written permission from the participants, to allow the researcher to re-listen and transcribe the interviews at a later date. No written notes were taken during the interview, but some notes were written immediately following the interviews by the researcher to record key information or emerging themes.

4.4.2 Participant selection

It is fortunate that one of the case study's settings is one that the researcher is familiar with. Having grown up on a dairy farm on the Rangitāiki Plains, all of the eventual interview participants for this case study were familiar with the researcher's family. For this reason, obtaining access to informants was a simple process of telephoning known contacts and giving them the research information for them to decide to participate. While this streamlined access to participants was beneficial, there was also a risk of the participants feeling pressured to participate in the interview, alongside the potential development of researcher bias due to personal involvement with the informants

It is difficult to remain completely neutral regardless of familiarity with research participants. Instead of seeking complete neutrality during interviews, Taylor et al. (2015) explains that it is important to also be aware of personal perspectives and to take this into account during data analysis. To address the issue of participants feeling compelled to have an interview, the researcher made sure to confirm they were completely comfortable with their participation: participants were given control over when the interview would be held (to ensure sufficient time to withdraw if necessary) and were verbally told they could withdraw any time leading up to, and following the interview until late December 2016. In order to decrease the influence of bias during the interviews for this research, the author made an effort to ask pre-written neutral questions (see Appendix A), attempted to give complete control of the responses to the participants (in some cases further probing was required to gain a full response), and recognised the emergence of any personal perspectives during data analysis. To facilitate this it was helpful to remember Taylor et al. (2015)'s explanation that one version of reality, or an individual's behaviour and perceptions, is only one out of many potential realities. By recognising the importance of neutrality and attempting to remove bias due to the researcher's familiarity with participants in this research, the author feels confident that this study has resulted in credible research.

Interviewee selection was influenced by the participant’s availability and willingness to contribute to the study. Contacts were found through the area’s community network, with seven Rangitāiki Plains dairy farmers, six Rotorua Lakes dairy farmers and two farm consultants interviewed (see table 4.1 below). Participants in the different groups received a mixture of questions, some given to all groups, and some specific to their group (interview questions are provided in Appendix A). Due to the size and time constraints of this study, the informants do not represent all the potential perspectives of the study area. It should however, deliver an insight into a number of perceptions relating to the research question, which contributes to the wider research on social environmental science.

The interviews were completed in the Rotorua Lakes area and on the Rangitāiki Plains between late September and mid-December 2016. In total, fifteen participants were interviewed in person and recorded electronically. Table 4.1 below tabulates the participants and to which of the three participant groups they belong. To ensure anonymity, each participant has been designated a code. These codes have been used in the results and discussion chapters to refer to each participant.

Table 4.1 Research participant codes

	Description	Assigned code in text*
Participant 1	Dairy farmer, Rangitāiki Plains	1(D,P)
Participant 2	Dairy farmer, Rangitāiki Plains	2(D,P)
Participant 3	Dairy farmer, Rangitāiki Plains	3(D,P)
Participant 4	Dairy farmer, Rangitāiki Plains	4(D,P)
Participant 5	Dairy farmer, Rangitāiki Plains	5(D,P)
Participant 6	Dairy farmer, Rangitāiki Plains	6(D,P)
Participant 7	Dairy farmer, Rangitāiki Plains	7(D,P)
Participant 8	Dairy farmer, Rotorua Lakes	8(D,L)
Participant 9	Dairy farmer, Rotorua Lakes	9(D,L)
Participant 10	Dairy farmer, Rotorua Lakes	10(D,L)
Participant 11	Dairy farmer, Rotorua Lakes	11(D,L)
Participant 12	Dairy farmer, Rotorua Lakes	12(D,L)
Participant 13	Dairy farmer, Rotorua Lakes	13(D,L)
Participant 14	Farm consultant	14(C)
Participant 15	Farm consultant	15(C)
* Where D = Dairy farmer, P = Plains (of the Rangitāiki Plains), L = Lakes (of the Rotorua Lakes), C = Farm Consultant		

4.4.3 Human ethics

Data collection in this case study involved the interviewing of fifteen human participants. Even though the risk of harm to participants was perceived to be low, it was important that each participant was treated ethically, in line with the Lincoln University Human Ethics Committee guidelines. For this reason, approval was sought, and gained, from the Lincoln University Human Ethics Committee prior to the initiation of data collection. The following steps were taken to ensure the rights of the study participants were respected:

- Participants were given a research summary prior to engaging in an interview, ensuring they fully understood the research intentions and their involvement
- All participants were given the option to withdraw from the study up until 31st December 2016
- Participant identity has been kept anonymous by the use of code names within the results and discussion chapters.

No summaries of the interviews were forwarded to the participants, but the researcher's phone number was provided for any queries or requests to withdraw from the research. All private information related to participants was kept confidential, with access restricted to the researcher and the supervision team.

4.5 Data analysis

Thematic analysis was used to examine the interview data. Thematic analysis is a process of coding data, resulting in organised and descriptive information about a research topic through the identification and analysis of themes within the data (Braun & Clarke, 2006). Due to the thematic analysis potentially facilitating a wide range of themes within research data, it was important to be consistent with defining the occurrences of themes during analysis. The analytical structure used in this research project was as follows:

- *Data familiarisation*: a post-interview written summary and transcription process with repeated reading to allow immersion of the data. Notes were taken for future coding as initial themes began to emerge, aided by the theoretical framework.

- *Initial coding*: coding for as many potential themes as possible, organising data into meaningful groups.
- *Searching for themes*: once a long list of all the different codes had been created they were collated into potential themes. Tables, mind-maps and codes written on pieces of card were sorted and re-sorted into theme-piles.
- *Reviewing themes*: this step refined the potential theme groups, removing, merging or splitting groups as appropriate.
- *Defining/naming themes*: each theme was refined in terms of identifying the essence of what it represented. This phase resulted in clear definitions of the themes.
- *Writing*: to tell the complicated story of the data in a convincing way.

Coding was kept within the research scope with frequent referral to the research question, aim, objectives and theoretical framework.

4.6 Summary

A qualitative research approach was employed for this study, allowing in-depth analysis into farmers' perceptions on Overseer. The case study is in the Bay of Plenty and includes two groups of dairy farmers. One area uses Overseer for compliance and one that uses Overseer for decision-support. These dairy farmer interviews were accompanied by interviews with farm consultants from both areas. This research design means that different perceptions of Overseer's use were investigated. Data was collected by semi-structured interviews and examined using thematic analysis with reference to the research questions, aim, objectives and theoretical framework.

Chapter 5

Results

This chapter presents the results of the research. To begin with, the context of the results is explained, providing a summary of the key events which occurred prior to the interviews. The experiences and perceptions of the research participants are then described, outlining the farmers' perceptions of the implementation challenges of using Overseer for regulation, followed by questions of the model's accuracy. Farmer relationships with council staff, industry professionals, and members of the public are then described, followed by a summary of the outlook participants have for their farming future.

5.1 Results context

5.1.1 Nutrient management prior to Overseer

Before the introduction of Overseer into the Bay of Plenty area, nutrient management for dairy farming had not been commonly related to environmental issues. Participant 8(D,L) described how they had never heard of nutrient issues prior to Overseer and the announcement that nutrient losses from dairy farming were having a detrimental effect on the environment came as a surprise. Participant 14(C) referred to how in the past it had been industry practice to design waste water systems that would get rid of as much waste water as possible within consent conditions, rather than paying any attention to environmental effects. Until recently, farmers were unaware, to an extent, of any of the detrimental effects these waste water systems had to waterways. But this has changed and local industries are more aware of issues now (participant 14(C)). All 13 of the dairy farmer participants have used, and still do use, soil tests to determine appropriate nutrient applications for the season. Their reasons behind using soil tests ranged from just following industry practice, to feeling confident in scientific analysis of soil deficiencies. Participant 6(D,P) described how the dairy industry message for nutrient management was entirely focused on point-source effluent pollution: "the industry just took an overall view that if you just took 500 cows you'll produce this much effluent, so there's this much [nitrogen] and [phosphorus]" (participant 6(D,P)). More recently, the industry message has changed: "DairyNZ has gone back to grass growing, back to basics ... being more self-contained" (participant 8(D,L)). Participant 8(D,L) went on to

state that the shift into using Overseer was a given, due to the previously limited understanding of effluent treatment:

I suppose farming does need a ruler or barometer of environmental issues, we've never had [much focus on environmental issues] since 2005, I'm not aware of there ever being [any attention to nutrient losses], other than effluent management, you could not put effluent into waterways (participant 8(D,L)).

5.1.2 Introduction to Overseer

In 2005 the Bay of Plenty Regional Council (BOPRC) released Rule 11, requiring every rural property in the Rotorua Lakes area over 0.4ha to obtain a nutrient benchmark (participants 8(D,L), 9(D,L), 10(D,L), 11(D,L), 12(D,L), 13(D,L)). The dairy farmers in the catchment originally gave a catchment collective figure to the council as they “were not keen to be giving their nutrient data to the regional council” (participant 8(D,L)), but following years of discussion, in 2013 the farmers provided individual figures to the council for benchmarking. The council contracted an independent to calculate benchmarks, using Overseer to model each farm. Those who attended the public meetings about Rule 11 were able to learn about council’s intended use of Overseer for compliance (participants 8(D,L), 10(D,L), where others in the area first saw Overseer during the calculation of their benchmark. Fertiliser representatives were a main source of introduction to Overseer for farmers in both locations (participants 1(D,P), 2(D,P), 4(D,P), 9(D,L), 11(D,L), 12(D,L)). Fertiliser representatives predominantly use Overseer as a reporting tool, producing fertiliser requirements for blocks of land by calculating a nutrient budget (participant 15(C)). Participant 5(D,P) does not use Overseer with a fertiliser rep and was only made aware of the program five years ago during data input into Fonterra’s ‘Nitrogen Recording Programme’. Federated Farmers has been a source for new information to those who attend the meetings, where farmers learnt about Overseer as a new tool being developed to model farms (participants 3(D,P), 6(D,P)).

5.1.3 Dairy farming effect on the environment

Rangitāiki Plains farmers have a varied understanding on the effects dairy farming have on the environment. However, several farmers pointed out that all the water from the Rangitāiki Plains itself did not enter back into the Rangitāiki or Tarawera rivers because all farm run-off flows through a man-made canal system that empties at the coast (participants 6(D,P), 7(D,P)). For this reason, the farmers were under the impression that any farm nutrients originating on

the Rangitāiki Plains itself would not enter back into the river systems. Participant 2(D,P) made it clear he did not know his farm's effect on the waterways, with participant 1(D,P) saying it was difficult to know individual farm contributions of nutrients to water on the property due to other industries in the area. Participant 5(D,P) did not think his farm had detrimental effects, stating: "we don't adversely affect the water quality, I guess if you put it all in trees or something it would be slightly better". Participant 3(D,P) explained he was unsure about his farm's effect on river water quality, but "my biggest impact will be down into the groundwater". Participant 4(D,P) pointed out a noticeable change in the composition of soil since he's been farming on the land, where the structure had degraded with, what he thought was, an increase of phosphorus: "inevitably we're going to be having an effect, we've got to be with the sort of intensity of the farming here" (participant 4(D,P)).

Conversely, when Rotorua Lakes farmers were asked whether their farm contributed nutrients into the lake, they all agreed their farms did: "absolutely, we're part of the catchment so it has to be [affecting the lake]" (participant 9(D,L)). Many farmers believed that while there was a farm contribution, the exact amount was uncertain (participants 10(D,L), 11(D,L)): "I think they're making it a lot worse than what it is". Participants 8(D,L) and 13(D,L) pointed out that many farmers believe Lake Rotorua is phosphate limited rather than nitrogen limited, and that the nitrogen leaching off farming properties is not as detrimental to the environment. Several farmers spoke of the recent positive changes farmers have made on their properties, as a result of Rule 11 and industry changes like fencing off waterways; compared to the past, nutrient leaching from farming properties is "not as bad now" (participants 11(D,L), 12(D,L)).

5.2 Overseer implementation challenges

5.2.1 Rangitāiki Plains reactions to the prospect of regulation

Rangitāiki Plains farmers see regulations as having both positive and negative characteristics. A benefit of regulation is the identification of poor performers and forcing them to improve their farming practices (participants 3(D,P), 6(D,P), 7(D,P)). "You're always going to have farmers who don't do things right and I've always said get rid of them, prosecute them out of farming, we don't want them" (participant 3(D,P)). Participant 6(D,P) explained how regulation can provide evidence against the public's 'dirty dairying' perception by providing proof that the farmers are meeting compliance and making positive changes to the environment. Regulations were important because the majority of farmer's care about the

environment and if regulations improve this, everyone benefits (participants 7(D,P), 2(D,P), 6(D,P)). Conversely, participant 5(D,P) explained that they felt nutrient regulations were going to harm farming as it is difficult to decide who was the better farmer, and regulation could result in farmers being “pushed down” to lower intensity (and less viable) farming systems to comply with rules. This informant’s concerns were that the set of rules in regulation can be too inflexible, and often do not allow for complex differences between every farm (participant 5(D,P)).

For participants 2(D,P) and 7(D,P), their major concern is holding onto their ‘licence to farm’. Two of the farmer’s regard regulations as just “boxes to tick” (participants 1(D,P), 3(D,P)). The reaction of farmers to regulation depends on the timing of the regulation relating to high pay out years (participant 7(D,P)), alongside how quickly the restrictions are imposed and how severe the limitations are for farmers (participant 4(D,P), 7(D,P)). An important influence in making change is the driver of the change, where a farmer-led approach was seen to be more influential as they could use relevant science and take their time (participants 7(D,P), 6(D,P)): “We need to do it from our heart and not forced upon us” (participant 7(D,P)). However, farmers knew regulation is inevitable, because there are people who will never change unless forced to (participants 3(D,P), 7(D,P), 2(D,P)). When discussing the lack of environmental action from dairy farmers around New Zealand, participant 7(D,P) argued that regulations were necessary when farmers were refusing to voluntarily cut back on nutrient use: “if [farmers are] not going to lead ... for better outcomes, expect to get regulated. And if you get regulated, expect it to hurt” (participant 7(D,P)).

5.2.2 Rotorua Lakes reaction to Overseer regulation

Thus far on the Rangitāiki Plains, farmers have not been subject to any compliance requirements using Overseer, whereas Rotorua Lakes farmers are in the middle of this process and thus are more familiar with the workings of the model (participant 9(D,L)). One of the farming consultants explained that farmers using Overseer for compliance purposes are less trusting of Overseer, as they are more aware of the consequences of the model’s outputs (participant (14(C)). The farmers feel frustrated that they are being told how to farm by council (participants 8(D,L), 12(D,L), 9(D,L)), where they do not feel suitably consulted about their concerns of the impending regulations using Overseer. Farmers were also concerned Overseer will lock them into future farming consents, meaning they would be farming to Overseer with impossible targets (participants 14(C), 8(D,L), 9(D,L), 13(D,L)). “They are not going to give us a

consent to farm. The longer they take to lock the rules in... the harder it will be for people to meet targets” (participant 13(D,L)). Being locked into farming to Overseer, farmers see themselves at the whim of council staff and Overseer developers (participant 8(D,L)). Farmers are reluctant to give information because for them it appears as a show of support for the policy changes, reducing their ability to argue against the changes. Participant 10(D,L), shared that he felt forced by the council into providing information for his farm. This occurred during the addition of a toilet to his property where he was asked to provide an updated whole farm nutrient report: “having one toilet did not make any difference at all [to the nutrient losses], it was a way of them making us do it”.

One of the farm consultants described how the regional council wanted to use Overseer as a blanket rule across the area, as it is easier to implement, while saving time and money (participant 14(C)). Rotorua farmers are concerned that the nitrogen regulations from Overseer are causing inflexibility in the farming system due to a production cap (participants 14(C), 13(D,L), 9(D,L)). Participant 14(C) explained that, on average, farmers have been paid the same price for their milk for decades, but cost of production is going up, so the easiest thing to do is increase milk production.

A nitrogen cap is a production cap. Once they've achieved maximum milk production efficiency, they've got nowhere to go. Even if they put all the infrastructure in to maximise nitrogen loss reduction, at a certain point they'll get to where they can produce no more milk, without exceeding their cap ... They're trapped (participant 14(C)).

Participant 13(D,L) stated that they are at the stage of requiring significant financial investment to meet their NDA, as they've exhausted all alternative options: “we've got to a stage where we can't do any more simple changes, we have done all ... we can to reduce leaching” (participant 13(D,L)).

While farmers are unhappy with the use of Overseer modelling for nutrient regulation, they acknowledge there is no current alternative (participants 14(C), 9(D,L)). Farmers also do not want to have nutrient input regulations, as this fully restricts farmer's options (participants 14(C), 9(D,L), 12(D,L)): “If we got rid of Overseer the only way of controlling this is input control, totally prescriptive farming. Totally inflexible” (participant 14(C)).

Explaining a positive change in the area, participant 14(C) told how the district council has had a rule change, employing an incentive scheme allowing farmers to sub-divide off pieces of land

if they change land use on another part of their property. If a farmer changes 10 hectares of land from dairy to dry stock, he can sub-divide off one lifestyle block and if the farmer retires 10 hectares from dairy to trees, he can sub-divide off two blocks. This is expected to incentivise farmers to retire unsuitable dairy land into natives, to benefit financially from converting an area into sub-division and selling the land (participant 14(C)).

5.2.3 Getting around the numbers

Three different ways of getting around the numbers in response to Overseer regulation were discussed by the farmers, the first being altering a farm's nitrogen allowance through the purchasing of additional land with a high nitrogen allowance. If this land is then amalgamated into the current dairy platform, the overall nitrogen allowance for the farm will be increased (participant 9(D,L)). The second method involves forward thinking to influence future nitrogen allowances for a farmer's property. Prior to the introduction of any regulation, farmers are able to manipulate their farming systems to influence grand-parenting benchmarking measurements. Participant 5(D,P) explained how, currently, he sees farmers in non-regulated regions reducing their farm inputs in order to look more environmentally-friendly during benchmarking, but he has advised neighbours and friends to overstate their nutrient inputs. Overstating nutrient inputs means that benchmarking data will be higher than usual, with a high baseline, providing more flexibility in the future if there are tighter restrictions for nutrient management. The benchmarking process in the Rotorua Lakes used this grand-parenting technique for the years 2001 to 2004. Because the farmers had not been introduced to the idea of benchmarking prior to 2005, they were not able to manipulate their figures to achieve higher benchmarks (participant 8(D,L)). Similar to participant 5(D,P)'s idea, those in the Waikato have been aware of impending changes and have been able to increase nitrogen inputs like fertiliser, feed, and stock numbers onto their farm (participants 5(D,P), 8(D,L)). There is an incentive to manipulate Overseer data to your advantage, where slight differences in monthly stock numbers and dates for fertiliser use can make a significant difference to the farms nitrogen budget (participant 3(D,P), 11(D,L)). For those using Overseer for decision support, reasons for giving incorrect data include lack of time, lack of accurate record keeping, and lack of perceived importance (participants 1(D,P), 2(D,P), 3(D,P), 5(D,P)). Participant 3(D,P) described how fertiliser representatives sometimes alter Overseer to suit their interests: "I know for a fact that fert[iliser] rep[resentatives]s do that, you know. Spits out a figure at the end that they don't like, so they go and tweak some of the inputs". However,

those in the fertiliser industry cannot assume their Overseer forecast report to be accurate because while farmers may receive a volume of fertiliser for a certain period due to the recommendation, the farmers can use the fertiliser at their own discretion (participant 15(C)).

5.2.4 Future farm checks

A significant concern held by farmers was how the regional council is going to police farm compliance. Not every farmer is honest (participants 1(D,P), 5(D,P), 15(C) and these farmers believe that every farmer needs to be held accountable for their individual actions. On the Rangitāiki Plains, farmers are aware they are not being held accountable by regional council for nutrient losses and as a result, farmer nutrient management in the past has been substandard (participants 1(D,P), 3(D,P)):

I just think what's the value of it ... because we're not being held to task on it. If that day ever comes that we were held to task, [farmer nutrient management] will change (participant 3(D,P)).

In the Rotorua Lakes area, farmers feel there needs to be equal supervision from the council to make sure all farmers are meeting their nutrient obligations, not just dairy farmers (participants 15(C), 12(D,L), 13(D,L)). Farmers question how compliance will be measured in the future if councils are failing to do so now for the farm plans: “they are not going to have the man power ... will just check on you from time to time?” (participant 12(D,L)). Referring to the level of policing Fonterra does for ‘best practice management’, farmers feel like there is no incentive to make changes: “I find it a joke ... they don't come around and inspect, they don't do anything” (participant 13(D,L)).

5.3 Farmer issues with Overseer

5.3.1 Fairness

Unfair focus on dairy farming

Rangitāiki Plains farmers are concerned about the level of environmental focus on the dairy industry and the resultant regulatory implications. When asked about their thoughts on their farm's contribution to declining freshwater quality, most farmers also brought up questions surrounding the role other industries play in this and the lack of regulation those industries are currently facing (participants 1(D,P), 2(D,P), 3(D,P), 4(D,P), 5(D,P), 7(D,P)). Farmers identified timber treatment plants, car yards, forestry projects, urban areas, dams and quarries as industries contributing to environmental degradation: “look at the Rangitāiki River,

we've got three hydro schemes on it. You can't tell me as a dairy farmer I have to worry, I think there's bigger fish to fry" (participant 3(D,P)). Participant 6(D,P) explained it was unfair (and incorrect) to assume that dairy farmers do not care for the environment, because in reality, it is also in a farmer's best interest financially to care for their land: "most farmers ... don't want to be putting nutrients down the drain. There's a cost to it" (Participant 6(D,P)). Farmers also mentioned the history of the Rangitāiki Plains, where it has been drained from a swamp in the early 20th century (participants 6(D,P), 7(D,P)). In the farmer's opinion, green, productive farmland is a better alternative to "swampy water" (participant 7(D,P)). Building on this, participant 5(D,P) explained that regulatory bodies have to balance the practicalities of restricting the agriculture industry, as the benefits of the industry to the country are significant.

Rotorua Lake farmers believe the expectations on increasing the water quality of the lake are unfair. When asked whether he thought the lake needed improving, participant 9(D,L) replied that the lake had never been a scenic, clear lake:

I'm old enough to have swum in it in the 1960's and it's always been a muddy lake ... but people don't swim in muddy water anymore ... expectations of swimming water have changed (participant 9(D,L)).

Farmers stated that they agreed with improving the water quality of the lake, but the confidence that regulating dairy farmers would achieve this was flawed and unfair (participants 9(D,L), 10(D,L)).

Similar to the Rangitāiki Plains farmers, Rotorua Lakes farmers voiced concerns over, what they felt was, an assumption that dairy farmers are to blame for the degradation of the lakes in the area. Participants 10(D,L), 11(D,L), 12(D,L), 13(D,L) all mentioned the inadequacies of public sewerage systems in the area, where until recently, for 60 years' raw sewage from Rotorua city had been pumped into the lake (participants 10(D,L), 13(D,L)). Participants 10(D,L), 12(D,L) explained that the city's sewage was now transported into a designated area in the hills, which has quickly become saturated and farmers are aware of the possibility that this sewage could leach back into the lake. Farmers also discussed how urban settlements immediately surrounding Lake Rotorua have recently had sewerage system upgrades from septic tanks (participants 10(D,L), 11(D,L), 12(D,L), 13(D,L)). Participant 12(D,L) questioned the fairness of the upgrade as they had been asking the council for "20 years on and off ... about doing something about [farmer's septic tanks]", to no avail. When participant 12(D,L) went to

council about connecting their private sewerage system to the new system they were told “the treatment plant only has a certain amount of capacity”, raising questions of fairness when the councils were also encouraging the growth of “new subdivisions and hotels, 600 bed hotels” in the areas surrounding the lake, which would all require space at the sewage treatment plant. Participant 12(D,L) felt that the priority given to other industries in utilising new sewerage infrastructure was unfair because farmers are being focused on to reduce nutrient losses from their properties while other industries are benefitting from tax payer developed infrastructure. Building on this, participant 10(D,L) vented his frustrations that following the recent upgraded sewerage system, the water quality of Lake Rotorua has significantly increased, but the blame remains on dairy farming in the area. He believes that it has been contributions from urban areas that have considerably diminished water quality. Questioning the fairness of targeting dairy farmer’s participant 10(D,L) stated:

I don't know how farmers have done it in the last 10 years, because they say what happens on my farm takes 50 years to get to the lake. Why is the lake so clear now? ... They've always said that the way dairy farmers were in the area it was going to be an eighty-year process before it came right (participant 10(D,L)).

Farmers feel like they are not wanted in the area where urbanisation is growing in previously rural areas (participants 10(D,L), 12(D,L), 13(D,L)), highlighted by the event where a councillor (since departed) “stood up in a meeting and said “ I’m going to get rid of you bastards”” (participant 13(D,L). Participant 8(D,L) gave another example of council wanting to reduce dairy farming in the area by promoting conversions into Manuka bee, nuts, goats, and sheep farming. “They’re all viable to some degree, but they’re not as economic as dairying. They’re asking the current generation of dairy farmers to take that economic loss” (participant 8(D,L)).

Unfair use of Overseer

The farmers in the Rotorua Lakes voiced concern over the fairness of using Overseer in the area for compliance purposes, due to the model’s uncertainty. Beginning with the benchmarking years, farmers felt that bad farmers were rewarded, while environmentally conscious farmers were unfairly punished (participants 10(D,L), 12(D,L)).

They measured what you were doing between 2001-2004 ... the end result was that the very careful farmer had a much lower NDA than the guy who is putting on fertiliser [more often] ... [a neighbour] did all the right things, he had low fertiliser to begin with and so now has a low NDA, he won't survive on that NDA (participant 12(D,L)).

Looking ahead, farmers pointed out it was unfair to rely solely on Overseer for compliance, where farmers would be taken to court and fined using Overseer, because the model contains significant inaccuracies (participant 11(D,L)). “The council are still using [Overseer] as a tool for compliance. That's where it's so unfair because at the end of the day, it isn't accurate. So they're making rules that we have to farm by, based on inaccuracies and it affects our livelihood, it affects our work, not only the worst thing, it affects the value of our farm” (participant 13(D,L)). Farmers felt that Overseer simplified their farming practice, not allowing for the complexities of trying to measure a biological system (participant 12(D,L)). Farmers also believe it is unfair that councils do not consider the financial strain of altering farm plans as Overseer updates between versions, changing NDA targets (participants 10(D,L), 12(D,L)). There are financial consequences of farming to a changing model: “we’re having to make a lot of financial decisions to something that may work and it may not work” (participant 10(D,L)).

Participant 9(D,L) discussed the unfairness of Overseer facilitating council’s reliance on nutrient figures for compliance. Using the term “anchoring”, participant 9(D,L) described the tendency of council to rely heavily on each farmers’ NDA figure, where Overseer is assumed to be precise enough to calculate a single number which represents each farm.

When you put somebodies [NDA figure] and say “OK that’s what you have to meet”, when the reality is the range around [the number] represents the reality of what’s going on within a biological system, where [for example,] it rains more one year than the next, doesn’t justify you looking at a figure as precise as that (participant 9(D,L)).

The farmer continues to describe the unfairness of potentially being measured and prosecuted using the numbers: “it’s the nature of the beast, it’s come down to figures” (participant 9(D,L)). Building on this idea, participant 9(D,L) explained the same tendency to regulate with figures was seen in the sustainable nitrogen load calculations for the lake, finding 435 tonnes as the target: “actually It could be anywhere from 400 to 700 as being a quite reasonable sort of figure, [but council says] “we’ve divided that 435 and that’s your part of it, that’s all you’re allowed” (participant 9(D,L)).

5.3.2 Data and science credibility

The accuracy of the numbers and processes which are embedded in Overseer are an area of concern for both case study sites. Rangitāiki Plains farmers had queries about how Overseer came up with the numbers for complex processes (participants 1(D,P), 6(D,P)), and whether

they were applicable to their farm in particular (participants 3(D,P), 5(D,P)). Participant 5(D,P) also explained that while they thought Overseer was representative of their farm, a lot of time was required to gain this accuracy, which farmers did not have. “I think there’ll be less than 50% of farms who put in accurate information” (participant 5(D,L)). When asked to share their opinion on what most Rangitāiki Plains farmers thought of the future with Overseer, one farmer concluded that accurate science is the most important aspect of Overseer’s success: “science is the answer, we have to have the science ... the farm is the lab, I do trust scientists” (participant 7(D,P)). While farmers voiced general concerns over Overseer’s uncertainties, digging into the minute details of Overseer is not “high on the priority list ... not on the radar” (participant 3(D,P)), as they were not needing to meet regulations.

Farmers in the Rotorua Lakes have a negative reaction to using Overseer because they do not think it is accurate enough to be used for compliance. One farmer spoke of an example where three different certified Overseer users produced reports for the same properties containing vastly different results:

I went to three different consultants and a fertiliser representative and ... the lowest [nutrient calculation] was 20 kg/ha lower than the highest one. I gave him the same folder of information” (participant 11(D,L)).

Farmers were very concerned over the accuracy of both Overseer’s figures and the science behind the sustainable load of Lake Rotorua, which is used as the backbone to calculate nutrient regulation for land owners and allocate their Nutrient Discharge Allowance (NDA) figure (participants 8(D,L), 9(D,L), 13(D,L)). Participant 8(D,L) pointed out:

We’ve always argued that Lake Rotorua is phosphate limited, not nitrogen limited. The scientists have actually now, in the last 6 months come around to agree with us. It’s really obvious in the fact that [aluminium sulphate] is actually controlling the water quality of the lake (participant 8(D,L)).

Many farmers were in support of Overseer’s value as a decision-support tool (participants 14(C), 8(D,L)) as “Overseer is very good for measuring change” (participant 9(D,L)). However, there are too many assumptions surrounding the data to be seen as accurate for compliance requiring absolute figures (participants 14(C), 9(D,L)). Farmer’s questioned the accuracy of the science behind determining groundwater catchment boundaries (participants 8(D,L), 14(C), 13(D,L)). The Lake Rotorua Primary Producers Collective (LRPPC), an organisation of local

farmers aiming to advance the interests of those in the catchment, had a meeting with council scientists. "it was "I guess", "I think", "maybe", "we assume", those were the words used by the scientists the whole time. There was actually no hard evidence" (participant 13(D,L)). The LRPPC brought in external scientists to review the council report in which they stated: "we don't understand how [the council scientists] have come to these conclusions" (participant 13(D,L)). The farmers are concerned about the accuracy of the science that underpins the estimating of the groundwater catchment zone, because it would significantly affect their Overseer figures, as they believe part of their land is outside the groundwater boundaries for Lake Rotorua (participants 8(D,L), 13(D,L)). Farmers also feel that council staff are unable to clearly communicate different aspects of Overseer and answer the farmer's queries about the science behind it: "council have as much or more difficulty getting their head around it than we do as farmers" (participant 12(D,L)).

Overseer's use of S-Map data was also seen as too inaccurate for regulation purposes: "Soils maps that we use are done at a scale of 1:50000, S-maps online, we're trying to ... break farms up on a 1:50000 scale, when the actual farm is on a 1:5000 scale" (participant 14(C)). Other inaccuracy frustrations included assumptions with the pasture clover content variable within Overseer, where users can choose between low, medium, high, or very high (participant 14(C)). Farmers explained that clover content in pasture was important for influencing nitrogen figures (participants 8(D,L), 9(D,L)), but clover content was difficult to measure accurately, leaving users to use the medium default level. This was an issue because: "it can make a big difference... if you go to very high clover content you almost double your nitrogen leaching" (participant 14(C)). Further accuracy issues are due to Overseer generalising important inputs like rainfall and soils, where one block or property can vary significantly (participants 14(C), 13(D,L)). Participant 13(D,L) explained on their property: "it's 2.1 metres per year down at the bottom of this farm, and at the top of the farm it's 2.6 meters. That's half a metre difference. How do they take that into consideration? The accuracy is in question". Overseer uses rainfall data from the G.P.S. coordinates of the dairy shed, but the shed could be located anywhere on the farm (participant 14(C)). Participant 13(D,L) sums up their frustration with having to go into detail with some of Overseer's inputs, but still end up receiving a high level of uncertainty:

You're calculating everything to seven decimal points, and then all of a sudden you're going plus or minus 10% contingency. It just doesn't

make sense. Yeah it is the accuracy of Overseer we are concerned about (participant 13(D,L)).

Farmers are frustrated that they are having to make significant farm system changes using inaccurate outdated science, and want the council to invest in more ground monitoring (participants 8(D,L), 9(D,L), 13(D,L)).

5.3.3 Overseer version changes

Concerns about the accuracy of Overseer arise from the model's regular updates, where farmers lose trust in the model's ability to model their farm (participants 3(D,P), 7(D,P), 8(D,L), 9(D,L), 10(D,L), 11(D,L), 12(D,L), 13(D,L)). Even though there are no regulatory consequences for farmers in the Rangitāiki Plains, they find it concerning that the model can alter their figures overnight (participants 3(D,L), 7(D,L)). While there is frustration, farmers also acknowledge the importance of updating and improving the model to follow science (participant 6(D,P)). Farmers in Rotorua echo that Overseer has become more accurate than in the past (participants 8(D,L), 9(D,L), 11(D,L)), but because they are having to make farm system decisions based on their Overseer figures, the version changes are costing them time and effort (participants 14(C), 8(D,L), 9(D,L), 10(D,L), 11(D,L), 12(D,L), 13(D,L)). Participant 9(D,L) gave an example:

I got a phone call [from the consultant] to say I'm looking at the figures again and it looks like you're not even compliant with your benchmark ... Another phone call a couple of weeks later saying it's okay, we've got a new version out, get back to [what you were doing]' (participant 9(D,L)).

Farmers base their system decisions for the whole season on keeping within their nutrient regulation limits. Participant 8(D,L) described a similar scenario when the Overseer version changed overnight: "Instead of being 5 points away from our NDA target, we were 15 away. We just gave up, we thought what's the point?". Participant 10(D,L) voiced the same opinion stating their response to the version changes is: "It doesn't matter what we do, they're going to keep changing it anyway". Participant 14(C) further explains that in the Rotorua area, due to changes in the model, environmental farm consultants are likely to be required to re-visit all farms in the Rotorua area to re-do nutrient management plans prior to applying for a farming consent in 2017, in accordance with plan change 10. It takes over 12 months for many of the nutrient mitigation plans to be created by farmers and consultants (participant 10(D,L)),

the potential of redoing everything: “destroys all the model’s credibility and faith in the regional council” (participant 14(C)).

5.3.4 Distance from the data

With a few exceptions, most of the dairy farmers from both study sites do not have any hands-on experience with using Overseer to model their farm. Rangitāiki Plains farmers spoke of a general lack of understanding how Overseer works among farmers in the area. Participant 2(D,P) explained that due to Overseer not being required for anything beyond decision-support currently, he hadn’t pursued researching the model “I haven’t had the desire to find out. It’s such a science”. Building on this idea of Overseer being a ‘science’, participant 7(D,P) told of donating two full days to gain a brief understanding of the model. Participant 6(D,P) has a working idea of Overseer, but spoke of spending “a hell of a lot of time in the office”, where trying to suggest the same for most farmers is like “dragging a squealing pig to slaughter”. When asked what happens to their Overseer reports, most Rangitāiki farmers spoke of filing them out of sight unless: “Shelved ... No one’s bothered to refer to it since, to be honest and a shame to say. Nobodies got to the point of asking us to justify what we’re doing” (participant 4(D,P)). Farmers on the Rangitāiki Plains are also concerned about Overseer’s lack of incorporating real-time data from their own recordings. Farmers would like to see the many different farming programmes (fertiliser purchases, irrigation data etc.) syncing to one another, resulting in more accurate figures and representation of their farm (participants 6(D,P), 7(D,P), 3(D,P)). Farmers also acknowledged the difficulty of getting information about the workings of Overseer, where there was a lack of communication between the council, industry and farmers about current developments and future changes (participants 1(D,P), 4(D,P), 5(D,P)).

Speaking about the level of understanding farmers have of Overseer, one of the farm consultants stated that “for compliance purposes, for the individual farmer, 99% of farmers don’t know how to use Overseer. For the actual farmer, they’d need to get somebody in to do the modelling themselves” (participant 14(C)). Rotorua Lakes farmers feel that they need to understand how Overseer works because their farming future depends on it: “Overseer from my perspective was never a powerful tool, it’s only since we’ve gone into the nutrient aspect that it’s certainly increased in mana. And coupled with that, the frustration that we have is that for us to be able to focus on nutrients on farm, we need to know how Overseer works” (participant 8(D,L)). Participant 9(D,L) described his lack of understanding when it came to

working with council-appointed consultants: “I’m not up to speed in terms of its use. [I have] been alongside consultants as they put the data in, but then it becomes a black box”. Farmers spoke of being so detached from Overseer due to the complexities of the model, changing regulations, and the frequent version changes (participants 8(D,L), 9(D,L), 10(D,L), 12(D,L)): “the rules have changed so many times that I’ve just lost interest in it, I don’t really care now how it all pans out because things have been changing so much” (participant 10(D,L)). Participant 10(D,L) went on to explain that he avoids trying to understand what his number represents, leaving it to his farm advisor to understand the details:

I am not really interested in the number; my farm advisor says we are right now to farm [at the moment] and I’m just happy with that. He said everything’s all right. If he’s happy with it, then I’m happy with it (participant 10(D,L)).

Describing concern of using Overseer to justify actions worried participant 12(D,L) as they are not familiar enough with Overseer to defend their actions:

We are going to be spending half our time justifying, or worried that someone is going to ask us to justify why we’re doing it, and if we’re not really cognizant with Overseer and how it works ... how are they going to understand? (participant 12(D,L)).

Farmers are frustrated that regional council is not giving them enough time to fully understand the changes to regulation or the Overseer model itself (participants 8(D,L), 9(D,L), 10(D,L)). Talking about the differences in farmer regulation acceptance relating to where the regulation is coming from, councils were seen to be heavy handed and making quick changes: “we’re doing what we’re asked of, it just takes a little bit of time, I don’t know what they want from us” (participant 8(D,L)). When discussing the extent of farmers understanding the reason for Overseer’s updates, farmers vented their frustration over the reasons behind the frequent changes. While Overseer is continuously updating with science coming from different industries, Rotorua Lakes farmers perceive there may be more focus on improving the model from a regulatory point of view, rather than a farming systems point of view (participant 8(D,L)). Participant 8(D,L) and 13(D,L) both spoke of seeking independent training on using Overseer, stating “we need help to play around with it, [we] need guidelines” (participant 13(D,L)) and “we need to make on-farm decisions and tweak the system, so that what comes out the bottom end is more positive”(participant 8(D,L)). Participant 8(D,L) also spoke of “flying blind” where requests to council on farmer Overseer training days were never followed

through, potentially to council's advantage: "they felt that if we had that little bit of knowledge, it might create more problems". Looking forward, farmers acknowledge there's going to be a need for better understanding of how Overseer works as a tool for people trying to manage their NDA (participant 9(D,L)).

5.4 Overseer and farmer working relationships

5.4.1 Trust in authority

In the Rangitāiki Plains, dairy farmers spoke of having a mostly positive relationship with the regional council (participants 2(D,P), 3(D,P), 4(D,P), 6(D,P)), and being fortunate to live in an area that has this. The council were not seen as heavy handed when authorising effluent, irrigation and water takes, rather they were "only doing their jobs" (participant 4(D,P)) and seemed "quite reasonable" (participant 3(D,P)) during interactions on these issues.

In comparison, farmers in the Rotorua Lakes revealed they feel distant from the regional council (participants 8(D,L), 9(D,L), 10(D,L), 11(D,L), 12(D,L), 13(D,L)), citing a lack of understanding, distrust, and a lack of communication. There is frustration at what has been described as council pushing their weight around and blowing actions out of proportion (participants 9(D,L), 10(D,L), 12(D,L)). For example, participant 12(D,L) described ringing council to inform them of minor farming changes that might've affected their effluent consent conditions, which resulted in unnecessary alarm due to a lack of farm systems knowledge: "they may be intelligent people, but they are not farmers" (participant 12(D,L)). Concerns were also raised that while the banking sector plays an important role in all farmers' future planning (participant 12(D,L)), council does not appear to consider farmer mortgages, and their influence on making system changes in response to regulation (participant 10(D,L)). There is also confusion among the Rotorua farmers about what the council does with any of the data collected from farmers (participants 9(D,L), 10(D,L), 12(D,L), 13(D,L)). It would appear that this confusion is caused, in part, by frequent employment changes at the council where new staff have different understandings of the regulations, resulting in different interpretations of information relayed to farmers: "it says one thing in the proposed rules about compliance to the actions, and they are actually starting to say another thing on a query basis" (participant 9(D,L)). Farmers also feel like council is too inflexible on adapting plans to new scientific findings (participants 14(C), 8(D,L), 9(D,L), 13(D,L)). This is coupled with many other examples of council being unwilling to shift its views on past scientific findings: "council are so pig

headed, the science is clearly wrong because it's not stacking up with what the lake is actually doing ... but they won't accept it" (participant 11(D,L)). Rotorua Lakes farmers hold a more negative future outlook than those on the Rangitāiki Plains, where in their opinion, any improvements to Overseer and science in general are unlikely to change the view of the council, which is inflexible on the current plan (participants 8(D,L), 9(D,L), 11(D,L)): "politicians, being the way they are, won't change, and we'll have to meet it" (participant 9(D,L)).

5.4.2 Private agendas

Fertiliser representatives are the main source of information for nutrient advice, through the formation of fertiliser recommendations using Overseer, for many of the Rangitāiki Plains farmers (participants 1(D,P), 2(D,P), 4(D,P), 7(D,P)). It was noted by some farmers how important it was to recognise that fertiliser representatives are not as invested in the farm as a farmer would be; they had an agenda to sell fertiliser (participants 2(D,P), 3(D,P), 6(D,P), 7(D,P)). Participant 3(D,P) has sought independent advice for fertiliser recommendations on his farm: "there was just some doubt that we were getting totally [un]biased recommendations". The result after a few years of obtaining independent advice was a reduction in fertiliser use, but higher cost in management fees. It was important for some farmers to get a second opinion of the farm's fertiliser recommendation through a farm advisor, who were seen to hold a balanced opinion on soil issues, grass growth and animal health (participant 2(D,P)). Two farmers, participants 1(D,P) and 7(D,P), stated that it was difficult to retrieve information about environmental and nutrient management developments from their fertiliser rep.

Many farmers spoke of following the industry message and attempt to alter their farming systems in response to changing messages from the industry. Farmers in both catchments pointed out the swinging behaviour of the dairy industry's message in the past decade in response to environmental issues (participants 7(D,P), 8(D,L), 9(D,L)), where:

A decade ago it was all about ... increase[ing] production: more nitrogen, more pasture, more cows. The message changed very quickly, all of a sudden there was a panic about the amount of nitrogen being used (participant 8(D,L)).

Participant 2(D,P) noted that there is often a backlash from farmers towards the Fonterra on these matters as: "Fonterra is there to manufacture and market our milk and our milk products and not there to tell us what to do". However, he then explained it was beneficial for Fonterra

to advise and develop sustainable farming practices, alongside information from fertiliser representatives as: “if everyone’s working for the same goal, it’s got to be good”. It was noted by other farmers in the Rangitāiki Plains area how Fonterra was continually improving the dairy farming image (participants 3(D,P), 5(D,P)).

Rotorua Lakes farmers value their fertiliser representatives for offering advice from a farming systems point of view, and have often worked with the same representatives for years (participants 8(D,L), 10(D,L)). Fertiliser representatives spend more time with the farmers and due to their history of knowledge about the individual farm, are able to input a lot of the data independently: “what we do with the fert[iliser] rep is simple” (participant 8(D,L)). Participant 13(D,L) described how fertiliser representatives in the area were inundated with work at the moment and they were displeased having to work with a different consultant. That doesn’t mean to say all farmers take what the fertiliser rep says at face value, participant 10(D,L) noted that while they are more involved with their fertiliser rep, this also meant they were able to analyse their fertiliser recommendations more carefully.

There are seven regional council-approved farming consultants in the Bay of Plenty which farmers can choose from to plan farm nutrient management reports (participant 8(D,L), 11(D,L)). These farming consultancies are able to receive grants from the regional council if they promise to offer relevant research using local farmer’s data and plans. There is a perception from farmers of being trapped with certain consultancies, where all a farmer’s data since 2005 is with a singular consultant. The farmer would be required to start from scratch with another consultant if they wanted a change. Participant 8(D,L) described this as: “a blackmail situation” where they feel forced to provide information to their current consultant on request, as they do not have the time to change consultancies. Farmers acknowledged how important it was to choose who you used to work your farm figures with, where there’s a feeling that consultants are influenced by monetary grants rather than the farmers’ best interests (participants 8(D,L), 9(D,L), 11(D,L), 12(D,L)). “To be quite blunt, they don’t care whether the farmers go bust or not” (participant 9(D,L)).

5.4.3 Information-sharing between neighbours

On the Rangitāiki Plains, farmers reported that knowledge-sharing between farming neighbours has been beneficial for improving their farming practices (participants 6(D,P), 7(D,P), 2(D,P)). Participant 2(D,P) explained how shared farmer knowledge was, in his mind,

the cause of the dairy industry's success: "we don't compete with our neighbours in farming ... we freely tell people how much our accountants cost us, or how our tractors run, that information is just so available, which is wonderful for our industry". Alongside sharing knowledge and advice among neighbours is the showcasing of management techniques and new technologies. Participants (6(D,P) and 7(D,P)) reported that they, among many others in the area, had hosted numerous field days on their properties to share information about successful farming technologies. Building on this, participant 7(D,P) described visiting farms with alternative management strategies and witnessing positive changes to neighbouring farms as a result of shared knowledge. Physically witnessing changes to surrounding farms or hearing information about farming properties similar to theirs was influential for making farm system changes (participants 7(D,P), 6(D,P), 2(D,P)). Another aspect of this influence was revealed by participant 6(D,P), who described how he recently made a point to seek advice from other farmers, alongside agricultural scientists. The farmer wanted other farmers to 'peer review' his investigations into a system change for his farm, resulting in the development of a significant piece of farming infrastructure. In terms of sharing Overseer information between neighbours, none of the farmers reported having shared their nutrient figures with neighbours in the past, with participant 3(D,P) explaining that doing so is not high on the priority list compared to other farming matters. Most of the interviewed Rangitāiki Plains farmers (participants 5(D,P), 4(D,P), 2(D,P), 1(D,P)) voiced interest in seeing how their nutrient figures compared with their neighbours in the future. In particular, participant 5(D,P) commented that he would be interested in discussing Overseer among neighbours because he was currently "sceptic that you could create a model that's going to be of great benefit".

Similar to the Rangitāiki Plains, information-sharing between Rotorua Lakes neighbours for some people is seen as a valuable tool for improving farming systems and technology (participants 8(D,L), 9(D,L)). Discussing the extent of information sharing between Rotorua Lakes farmers, participant 8(D,L) described how for many farmers in the catchment, the main source of shared communication is the Lake Rotorua Primary Producers Collective (LRPPC). The LRPPC aids information sharing and organises funding for projects that will benefit farmers (with the sustainable farming fund project recently sponsoring a phosphate mitigation project on a local farmer's property). Participant 8(D,L) described how in the past, the LRPPC analysed some of the member's Overseer figures and discussed the mitigation options as a group. The only example of farmers sharing their Overseer figures external to the LRPPC was

the mention of a field day by participant 9(D,L), where farmers gathered at a property to discuss nutrient management strategies and individual figures were compared by some participants.

While some farmers have been attending meetings about Overseer held by the LRPPC for over a decade (participants 8(D,L), 10(D,L), 13(D,L)), the sharing of Overseer figures between individual farmers outside of the LRPPC appears to have been limited so far (participants 9(D,L), 10(D,L)). Some farmers in the Rotorua Lakes were more hesitant to discuss their Overseer information with neighbours (participants 11(D,L), 12(D,L)). The reasons for this varied, with participant 11(D,L) suggesting that many farmers in the area held negative views when discussing Overseer stating: “the problem with farmers is most people pick things apart, [they have a] ‘that won’t work for me’ negative vibe”. Participant 11(D,L) explained that the same negative opinions were evident during discussions and field days on mitigation technologies and management systems from neighbouring farms. It would appear some farmers in the Rotorua area prefer to avoid Overseer discussions with neighbours due to this negativity, with one farmer explaining that it was easier to keep it to yourself and just prioritise gaining individual compliance for your farm rather than investigate your neighbour’s issues. Participant 12(D,L) revealed that they were currently compliant but were withholding this information from their neighbours. They explained that under the compliant farming system they were currently running, but their farm was unprofitable. They were concerned how their farm could move forward financially. For this reason, they were reluctant to discuss their concerns with neighbouring farmers, as these farmers were just concerned about getting their farm compliant. Even though their farm was potentially unviable, sharing their compliant figures ran the risk of “sound[ing] cocky” where there would be no sympathy from neighbouring farmers. Participant 12(D,L) then described their situation as similar to an experiment where their farming direction could be used as a warning to their neighbours: “if it’s not going to work for us, it’s not going to work for them”. In contrast to this, participant 9(D,L) highlighted the need to share Overseer figures and relating farming systems to result in “drilling down and finding out what particularly has made that difference [between complaint and non-compliant farmers]”. He explained that it helps everybody to have a dialogue where farmers pick out successful elements of different farming systems and move forward with nutrient losses and positive economic outcomes.

5.4.4 The rural-urban divide

The relationship between urban and rural dwellers was found to be an area of contention for farmers in the Rangitāiki Plains and Rotorua Lakes. Farmers commented that those living in urban areas do not appreciate the importance of the dairy industry to New Zealand's economy (participants 14(C), 6(D,P), 7(D,P)). In big cities like Auckland they perceive that there is a detachment to rural areas and any understandings of rural issues; people are less likely to have contact with those living rurally and have opportunities to visit dairy farms (participants 4(D,P), 6(D,P)). This was summed this up as follows:

Urban people don't give a toss about farmers, especially Auckland City. There's a major lack of understanding on the importance of New Zealand agriculture to the New Zealand economy. If we make all these changes to farming and they no longer become profitable, what do we do with all this land? (participant 14(C))

Farmers felt like those who lived in urban environments are less likely to respond positively to farming practices they do not understand (participants 12(D,L), 9(D,L)). Farmers felt a lot of the bad publicity comes from the media which groups all farmers together (participants 14(C), 4(D,P), 5(D,P), 3(D,P), 10(D,L), 13(D,L)) and allow out-spoken environmentalists like Mike Joy to present a persuasive view on the negative sides of the industry (participant 6(D,P)). It was perceived that because urban populations are greater, their opinions are louder and hold more influence over national policy decisions which in turn can negatively influence farming futures (participants 6(D,P), 11(D,L), 12(D,L)). Farmers also discussed the perception of successful and "rich dairy farmers" often portrayed in the media (participants 14(C), 3(D,P), 6(D,P), 11(D,L)), resulting in a lack of empathy from those living in urban areas. In order to change public perceptions surrounding dairy farming, participants from both groups suggested that better stories need to be told about the positive things farmers are doing for the environment (participants 3(D,L), 5(D,P), 6(D,P), 9(D,L)). In saying this, participant 3(D,P) thought that the rural-urban divide was relatively small in the Rangitāiki catchment, which could be attributed to many of the farms being several generations old and always being an important part of the community and local economy.

I think Whakatāne, Kawerau and Opotiki are well aware their fortunes are tied to the dairy farmers, they're not going to bite the hand that feeds them (participant 3(D,P)).

A farmer from the Rotorua catchment (participant 9(D,L)) commented further on this, describing the uncommon situation of the areas surrounding the Rangitāiki Plains remaining relatively undeveloped, but felt it is only a matter of time until those from urban areas begin making noise.

5.5 Looking ahead: future fears

5.5.1 Rangitāiki future

Most farmers on the Rangitāiki Plains believed Overseer regulations were in the near future (participants 1(D,P), 3(D,P), 4(D,P), 5(D,P)): “It’ll get more regulated I’d imagine, we just want to keep [our] licence to farm” (participant 5(D,P)). Participant 4(D,P) described how farmers in the area were “very concerned, you’d be nuts if you owned land and were not” but then went on to explain how farmers often exaggerate the severity of policy changes due to the speed at which they are introduced. He believed regulations will have a limited effect on farmers who are already environmentally conscious:

Farmers protest all the time that they are guardians of the land and supposedly water quality. I don’t think there’s too many guys actively going out of their way to be off-hand about this sort of thing, it just depends on how quickly and how severe limitations are imposed (participant 4(D,P)).

Participant 5(D,P) spoke similarly to this, where it just took time for farmers to accept the regulation “it did seem outrageous in other places around New Zealand, but eventually the farmers have started coming around”. Participant 6(D,P) held the most optimistic view of using Overseer, explaining that “if you can start using it to demonstrate what you’re doing, I think that [the council will] work with you, everyone will work with you”. Participant 6(D,P), who is privy to what’s happening in areas already regulated in New Zealand describes the Rangitāiki Plains as being “asleep ... we think people are less aware environmentally, but we’ve got this big water issue now, working its way through the district”. “There’ll be a day of reckoning. Once they’ve sorted that Lake Rotorua out, look out. There’ll be a league of people coming this way” (participant 4(D,P)).

5.5.2 Overseer: the wrong path?

There are two significant concerns for the future, the first being that after making irreversible farm systems changes, it will become apparent to regional council that Overseer is incorrect and will be thrown out. The second concern is that it will be found that Overseer is inadequate

and will be replaced by an entirely new system for managing nutrients (participants 14(C), 7(D,P), 13(D,L)). One of the farmer consultants, participant 14(C), summed this concern with the statement:

Overseer modelling may show that they're compliant now, but down the track they're not. And they've possibly spent a lot of money on something which will not be enough to meet compliance. Or conversely, that they find they never needed to spend that money [in the first place] (participant 14(C)).

Alongside this is the potential that: "all these things are based on the assumption that Overseer is correct. If it's not, if there's a flaw in the model, we can make all these changes unnecessarily" (participant 14(C)). Both of these concerns worry farmers because they both could result in unnecessary, expensive farm system changes.

Chapter 6

Discussion

The aim of this study was to examine how perceptions of Overseer have changed with its shift from a decision-support tool to a regional council compliance tool and the implications for farm nutrient management. The study's objective has been to examine the role standardisation through numbers plays in forming perceptions regarding Overseer. Overseer was designed to be used as a qualitative decision-support tool, analysing the benefits of different fertiliser use, stock rates and farm management practices. With the shift to its use in compliance by regional councils, Overseer has quickly switched to become a quantitative regulatory tool, producing numbers which advise council staff whether farms have met compliance according to set limits. With this switch has come higher stakes for dairy farmers. This study found that Rotorua Lakes farmers feel that they need to understand how Overseer works because their farming future depends on it: "Overseer from my perspective was never a powerful tool, it's only since we've gone into the nutrient aspect that it's certainly increased in mana. And coupled with that, the frustration that we have is that for us to be able to focus on nutrients on farm, we need to know how Overseer works" (participant 8(D,L)). It has been shown that when Overseer shifts from decision-support to being used for compliance, the numbers it produces change meaning, becoming a representation of the farmer's performance. Although the numbers might be the same in both contexts, Overseer's shift to be used as a compliance tool has gone from standardising the farm, to standardising the farmer.

In this chapter, the results of the fieldwork in chapter 4 are linked to the theoretical framework described in chapter 2. To begin, the role of numbers, power and authority, perceived fairness, and the relationship to data production are explored to analyse the issues farmers face in accepting Overseer. This is followed by revisiting the work of Wynne (2013, p. 302) and his "lay criteria for judgement of science" and relating the research case studies to his ideas about public science acceptability. These criteria, along with other concepts, are used to bring together the theory and case study, highlighting the significance of credibility by analysing the social identity of farmers and their relationships to authority, and how this affects their perceptions towards the regulators of Overseer. Addressing the aim of this research, the

perception farmers have of Overseer is a key influence in their acceptance of nutrient regulation and adoption of sustainable nutrient management practices.

6.1 Acceptance of Overseer

6.1.1 Trust in numbers: the incentive to standardise

Numbers by themselves are assumed to be neutral and objective, and able to accurately describe the environment without serving any interests, promoting any agendas or persuading individuals (Stone, 2002). The use of Overseer to represent a farm system has the added benefit of being able to provide a representation of nutrient outputs in the form of a number, thus allowing the outputs of the Overseer model to be used for policy. Timmermans and Epstein (2010) describe standardisation technologies as aiming to portray legibility through governance, which is what Overseer seeks to do when it is used for compliance. Standards do not exert any power unless they are used and enforced across social domains (Timmermans & Epstein, 2010). Achieving this power for regulation purposes over social domains and distance requires methods that are easy to apply, thus the use of Overseer for nutrient management.

Busch (2011) explains that standards are important because they facilitate order and stability in a complex world. The complicated interactions and combination of multiple values ascribed to the environment can be ordered and resolved by standards, bringing clarity and control. Overseer embeds modules (which standardise climate, soils, farm practices etc.) resulting in an ordering of complex farming processes and the creation of more parameters for quantification. The use of Overseer by council in the Rotorua Lakes area represents a filter type of standard. Filter standards are designed to separate the acceptable from the unacceptable, where farmers in this area are either compliant or not compliant with pre-determined nutrient allowance discharge numbers. The regional council is expecting Overseer to produce numbers for nutrient management on a wide scale, providing a quantitative 'limit met' or 'limit not met' answer for nutrient output compliance. This research found that those being regulated by Overseer, i.e. dairy farmers, would prefer qualitative descriptions or singular standards in order to alter management practices as necessary to meet overall compliance. Singular standards describe the processes relating to why they fail to meet compliance and what strategies can be used to fix them.

6.1.2 Power relations and authority

Lampland and Star (2009) describe how standards can exert uneven levels of power across different social landscapes. Individuals are more likely to follow the requirements of a standard if it is deemed important and has come from a place of authority. For example, people are likely to follow options beneficial to their own interests, but if there are penalties for going against a standard, they are more likely to follow the rules and put their interests aside. The incentive of avoiding penalty and following the standard can result in a reduction in opportunities to be creative. Busch (2011) explains this characteristic of standards as containing the ability to empower and disempower people. When conceptualizing Overseer as a collective of standards which have the capacity to control what farmers do, farmers in both areas were concerned that Overseer was limiting innovation in their individual properties and in the industry. Rotorua farmers spoke of being worried about ever reaching their NDA targets, investing in new technology or making significant farm system changes could be seen as too risky, because meeting NDA targets at any means necessary is a priority. This can also be described as farming to Overseer. One of the greatest frustrations felt by Rotorua Lakes farmers is the prospect of being locked in to the ostensibly arbitrary movements of Overseer through their farm consents, resulting in farmers farming to Overseer. Participant 14(C) explained that, on average, farmers have been paid the same price for their milk for decades, but the cost of production is going up, so the easiest thing to do is increase milk production. However, when regulated by Overseer, a “nitrogen cap is a production cap. Once they’ve achieved maximum milk production efficiency, they’ve got nowhere to go. Even if they put all the infrastructure in to maximise nitrogen loss reduction, at a certain point they’ll get to where they can produce no more milk, without exceeding their cap ... They’re trapped” (participant 14(C)). The Rotorua farmers are aware of this possibility, because they are the ones living this reality. They feel like decision-makers are not taking this potentially constrained future into consideration and not realising that by farming to Overseer, farmers are feeling they will soon have nowhere to move. Because the penalties for not meeting NDA targets are potentially severe, farmers have no choice but to abide by the numbers, regardless of their opinion; the level of power Overseer and its associated NDA numbers now have in a regulatory environment are deemed as controlling and inflexible.

6.1.3 Keeping Overseer fair

Scott (date) argues that people do not react well to being standardised in particular by government-led processes that assign numbers to people for purposes of imposing simplicity which is perceived by those subject to standardisation as taking away their individualism. This theme of social identity came through strongly in the research. It is described in more detail in section 1.2 below, but to summarise: farmers feel as though their social identity as specialists in their particular environment is under threat from the use of Overseer by government. Stone (2002) describes that when the distribution of resources is perceived as unequal, community spirit can diminish from the imbalance. Feeling part of a wider group or community is essential to understanding social identity of individuals. The reduction in community spirit is caused by individuals feeling like they have less in common with their neighbours, or have been 'picked-on' unfairly by authorities (Stone, 2002). The results are less trust between neighbours, and community division. With policy that aims to allocate nutrient output allowances, as Overseer is being used to do, it is important that individuals deem the process of distribution as fair, with an equal share amongst resource users. If the process is seen to be unfair, conflict between the community can result in a dismantling of trust in the regional council.

Both groups talked about the unfairness of Overseer and an expanding rural-urban divide occurring in their area and around the country where there is a lack of understanding between urban and rural dwellers. Respondent 14(C) summed this up as follows: "urban people don't give a toss about farmers". The perception of farmers is that because urban populations are large, their opinions are louder and hold more influence over national policy decisions which in turn, can negatively influence farming futures. Rotorua Lakes farmers are concerned that if they follow the current scientific advice led by Overseer they may be being led towards unnecessary farm-systems changes which make their farm business unviable. Farmers expressed the view that Plan Change 10 is trying to undermine farming in the Rotorua area. The farmers mentioned how undesirable it was for the council to support the industry when the land is more valuable for other uses. Wynne (2013) describes a case study where farmers feel subjected to "socioeconomic threats such as subordination to tourism ... and authorities who appear to be more and more concerned with meeting environmental and urban recreational demands on the country than with ... farming" (p. 286). This idea of 'prioritizing farming last' echoed through interviews with farmers in the Rotorua Lakes area. Farmers

talked about the regional council's focus on tourism and urban growth in the region, highlighted by the event where a councillor (since departed) "stood up in a meeting and said "I'm going to get rid of you bastards" (participant 13(D,L). The farmers gave other examples of the council trying to reduce dairying by discussing the promotion of conversions into manuka honey farms, nuts, goats, and sheep farms, alongside nutrient-limit reduction incentives for farmers to sub-divide their land for residential purposes. While these ideas for regeneration may seem reasonable from the outside, farmers were less keen: "They're all viable to some degree, but they're not as economic as dairying. They're asking the current generation of dairy farmers to take that economic loss" (participant 8(D,L)). These Rotorua farmers feel like the process of mitigating nutrient loss is unfair, where council is prioritizing other industries over dairying and encouraging land use change, rather than working with dairy farmers to encourage better farm management practices.

Another area of concern discussed by farmers was the unfairness, and risk to council, of completely relying on only Overseer to calculate and manage nutrient numbers. Wynne and Shackley (1994, p. 8) use the term "truth machines" to describe an over-reliance on models in decision-making when their outputs are controlled by their inputs (which could be inaccurate) and assumptions (which could turn out to be wrong). This idea of the use of models as truth machines is useful for understanding responses from both farmer groups. They were concerned that council are intent on using Overseer as the only regulatory tool for measuring nutrient losses. Rangitāiki farmers spoke of relying too heavily on Overseer being one of their greatest concerns, articulated by participant 3(D,P) who stated: "I just hope they do not have their blinkers on and that they make Overseer the bible, because it isn't". Rotorua Lakes farmers held similar concerns, using a different phrase "[council] have latched onto [Overseer] and have said it's our holy grail and it's not" (participant 11(D,L)). Farmers are concerned about the regional council using Overseer as a truth machine where the flexibility of tailoring management plans to individual farms can become compromised, resulting in a high level of trust being placed on a computer model rather than 'real-life'. Farmers require flexibility in their farming practices due to the unpredictable behaviour of agri-environmental systems and potentially very specific processes that affect their farm. For example, Overseer uses a three year rolling average to calculate nutrient figures, but farmers are concerned that climate fluctuations, among other environmental and farm parameters, do not follow the same scale and could negatively impact their NDA numbers and any resulting requirements

for farming system changes. In another case on the Rangitāiki Plains, Overseer was found to over-estimate nutrient losses for a farm that utilises modern technology that is currently beyond Overseer's capabilities to calculate. This farmer used in-situ metres and laboratory tests to determine nutrient levels and was concerned with the discrepancies between the two. This farmer, along with another on the Rangitāiki Plains hoped that the regional council would be willing to accept alternative measurements they had done and paid for themselves, but were not optimistic.

The unfairness of using Overseer for compliance was discussed by farmers in Rotorua, using the term 'anchoring'. Participant 9(D,L) described the tendency of council to rely heavily on each farmers' NDA figure, where Overseer is assumed to be precise enough to represent a complicated process using a single numeric figure. In reality, a farmer's NDA figure fluctuates continuously due to processes out of a farmer's control (i.e. rainfall) and farmers feel it is unfair for council to focus entirely on Overseer's nutrient figures. Regulatory bodies may find it easier to think of Overseer as 'all-knowing' because of its extensive use and history as a decision support tool. However, all aspects of standardisation can be vulnerable to disruption from new variables (Porter, 1995). This is where unmeasurable or difficult to measure variables often become invalid or highly controversial as they fail to fit into the right, prescribed standards. Farmers from both groups spoke of the regional council relying too heavily on Overseer which they perceived to be unfair, where the ability of Overseer to accurately represent their farm, by itself, was seen as impossible.

6.1.4 The certainty trough

MacKenzie (1990)'s certainty trough is useful for understanding farmers' perceptions of alienation, exclusion, and detachment in the process of creating the scientific knowledge that sits behind Overseer. The certainty trough describes a transition of certainty about an idea or technology from moderate uncertainty, to low uncertainty, to high uncertainty as you move further away from the site of knowledge production. For Rangitāiki Plains farmers, for whom the stakes are currently low, there is currently a lack of incentive to analyse the specifics of Overseer and expend the time to dig into the detail. This has resulted in a feeling of detachment from the model for many farmers, where they hold less concern for the application of Overseer for regulation. Rotorua Lakes farmers also feel detached from Overseer because they feel like they were not involved in the development of the regulations that rely on it, have not had any input into what information goes into the model, and do not

fully understand how to use the model. Using MacKenzie (1990)'s certainty trough, different perceptions of Overseer can be plotted to show their level of perception of uncertainty in relation to their distance from the knowledge production of Overseer. Figure 6.1 identifies the scientists at point (A), regional council staff at (B), Rangitāiki Plains farmers at (C) and Rotorua Lakes farmers at (D), in terms of their perceptions of how uncertain Overseer is. It can be seen that council staff (b) and RP farmers (c) are caught in what MacKenzie describes as the certainty trough which is in the centre of the graphic where uncertainty is lowest.

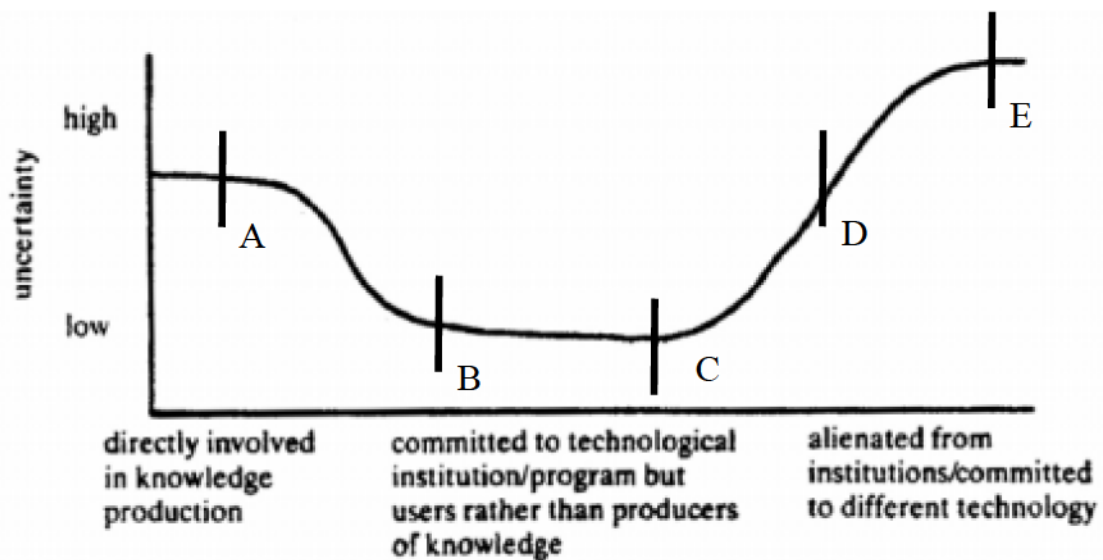


Figure 6.1 The certainty trough with research case study plots (source: (MacKenzie, 1990, as cited in Duncan, 2008, p. 56))

Those directly involved in the production of the science for Overseer itself, shown as point (A) in figure 6.1, have not been analysed in depth for this research, but are likely to be aware of the uncertainties surrounding Overseer (Overseer, 2016). This awareness is evident in the regular model updates, where Overseer's processes are restructured and new information is added. These scientists and modellers directly involved in the knowledge production process are aware of inherent uncertainties and the assumptions required to attempt to characterise a complex agri-environmental system.

Regional council staff (B) include all those employed in the application of Overseer in regulating nutrient outputs in the case study areas. It is important to note that council scientists are not involved in the production of knowledge for Overseer. Rather, they are focused on the application of the model to the specific conditions of the area being regulated. These scientists are involved in processes that investigate which areas should be regulated,

what nutrient limits can be expected to be acceptable for farms, and the desired outcomes for water quality (Arbuckle, 2015). Alongside council scientists, other council staff interact with farmers and include those working in compliance and regulation. The regional council staff are committed to using Overseer to regulate nutrients in the area, as directed by central government and included in their own regional plans (Arbuckle, 2015). Rather than being knowledge producers for Overseer, they are knowledge users – users of the model for regulation. Situated in the middle of the figure, in the certainty trough, perceptions of uncertainty related to Overseer are at their lowest (and certainty is perceived to be highest) compared to the different groups on either side. Council scientists are distant enough from the site of knowledge production that they are unaware of or unconcerned about Overseer’s limitations and assumptions. This positioning of council staff explains why Rotorua Lakes farmers feel that council staff are unable to clearly communicate different aspects of Overseer and answer the farmer’s queries about the science behind it: “council have as much or more difficulty getting their head around it than we do as farmers” (participant 12(D,L)). Reiterating Duncan (2008), in this case the council staff’s distance from the production site of the science that sits behind Overseer has resulted in a lack of intimate connection with the experiments that inform the science and knowledge surrounding Overseer’s parameters and any implications of the results. Hence, a relatively low level of uncertainty is perceived for these actors situated in the certainty trough.

Fertiliser representatives are shown as point (C). Similar to the regional council, but further away from the source of knowledge production, these actors are direct users of the technology. Fertiliser representatives are more likely to be fully committed to using Overseer and have the highest levels of perceived certainty. For example, it was stated by participant 15(c) that “The benefits are huge in the sense that we can measure what's going on and what's coming out... if the information put in is correct, the science continues [to develop and be] calibrated, it's a wonderful tool”.

Moving further to the right of the certainty trough reaches point (D), where I have plotted the Rangitāiki Plains dairy farmers. Along with point (E), the Rotorua Lakes dairy farmers, this section of the trough represents a range from high to very high levels of perceptions of uncertainty (i.e. low levels of certainty) surrounding the science and application of Overseer. The level of uncertainty perceived by Overseer’s producers (point (A)) include numerous scientific assumptions and as predicted by MacKenzie (1990), these uncertainties are used as

opposition by the farmers (points (C) and (D)) facing regulation by Overseer. Discontent about the model's certainty has resulted in a repeated call for more "good science" from farmers (participants 7(D,P), 8(D,L), 9(D,L), 13(D,L)) where they are aware of the model's limitations and assumptions. MacKenzie (1990) explains that those situated in this area will feel alienated from the proposal, technology or issue under investigation. These concerns were expressed by both groups in this research in terms of authorities overstepping their boundaries. While they do hold some concerns about the certainty of Overseer, the Rangitāiki Plains farmers are not placed very high on the right of the trough due to the lack of regulation in the catchment, resulting in lower stakes and a lack of incentive to understand Overseer. For Rangitāiki Plains farmers digging into the details of Overseer is not "high on the priority list ... not on the radar" (participant 3(D,P)).

Rotorua Lakes farmers on the other hand are placed much higher in terms of their perceptions of uncertainty, which can be directly attributed to Overseer's influence on farming practices under regulation, resulting in higher stakes for farmers in this area and far more incentive to dig into the detail. There is concern from Rotorua Lakes farmers of not being able to justify and defend their farming actions to regulators due to not understanding how Overseer works. As explained by participant 12(D,L): "we are going to be spending half our time justifying, or worried that someone is going to ask us to justify why we're doing it, and if we're not really cognizant with Overseer and how it works ... how are they going to understand?" These farmers feel frustrated because they do not trust those in authority and do not understand what information is being used to regulate their farming practices. Some Rotorua Lakes farmers asked for Overseer training days but this was not offered by council, leaving a sense of detachment and distrust in council, questioning council motives for not encouraging farmer training days. Illustrating the level of distrust, one informant maintained "... if we had that little bit of knowledge it might create more problems" (participant 8(D,L)). There are clearly feelings of alienation. Plotting these perceptions across the certainty trough illustrates how perceptions of uncertainty vary with distance. While perceptions of certainty surrounding Overseer is high among its producers and users, the understanding of the model itself is low.

6.1.5 Improving the science of Overseer

Jasanoff (1990) explains that there appears to be an unspoken presumption in policy science that improving the scientific understanding of a problem will lead to the creation of better policy. However, it is unwise to assume that reducing scientific uncertainties automatically

increases the approval of the science itself. Using an example of updating safety standards for suspected carcinogens by the United States government, Jasanoff (1990) described how regulatory decision-making “highlights uncertainty, polarizes scientific opinion, and prevents efficient resolution of disputes about risk” (Jasanoff, 1990, p. 8). Attempts to increase scientific accuracy can lead to an emphasis of previous inaccuracies held to be true and a focus on disputes among scientists relating to the scientific information and associated risks. While farmers acknowledged the importance of updating the science in Overseer, from their perspective there are financial consequences of farming to a changing model: “we’re having to make a lot of financial decisions to something that may work and it may not work” (participant 10(D,L)). Farmers feel like they are being directed by scientists down a blind alley in which costly complications to their farm’s management practices may occur, using inaccurate numbers which may change. Due to the continuous reopening of Overseer’s black box, which effectively occurs when the model is updated, Rotorua farmers are frustrated with the constant changes, feeling as though the model was working against their farming practices. Alongside accuracy, farmers would prefer a degree of stability in order to make seasonal farming decisions.

A ‘black box’ describes a complex scientific or technical process for which inputs and outputs may be known, but the internal mechanisms which drive the inner processes and derive the outputs are not accessible and hence not fully understood. In the pursuit of accuracy for policymaking, the creators of Overseer are continually revising and updating the science. Overseer is a black box; Overseer’s inputs include the figures relating to stocking rate, average rainfall, and soil types, and the outputs include various nutrient emissions, leaching, and runoff figures from a property. The internal workings which take the input figures and calculate the output figures are hidden from the view of the user. Chapter 2 discussed a series of decisions Latour (1987) described during confrontation with a black box: “Do we take it up? Do we reject it? Do we reopen it? Do we let it drop through lack of interest? Do we make it more solid by grasping it without any further discussion? Do we transform it beyond recognition?” (pg. 29). While the continued updating of technology aims to foster scientific credibility, it can invalidate the old technology as it appears inaccurate when the new is introduced. The interviews revealed that Rotorua farmers are choosing to reject Overseer’s black box, frustrated by its continual updates, adding to their concerns surrounding the accuracy and credibility of the model. Each model update highlights the inaccuracies of the

previous version, potentially disputing any farm-system changes the farmers may have initiated and calling into question potential future changes. decisions.

6.1.6 Maintaining objectivity with Overseer

To reflect on Porter (1995)'s reference to objectivity, the use of numbers and rules in regulation is expected by governments to foster a process removed from bias and self-interest. From these insights, objectivity can be seen as a key goal of any environmental model as high levels of precision and standardised measurement theoretically resolve trust issues across distances as parties can be confident that decisions have not been made arbitrarily and they can feel they are being treated fairly. In reality, farmers interviewed for this research revealed low levels of trust in Overseer to fairly represent their farm in an objective manner, mechanical or otherwise. The significance of farmers perceptions of objectivity relating to distrust in Overseer can be explained using Busch (2011)'s notions of objectivity, where objectivity is a product of:

- The ability to measure things precisely
- Avoiding human subjectivity by using non-human measurement techniques
- The emergence of standards from a community of practitioners
- Respecting the outcomes of environmental processes.

When applied to Overseer, the first notion is not achieved and is evident from the numerous controversies surrounding inaccuracies of the science and data systems that operationalise Overseer. Speaking to Rotorua Lakes farmers and a private consultant working alongside these farmers revealed that the most significant concerns were related to Overseer's use of S-Map, which they believe extrapolates important soil data from a limited pool of research. Participant 14(C) explained the issues with Overseer's soil measurements: "Soils maps that we use are done at a scale of 1:50000, S-maps online, we're trying to ... break farms up on a 1:50000 scale, when the actual farm is on a 1:5000 scale". Another one of the farmer's substantial concerns was connected to Overseer's method of calculating rainfall for the property, where Global Positioning System (G.P.S.) coordinates are taken from each farm's cowshed, but: "it's 2.1 metres per year down at the bottom of this farm, and at the top of the farm it's 2.6 metres. That's half a metre difference. How do they take that into consideration?"

The accuracy is in question” (participant 13(D,L). Both of these examples describe the application of generalising methods to calculate processes that highly influence the outcome of Overseer’s numbers. This frustration is summarised by participant 13(D,L) with: “you’re calculating everything to seven decimal points, and then all of a sudden you’re going plus or minus 10% contingency. It just doesn’t make sense. Yeah it is the accuracy of Overseer we are concerned about”. Explained by the two examples above, farmers perceive that Overseer’s ability to measure their farms precisely is impaired. The farmers are being standardised by Overseer through being represented by a figure used for compliance. Overseer’s inability to demonstrate precision weakens the farmer’s perception of the model’s suitability as a regulatory tool.

Busch’s second notion that encourages objectivity is removing human subjectivity and bias from measurement techniques by employing computers and models. In this case, Overseer fulfils this criterion with its internal processes utilising the same calculations for every farmer. What undermines this objectivity and what farmers focus on, is the subjectivity involved with inputting the data into Overseer. Acknowledging the fact that Overseer owners have attempted to overcome user subjectivity by releasing a ‘Best Practice Data Input Standards’, and many regional councils only accept nutrient reports created by certified nutrient advisors. Rotorua Lakes farmers spoke of different certified users producing reports for the same properties containing vastly different results.

I went to three different consultants and a fertiliser representative and ... the lowest [nutrient calculation] was 20 kg/ha lower than the highest one. I gave him the same folder of information” (participant 11(D,L)).

In the area using Overseer for decision-support, a Rangitāiki Plains farmer also spoke of witnessing a fertiliser representative manipulate Overseer figures for the fertiliser representatives’ best interests (i.e. to sell more fertiliser). Here, farmers saw subjectivity in the inputs of Overseer, rather than the internal processes of the model itself. Furthermore, both groups of farmers witnessed subjectivity in the measurements of their properties from the model outputs, resulting in a lowering of trust in Overseer to be used objectively for compliance.

The third notion describes how objectivity is created through reaching consensus within the relevant community of experts. Farmers consider themselves to be experts within their own

realm (Wynne, 2013), and Rotorua Lakes farmers feel as though they were left out of the decision making process for the rules that rely on Overseer. From their perspective, the use of Overseer cannot be objective as they perceive that farmer knowledge is lacking, where only scientific information and opinions are represented in the knowledge that sits behind Overseer. This idea of being 'left out' was questioned further by participant 8(D,L), who noted that they believed Overseer version updates were initiated by council requests for streamlining the regulatory processes. Farmers feel as though there is greater focus on model improvements from a regulatory point of view, rather than a farming systems point of view. Farmers are focusing on the contextual factors surrounding Overseer rather than the model itself, where they feel that any improvements to the science overlook farmers and is for intended for regulation not farming. This shows that a focus on improving the accuracy of Overseer will not resolve these issues of distrust.

Busch's fourth notion of objectivity describes the conformity of theoretical concepts to environmental processes. In other words, does the theory match reality? Rotorua Lakes farmers feel that the use of Overseer portrays a simplified version of the real farming environment. In reality, Overseer cannot reflect the real world. Overseer will only ever represent a world which follows the set of standards encoded into the model by its producers. Porter (1995) describes how scientific data input from the scientific community, who influence data based on scientific consensus, maintains a degree of objectivity due to the institutionalised norms of science it must follow. For Overseer, measurers inputting data have discretion in their choice of parameters. As long as there are government actors, who are focused on policy rather than science and farming, directing the data Overseer uses to represent farms, objectivity cannot be achieved. Rotorua farmers perceive government bodies as interfering with the production of "good science" for Overseer (participants 8(D,L), 9(D,L), 13(D,L), 14(D,L)). As a result, farmers have a lack of trust in Overseer, where the model's science has been subjectively influenced to suit the authoritative bodies rather than represent, what farmers perceive to be, real life.

6.2 Regulation relationships: remaining credible with Overseer

Looking at the wider picture of perceptions relating to Overseer, the greatest differences between Rangitāiki Plains farmers using Overseer for decision-support, and Rotorua Lakes farmers using Overseer for compliance, is that Rotorua Lakes farmers have a more negative perception of Overseer and this appears to be because they stand to lose more from its

outputs. Rotorua Lakes farmers are one step ahead of Rangitāiki Plains farmers in that they perceive the pressures of being standardised by the model, whereas Rangitāiki Plains farmers are only aware of possible changes in the future and have not felt compelled to start digging into the specifics of the model. In this case, looking at the differences in the social realm of each farmer group provides more understanding of how farmers are likely to perceive the use of Overseer, to which I now turn.

Taking Wynne (2013)'s conception of public responses to scientific knowledge, perceptions of trustworthiness are closely linked to assessments of the credibility of the knowledge or policy regimes reliant on science. In other words, public understanding of scientific knowledge is not only dependent on the potential level of understanding of technical information, it is also influenced by perceptions regarding the trustworthiness or credibility of the institution providing the information.

As already discussed, the social identity of farmers is an important factor in understanding how farmers' encounter and engage with scientific knowledge. By taking the focus away from individual's technical understandings of scientific knowledge, this research has attempted to explore the social identities that characterise public responses to the science that underpins regulations. Trust and credibility emerged as key themes in the development of perceptions to the use of Overseer by farmers, shaped by the working relationships between farmers and council staff, council scientists, private consultants, members of the public, and industry workers. Using Overseer as either a decision support or compliance tool was found to have an effect on these working relationships, and vice versa, in which both the existing and development of relationships have shaped the responses to Overseer.

6.2.1 Social trust relating to model acceptability

Wynne (2013) describes how perceptions of trustworthiness and credibility of institutions disseminating knowledge is paramount to how people engage with that knowledge. Wynne also highlights how social relations and identity-negotiation are evolving processes that can affect an individual's ability willingness to engage with and accept information (Wynne, 2013). Chapter 2 introduced Wynne (2013)'s set of seven criteria that are presented as central to the public acceptance of scientific information. The seven criteria are discussed below:

Criteria 1: Does the scientific knowledge work?

For Rangitāiki Plains farmers, they do not have any regulation-induced incentives or imperatives to check the accuracy of Overseer's predictions or how it calculates the numbers. Investigating the accuracies of Overseer is not important to these farmers and they are able to spend more time on other farming matters. The farming consultant, participant 14(C), explained that because these farmers used Overseer for decision-support to indicate trends in nutrient losses, they looked at the bigger picture and did not feel compelled to look specifically at the models uncertainties or be concerned about its inner workings. Dairy farmers are likely to appreciate the help Overseer offers for decision-support, as it helps them make decisions about what actions to take using the numbers as guidance. For the most part, these farmers felt that Overseer adequately represented their farm for what they were using it for.

Conversely, Rotorua Lakes farmers hold significant concerns on the accuracy of Overseer. Their fears are significant because the ability to profitably run their businesses could be undermined by a model that appears to produce numbers which are too inaccurate and cannot adequately represent their farming system. Farmers mentioned specific examples of imprecise data including the soil map data layer, rainfall assumptions, and groundwater catchment boundaries. However, the most notable inaccuracy examples were those which unfold following Overseer version changes. Version changes occur overnight, usually once every six months, and automatically update farm nutrient budgets resulting in an increase or decrease in nutrient output predictions. According to farmers, Overseer is seen to be imposing order and control over their ability to farm how they see fit. The typical features of certainty and control expected from science have not been experienced by farmers using Overseer; farmers believe that the current regulations that use Overseer aim impose significant control over the management of the farm, where rather, farmers believe what is needed is flexible adaptation in an uncertain world is necessary.

Rangitāiki Plains farmers do not have specific examples of how Overseer misrepresents their farm. In contrast, Rotorua Lakes farmers have more invested in the numbers Overseer produces. Rotorua Lakes farmers have spent more time on investigating the assumptions and inaccuracies Overseer employs to represent their farm. Rotorua Lakes farmers perceived Overseer to be more inaccurate than Rangitāiki Plains farmers, and held greater concerns

about these inaccuracies due to the higher stakes they had in the numbers it produced to represent their farm.

Criteria 2: Do scientific claims pay attention to other available knowledge?

Focusing this criterion solely on Rangitāiki Plains farmers, they feel as though the council and scientists are ignoring farmers' knowledge of different farm practices and avoiding working with farmers who have a better understanding of real world practices (participants 6(D,P), 7(D,P)). This is why some Rangitāiki farmers are concerned that their identity as farmers will be compromised by Overseer in the future. Currently, the only Overseer reporting these farmers currently do is thought of as a "box to tick" (participants 1(D,P), 3(D,)) for Fonterra. There is minimal prospect of regulation from this exercise and farmers think of it as a nuisance rather than a threat to their farming practice. Looking ahead, farmers spoke of wanting to "keep [their] licence to farm" (participant 5(D,P)), where future regulations with Overseer could shift from 'boxes to tick', to boxes to live by. While Rangitāiki Plains farmers voiced concerns for their farming future, at present they are not concerned enough, i.e. the stakes are not high enough, to fully invest in exploring the problems of Overseer in detail.

Criteria 3: Does scientific practice pay attention to other available knowledge?

Addressing this criterion towards the events unfolding in the Rotorua Lakes catchment, the farmer here articulated the perception that Overseer is destabilising their identity as a farmer. Farmers feel that council scientists have left them out of the decision-making process, ignoring the knowledge they have of their local environments. An example of the disagreement in knowledge between farmers and council scientists was explained by participants 8(D,L) and 13(D,L) where the new assumption that groundwater and surface water boundaries are the same, was disputed. The farmers believe that council have over-estimated the extent of the boundaries to include properties which are in another zone, incorrectly including additional land under the Overseer regulations. These farmers pointed out that they know surface water from these farms does not run into the lake; they bear physical witness to where the water runs every time it rains on the property. Participant 13(D,L) recalled a council scientist coming onto his property when Rule 11 was introduced in 2005 to confirm the surface water movement into a different catchment. This information is not accepted by the council, who continue to regulate these additional areas within the rest of the lake catchment. Farmers perceive these encounters as their knowledge being ignored which results in farmers feeling

as though their social identity as specialists in their particular environment is under threat by Overseer regulations.

Criteria 4: Is the form of the knowledge as well as the content recognizable?

The significance of knowledge and content is described by Wynne (2013) as how lay people acknowledge the degree of certainty expressed by scientists and those in authority. Rangitāiki Plains farmers have had limited experiences with being affected by council science and appear confident in council's ability to handle Overseer regulations. There is some concern regarding Overseer's representation of individual farms, but farmers were found to consider that a problem of model application rather than limitations of the model. For example, participant 5(D,L) stated "I think there'll be less than 50% of farms who put in accurate information", due to a lack of interest in sacrificing valuable time to correctly input the data.

Farmers in Rotorua hold on to the fact that council scientists have pushed through regulations using science that the farmers understand is incorrect. Consequently, farmers do not trust the science used by council. An example of this rejection of science is shown when revisiting the groundwater catchment boundaries conflict with Rotorua Lakes farmers. The uncertainty surrounding the boundaries has resulted in an undermining of scientist's credibility with farmers, due to the lack of proof the scientists have been able to give farmers. Participant 13(D,L) described a situation during a meeting with council: "it was "I guess", "I think", "maybe", "we assume" ... there was actually no hard evidence". Farmers consider Overseer as part of the package of inaccurate science within multiple policies; there is a general lack of trust towards many things the regional council enforce.

In this situation described above, farmers felt like the council had exaggerated the certainty of the science, where in reality, as far as farmers are concerned, the science was uncertain and not accurate enough to be used for regulation. This is what Wynne (2013) describes as the "reflection of the culture and institutional form of science, not of what specifically it claims to know" (p. 209). This tension described by Wynne (2013) can be attributed to how farmers' knowledge conflicts with the typical scientific idiom of prediction and control. Farmers are accustomed to working with complicated, uncertain circumstances in which sudden changes in the environment or farm system require suitable adjustments to farm management. Scientific processes aim to produce accurate predictions and control over the environment or processes, which is discordant with the reality of farmers who need the capacity for flexibility

and adaptation in farming practices. Examples like the one described above, where council staff have been unable to convince farmers of their scientific certainty, have resulted in a contradictory loop of negative perception of farmers towards authority, separated into two concepts of which Wynne (2013) names the “conspiracy theory” and “arrogance theory” (p. 290). Supported by the perception of threat to social identity, both result in negative perceptions towards regulators. Because the farmers believe that their knowledge is accurate, the conspiracy theory suggests that council scientists are aware the science they are using is incorrect and have an agenda against the farmers (see criteria 6). The alternative option, the arrogance theory, is that council scientists are unaware that they are incorrect, and therefore inept to control farmers who hold more knowledge about the environment they are attempting to regulate. These concepts describe a lose-lose scenario for increasing farmer confidence in council, and trust in Overseer.

Criteria 5: Are scientists open to criticism?

Wynne (2013)’s criteria here looks into whether scientists are willing to accept that they have made mistakes and whether they would be willing to use alternative methods of regulation or incorporate other ideas into their models. What separates the two farmer groups is how they perceive the future outlook, with Rangitāiki Plains farmers, participants 3(D,P) and 6(D,P), speaking positively of wanting to work alongside council with Overseer and use their own data to shape future nutrient regulations. They were confident in council’s attitude of accepting farm-specific data which may contradict Overseer. These farmers feel this way about council due to past experiences where regulations have been flexible enough to change on a case-by-case basis: “my dealings with regional council, if you can provide factual information on the effect on your property, it’s very easy to get on with them and get what you want” (participant 6(D,P)). These farmers feel assured that council’s use of Overseer will not be heavy-handed, and unlikely to be detrimental to their ability to farm as long as they have options to supplement Overseer with their own data, as needed. This positive outlook is summarised by participant 6(D,P): “if you can use [Overseer] to demonstrate what you’re doing, I think [council] will work with you, everyone will work with you”.

Having used Overseer for regulatory purposes for over a decade, Rotorua farmers feel differently about council accepting alternative information, feeling trapped by the impending regulations. Again taking the groundwater-surface water catchment boundary issue, farmers felt as though council were unwilling to listen to their opinion. Unlike in the past, no council

staff had returned to the Rotorua farmer's property to physically witness surface water movements, or had been able to supply substantial scientific evidence to explain the councils reasoning. This is coupled with many other examples of council being unwilling to shift its views on past scientific findings: "council are so pig headed, the science is clearly wrong because it's not stacking up with what the lake is actually doing ... but they won't accept it" (participant 11(D,L)). Participant 8(D,L) described how after many years of farmers arguing against the science stating Lake Rotorua was nitrogen limited, "[council] have actually now, in the last six months, come around to agree with us". Farmers are concerned that council is too slow in their ability to accept alternative information, refusing the farmers' knowledge that could improve the benefits of nutrient management.

Criteria 6: What are the social/institutional affiliations of experts?

Decision-making is never without some form of bias. According to Jasanoff (1990), policy compromises a trade-off between health and environmental risks, and economic and social costs of regulation. Because it is difficult to accurately estimate the values of each trade-off, it is nearly impossible to guarantee whether regulators are objectively making policy decisions, or being swayed by political inclination and judgement.

Both case study groups spoke about the importance of 'the industry message', where farmers were influenced to alter their farming practices as suggested by the industry players such as Fonterra, DairyNZ and fertiliser companies. What stood out was that some Rangitāiki Plains farmers mentioned a degree of distance felt by farmers to these messages, where the top-down information annoyed some farmers who felt like they were being told how to farm. This was not the case in the Rotorua Lakes where farmers spoke only positively about the industry messages, perhaps suggesting that the farmers were more receptive to information from players within their industry, harnessing an 'us versus them' outlook. If this is the case, it could explain why Rotorua farmers also spoke highly of their relationship with fertiliser representatives, recognising a sense of kinship as members of the same industry. Comparing this relationship with that of a council-appointed consultant, Rotorua Lakes farmers spoke of feeling frustrated that the consultants did not understand their property like the fertiliser representatives did, and feeling left-out of the process when the consultants utilised Overseer. Fertiliser representatives on the other hand, had been able to develop a history with the farmer and their property, and had made a point to sit down and discuss the fertiliser budget with the farmer. Fertiliser representatives were not trying to tell farmers how to farm.

Although farmers were still aware that fertiliser representatives were salesmen and made sure to check their fertiliser recommendation to make sure it was correct, they felt a greater sense of trust in the fertiliser representatives than with the council-designated consultants in town. This was different to the Rangitāiki Plains farmers, who spoke of holding fertiliser representatives with the same regard as anyone coming onto their property trying to sell them a product, with a “pinch of salt” (participants 2(D,P), 3(D,P)). The interviews with dairy farmers revealed the importance of trust and working relationships between different actors in the dairy industry and the authorities who regulate their activities. To Rotorua Lakes farmers, council staff and council-appointed consultants were influenced with the agenda to control how farmers used their land, to reduce the level of farming in the area.

Criteria 7: What issue “overspill” exists in lay experience?

Criteria seven refers to how acceptance of scientific knowledge by lay people is shaped by a history of perceptions and experiences which have affected the person. Overspill relates to past experiences, where overspill of past perceptions and experiences is not recognised by the scientific method of developing knowledge as the institutional dimensions of science are governed by connecting theory to relevant experiments (Wynne, 2013). For laypeople, decision-making, knowledge construction, and acceptance of information are constructed continuously by the coalescence of social dependencies, self-identity, and past experiences, shaping the position and mentality of a person towards new information.

Rangitāiki Plains farmers have a history with their regional council that is seemingly unscathed by any recent environmental controversies. The Rangitāiki area is dominated by the rural industry, where urbanisation has been limited thus far and farmers have been largely left as they are. Rangitāiki Plains farmers were aware of challenges between farmers and council with using Overseer elsewhere in the country, but consider themselves lucky to be living in an area that maintains a positive council relationship. Contact was described with regional council “only doing their jobs” (participant 4(D,P)) and seeming “quite reasonable” (participant 3(D,P)). In terms of ‘overspill’, Rangitāiki Plains farmers are limited on experiences that cause negative perceptions of Overseer, but are wary of the future as introducing Overseer regulations will increase the incentive to query present concerns about the model further.

In comparison, many Rotorua Lakes farmers have been exposed to Overseer regulations from regional council for over a decade, since 2005. While no farmer mentioned any events leading

to their perceptions of Overseer prior to 2005, the decade since has provided enough experiences to shape their perceptions of the model, its outputs and the policy prescriptions it operates. Examples of this include the meeting of when a councillor stood up to announce his goal of getting rid of farmers in the area, the debate and eventual acceptance by council of the importance of phosphorus to water quality degradation, and the controversies surrounding the groundwater – surface water catchment boundaries, among others. All previous experiences are brought to the present, influencing the perceptions of Overseer updates. Wynne (2013) describes ‘overspill’ using a past example of an environmental controversy unrelated to the present, but very much part of shaping knowledge acceptance, but unaccounted for in the scientific process. The experiences in this case study, referring to the incomplete list of examples portraying controversy for the Rotorua Lakes farmers above, show that even though they should not impact the science Overseer uses, they shape the way farmers perceive and accept the information it produces. The findings indicate that Rotorua Lakes farmers have far less trust in Overseer than Rangitāiki Plains farmers, at least in part, due to their past experiences with the regional council.

Chapter 7

Conclusions

In this concluding chapter, the main findings from this research are summarised. This chapter also includes an evaluation of the study limitations, which outlines any shortcomings of the study and their effect on the validity of the research, and a brief exploration of opportunities for future research.

7.1 Conclusions from this research

The purpose of this research was to investigate the perceptions of dairy farmers and farm consultants with Overseer's change from a decision-support to compliance tool. This research has found that the role of numbers, power and authority, model credibility, perceived fairness, farmer social identity, and the relationship to data production were significant to the perception of Overseer by farmers. The perception farmers have of Overseer is a key influence in their acceptance of nutrient regulation and adoption of sustainable nutrient management practices. The following sections are broken down into separate summaries addressing the three research objectives.

7.1.1 Differences between decision-support and compliance use

The first research objective was to assess the differences in perception of Overseer between farmers using Overseer for decision-support verses farmers using Overseer for compliance purposes. As of late 2016, when the interviews for this research took place, Rangitāiki Plains farmers used Overseer for the purpose of decision-support. With no regulatory incentives to question Overseer's figures, this research found that farmers in this catchment were less interested in investigating the processes and calculations that Overseer uses. However, the farmers were aware of the introduction of nutrient limit regulations around the country and had been influenced by news that Overseer was not accurate, so there was concerns about future policy reaching the Rangitāiki Plains. Nevertheless, at present, for many of the farmers this was not an incentive great enough to warrant pro-active farm system changes.

Overseer's use for compliance by regional councils has resulted in a shift from qualitative to quantitative use. While Rangitāiki Plains farmers are wary of impending nutrient limitations, Overseer's shift has resulted in the creation of higher stakes for Rotorua Lakes dairy farmers,

who are regulated by their figure produced by Overseer. This research has found that the Rotorua Lakes farmers, with higher stakes, have more incentive to oppose the regulations, spending more time investigating the limitations of using Overseer to model nutrient losses, and are more convinced that the process is inaccurate. Rotorua Lakes farmers feel that they need to understand how Overseer works because their farming future depends on it: “Overseer from my perspective was never a powerful tool, it's only since we've gone into the nutrient aspect that it's certainly increased in mana. And coupled with that, the frustration that we have is that for us to be able to focus on nutrients on farm, we need to know how Overseer works” (participant 8(D,L)). The Rotorua Lakes farmers also feel that the process of mitigating nutrient loss is unfair, where council is prioritizing other industries over dairying and encouraging land use change, rather than working with dairy farmers to encourage better farm management practices.

7.1.2 The effect of standardisation on model credibility

The second research objective was to evaluate how standardisation affects perceptions of the on-farm applicability of Overseer and its credibility as a regulatory tool. This research found that when Overseer is used for compliance, the numbers it produces change meaning, becoming a representation of the farmer's performance. Using Overseer for compliance has resulted in a shift from standardising the farm, to standardising the farmer. The Rotorua Lakes farmers spoke of feeling frustrated that Overseer represent their farm and themselves as farmers; Overseer was too inaccurate and simplified. Both groups of farmers were concerned about regional council's use of Overseer as a 'truth machine', where in a high level of trust is placed on Overseer, a computer model, rather than real life. Farmers pointed out that they require flexibility in their farming practices, due to the unpredictable behaviour of agri-environmental systems and specific processes that affect their farm.

Rotorua Lakes farmers perceive that Overseer's ability to measure their farms is impaired and not representative of their farm. This frustration is summarised by participant 13(D,L) with: “you're calculating everything to seven decimal points, and then all of a sudden you're going plus or minus 10% contingency. It just doesn't make sense. Yeah it is the accuracy of Overseer we are concerned about”. This concern surrounding Overseer's inaccuracies is made greater by the perception that model improvements (i.e. version changes) are developed for regulatory purposes, rather than addressing farming system points of view. It is likely that council staff are less concerned about Overseer's limitations and assumptions than farmers.

This explains why Rotorua Lakes farmers feel that council staff are unable to clearly communicate different aspects of Overseer and answer the farmer's queries about the science behind it: "council have as much or more difficulty getting their head around it than we do as farmers" (participant 12(D,L)). Farmers are focused on the contextual factors surrounding Overseer, rather than the model itself, where any improvements to the science are intended for regulation and felt to overlook farmers. The farmers are being standardised by Overseer by being represented by a figure used for compliance. Overseer's inability to demonstrate precision weakens the farmer's perception of the model's suitability as a regulatory tool.

7.1.3 Implications for sustainable nutrient management

The final research objective was to identify the implications of the use of Overseer as a compliance tool for nutrient management and the challenges these present for the implementation of water quality limits. By taking the focus away from individual's technical understandings of scientific knowledge, this research has attempted to explore the social identities that characterise public responses to regulations. Trust and credibility emerged as key themes in the development of perceptions to the use of Overseer by farmers, shaped by the working relationships between farmers and council staff, council scientists, private consultants, members of the public, and industry workers. This research has shown that when many farmers consider Overseer, they focus on the contextual factors surrounding its use, rather than the practicalities of the model itself. An example which emphasises the focus on Overseer's contextual factors was described by several farmers, where farmers felt that council wanted to remove all farming in the region to make way for other industries. This idea was unfortunately highlighted by the event where a councillor (since departed) "stood up in a meeting and said "I'm going to get rid of you bastards" (participant 13(D,L)). These Rotorua farmers feel like the process of mitigating nutrient loss is unfair, where council is prioritizing other industries over dairying and encouraging land use change, rather than working with dairy farmers to encourage better farm management practices.

One of the greatest frustrations felt by Rotorua Lakes farmers is the prospect of being locked in to the seemingly arbitrary movements of Overseer through their farm consents, resulting in farmers farming to Overseer. Because the penalties for not meeting NDA targets can be severe, farmers are likely to abide by the numbers. Rotorua Lakes farmers feel trapped by Overseer where decision-makers are not taking their likely constrained future into consideration.

Assessing the implications of using Overseer for sustainable nutrient management in the implementation of water quality limits, it is likely that farmers will remain sceptical of Overseer's suitability as a compliance tool unless efforts are made to improve farmers' relationship with council. The results from this research demonstrate the predictions made by Duncan (2014) and concepts discussed by Porter (1995) in which the use of numbers and quantitative modelling does not provide clarity and remove ambiguity during the implementation of resource limits. Continued efforts to increase the scientific accuracy of the model, alone, will not resolve the issue of distrust between farmers and Overseer.

7.2 Study limitations

The most significant limitations of this study were in relation to the methodology and temporal constraints of the research period. Participants for the Rangitāiki Plains dairy farmers group were selected from a pool of personal contacts of the researcher. The fact that all seven participants were known to the researcher and willing to participate in the research, meant that there was the possibility of only representing a limited pool of perspectives. In order to overcome this, the researcher actively tried to contact a diverse group of participants, selecting farmers whose farms varied greatly in size, location, geography and management practice. However, it cannot be assumed that all Rangitāiki Plains farmers' perspectives were represented in this study.

Due to not having any personal contacts within the Rotorua Lakes dairy farmers group, initial participants were contacted by obtaining their details from their submission against Plan Change 10. The fact that these farmers had submitted documents for consideration indicates that they are proactive within the community, which could indicate that they only represent farmers who are in opposition to the plan change. Their act of submitting indicates that they hold strong perspectives opposing the introduction of nutrient limits and use of Overseer in their catchment. Although those interviewed spoke of their opinion being representative of all farmers in the catchment, it also became apparent that many farmers did not openly discuss their NDA figures, and thus it should not be taken for granted that all farmers in the catchment hold the same opinion as the six interviewed for this research.

Another limitation was the lack of perspectives held by regional council staff and private council-appointed nutrient consultants. This research focused entirely on the perspectives held by the users of Overseer (i.e. dairy farmers and farm consultants) due to the infeasibility

of obtaining and analysing qualitative interviews for more participant groups. However, for contextual purposes, it would have been valuable to gain insights from those developing and enforcing the nutrient regulations and those benefitting financially from using Overseer for compliance use. The inclusion of the two farm consultants was beneficial for contextual purposes, but did not fully represent the Bay of Plenty region.

Finally, the procedure used to code the qualitative data (using MAXQDA software) included some unavoidable subjectivity. In order to make the analysis as objective as possible, coding rules were created and followed to identify themes. Although coding was attempted to be kept within the research scope (with frequent referral to the research question, aim, objectives and theoretical framework) some amount of subjectivity is inevitable.

7.3 Future research opportunities

The limitations of the research described in the previous section could be addressed through further research. Future research would benefit from involving greater numbers of participants, representatives from all affected groups (i.e. farmers from all disciplines, regional council staff, farm consultants and industry professionals), and a larger temporal scale to allow for understanding changes to perceptions during rule changes and regulation enforcement.

This study focused on a narrow temporal scale from the introduction of Overseer, to the calculation of NDA figures for farmers in the Rotorua Lakes area, and a time period where Rangitāiki Plains farmers were without nutrient limits. By continuing research into the period of enforcing NDA targets in the Lake Rotorua catchment, a greater understanding of the complexity surrounding farmers' perceptions of trust towards authority could be achieved. Obtaining qualitative data during and following the release of Plan Change 12, on the Rangitāiki Plains, would also add depth to understanding the perceptions of trust and credibility towards predictive models.

Finally, this research has only focused on dairy farmers and farm consultants in two catchments in the Bay of Plenty. Nutrient regulations involving Overseer have been implemented throughout the country, and will continue to as regional plan changes are produced to fulfil NPS-FM requirements. Further studies could be undertaken in other catchments around New Zealand to enable comparisons with the findings of this study.

Appendix A

Interview Questions

A.1 Questions used for semi-structured interviews with Rangitāiki Plains dairy farmers

Background – Describing your farming operation

1. How long have you been farming, been on this farm?
2. Can you please describe your farming operation? E.g. farm size, production type, length of time the farm has been in this production type.
3. Can you please discuss the irrigation and effluent management on the farm? What soil types are on the property? (i.e. free or poorly draining, clay content)
4. How would you describe the water quality of streams and rivers in or near your property?
5. How would you describe your farm's contribution to the level of nutrients in waterways in this area?
6. What is your understanding of how Overseer is being/to be used in this catchment to address water quality?

Overseer use

7. How long have you been using Overseer, and who introduced you to it?
8. How do you use Overseer?
9. What information are you most interested in receiving from Overseer?
10. What happens to your Overseer reports once they have been produced?
11. How well do you think the inputs and outputs of Overseer represent your farm?
12. Are there any parameters or aspects of the model you'd like to know more about?
13. What is your understanding of how Overseer calculates nutrient losses to water?
14. Can you explain if/how you use any mitigation features in Overseer following the initial reports?

Overseer and nutrient measurement

15. Did you have any form of nutrient measurement in place before you used Overseer?

16. How have your farm operations benefitted from the use of Overseer?
17. Have you been affected by changes in versions of Overseer? If so, were the numbers higher or lower than expected?
18. Are you interested to know how your nutrient output compares to others?

Broader picture

19. How do you think Overseer data will be used to address water quality and nutrient issues in the Bay of Plenty? How do you think it should be used?
20. What do you think the benefits of Overseer are for addressing water quality through nutrient management on farms?
21. Any other comments you would like to add?

A.2 Questions used for semi-structured interviews with Rotorua Lakes dairy farmers

Background – Describing your farming operation

1. How long have you been farming, been on this farm?
2. Can you please describe your farming operation? E.g. farm size, production type, length of time the farm has been in this production type.
3. Can you please discuss the irrigation and effluent management on the farm? What soil types are on the property? (i.e. free or poorly draining, clay content)
4. How would you describe the water quality of streams and rivers in or near your property?
5. How would you describe your farm's contribution to the level of nutrients in waterways in this area?
6. What is your understanding of how Overseer is being/to be used in this catchment to address water quality?

Overseer use

7. How long have you been using Overseer, and who introduced you to it?
8. How have you used Overseer in the past?
9. How do you use Overseer currently? Have you begun working with a consultant to calculate your nitrogen allowance number?

10. What information are you most interested in receiving from Overseer?
11. What happens to your Overseer reports once they have been produced?
12. How well do you think the inputs and outputs of Overseer represent your farm?
13. Are there any parameters or aspects of the model you'd like to know more about?
14. What is your understanding of how Overseer calculates nutrient losses to water?
15. Can you explain if/how you use any mitigation features in Overseer following the initial reports?

Overseer and nutrient measurement

16. Did you have any form of nutrient measurement in place before you used Overseer?
17. How have your farm operations benefitted from the use of Overseer?
18. Have you been affected by changes in versions of Overseer? If so, were the numbers higher or lower than expected?
19. Are you interested to know how your nutrient output compares to others?

Broader picture

20. How do you think Overseer data will be used to address water quality and nutrient issues in the Bay of Plenty? How do you think it should be used?
21. What do you think the benefits of Overseer are for addressing water quality through nutrient management on farms?
22. Any other comments you would like to add?

A.3 Questions used for semi-structured interviews with farming consultants

Background – Describing your role

1. What services do you provide for dairy farms in the Bay of Plenty?
2. What is your understanding of how Overseer is being/to be used in this catchment to address water quality?

Overseer use

3. How long have you been working with Overseer? How is Overseer used in your current role? Have you worked with Overseer in other regions in NZ?
4. What information are you most interested in receiving from Overseer as a

consultant?

5. What challenges do you face in using Overseer to accurately represent farm systems?
6. Have there been any challenges incorporating S-Map and rainfall data into the model? Have these environmental databases improved your ability to represent the farm system?
7. Have you noticed any change in how farmers approach Overseer when it is being used for compliance rather than for decision support for fertilizer application?
8. Can you explain if/how you use any mitigation features in Overseer following the initial reports?

Overseer and nutrient measurement

9. Can you explain if you think the shift in Overseer's role from decision-support to compliance will improve farm nutrient management?
10. In your opinion what are the key benefits of using Overseer for nutrient management compliance?
11. What are the disadvantages of using Overseer?
12. What have been the main challenges during this role shift?
13. How have farmers responded to the shift in the use of the model?
14. How have farmers responded to changes in versions of the model?

Broader picture

15. Can you please describe your opinion on the current status of water quality in the Bay of Plenty?
16. Do you think Overseer's data will be useful in addressing nutrient issues in the Bay of Plenty?
17. What do you think the benefits of Overseer are for addressing water quality through nutrient management in NZ?
18. Any other comments you would like to add?

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